rare!

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Astronomy in its Relations to Horology.

NUMBER ONE.

However accurate an instrument for the mensuration of time may be, it would be of little use for close observation unless we have some standard by which to test its performance. We look to Astronomy to furnish us with this desideratum, nor do we look in vain. The mean sidereal day, measured by the time elapsed between any two consecutive transits of any star at the same meridian, and the mean sidereal year—which is the time included between two consecutive returns of the sun to the same star—are immutable units with which all great periods of time are compared; the oscillations of an isochronous pendulum affording us a means of correctly dividing the intermediate space into hours and days.

We must premise that the whole theory of taking time by sidereal observations is based on angular motion, the mensuration of one of the angles of motion giving a measurement of space, so that to say space, or distance, is equivalent to saying time. From noon of one day to noon of another is the whole problem to be solved by correct division. The astronomical day begins at noon, but in civil law the day is dated from midnight. So in the year the astronomical day is dated December 31, while in common reckoning the 1st of January is the initial point. This day is divided into twenty-four hours, counted in England, America, and the most of the Continental nations of Europe, by twelve and twelve. The French astronomers, however, adopted the decimal system, for ease in the computation. Thus they divided the day into ten hours, the hour into one hundred minutes, and the minute into one hundred seconds. This plan was in conformity with the French system of decimal weights and measures. Again, in Italy, the day was divided into twenty-four hours, but counting from one to twenty-four o'clock. The French system presents some features well worthy of adoption, as it gives results so much more easy in computation—a facility unattainable in the common division; yet it did not come into general use in other countries, and although some French astronomers still hold to the system, it is gradually dying out.

At one time during the Revolution in France a clock in the gardens of the Tuileries was regulated to show time by the decimal system.

For the Horologist the mean length of the day is sufficient to show the rate of his instrument for that particular day, but the astronomical and civil division requires a much longer period of observation. This is obtained by the position of the mean annual equinoxes or solstices, and is estimated from the winter solstice, the middle of the long annual night under the North Pole; and the period between this solstice and its return is a natural cycle, peculiarly suited for a standard of measurement.

Even with such a standard as the civil year of 365d. 5h. 48m. 49.7s., the incommensurability that exists betwen the length of the day and the real place of the sun makes it very difficult to adjust the ratio of both in whole numbers. Were we to return to the point in the earth's orbit in exactly 365 days, we would have precisely the same number of days in each year, and the sun would be at the same point on the ecliptic at the same second at the beginning and end of the year. There is, however, a fraction of a day, so that a solar year and civil are not of equal duration.

It is thus we have our bissextile year, from the fact that the inequality amounts to nearly a quarter of a day, so that in four years we have a whole day's gain; but not exactly, because a fraction still remains to be accounted for. Now, if we should suppress the one day of leap-year once at the end of each three out of four centuries, the civil would be within a very small fraction equal to the solar year, as given by observation; this small fraction would be almost entirely eliminated, provided we suppressed the bissextile at the end of every four thousand years. Were this fraction neglected, the beginning of the new civil year would precede the tropical by just that much, so that in the course of 1507 years the whole day's difference would obtain.

The Egyptian year was dated from the heliacal rising of the star Sirius; it contained only 365 days. By easy computation it can be shown that in every 1461 years a whole year was lost; this cycle was called the Sothaic period, in which the heliacal rising of Sirius passed through the whole year and took place again on the same day. The commencement of that cycle took place 1322 years before Christ. The year by the Roman calendar was dated by Julius Cæsar the 1st of January, that being the day of the new moon immediately following the winter solstice in the 707th year of Rome. Christ's nativity is dated on the 25th of December, in Cæsar's 45th year, and the 46th year of the Julian calendar is assumed to be the 1st year of our era. The preceding year is designated by chronologists the 1st year before Christ, the dates thence running backward the same as they run forward subsequent to that period.

Astronomically, that year is registered 0; the astronomical year begins at noon on the 31st of December, and the date of any observation expresses the number of days and hours which have actually elapsed since that time, the 31st of December—Year 0.

The year is divided into months by old and almost universal consent, but the period of seven days is by far the most permanent division of a rotation of the earth around the sun. It was the division long before the historic period. The Brahmins in India used it with the same denominations as at the present day the Jews, Arabs, Egyptians, and Assyrians. "It has survived the fall of empires, and has existed among all successive generations, a proof of their common origin."

Nothing can be more interesting in the study of astronomy than its chronological value. La Place says: "Whole nations have been swept from the earth, with their languages, arts, and sciences, leaving but confused masses of ruins to mark the place where mighty cities stood; their history, with but the exception of a few doubtful traditions, has perished; but the perfection of their astronomical observations marks their high antiquity, fixes the periods of their existence, and proves that even at that early time they must have made considerable progress in science."

The earth revolving around the sun in an ellipse, the position of the major axis of the orbit would indicate something in regard to eras in astronomy extending not only beyond the historical period, but so far back in the past that imagination is almost at fault. The position of the major axis of the orbit depends on the direct motion of the perigee and the precession of the equinoxes conjointly, the annual motions respectively being 11″.8 and 50″.1, the two combined motions being 61″.9 annually. A tropical revolution is made in 209.84 years. This being a constant quantity, we may ascertain when the line of the major axis coincided with the line of the equinoxes. This occurrence took place about 4,000 or 4,090 years before the year 0. In the year 6,483 the major axis will again coincide with the line of the equinoxes, but then the solar perigee will coincide with the vernal equinox. So, it will be seen that the period of revolution is 20,966 years. But in the progress of this revolution there must have been a time when the major axis was perpendicular to the line of the equinoxes. A simple calculation will show that the eventful year was 1250; and so important is this event considered, that La Place, the immortal author of the *Mechanique Celeste*, proposed to make the vernal equinox of this year the initial day of the year 1 of our era. Again, at the solstices the sun is at the greatest distance from the equator; consequently the declination of the sun is equal to the obliquity of the ecliptic. The length of a shadow cast at noonday from the stile of an ordinary sun-dial would accurately determine the precise time on which this position occurs.

Though wanting in accuracy, such a measurement is of interest, from the fact that there are recorded observations of this kind that were taken in the city of Layang, in China, 1100 years before our present era is dated. This observation gives the zenith distance of the sun at the moment of the observation. Half the sum of the zenith distances gives the latitude, and half their difference gives the obliquity of the ecliptic at the period. Now the law of the variation of the ecliptic is well known, and modern computation has verified both the moment of taking the observation and the latitude of the place. Eclipses were the foundation of the whole of Chinese chronology, and recorded observations prove the civilization of that strange race for 4700 years.

Horology, with astronomy, was not neglected even as early as 3102 years before Christ, as the following will show.

The cycles of Jupiter and Saturn are very unequal, the latter being a period of 918 years; the mean motion of the two planets was determined by the Indians in that part of the respective orbits where Saturn's motion was the slowest and Jupiter's the most rapid. This observed event must have been 3102 years before, and 1491 after the year 0; but the record shows that the observation was taken before the last-named date.

Since both solar and sidereal time is estimated from the passage of the sun and the equinoctial point across the meridian of the place of observation, the time will vary in different places by as much as the passage precedes each. It being obvious that when the sun is in the meridian at any one place, it is midnight at a point on the earth's surface diametrically opposite; so an observation taken at different places at the same moment of absolute time, will be recorded as having happened at different times. Therefore when a comparison of these different observations is to be made, it becomes necessary to reduce them by computation to what the result would have been had they been taken under the same meridian at the same moment of absolute time. Sir John Herschel proposed to employ mean equinoctial time, which is the same for all the world. It is the time elapsed from the moment the mean sun enters the mean vernal equinox, and is reckoned in mean solar days and parts of days. This difference in time is really the angular motion of the earth, and by measuring it the longitude of any place on the surface of the earth can be determined, provided we have a standard point of departure, and an instrument capable of accurately dividing the time into small quantities during its transit from the meridian on which it was rated.

As will be hereafter shown, the axis of the earth's rotation is invariable. Were the position of the major axis of the earth's orbit as immutable, an observation of any star on the meridian taken at any place would always be the same. Again, the form of the earth has an important effect; the equatorial diameter exceeds the polar, thus giving a large excess of matter at the equator. Now the attraction of an external body not only draws another to it in its whole mass, but, as the force of attraction is inversely as the square of the distance, it follows that the attracted body would be revolved on its own centre of gravity until its major diameter was in a straight line with the attracting body.

The sun and moon are both attracting bodies for the earth; the plane of the equator is at an angle to the plane of the ecliptic of 23° 27′ 34″.69, and the plane of the moon's orbit is inclined to it 5° 8′ 47″.9 Now from the oblate form of the earth, the sun and moon, acting obliquely and unequally, urge the plane of the equator from its own position from east to west, thus changing the equinoctial points to the extent of 50″.41 annually.

This action, were it not compensated by another force, would in time alter the angle of the ecliptic until the equatorial plane and the ecliptic coincided. There are few but have seen the philosophical toy called the Gyrascope. This toy, on a miniature scale, gives a fine illustration of the force brought in to correct the combined action of the sun and moon on the obliquity of the equator. The rotation of the earth is held in its own plane by its own revolution, the same as the gyrascope seems to overcome the laws of gravitation by its force of revolution.

But not only do the sun and moon disturb the plane of the ecliptic, but the action of other planets on the earth and sun is to be taken into account. A very slow variation in the position of the plane of the ecliptic, in relation to the plane of the equator, is observed from these influences. It must be remembered that a very slight deviation in the angle can and would be detected by observation with modern instruments. We do find that this attraction affects the inclination of the ecliptic to the equator of 0″.31 annually.

This motion is entirely independent of the form of the earth. Now, if we assume that the sun and moon give the equinoctial points a retrograde motion on the ecliptic, we must deduct the influence of the planets. We may then calculate the mean disturbance by subtracting the latter from the former—the difference is settled by both theory and observation to be 50″.1 annually. This motion of the equinoxes is called the precession of the equinoxes. Its consideration forms a very important element in the estimation of time, as the position of the various fixed stars, though so very distant, are all affected in longitude by this quantity of 50″.1—being an increase of longitude. Therefore, if we were to calculate the position of any given star in order to get a transit for mean time, or true time, we must take this quantity into consideration. The increase is so great that the earliest astronomers, even with their imperfect modes of observation, detected it. Hipparchus, 128 years before Christ, compared his own observations with those of Timocharis, 153 years before. He found the solution of the problem the same as Diophantus found the solution of the squares and cubes, by analysis. In the time of Hipparchus, the sun was at a point 30° in advance of its present position, for it then entered into the constellation of Aries near the vernal equinox.

At the present time the position of the equinoctial points shows a recession of the whole, 30° 1′ 40″.2. At this rate of motion the constellations called the Signs of the Zodiac are some distance from the divisions of the ecliptic that bear their names. At the rate of 50″.1 the whole revolution of the equinoctial points will be accomplished in 25,868 years; but this is again modified because the precession must vary in different centuries for the following reasons: the sun's motion is direct, the precession retrograde; therefore, the sun arrives at the equator sooner than he does at the same star of observation. Now, the tropical year is 365d. 5h. 48′ 49″.7; and as the precession is exactly 50″.1, we must suppose it takes some time for the sun to move through that arc. By direct observation it is found that the time required for such translation is 20′ 19″.6. By adding this amount to the tropical year we have the sidereal year of 365d. 6h. 9′ 9″.6 in mean solar days. This amount of precession has been on the increase since the days of its first recorder, Hipparchus, as the augmentation amounts to no less than 0.″455. By adding that to the known precession we find that the civil year is shorter now by 4″.21 than in his time; but, as a great division of time, the year can be changed by this cause not more than 43.″

The action of the moon on the accumulation of matter at the earth's equator is a source of disturbance that in very accurate observations for time should be eliminated. Thus the moon, with the conjoint action of the sun, depending on relative position, causes the pole of the equator to describe a small ellipse in the heavens with axes of 18″.5 for the major, and 13″.674 for the minor; the longer axis being directed to the pole of the ecliptic. This inequality has a period of 19 years,—it being equal to the revolution of the nodes of the lunar orbit. The combination of these disturbances changes, by a small quantity, the position of the polar axis of the earth in regard to the stars, but not in regard to its own surface. With so many disturbing causes, we must add that of Jupiter, whose attraction is diminishing the obliquity of the ecliptic by 0″.457 according to M. Bessel.

The results of all these forces must affect the position of all the stars and planets as seen from our earth. Their longitudes being reckoned from the equinoxes, the precession of these points would increase the longitude; but as it affects all the stars and planets alike, it would make no real or apparent change in their relative positions. Nutation, however, affects the celestial latitudes and longitudes, as the real motion of the earth's polar axis changes the relative positions. So great is the change that our present pole star has changed from 12° to 1° 24′; in regard to the celestial pole, the gradual approximation will continue until it is with 0° 30′, after which it will leave the pole indefinitely until in 12,934 years *α* Lyræ will be the pole star.

So far we have given only the causes that affect the meridian, and consequently our standard for time; but that point being established for the yearly and diurnal revolutions, it becomes necessary to find some means to divide the day into minute fractional parts, such as seconds and parts of seconds. This, it has been stated, is effected by means of an isochronous pendulum. On this instrument no comment is required but of the causes that disturb its accuracy much is needed. In 1672, at Cayenne, the astronomer Richter, while taking transits of fixed stars, found his clock lost 2′ 28″ per day. This was an error that arrested his attention, and he immediately attributed it to some variation in the length of the pendulum—due to other causes than atmospheric changes and expansion. He determined the length of a pendulum beating seconds in that latitude, which was 5° N. in South America. He found that that pendulum was shorter than one beating seconds in Paris, by 0833+of an inch. Now, if the earth was a sphere, the attraction of gravitation at all places on its surface would be equal, and the oscillations of a pendulum would also be equal, + or − the disturbing effect of centrifugal force—an amount that can be easily determined. The real reason of the variation is found in the configuration of the earth.

The amount of the attraction of gravitation at any point of the earth's surface is found by the distance traversed by any body during the first second of its fall. The pendulum is a falling body, and may be by the same analysis reasoned on that pertains to the laws of gravitation; the centrifugal force is measured by any deflection from a tangent to the earth's surface in a second.

It follows that the centrifugal force at the poles, where there is the least motion, would not be equal to the force of gravitation, and at the equator must be exactly equal; but the deflection of a circle from a tangent measures the intensity of the earth's attraction, and is equal to the versed sine of the arc described during that time, the velocity of the earth's rotation being known, the value of the arc is deducible. The centrifugal force at the equator is equal to $\frac{1}{289}$th part of the attraction of gravitation. Again, the uniformity of the earth's mass becomes an object of consideration. Assuming that the figure of the earth is an ellipsoid of rotation, we will show the relation that form bears to the equal oscillation of a pendulum.

Taking the earth as a homogeneous mass, analysis gives us the certainty that if the intensity of gravitation at the equator be taken as unity, the increase of gravity to the poles eliminating the differences of the centrifugal force must be = to 2.5, the ratio of the centrifugal force to that of gravitation at the equator. Now, taking the 2.5 of .346 $= \frac{1}{115.2}$, this then must be the total increase of gravitation. Did we know the exact amount of increase at every point, from the equator to the poles, a perfect map of the form of the earth could be produced from calculation; experiment being from physical causes totally impracticable. The following analysis, quoted from an eminent physicist, gives a very lucid idea of the reasoning:

"If the earth were a homogeneous sphere without rotation, its attraction on bodies on its surface would be everywhere equal. If it be elliptical and of variable density, the force of gravity ought to increase in intensity from the equator to the pole as *unity plus* a constant quantity multiplied into the square of the sine of the latitude. But for a spheroid in rotation the centrifugal varies by the law of mechanics, as the square of the sine of the latitude from the equator, where it is greatest, to the poles, where it is least. And as it tends to make bodies fly off the surface, it diminishes the force of gravity by a small quantity. Hence, by gravitation, which is the difference of these two forces, the fall of bodies ought to be accelerated from the equator to the poles proportionably to the square of the sine of the latitude, and the weight of the body ought to increase in that ratio."

Assuming the above reasoning to be correct, it follows, that the rate of descent of falling bodies will be accelerated in the transition from the equator to the poles. Now, it has been before stated that the pendulum is a falling body; therefore, with the same length of pendulum, the oscillations at the pole should be faster than at the equator. Theory, in this case, is verified; for it has been proved by experiments, repeated again and again, that a pendulum oscillating 86,400 times in a mean day at the equator, will give the same number of oscillations at any other point, provided its length is made longer in the exact ratio as the square of the sine of the latitude.

The sequence to be derived from all the foregoing considerations is, that the whole decrease of gravitation from the equator to the poles is 0.005.1449, which subtracted from the $\frac{1}{115 \cdot 2}$ gives the amount of compression of the earth to be nearly $\frac{1}{285 \cdot 26}$. But this form of the earth would give the excess of the equatorial axis over the polar about 26½ miles. The measurement is confirmed by Mr. Ivory in his investigations on the five principal measurements of arcs of the meridian in Peru, India, France, England, and Lapland. He found that the law required an ellipsoid of revolution whose equatorial radius should be 3,962.824 miles, and the polar 3,949.585 miles; the difference is 13.239 miles; this quantity multiplied by two gives 26.478 as the excess of one diameter over the other. Thus, by two different processes the figure of the earth has been determined; but another remains that is the result of pure analysis, derived from the nutation and precession of the equinoxes—for, as explained before, these effects are caused by the excess of matter at the earth's equator. The calculation does not lead us to certainty, but it does show the compression to be comprised between the two fractions $\frac{1}{270}$ and $\frac{1}{573}$. There is this advantage in the lunar theory, that it takes the earth as a whole, disregarding any irregularities of surface, or the local attractions that influence the pendulum—the difficulties of measuring an arc of the meridian being an obstacle to perfect accuracy.

The form of the earth has, however, a value confined not alone to those interested in horology—it furnishes us with a standard of weights and measures. In England and the United States, the pendulum is the unit of mensuration, or at least the common standard from which measurement is derived. It has been shown that, deducting the effects of nutation, the axis of the earth's rotation is always in the same plane. Now, the mass being the same constant quantity, a pendulum oscillating seconds at the Greenwich Observatory, has been adopted by the English Government as its standard of length. Oscillating in vacuo at the level of the sea, at 62° Fahr., Captain Kater found its approximate length te be 39.1393 inches; as this must be invariable under the same circumstances, it becomes a standard for all time. The French deduced their standard from the measurement of the ten-millionth part of a quadrant of the meridian passing through Formentera and Greenwich. They have also adopted the decimal system; yet it seems to prove that nothing under the sun is new, for over forty centuries ago the Chinese used the decimal system in the division of degrees, weights, and measures.

The antiquity of the pendulum is also shown by the fact that the Arabs were in the habit of dividing the time in observations, by its oscillations, when Ibn Junis, in the year one thousand, was making his astronomical researches. Before we lose sight of the influence of the form of the earth on the pendulum, it may be well to state another source of disturbance, arising from the combined influence of the earth's rotation and the fact that a body moving in its own plane seeks to maintain that plane. It will be seen from the very beautiful experiment showing the rotation of the earth, that if a body like a pendulum be suspended so as to be free in every direction, and not be influenced by the motion of the earth when set in oscillation in any plane, that that plane will preserve its line of motion, while the earth in its motion beneath the body can be seen to slowly move, as though the minute hand of a watch were made stationary while the dial revolved. The same principle is the one that maintains the spinning-top in a parallel position to the horizon, or the gyrascope in its apparently anomalous defiance of all the laws of gravitation. In the pendulum this tendency to preserve the same plane of motion becomes a cause of error—slight, it is true, but can be very easily remedied by so placing it that the plane of oscillation shall be parallel to the equator. It will be readily seen that this precaution will become more important as we recede from the equator; for if we were to suspend a pendulum at the pole in a true line with the axis of rotation, and if the plane of vibration remained constant, the earth would turn once around that plane in the diurnal period. During this time there would be a continuous torsion on the point of suspension, that would in time materially affect the accuracy of the instrument. The reasoning holds good for every latitude—degree of influence being the only difference.

Having given the action of the earth's form, mass, and rotation on the pendulum, there remain the disturbances due to expansion and contraction, owing to changes of temperature and those of atmospheric causes. The astronomical points to be observed are somewhat too fully laid down, but it must be remembered that an exact science requires the premises to be fully established before a sequence can be drawn.

As the standard of time depends on the passage of a star or the sun, or any known celestial object, at a certain time across the meridian of the place where the observation is taken, it was absolutely necessary to give the modes of calculation, together with the disturbing causes. Moreover, a full appreciation of the indebtedness of horology to astronomy could not be obtained without a general knowledge of the change of the position of the major axis of the orbit described by the earth around the sun. Also, the difference between mean and apparent solar time was required to illustrate the use of the tables of equated time, the necessity of which will become patent when the use of the transit instrument for the establishment of time, or a fixed standard, is introduced. Also, the disturbing effects of the sun and moon collectively and relatively as to position, could not be passed, as they produce the precession of the equinoxes and the nutation of the pole—essential elements in the computation of time.

Watch and Chronometer Jewelling.

NUMBER ONE.

This whole subject is well worthy an article both in a scientific and mechanical sense, whether we consider the delicacy of the operations or the intractable character of the material operated on—for there has been no improvement in the horological trade of more importance to accuracy and durability of time-keepers.

The substitution of stone for common brass or gold bearings, was prompted by the inevitable wear of the holes from frequent cleaning, and the abrasion of the pivots, produced by the accumulation of dust with viscid oil; the pivot being cut away, or the hole opened too large. So long as the verge and cylinder were the prevailing escapements, the necessity for jewelling was not so strongly felt, except in the balance holes. The introduction of the lever escapement brought with it a better watch,—capable of more accurate time, but demanding an improved construction.

An Italian, in 1723, first introduced the practice of using stone for bearings. He not only conceived the idea, but was successful as an artisan in making his own jewels; ingenious and skilful as he was, however, he encountered obstacles almost insurmountable.

The art of cutting gems, it is true, was at that time well understood, but no one had attempted to drill a hole in a hard stone fine enough for a properly sized pivot. The watches at that time that were jewelled could boast of nothing more than the balance holes, and they were not pierced to let the pivot *through.*

It is a very difficult matter to polish a taper indentation in a stone, even with modern appliances, in consequence of the tendency to create a *tit* at the bottom,—thus throwing the balance staff out of upright. The difficulties in the then state of knowledge retarded the general introduction of stonework for many years. The Swiss, however, seeing the advantages derived, finally struck out the various manipulations with success. Time and experience gave more skill, and at the present time it is impossible to find a Swiss watch, even of the cheapest class, that is not jewelled in at least four holes. The English trade adopted the art later; but even then it did not become general for many years. Within a generation, only fine English levers were jewelled.

The mere substitution of a harder substance was not the only improvement; other conditions necessary to accuracy were insured. The hole could be made *round*—the material of such a character that no chemical action could be effected on the oil used for lubrication, and the vertical section of the hole could be made so as to present the least amount of frictional surface, yet still giving a perfectly polished bearing, thus avoiding the cutting of the pivot.

The whole "*modus operandi*" from the stone in the rough to the last setting up is well worth the attention of the watch repairer, and certainly that of the manufacturer.

Of the materials used in the trade, the first and most important is the diamond, used only in the time-piece as an end-stone—but at the bench all-important, as a means of making the other jewels. The diamond possesses the requisite susceptibility of polish, combined with greatest hardness of any substance known; but this adamantine quality precludes its being pierced with a through hole Considered chemically, the diamond is pure carbon,—its different varieties differing only in structure—common charcoal, its lowest—plumbago, its intermediate grade. Another variety, called the "black diamond," or "diamond carbon," occurs, which is interesting as being a parallel with emery, compared with crystallic sapphire. The form of diamond most in use for mechanical manipulations, is almost always crystallized; yet it will be seen that the agglomerated form of diamond carbon plays no unimportant part in jewelling. As a jewel, no use is made of the diamond other than as an end-stone Marine chronometers, in which the balance will weigh from five to nine pennyweights, are almost invariably furnished with a diamond end-stone, set in steel. Yet, hard as the substance is, it is often that a pivot will cut an indentation in its face. The cause of this apparent anomaly is to be found in the structural character of the gem, and its value. The lapidary, saving in weight as possible, does not care, in "Rose Diamonds," to pay attention to the lines of cleavage. If the face of the stone makes a slight angle with the strata of the jewel, there occur innumerable small angles of extreme thinness—the pivot, coming in contact with any of these thin portions, may fracture it, and the fragment, becoming imbedded in the tempered steel pivot, becomes a drilling tool. In our ou rexperience we have had marine chronometers sent for repair, that have lost their rate so much as to become utterly unreliable from this cause alone—the pivot having produced an indentation of the stone, creating more friction, and thus destroying the accuracy of the instrument.

As a general rule, the rose diamonds sold for this purpose are sufficiently good for general work. In a very fine watch or chronometer the stone should be selected with reference to its polish on the face, and its parallelism in the lines of cleavage. The diamond, however, gets its great importance from being the only agent we can use in working other stones. Without it the whole art of jewelling would not be practicable. The various steps are all connected some way with diamond in its different shapes. "Bort," the technical name for another variety, is merely fragments of the stone that have been cleaved off from a gem in process of cutting, or gems that have been cut, but found too full of flaws to become of use for ornamental jewelry purposes, the cost depending on the size, varying from $5.50 to $18 per carat. This "Bort" is used as turning tools—the larger pieces being selected and "set" in a brass wire and used on the lathe, in the same manner, and with the same facility, as the common graver. For tools, even the diamond is not of equal value—a pure white and crystalline in structure generally being too brittle (though hard) to endure the work. Among the workmen the "London smoke," a clouded, brownish stone, is most prized—it possessing the twofold qualities of toughness and hardness.

Another form of "Bort" comes in the shape of a small globule, sometimes the size of a pea; it is crystallic, and when fractured generally gives very small, indeed minute pieces of a needle shape. These are carefully selected, and form the drills with which the English hole-maker perforates the jewel. These drills, when found perfect, for soundness, form, and size, are very highly prized by the workman, as the choice of another, together with the setting, will often take a vast deal of time and labor.

"Bort" is also used in the making of the laps or mills with which the jeweller reduces the stones to a condition for the lathe and subsequent processes. For this purpose such pieces as are not fit for cutting-tools, or drills, are selected. A copper disk, having been first surfaced and turned off in the lathe, is placed on a block or small anvil; each piece of stone is then separately placed on the copper, and driven in with a smart blow—care being taken that no place shall occur in the disk that does not present, in revolution, some cutting point. It would seem impossible to retain the diamond fragment, but it must be remembered that the copper, being a very ductile metal, receives the piece; the first rubbing of a hard stone then burnishes the burred edges of the indentations over every irregular face of the diamond, leaving only a cutting edge to project. The rapidity with which such a lap, well charged, will reduce the hardest stone, is somewhat marvellous. It is the first tool used in jewelling, and so important that a more detailed and explicit description of its make will be given when the process of manufacture is treated upon.

Diamond powder is equally as important as "bort," being used in nearly every stage of jewel-making. The coarsest charges the "skives" or saws used for splitting up the stone. These skives are made of soft sheet-iron, and act on the same principle as the laps. The finer grades, in bulk, resemble very much ordinary slate-pencil dust; indeed, the latter is often used as an adulteration. This powder is not uniform in fineness, and the jewel-maker is under the necessity of separating the different grades. This is effected by a simple process called "floating off," and is conducted as follows: A certain quantity of powder, say a carat, is put into a pint of pure sweet oil, contained in some such shallow vessel as a saucer. Depending on the fluidity of the oil, the mixture, after being thoroughly incorporated, is allowed to stand undisturbed for about an hour or an hour and a half. During this time, owing to their greater gravity, the largest particles are precipitated, leaving held in suspension a powder of nearly uniform fineness. The mixture is now carefully decanted into another similar vessel, leaving the coarse powder at the bottom of the first. This coarse deposit is denominated No. 1, and is used for skives, laps, and other rough purposes. The decanted mixture in the second vessel is allowed to remain quiescent for twelve hours, when the same operation is performed; and the third vessel now contains most of the oil, together with the finest particles of powder. The precipitate from the second decantation is the ordinary opening powder; the finest being for polishing both the holes and outsides of jewels, and giving the final finish to the faces of pallets, roller pins, locking spring jewels, etc.

The good workman is careful to keep the powder in this condition as free as possible from any extraneous dust, and above all to preserve the different grades from any intermixture, as a small quantity of a coarser grade would destroy a finer one for all its purposes, and the process of "floating off" would have to be repeated.

The most important stone in jewelling, the diamond, becomes more of an agent of the manufacture than an object.

Properly, for jewelling the ruby and sapphire are pre-eminent; inferior only to diamond in hardness, possessing a sufficient degree of toughness, susceptible of an exquisite polish, this (for they are one and the same) stone is the favorite of the Swiss, English, and American, for all high class work—the Swiss, however, using it indiscriminately in all watches.

The ruby proper is of one color, but in its varieties of intensity may change to a very light pink. When still lighter it is ranked a sapphire, which comes in almost every possible color and shade, from ruby to a perfect transparent colorless crystal. This stone differs in degrees of hardness and capacity of working — the hardest being a greenish yellow, in the shape of pebbles, with very slightly rounded edges, difficult to work, but forming the strongest and most perfect jewel known.

It must be remembered that this description gives the value of the ruby and sapphire as a material for jewelling only. For ornamental jewelry, the value depending on color, of the most intense ruby or blue for sapphire, together with brilliancy and weight. The ruby and sapphire are formed on an aluminum base, the common emery being another form of structural arrangement, but of the same chemical constitution.

These stones possess every quality to make them the base of perfect jewelling; and still the chrysolite is equally in favor with most jewellers. It is not quite so hard, but it is more easily worked and cheaper in price, and it would be difficult to tell wherein it is inferior to either the ruby or sapphire. It has a yellowish tinge, verging to the color of the olive. As a stone for jewelry it is not fashionable, and only in Persia is it valued. There are, however, some very strong objections to its use by the workman; it is not uniform in hardness; in polishing it will *drag*, that is, the surface will tear up in the process. Unfortunately the eye is not able to detect the fault before working, and it is found only when much preliminary time and trouble has been expended. It is susceptible, when good, of a perfect polish, and is much used in chronometer work, especially for jewelling the 4th hole, as its non-liability to fracture renders it valuable.

"Aqua Marine" is a brother to the emerald, differing from it only in intensity of color, and composed of the same constituents. These two gems are the only ones in which the rare metal, glucinum, has been detected. It is extensively used in the American and English watches, but never in the Swiss. It is soft, not much harder than quartz, but comes in large pieces, perfectly transparent, and of a color which is that pure green of sea-water, from which it takes its name, "Aqua Marine."

The garnet in English watches plays an important part for pallets, also for roller-pins; a very soft stone, but very porous. When set in the pallet with a pointed toothed wheel, it is apt to act as a file from its porosity, cutting the end of the tooth. This may be detected in any pointed tooth lever watch, by observing the color of the back of the tooth. "Black vomit" it used to be called in the Boston factory. Most of the garnet used is an Oriental stone, the best quality coming in bead form, the holes having been pierced by the natives. The cost of piercing the stone in Europe or America would be far above its value. The Oriental is the best for Horological purposes, though Hungary and Bohemia furnish the most highly prized stones used for ornamental purposes; indeed, in some German towns the cutting and setting of the garnet is a specialty, giving employment to a large number of people. And, strange to say, the best market for their sale is the United States.

This comprises about all the stones used in watch and chronometer jewelling. Still in clock work the pallets are generally jewelled in agate, a stone not at all suited to the purpose, it having, even in the best specimens, a decided stratification that prevents an uniform surface being formed by any process. The cornelian form of the agate is not open to this objection, and makes capital bearings for knife edges of fine balances, and compass stones for centres of magnetic needles. For watch or chronometer purposes the only really useful stones are sapphire, ruby, chrysolite, and aqua marine—all possessing peculiarities that deserve some remarks, as they are of the utmost importance to the hole maker. The sapphire is the hardest stone, next to the diamond, and yet specimens can be, and are found, so soft as to *drag* in polishing. Again, if stratified very clearly, will "fire crack" in opening the hole. The ruby is more uniform in its structure, and is more highly prized on that account; its hardness being all that is necessary, while its susceptibility of receiving a high polish is equal to that of the sapphire or chrysolite. The aqua marine is always uniform and may be polished both externally and in the hole with "tripoli," saving something in diamond powder in the process of making. In our estimation, however, the chrysolite is the most valuable of all the stones. True, when purchased in the rough, many pieces will be found unfit for the jeweller's purpose; but when the right quality is found, nothing can be better adapted to jewelling. Hard, it is easily wrought, taking a peculiar *unctious* polish, retaining oil in its most limpid condition for a long time.

These stones form the general stock by and from which jewels are made. The details of the various manufacturing manipulations, the tools used, also the setting in the work, together with the important item of the screws, will form the subject of the next article on Watch and Chronometer Jewelling. Not having been able to get our engraving done in time for publication, we are compelled to reserve the remainder for the next number.

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Hints on Clocks and Clock-Making.

NUMBER ONE.

Twenty-five years of hard labor amidst the dust and din of machinery, with hands cramped, and fingers stiffened by the continual use of tools, and with a brain constantly occupied in ringing the changes upon wheels and levers in their almost infinite combinations,—it requires a degree of courage to undertake to write anything that can be dignified with the name of an "article," although it does propose to treat upon a subject with which we are fairly familiar; but it is consoling to think that one is not expected to write for the pages of this practical journal with the same degree of elegance and polish that should grace the columns of a review or magazine; that we can appear here as plain, practical mechanics, and use good hard, round words to express our ideas, backed by an experience which should add some weight—and we welcome the appearance of the "American Horological Journal," which is to serve a good purpose by bringing out the actual experience of men who have grown gray in the art and mystery of clock-making, and preserving, by means of the "art preservative of all arts," their dearly bought knowledge and experience, for the benefit of those who in their turn shall follow them; and it will also benefit the people in general by giving information that will lead to the purchase of good and tasteful clocks for household use.

That such a journal is needed to enlighten us, is made plain by the fact that in almost every newspaper we have a vivid account of some wonderful clock "recently invented," which may possess some merit, but they are so grossly exaggerated by some ignorant "penny-a-liner," that we are almost led to believe in the Irishman's marvellous "eight-day clock, that actually ran three weeks." Even the proverbially correct "Scientific American," of which I am a constant reader, has in its issue of June 19th, an account in its "editorial summary" of a clock in France containing "90,000 wheels," and perhaps the most curious part of the mechanism is that which gives the additional day in leap-year," etc. Now, it will require but little knowledge of clocks to tell us that one with 90,000 wheels was never made and never will be, but "the additional day in leap-year" has been given by calendar clocks in this country since the year 1853.

It is not proposed in the series of articles to follow, to discuss the early history of clocks. Reid and Dennison have written enough to convince the most skeptical that the clock is an old invention. It is not important to us who invented the pendulum, or this or that escapement, but who makes the best pendulum, the best escapement, the most perfect train of wheels and pinions. These are vital points, and we shall endeavor to give them that attention that their importance demands. It is proper to state here that any assertion made, or rule given, has been tested, and is the result merely of our experience, and we do not claim that it is all there is of the subject; for we are aware that the experience of others may have led to results entirely different; but if all clock-makers will avail themselves of the columns of this journal, we shall not only become better acquainted by an exchange of ideas, but better clock-makers.

The subject of wheels and pinions is of the greatest importance in clock-making, and the utmost care and skill are required to execute a train which shall not only run with as little friction as possible, but the friction must be equal; for if there is no variation in the train force, the escapement and pendulum will always be actuated by the same amount of power, and the performance of the clock can be relied upon. Clock text-books do not fully impress this subject. We find a great deal upon this or that escapement, and the different pendulums. Dennison has a couple of pages full of abstruse calculations upon a method of shifting an extra weight upon a rod, so that the going of a clock can be varied one second per day; but if his wheels and pinions are not perfect, a large tooth here and there will vary the clock more than that.

Reid overawes us with his knowledge of the proper curves of the teeth of wheels; but it must have been only theory, for his practice was to saw his teeth, and his cycloids, epicycloids, and hypocycloids were left to the mercy of the "topping file" in the hands of his "wheel teeth finishers," instead of shaping up the teeth in the engine, as is done now. We have generally cut the wheels of fine clocks over several times with different cutters before taking them from the engine; the last cutter having but one tooth, which can be made perfect as to cut and shape, and, running with great speed, will leave the teeth the proper shape, very smooth, and as true as the dial of the engine. Escape wheels, especially, require great care in cutting, as the teeth for dead-beat escapements are somewhat long and thin; the least inaccuracy is certain to cause trouble. It is absolutely necessary that the dial plate of the cutting engine should be perfectly true, with clean, round holes, and a perfect fitting index point, with a cutter arbor without end play or lateral motion—these are the essentials of a good cutting engine, without which a good clock cannot be made.

We have generally made a practice, upon the completion of the train for a fine clock, to put in the place of the escape-wheel a very light, well-balanced fly, to prevent "back-lash," and a very fine soft cord on the barrel; then hang on a very light weight; so slight that—all of the wheels being balanced, and no oil upon the pivots—the fly will move so slowly that its revolutions may be counted. By taking care that the weight be not too much in excess of the resistance, the least inaccuracy in the wheels and pinions may be discovered by the difference in the velocity of the fly, or by its suddenly stopping, which will be occasioned by any inequality in the train teeth, which would not have been discovered by the closest scrutiny. It was by means of this test that we discovered an inaccuracy in a pinion, caused by hardening, which could not have been discovered by a less delicate test.

The wheels in the train should be as light as possible, for as the whole train is stopped every time a tooth drops on the pallets, it is plain that the driving weight must overcome the inertia as well as the friction of the train at every beat. To this end it has been customary to "arm out" the wheels, leaving a very light rim supported by light arms, the wheels being generally of cast brass, turned up, and cut, then lightened. We followed this plan for some time, but abandoned it, as we found great difficulty in making a perfectly round wheel. The arms serve as posts to support the rim in cutting or turning, but the space between is very apt to spring down. We prefer making the wheels of fine hard-rolled sheet brass; it is superior to cast brass, much finer, harder, and more durable, and is freer from flaws. After the wheels are cut, they are turned out on each side, leaving a thin web in the centre; they can be made lighter, finished easier, and are round.

As to the shape of the teeth in clock-wheels, the subject has been so ably treated by Reid, Dennison, and Prof. Willis (who has invented an instrument to assist in laying out the curves for the teeth of wheels), that we shall not attempt it in this paper; besides, there is so little of the entire theory that can be applied to a clock-wheel of two and a half inches in diameter, with 120 to 140 teeth, farther than to leave the wheel and pinion of the proper diameter, that we consider it unnecessary; for if makers of regulators and other fine clocks will use pinions of 16 or 20 teeth, the friction or driving is all after the line of centres, and the whole subject of cycloids, epicycloids, and hypocycloids is reduced to a very small point, and might be said to "vanish into thin air."

Having given only a few practical hints, and not yet crossed the threshold of the subject, we propose to continue from month to month —if the readers of the Journal do not weary— the discussion of the various parts that go to make the sum total of a fine clock, with notices of the various clocks made in this country.

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It certainly comes within the province, and is the duty, of a journal devoted to Horology, to make a note of any and all the new improvements that pertain to the science. We give, then, some few, the merits of which have struck us as being a very important matter of consideration.

The best clock time-keeper is not absolutely perfect, so its rate must be kept; but the watchmaker ordinarily has no means of correcting the error of his regulator, until the accumulation renders it a serious inconvenience. Did he possess a Transit instrument, properly set and adjusted for meridian, together with the required books and knowledge of observing, he could from day to day correct his clock and keep accurate time; but these are all expensive, as well as involving time and labor. Suited to the wants of the artisan is a little instrument called the Dipleidescope; simple in its construction, and not liable to get out of position or order, it forms the best substitute for the transit we have seen It is founded on the theory that the double reflection from the two surfaces of planes at an angle of 60° will coincide when the object reflected is in a true line with half the base of the whole triangle. Having a prism cut in an equilateral triangle, one angle is set directly down toward the centre of the earth, the base being brought parallel with the line of the horizon. Now, if the axis of the prism is in a line with the meridian, a reflection of the sun will appear, at the instant of crossing the meridian, on itself—that is, there would be but one image. If the instrument is well made, there can be no doubt of its accuracy and value to those who, wishing to verify their time, are not situated so as to use a transit.

Another improvement is a Bench-Key for watchmaker's use. No one who has had any experience at the bench but will appreciate an article that facilitates the setting of timepieces for his customers. In winding, it is equally valuable. It is not dependent for its strength of torsion on the spring-chuck principle, the power being applied close to the square by means of a pin that passes through the key.

Hall's Patent Cutting Nippers are a positive desideratum; a large wire can be cut off without the least jar to the hand, the leverage is so great. The smallest sizes are suitable to the ordinary run of watch-work, and can be used in clock-work better than any cutting-plyers extant. Strong and durable, they possess one quality that all watchmakers will appreciate—if a cutting-jaw is broken it can be replaced by another.

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Greenwich Observatory.

About two hundred years ago, England began to take a lead in the mercantile commerce of the world; her ships were daily passing across the Atlantic, and India also was beginning to attract her attention. It was therefore of the utmost importance that navigators should be enabled to find their longitude when at sea, independently of watches or clocks; and a reward was offered to any one who should discover a method by which this result might be obtained.

The plan proposed was, that the angular distance of the moon from certain stars should be calculated beforehand, and published, so that, for example, it might be stated that at ten minutes and five seconds past nine on such a day, the moon should be distant from Mars 40 degrees. If from a ship in the middle of the Atlantic, Mars and the moon were found to be 40 degrees apart, then it would be known that the time in England was ten minutes and five seconds past nine.

Here, then, was one item ascertained, and the method was a good one; but in consequence of the want of accuracy as regarded the moon's motions, and the exact positions of the stars, it could not be practically carried out.

Under these circumstances, Charles II. decided that a national observatory should be built, and an astronomer appointed; and a site was at once selected for the building. Wren, the architect, selected Greenwich Park as the most suitable locality, because from thence vessels passing up and down the Thames might see the time-signals, and also because there was a commanding view north and south from the hill selected for the site. The observatory was completed in 1676, and Flamsteed, the chief astronomer, immediately commenced his observations, but with very imperfect instruments of his own. During thirty years, Flamsteed labored indefatigably, and formed a valuable catalogue of stars, and made a vast collection of lunar observations. He was succeeded by Halley, who carried on similar observations; and from that time to the present, Greenwich Observatory has been our head-quarters far astronomical observations.

The work carried on at Greenwich is entirely practical, and consists in forming a catalogue of stars and planets, and so watching them that every change in their movements is at once discovered. Now that this work has been performed for several years, the movements of the principal celestial bodies have been so accurately determined, that the *Nautical Almanac*— the official guide on these subjects— is published four years in advance, and thus we find that on a particular night in 1868, the moon will be at a certain angular distance from a star, and the second satellite of Jupiter will disappear at a particular instant. On the exterior wall of the observatory there is a large electric clock, which, being placed in "contact" with the various other clocks in the observatory, indicates exact Greenwich time. The face of this clock shows twenty-four hours, so that it requires that a novice should look at it twice before comparing his watch. On the left of this clock are metal bars let into the wall, each of which represents the length of a standard measure, such as a yard, foot, etc. And let us here say a few words about these standards. To the uninitiated a yard is simply three feet, and a foot is twelve inches —an inch being, we are told in our "Tables," the length of three barleycorns. Now, as the length of a barleycorn varies considerably, it requires something more definite than this to determine our national measures. Thus, the question, what *is* a foot? is more difficult to answer than at first sight appears. Many years ago the French perceived the difficulty appertaining to the national standard, and they, therefore, decided that a metre should be the ten-millionth part of one-fourth of the earth's circumference—that is, ten-millionth of the distance from the Equator to the Pole. But here another difficulty was encountered, because different calculators found this arc of different lengths. By *law*, however, it was decided that one measurement only was correct, and so the metre was fixed at 3.0794 Paris feet; though since then, more accurate observations and improved instruments have shown these measured acres to have been very incorrectly ascertained, and thus the French method failed when practically tried.

The length of a seconds pendulum oscillating in a certain latitude has been our method of obtaining a standard; but this also has its weak points, so that to obtain a constant standard it is necessary to have some pattern which is unchangeable, and thus a metal has been chosen that expands or contracts but little either with heat or cold; and this, at a certain temperature, is *the* standard measure, and such a standard may be seen on the exterior wall of Greenwich Observatory.

On entering the doorway—which is guarded by a Greenwich pensioner, who will possibly first peep at the visitor, in order to see who the individual may be who is desirous to tread within the sacred precincts—one finds a court-yard, on the left of which are the transit-room, the computing-room, and the chronometer-room. The transit room takes its name from the instrument therein, which is a large "transit." This consists of a large telescope, the outside of which is not unlike a heavy cannon, as it is of solid iron. The instrument is supported by trunnions, which allow the telescope to be elevated or depressed to point south or north, and, in fact, to make a complete revolution, but never to diverge from the north or south line. The magnifying power of this instrument is not very great, so that it admits plenty of light, for it is intended, not as a searcher for or for gazing at celestial objects, but for the purpose of noting the exact time at which stars and planets pass south or north of Greenwich. Upon looking through this telescope, the observer's eye is first attracted by a vertical row of what seem to be iron bars, placed at equal distances from each other. These, however, prove to be only spiders' webs, and are used for the purpose of taking the time of passage of a star over each wire, and thus to ascertain the exact instant of its being in the centre of the telescope. During even the finest and calmest nights, there is occasionally found a tremulousness in the instrument, which, as it is rigidly fixed to the walls of the building, must be due to a slight vibration in the ground itself. Thus, many a feeble earthquake unfelt by the outsider may be perceived by the astronomer by the aid of his delicate instruments.

The various stars seem to be travelling at an immense rate when seen in the field of the transit telescope, and it is really nervous work noting the exact time when each wire is passed. The experienced observer, however, not only will give the minute and second, but also the decimal of a second when the star was on the wire. The result is obtained by counting the beats of a clock the face of which is opposite the observer. Thus, if at three the star seems as much short of the wire as at four it had passed it, then 3.5 might be the instant of "transit."

At noon each day the sun's passage is observed by nearly the whole staff of observers. One individual looks through the telescope, and gives the time for each wire, while others examine a variety of micrometers in order to ascertain the fractional parts of seconds, etc.,—these micrometers being placed at the side of the instrument.

In the morning, the principal work consists in making what are termed the "reductions" to the observations of the previous night. These reductions are the corrections requisite for the slight instrumental inaccuracy, for the refraction of the atmosphere, and for the known constant error of the observer. When, therefore, a bright winter's night has occurred, the work on the following morning is usually very heavy. At noon the sun's time of transit is taken, and at one o'clock the "ball" is dropped, by means of which the various vessels in the Docks and in the Thames set their chronometers, or ascertain their rate. In addition to this, the time is sent by electricity to Deal and one or two other seaports, in order that every vessel may be able to know the accurate time, if within sight of those places.

Not the least interesting portion of the observatory is the chronometer room. For a very small charge, manufacturers or owners may have their chronometers rated at Greenwich, which is accomplished in the following manner:

The chronometer is placed in the chronometer room, and compared with the large electric clock in the room, this clock being kept in order by the stars. Each day the chronometer is examined, and thus its rate is ascertained in its then temperature. It is afterwards placed in a sort of closet warmed by gas, a condition supposed to represent the tropics, and it is there kept for a certain period, being tested each day as before. This change of temperature is found to produce very little effect on the best instruments, which, when they have passed the ordeal, are returned to the owners with their character ticketed to them. Some hundred chronometers are often placed in this room; and to compare them is a science, the "expert" by a glance discovering the difference between the two instruments, whilst a novice would require to mentally add or subtract, and thus slowly to arrive at the same results.

As soon as it becomes dark enough to see stars by the aid of a telescope, one of the staff commences his observations. These are continued during the night; and a register is kept of each star, planet, comet or moon, which is "doctored" in the morning by the computers.

As all mortals are fallible, it is desirable to bring machinery into use where possible, and this has been managed in connection with astronomical observations. Instead of the computer registering by judgment the time of a star's transit over the various wires, he strikes a small indicator, which, completing the electric circuit, causes a pricker to fall and make a hole in a piece of paper that is attached to a slowly revolving barrel. Each time the star passes a wire, the pricker descends and leaves its mark; and the interval between these marks being measured by scale, the mean time of transit may be obtained.

There is usually a feeling of the sublime that comes over us when we reflect upon the vast unexplored regions of space, or contemplate the stellar world that shines upon us. The magnitude and grandeur of some of the planets in the solar system strike us with a feeling of awe and wonder, while we are puzzled at the mysteries attending comets, double stars, nebulæ, etc. No such feelings or sentiments, however, are allowed to enter into the constitution or mind of an observer at Greenwich. Saturn, the glorious ringed planet, with its galaxy of moons, is simply "Saturn, Right Ascension 10 hours 8 min. 12 sec., North declination 16° 12′ 2″." Anything appertaining to the physical constitution, the probable cause of the ring, or the object of so grand an orb, does not come within the range of the observations at Greenwich, which are limited to bare matter-of-fact business work.

The southern portion of the observatory ground is devoted to the investigation of meteorological subjects, and is under the superintendence of Mr. Glaisher, who is now well known as an aerial voyager. It is here that an exact record is kept of the amount of rain that daily falls, of the direction and force of the wind, of the magnetic changes, of the temperature, amount of ozone, etc.—all matters which may, and probably will, lead us eventually to the discovery of some laws connected with the states of weather, and enable us to predict what may be expected from day to day. Whilst we are now able to calculate to a few seconds, and for years in advance, the instant when an eclipse may occur, and to explain the causes of the various planetary movements, yet we are in a sad state of ignorance as regards the causes of hurricanes, thunder-storms, continued rains and droughts; and thus we find that all the would-be prophets who from time to time spring up and oracularly announce a coming frost or fine weather, or the reverse, are perpetually meeting with most signal failures, which, however, does not deter future adventurers from attempting to gain a cheap temporary renown by trying their luck at a prophecy.

The perpetual accumulation of facts at Greenwich, whether these be of an astronomical nature, or appertaining to the air we breathe and its subtle changes, is a proceeding that must eventually lead us on to a correct knowledge of the laws which govern these matters, and also keep us acquainted with any variations that may be occurring in the elements that surround us.

The order and quietness necessary in such calculations as those carried on at Greenwich prevent it from being a "show" establishment, and hence visitors are not admitted except on special business. Then, however, every aid and assistance are offered to the student and inquirer; the use of books and instruments is freely given, and such information supplied as the little spare time of those belonging to the establishment enables them to afford. Thus a visit to or a period of study at Greenwich Observatory will amply repay those who wish to gain the latest and most accurate information on astronomical subjects, or to practise themselves at the adjustments and use of the instruments; and to those who have not such opportunity, we offer this slight sketch.

[*Chambers' Journal.*

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Pinions,

Well made as to truth of centring, of division, of form of leaves, and polish, are, as the trade well knows, of vital importance to the value of the time-piece.

The making and finishing is one of the most troublesome, as well as most expensive of all the processes in watch work. The nature of the material renders it difficult as it approaches so nearly in hardness to the tools used in cutting. In the ordinary Yankee clock, the *lantern pinion* has entirely superseded the solid leaf, which substitution was the greatest element of success in their cheap construction. The lantern pinion is really a nearer approximation to the required anti-frictional form than a majority of cut pinions in ordinary clocks. In the process of manufacture of the cut variety, the first consideration is the quality of the steel to be used. For this purpose it should be carefully selected by trial, thus ascertaining its fineness, uniformity, softness when annealed, together with its capacity for taking a good temper, with the least amount of springing during the hardening process. Very few pinions are cut from the solid piece—the drawn pinion wire being quite good enough, when milled and finished, for the ordinary run of watch work.

The steel wire having been selected, the first process is to cut it up in lengths a trifle larger than the required pinion. The separated pieces are then centred with care, and having been placed in a lathe, the staff and pivot are turned up to nearly the required gauge, leaving a portion of the whole piece the full size for the leaves. They are now taken to the milling tool to have the proper form given to the leaves. As this form is of the highest importance, it may be as well to give here the reasons. Supposing a wheel of 60 teeth, depthing into a pinion of 8 leaves, it can readily be seen that the arc of the motion of the wheel tooth is of greater radius than that of the leaf of the pinion, and it follows that if the teeth and the leaves are made in taper form with straight sections, there must occur a sliding motion on the surfaces of both—the power thus absorbed being totally wasted; but if we curve the surfaces we may approach a form so nearly perfect that the wheel teeth, being motors, really roll on the leaves, avoiding almost entirely the friction caused by sliding; the necessity for this curvature becoming greater the more the wheel exceeds the pinion in diameter. This curve, which has been demonstrated by very profound mathematical researches, is the "epicycloidal;" theoretically it should give no more sliding motion than the surfaces of two plain wheels revolving on each other. To obtain this perfect form, very great pains have been taken and expenses incurred, especially by the makers of the best time-keepers.

In the American factories the cutters are very elaborately made, the section being an object of great solicitude—it being an exact counterpart of the space between any two leaves, and also of one-half the top of the leaf from the curvature to the point, so that in milling, the space made by the cutter is its shape, leaving the leaf of the proper form. Generally the pinion passes under two cutters; the first to strike down the rough stock, the other to dress it to size and shape, with a light cut. The care and skill required to make these is certainly very great, and it is a proof of the wonderful ingenuity of man that they are made so perfect as to shape and cutting power.

A very ingenious device is used for dividing the leaves under the cutter, which revolves at a moderate speed, over a slide, carrying a pair of centres, between which the turned up piece of pinion wire is placed. The slide is now pushed up to and under the cutter, and in its passage as much of a cut is taken as is desirable; in drawing back the slide the fresh cut space passes under a flat piece of thin steel, screwed on the frame, and set at a slight angle to the axis of the centres. On moving the slide towards the cutter for a fresh cut, the steel plate takes the last cut, and in passing by it the pinion is turned just as much as the angularity of the plate, which must be just one leaf. By this very clever device the division is effected without an index plate. This process, however, is not good enough for work intended to be very accurate—the pinion wire not being always, or indeed rarely correctly divided, the original error will be perpetuated in all the subsequent processes. These are all milled, with oil or soda water for a lubricator, and it follows that the speed of the cutter is regulated to get the greatest cut without dulling the tool. When dull, however, the mill is sharpened on the *face* of the cutting tooth by means of small grinders of iron, using Arkansas oil-stone dust for the first grinding, and giving the necessary delicacy of the edge by means of crocus, or sharp, followed, when fine work is needed, by rouge.

It is necessary that this care should be taken, for if the edge is left coarse it will become speedily dulled, and leave a very unequal and rough surface on the cut of the pinion, which in the subsequent grinding gives rise to error in shape and size. The pinions, thus cut to gauge, are dried in sawdust, hardened, and tempered; the staff and pivots are now turned up to size, and then pass to the polishers. In the factory they are finished by means of what are called *Wig-Wags*, which it may be interesting to the reader to have a general description of.

Two Vs are arranged as centres, the pinion is placed between them, the circular parts resting in each V, but free to turn on its own axis. Immediately above the Vs is a frame on which a slide, carrying the polisher, may traverse—generally about two inches. This slide is movable vertically so as to accommodate itself to the pinion; attached to the slide is a connection which leads to a vertical lever, which is put in motion from a crank on the counter shaft. The grinding is effected by bringing the grinder, charged with oil-stone dust in oil, in one of the spaces of the pinion, which, of course, is so arranged as to bring it parallel and central with the grinder. The power being applied, the slide takes a very rapid reciprocatory motion, and the face of the grinder, so charged, rapidly reduces the uneven surface left by the cutter to what is called the *gray*.

The form of this grinder must be as perfect as the cutters, and the care taken to get the requisite parallelism is in equal proportion, and in all the best polishers is planed up while in its position. The grinder is composed of tin and lead, with sometimes a slight admixture of antimony, rolled to an even thickness, cut off in suitable lengths, and then mounted in the carrier of the Wig-Wag to be planed up to shape. There are too many minute adjustments in the machine to render a full description in this article admissible. It is large compared with the work it has to perform, but it is very admirably made, as indeed all the tools are, in the American factories.

The polishing of the leaves is the next step, and this is effected by means precisely the same as grinding. In each stage the pinions are thoroughly cleansed before entering on another. The polisher is made precisely like the grinder; but instead of oil-stone dust, crocus mixed with oil is substituted. Owing to the less cutting quality of the material used, the polisher loses its form sooner than the grinder, and has to be more frequently reshaped. In very fine work the crocus is succeeded by fine well-levigated rouge to bring up that jet black polish, which is considered a mark of quality by chronometer and watch makers.

With the exception of turning up the staff and pivots, all the work hitherto described has been expended on the leaves—a very tedious process, yet done, when the tools and materials are in proper order, with marvellous rapidity; but tedious as these have been, there are two others quite as much so before the leaves are finished.

The ends are to be faced—they must be flat (that is a true plane) and receive the same finish that the leaves took, and is effected by the wig-wag; only the pinion revolves between centres, at a high speed, the grinder being brought up to the turned face. Two motions operate—one rectilinear, the other circular—the result being a compound motion which prevents the grinder from touching the same spot twice in succession. To effect this more surely, the operator gives the grinder a slight vibratory vertical motion. The polishing of the two faces is effected in the same manner as the grinding; in all cases the cutting face of the grinders and polishers being kept in a plane perpendicular to the axis of the pinion, both vertical and horizontal.

The staff and pivots being in the same condition they came from the lathe, the next step is to grind and polish them. Before, however, we treat on this process, it may not be amiss to give the general watch repairer a process by which the facing may be done on a small scale.

As a rule, when the watch repairer has to replace a pinion he selects one from the material dealer, finished in the leaves, but not on the ends or faces. The following operations are simple, and any one may finish these faces with little trouble. Having turned up your pivots and squared down the face of the leaves with the turning tool, grind it in the lathe by means of a ring of metal, the inside diameter being somewhat larger than the diameter of the staff. This ring is held between two centres, thus allowing it a vibratory motion, so that when it comes up to the face it accomodates itself to its plane, and thus has no tendency to force it out of a true flat; the ring, being larger than the staff or pivot, admits a small lateral motion, enough to effect a continuous change of surface. The same little tool may be used for polishing by substituting another polisher and using crocus and rouge. For the repairer, perhaps on general work the rouge would be superfluous. Vienna lime, used with a little slip of boxwood, brings up a very fine and brilliant polish, and in replacing new work in an injured time-piece, the steel may always be polished with great rapidity by using the lime on the gray surface left from the oil-stone dust; being quickly done and affording a very handsome finish.

To resume the consideration of the pinion, the last stage is the polishing of the circular portions. Here again the wig-wag is the most useful tool, but it operates somewhat differently, for the grinder or polisher is pressed down by the finger of the operator, the pinion being held between the centres of a small lathe attached to the wig-wag; the staff is first ground and polished as the leaves have been before, and this is the last operation performed with the pinion between centres. From this stage it is chucked in a lathe very peculiarily fitted, the mandrel being hollow; and in it is fitted what is called a pump-centre, which is movable in direction of the axis of the mandrel, and capable of being securely fastened at any desired point. On the nose of the mandrel is secured a hollow steel chuck, the two sides of which have been filed out, thus leaving an open space between the end of the pump-centre and the end of the chuck. On this end a small steel plate, extremely thin, is fastened by means of shellac, and a hole drilled in the plate capable of taking in the chamfer on the shoulder of the pivot. The pump-centre being drawn back, the pinion is introduced into the chuck, the pivot placed in the hole in the steel plate, and the pump centre is drawn forward until it forces the chamfer to fill the hole; the pivot projecting from the chuck is now ready for all the grinding and polishing processes. Here the wig-wag steps in again, and from the delicacy of the pivots is modified to suit the case; this is done by having a polisher hung in the wig-wag on centres, so it may revolve; when in operation one side of the polisher rests on the pivot, the other on a ruby placed in a screw, and which screw enables the operative to insure the parallelism of the pivot. The ends of the pivots are next rounded off and finished in another set of tools. The pinion is now ready for use, assuming it to be of the proper gauge. In the American watches the scape and fourth wheels are generally staked on the staff pinch tight; the third and centre are staked on the pinion leaves, a rebate having been turned down on the ends, the wheel set on the shoulder, and the projecting ends of the leaves riveted down. This has not been designed as an exhaustive article on pinions; it is merely intended to open the subject as pursued in the factories. There is much more to be said; and the various processes on the small scale, as performed by the Swiss and English, together with their tools, will bear more than a general description, as they are applicable at any watch bench.

The subject will be continued, in the effort to give a full and useful article.

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New Three-Pin Escapement.

A contributor to the *London Horological Journal* gives the following description of his invention:

"The merit of this escapement is in a newly invented escape-wheel which is self-locking and requires no banking pins; the pallets are curved inside the impulse and outside the locking, to work with the curved points of the teeth of the wheel; being made of gold the wheel will go without oil. From its form it has the power of double impulse and double locking with the lever. The first takes place at the discharge of the escapement, the second does not act unless the watch receives a sudden motion, and then the pin or pallet in the roller strikes lightly on the lever, when the propellant power drives it back again. The balance passes through two turns before the second locking takes place, and is formed so as to be able to take up the lever, and the watch soon rights itself, and its time will not be affected. Another advantage is, that the lever is made of a flat piece of steel, as I have introduced a gold stud to receive the ruby impulse stone, which is made to adjust easily so as to bring the escapement to the closest geometrical accuracy. By its formation this ruby guides the impulse to the external edge of the roller notch. These advantages, and its simplicity, render it suitable to the best chronometer watches."

A FEW years ago, in 1859 or '60, Mr. Peabody, a very talented gentleman of this city, patented a three-pin escapement that performed extremely well. A full description of his patent and plan is not at hand, but we will endeavor to give it to our readers in our next issue.

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English Opinion of American Watch Manufacture.

In the London circle of Horologists, more attention is paid to the scientific departments than the mercantile; but for all that, a Mr. Henry Ganney has held forth before the "British Horological Institute," on "American Watch Manufacture." Though an Englishman, with English prejudices, he certainly gives a very fair and impartial statement of the subject; yet he views it almost entirely in the money-making aspect. He gives all the credit deserved to American enterprise and ingenuity, and yet there is a certain sense of a drawback. He had before him samples of machine work; among others, to quote, "several movements made by the British Watch Company, which flourished and failed about twenty-five years ago; these were machine-made, and the perfection and completeness of the machinery they used for producing these frames has not been equalled, I believe, in America; several machines being used there to accomplish what was begun and completed by one here."

Mr. Ganney is right in his statement, but the example given by the British Watch Company was the rock seen by the American navigators. One tool, for facing off, truing up, drilling, depthing, and doing all the work on the pillar plate, having cost, before completion, some three thousand pounds sterling, and from its very complexity being utterly inefficient—worse than useless. In the very inception of the American watch manufacture a similar mistake was almost made. Experience and sound reasoning proved, however, that a multiplicity of operations in any one machine rendered it entirely too complex, the adjustments too numerous, and the work totally worthless. We shall in another number refer again to Mr. Ganney's lecture, and perhaps give some beamings of light on the early history of the American watch manufacture, derived from personal observation at the time.

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Correspondence.

EDITORS HOROLOGICAL JOURNAL:

I received a Prospectus a few days ago advising me of your contemplated existence. I could hardly believe the fact; "the news was too good to be true." However, I shall take it for granted, for I cannot see why somebody has not before had the enterprise to launch out in the periodical line on subjects connected with Horology, the field being so extensive and the want so severely felt. Enclosed I send you the subscription price; in this much I have accepted your invitation, but I also enclose some few lines on a subject not particularly practical or theoretical, but very near the truth, and may perhaps give you a view of our wants.

To tell the "plain unvarnished truth," I am a watch repairer, located in a small country village, with a decent stock of tools and a moderate trade. In all this I am no exception; so I write this in the name of all who are similarly situated. Isolated as we are, we (the country village watch repairers) have few means to improve our knowledge of the trade, but work on the same old principles learned when we were boys and apprentices, and of better and more expeditious ways of doing our work we are entirely oblivious. True, our friends of the Hebraic persuasion, who, angel like, bring us face to face with the outer horological world by selling us material and tools, occasionally present to our benumbed vision something new, such as a Swiss lathe, or lathes used in the factories; but of what use are they to us? We purchase one; well, on the bench it may be an ornament, but for use, drilling large holes is the height of our ambition. We have not the time to learn by self-experience all the boasted usefulness and capacities of the tool; so we go back to our old verge or Jacot lathe when we have to put in a pivot or a new staff. We may know all about the escapement and be able to detect the cause of any trouble with it, but we have no knowledge of the latest modes of repairing the injury when it is discovered, and this knowledge is what I hope to find in your journal. I live in a section where the general class of work is of a very low grade, even the old verge being very common. Our stock of material has to be heavy in proportion to our trade, and then once in a while we are compelled to send our work to the city, some sixty miles distant, in consequence of not being able to do it, either from a lack of the material or want of a proper tool. To all intents and purposes we remain as stationary as the oyster. Not only do we have these vexations, but the ignorance of the public at large as to the treatment of their time-keepers is a fruitful source of annoyance; we are often charged with fraudulent practices, and a certain degree of caution is observed by more than the most ignorant. Thus, a few days ago, a stalwart son of the Green Isle made his appearance in front of the counter, and, projecting in front of our optics a huge English double-cased verge watch, spoke in almost dramatic tones:

"Plase, sir, av' ye could make me ticker here go, sir?"

Answering in the affirmative we reached for the silent "ticker." He drew back with alarm

"Bedad, an' ye'll not stale a morsle frae this?"

"Well, but let me see the watch."

"An' will ye let me eyes be on yes all the time?"

"Yes."

"An' yes'll not stale a jewil?"

"No."

"Thin, there it is."

On looking at the movement the verge was found broken, the injury explained, and the price given. He decided on the repairs being done, but said, "Give me the watch now and when ye gets the thing fixed its meself will come and git it and pay yes."

"But we cannot repair the watch without having it."

"Faith, thin, ye'll not have it; ye'll be taking something frae it."

Now, this is an extreme case of ignorance, pardonable, perhaps, in this instance, but the public embraces multitudes just as ignorant where an allowance cannot be made. I do not expect the JOURNAL to reach such cases, or to influence the general mass, but my hope is that it will, by raising the general self-respect and tone of the repairers, indirectly elevate the respect felt for them by the public at large.

But I am writing too long and rambling a letter. I wish to express my hearty wishes for your prosperity. And, in conclusion, will you allow me to express a hope that you will give us the knowledge we need—that is, post us up on the minutiæ of repairing in the latest styles, the newest processes devised, and, above all, give us an article on the lathe and its uses?

Yours truly,

W. L. C.

We have the pleasure to give our correspondent the assurance that an expert will contribute to our next number an article interesting as well as valuable in instruction as to the use of the lathe.

Eclipse of the Sun.

The approaching total eclipse of the sun, on the 7th of August next, is exciting much interest. The obscuration first occurs in latitude 39° 53′ 3″ north, longitude 138° 37′ 4″ west—Washington being the meridian. The first totality is on the Pacific coast of Siberia, at sunrise, in lat. 52° 41′ 9″ north, and long. 165° 26′ 4″ west. The eclipse is total at noon in Alaska, lat. 61° 46′ 9″ north, and long. 68° 4′ 6″ west. The line of the total eclipse now runs south-easterly, grazing the coast near Sitka, thence north into British America; then entering the United States, near the head of Milk River, long. 30° W.; thence through the south-west corner of Minnesota, diagonally through Iowa, crosses the Mississippi at Burlington; thence through Illinois, a little north of Springfield, crosses the Ohio river at or near Louisville, Ky., passes through the south-west corner of West Virginia, through North Carolina, just south of Raleigh, ending on the Atlantic coast at sunset, just north of Beaufort, N. C., in lat. 31° 15′ 2″ north, and long. 9° 36′ 6″ east. The line thus described will be that of totality, only partial in any other part of the United States.

The United States Government is, or has been, establishing a meridian line at Springfield, partly to make observations on this coming eclipse, and with the further view of determining a standard of surveyed lines—all of the Government surveys in Illinois having been geodetic. Professor Austin, of the Smithsonian Institute, is in charge of the work, aided by an able corps of assistants.

Diamond-Cutting.

At the Great Exhibition in Paris, in a part of the park contiguous to the Netherland section, M. Coster, of Amsterdam, has erected a building wherein all the processes of diamond-cutting are carried on.

The first rough shaping of the more important facets of the brilliants is here seen performed by the workman, who operates on two diamonds at once, by bruising each against the other, angle against angle. The dust that falls from the stones is preserved for the subsequent processes of grinding and polishing those facets that distinguish the many-sided brilliant from the dull, original crystal of the diamond. It is used, mingled with oil, on a flat iron disk, set revolving with vast rapidity by steam-power, the stone itself being held upon this disk or wheel by a tool to which it is attached by a mass of fusible metallic alloy, into which the stone is skilfully inserted. Skill of eye and hand, only attainable by great practice, is needed for this work; but a skill not less exact is needed for another process, which may here be seen in daily operation—the process of cleavage. The diamond, when a blow is struck on an edged tool placed parallel to one of the octahedral faces of the crystal, readily splits in that direction. But to recognize the precise direction on the complex and generally rounded form of the diamond crystal; to cut a little notch by means of a knife edge of diamonds formed of one of the slices cleaved from a crystal, and to cut that notch exactly the right spot; then to plant the steel knife that is to split the diamond precisely in the right position; finally, with a smart blow, to effect the cleavage so as to separate neither too large nor small a portion of the stone—these various steps in the process need great skill and judgment, and present to the observer the interesting spectacle which a handicraft dependent on experience of hand and eye always affords. But Mr. Coster's exhibition has other objects of interest. For the first time, we may see here, side by side, the diamond with the minerals that accompany it in the river beds of Brazil; and there are even examples in which crystals of diamonds are included within a mass of quartz crystals, which have all the appearance of having been formed simultaneously with deposits of the diamond.

The different districts of Rio and of Bahia are thus represented—the former producing a confusedly crystallized sort of diamond termed "bort," and the latter an opaque black variety; both these kinds being found associated with the crystallized diamonds used for jewelry. Though useful in state of powder, the black carbon and "bort" are incapable of being cut as a jewel.—"*Maskelyne's Report,*" *Great Exhibition.*

The Alloys of Aluminum with Copper.

When Sir Humphrey Davy announced the fact that soda, lime, potash, magnesia, and the other alkalies were but oxides of a metallic base, it would have been deemed chimerical to have supposed that the discoveries he made by the expensive aid of the battery would at later date become of really commercial value. He did obtain both sodium and potassium in the metallic state. The substances in this form were new to the chemical world, still more strange to the popular. So new was it to the chemists, that, on a globule of the reduced sodium being presented to a very distinguished chemist, he, with some enthusiasm, examined it; and, admitting the fact of its being a metal, exclaimed, "how heavy it is!"—when the real fact was that its specific gravity was less than water; the expression was the result of the general preconceived opinion that a high specific gravity was a test of a metallic body. It was reserved for a French chemist, Henry St. Claire Deville, to utilize the metal sodium, and that, too, in such a manner that the demand aroused attention to its production;—demand will inevitably bring a supply.

The original reduction was made by Davy, by means of the voltaic battery. After it had been proved that these bases were really metals capable of reduction, chemistry brought all its resources to bear on the problem, and they were produced by other methods than the battery. All the processes adopted, however, were too expensive and laborious, involving an extraordinary amount of complicated manipulations with but inadequate results. The metal sodium, which is the immediate subject of our inquiry, long remained an object simply of curiosity or experiment in the laboratory.

The methods of reducing the metal have of late years been so simplified that, to quote Prof. Chas. A. Joy in the *Journal of Applied Chemistry:* "A few years ago a pound of this metal could not have been purchased for two hundred dollars, and even at that price there were few manufacturers hardy enough to take the order. At the present time it can be readily manufactured for seventy-five cents, if not for fifty cents a pound; and the probabilities are that we shall soon be able to obtain it for one-quarter of a dollar."

Deville found that by the reaction of the metallic sodium on common chloride of aluminum a reduction was effected; the chlorine taking up the sodium, forming chloride of sodium (common salt), while the aluminum was left free in the metallic state. It is hardly necessary to go into the particulars of the process; but a metal well known to exist, had, for the first time, been brought to the world in such a condition of structure that its qualities could be tested, not only chemically, but mechanically. This was the direct result of Deville's metallurgic process of obtaining the reducing agent—sodium.

Aluminum in itself would be of but little use, so that a brief description will be all that is necessary. It is about the color of silver, but susceptible of a higher polish, especially on a fresh-cut surface; it is much less susceptible of oxidization than silver; its specific gravity is but little more than pine wood, and its tenacity, ductility, and laminating qualities are nearly equal to silver. Its use in the mechanical arts is limited, notwithstanding all these qualities, from the fact of its low point of fusibility, and at the heat of the fusible point being easily oxidized, so much so as to prevent soldering, except by an autogenous process. But aluminum does possess a property peculiar to itself—that of forming a purely and strictly *chemical alloy* with copper. It unites with it in any proportion; the compound formed by the addition of 10 per cent. of aluminum to 90 per cent. of copper has been found to possess all the properties of an entirely new metal, with qualities that render it a very valuable material in all fine work, such as astronomical instruments; and very fine machinery, such as watch-lathes, etc.

The French reports on the alloy are somewhat voluminous, but we give the following.

The color of this bronze so closely resembles that of 18 carat gold, such as is used for the best jewelry and watch-cases, that it is capable of receiving the highest polish, and is far superior in beauty to any gilding.

Samples taken from different parts of the largest castings, when analyzed, show the most complete uniformity of composition, provided only that the two metals have originally been properly mixed while in a state of fusion. These experiments have been made upon cylinders weighing many hundreds of pounds, and are entirely conclusive.

This valuable quality is not found in any of the more ordinary alloys of copper. The alloy of copper with tin, for example, known as *gun metal,* is notoriously subject to a phenomenon known as *liquation;* in consequence of which a great difference is found in the composition of the same casting, both in the top as compared with the bottom, and in the centre as compared with the circumference.

This phenomenon often causes great inconvenience, as the different parts of large objects will in consequence vary greatly in hardness as well as in strength. In casting artillery the difficulty becomes a serious one, and no means have yet been discovered by which it can be entirely removed.

This homogeneousness of aluminum bronze is a natural consequence of the great affinity existing between the two metals of which it is composed; and that there is such an affinity is clearly proved by the phenomenon attending the manufacture of the alloy. The copper is first melted in a crucible and the aluminum is then added to it *in ingots.* At first there is, of course, a reduction of temperature, because the aluminum in melting absorbs the heat from the melted copper; and this absorption is so great, in consequence of the great capacity for heat of aluminum, that a part of the copper may even become solid. But let the mixture be stirred a moment with an iron bar, and the two metals immediately unite; and in an instant, although the crucible may have been removed from the furnace, the temperature of the metals rises to incandescence, while the mass becomes as fluid as water.

This enormous disengagement of heat, not seen in the preparation of any other ordinary alloy, indicates, not a simple mixture, but a real chemical combination of the two metals. The 10 per cent. bronze may therefore be properly compared to a salt, the more so as it is found by calculation to contain, within a very minute fraction, four equivalents of copper to one equivalent of aluminum.

The 10 per cent. bronze may be forged cold, and becomes extremely dense under the action of the hammer. The blades of dessert-knives are thus treated in order to give them the requisite hardness and elasticity. But it has another valuable quality which is found in no other kind of brass or bronze: it may be forged hot, as well as, if not better than the very best iron. It thus becomes harder and more rigid, and its fracture shows a grain similar to that of cast steel. On account of the hardness of the aluminum bronze, rolling it into sheets would be a tedious and expensive process, were it not for this property of being malleable at a red heat. But it may in this manner be rolled into sheets of any thickness or drawn into wire of any size. It may also be drawn into tubes of any dimension.

From several experiments made at different times at Paris, it appears that the breaking weight of the cast bronze varies from 65 to 70 kilogrammes the square millimetre. The same bronze drawn into wire supported a weight of 90 kilogrammes the square millimetre. The iron used for suspension bridges, tested in the same manner, did not show an average of more than 30 kilogrammes. Some experiments were also made by Mr. Anderson, at the Royal Arsenal at Woolwich, in England, who tested at the same time the aluminum bronze, the brass used for artillery and commonly called *gun metal,* and the cast steel made by Krupp in Prussia. Taking for the maximum strength of the bronze the lowest of the numbers found as above, we are thus enabled to form the following table of comparative tenacities:

Aluminum bronze 10 per cent.......	65
Crupp's Cast Steel......................	53
Refined Iron..............................	30
Brass for cannon........................	28

The comparative toughness of these same four metals was also tested in the following manner: A bar of each was prepared of the same size, and each bar was then notched with a chisel to precisely the same depth. The bars were broken separately, upon an anvil, by blows from a hammer. The last three metals in the table broke each at the first blow, with a clean and square fracture. The aluminum bronze only began to crack at the eighth blow, and required a number of additional blows before the two pieces were entirely separated. And the irregular, torn surface of the fracture showed the peculiarly tough and fibrous nature of the metal.

The elasticity of the aluminum bronze was tested by M. Tresca, Professor at the *Conservatoire des Arts et Métiers.* The experiment was made upon a bar of simple cast metal, and the following is his report: "The coefficient of elasticity of the aluminum bronze, the cast metal, is half that of the best wrought-iron. This coefficient is double that of brass and four times that of gun metal, under the same conditions."

The specific gravity is 7.7, about the same as iron. Another very valuable quality is presented in the fact that it is acted on by atmospheric influences less than are silver, brass, or bronze. This places it in the same rank with gold, platinum and aluminum.

Very stiff and very elastic, tougher than iron, very little acted upon chemically, and in certain cases not at all, capable of being cast like ordinary bronze or brass, forged like iron and steel, of being worked in every way like the most malleable metals or alloys, having, added to these properties, a color analogous to that of the most precious metal, this bronze proves itself adapted to uses almost innumerable. At first sight, it seems difficult to admit that the relatively small proportions of aluminum which enters into the composition of this bronze can be sufficient to modify so extraordinarily the properties of the copper which constitutes so large a portion of its weight. But we must remember that the specific gravity of aluminum is very low, and that a given weight of this metal possesses a bulk four times as large as the same weight in silver. It follows from this that the ten per cent of aluminum contained in the bronze equals in bulk forty per cent. in silver.

The specimens of the ware we have seen, such as spoons, forks, cups, watch-cases, etc., are certainly very beautiful, having the color and high polish of gold, while dilute acids do not affect the surface.

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On the Reduction of Silver in the Wet Way.

Every chemist is familiar with the reduction of chloride of silver in the form of powder by means of metallic zinc in the presence of a little free acid. It is not easy to bring two such substances as the silver salt and the metal into close contact, and after the work is accomplished the removal of the excess of zinc has its difficulties. Dr. Grager suggests a modification of the old method that ought to be more generally made known. The chloride of silver is dissolved in ammonia and poured into a well-stopped bottle, and into this is introduced an excess of metallic zinc, in not too small fragments, so that any reduced metal adhering to it may be readily washed off.

The decomposition begins immediately, and is rapidly accomplished, especially if the contents of the flask be well shaken up. Three hours will suffice to reduce one-quarter of a pound of chloride of silver. It is easy to ascertain when the reduction is ended, by testing a portion of the ammoniacal solution with hydrochloric acid. As soon as no cloudiness or curdy precipitate is formed, the work may be regarded as completed.

A slight excess of ammonia is said to be favorable. The reduced silver must be washed with water until all odor of ammonia has disappeared. The pieces of zinc are removed by pouring the contents of the flask through a funnel, the opening of which is too narrow for the passage of the zinc fragments, while the reduced silver can be easily washed through. The finely divided silver can be digested in hydrochloric acid to restore it to a pure white color, and it is then ready for solution or fusion, and will be found to be perfectly pure. In dealing with large quantities it would be economical to recover a portion of the ammonia by distillation. In the same way an ammoniacal solution of nitrate of silver can also be reduced by zinc, and the silver obtained pure, even when the original solution of the nitrate contains copper —provided a small quantity of silver be kept in the bath.

It is better where copper is present not to take all of the zinc that may be requisite for the reduction of the silver. It will prove a great convenience to be spared the necessity of converting the silver into the chloride, as it is no easy task to wash out this salt on filters—and it will be found to be applicable to alloys which do not contain more than 25 per cent. of silver.—*From Prof. Joy in the Journal of Applied Chemistry.*

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Astronomy in Its Relations to Horology.

NUMBER TWO.

There is, however, another consideration in estimating the accuracy of the pendulum, depending not on the *form* of the earth, but its want of uniform density; thus, if we suspend a plumb bob near a mountain, we find a certain amount of deflection from the true straight line to the centre of the earth—in other words, the plumb line does not coincide with the true line of attraction of gravitation. Thus, in northern Italy the deflection of the plumb bob was found to be five or six times as much as the deflection caused by the immense mass of Chimborazo, in Mexico. We can attribute this variation to only one cause—a preponderating attraction of gravitation by some hidden mass in the earth. Bouguer, while measuring an arc of the meridian in Mexico, found that in the vicinity of the Chimborazo peak, his plumb line was out of the true vertical; and, as in the case of Mahomet, the mountain would not come, so the bob was deflected to the mountain. It must be understood that the attraction of gravitation is not to be considered simply in the fact of a body falling to the earth, but the mutual attraction existing, or rather manifested, between two bodies in position, modified by the superior force exerted by the earth; for the attraction of gravitation is in proportion to the mass of each body acted on, and it has been demonstrated by Newton that a particle of matter placed without the surface of a hollow sphere, is attracted by it in the same degree as though the whole amount of matter composing the sphere were concentrated in a compact mass in the centre. We would therefore expect that a small body in proximity to a larger, should be attracted in just the proportion of the two masses. Except in the case of the pendulum, no direct horological interest pertains to a further consideration of the laws of gravitation. Yet in observations for the passage of astral bodies over the meridian, all the calculations are modified, more or less, by the influence of mutual attraction; it will not, then, be amiss to spend a few minutes in its further consideration, as the great law laid down by the immortal Newton was the true father of subsequent astronomical science, and consequently Horology should acknowledge its value and admit its claims.

It has been stated that the attraction of a mass of matter external to a hollow sphere is the same as though the sphere was concentrated in a mass at its centre; but it has also been shown by the action of the earth on the pendulum, that in a spheroid the same law does not hold good, for the pendulum is found to fall—in other words, vibrate faster at the poles than at the equator. The slight differences in the polar and equatorial axes of the sun, planets, and fixed stars, compared with their immense distances, may be disregarded, and the various bodies considered as true spheres, obeying the law propounded by Newton. He also proved that the moon is held to her orbit of revolution around the earth by the same force that causes a body to fall to the earth. But the moon is the nearest body to the earth, and it is a law of gravitation, that its force is exerted in the inverse proportion of the squares of the distances; therefore we find that in obedience to this law the moon is really more of a disturbing cause than the sun in proportion to the mass. The figure of the earth, however, is not a perfect sphere; therefore the moon, in portions of her orbit, being out of the line of the centres of gravity that join the two bodies, causes a disturbance of the protuberance of matter at the earth's equator, and consequently of the polar axis, as we have shown when treating of nutation, the attraction of the two bodies being in proportion to their masses. The pendulum vibrates more rapidly at the poles, and therefore we infer that at that point the attraction of gravitation is greater than at the equator; the law of the increase being as the squares of the sines of the latitude, we can find between the equator and the pole some circle of latitude where all falling bodies would be equally affected by the attraction of the earth, and on that parallel it has been demonstrated by the Atwood machine that a body falling in vacuo traverses the space of 16.0697 feet in the first second of its fall. Taking this as the mean constant quantity, we can easily weigh the mass of the earth or moon, by ascertaining by the analysis of the law through how great a space the earth would fall toward the sun, and the same as regards the moon in her relation to the earth; in this calculation we would leave out altogether the centrifugal force of both bodies' motion in their respective orbits around their centres of gravitation.

The law of orbital motion, and the paths described by satellites around their primaries, are subservient to this attraction of gravitation; for from its consideration Newton found that a body projected into space will move in a conic section when attracted by a fixed body, the force of attraction being inversely as the squares of the distances. Comets are a strong example, and by observation it was proved by Kepler that the planets move in ellipses. The sun, in our system, being the greatest mass, attracts all the several planets inversely as the squares of the distance, and in proportion to the mass; the enormous diameter (886,877 miles) of the sun rendering its mass greater than the combined matter of all the bodies revolving around him. The stability of the whole solar system is thus secured as will be seen when the ellipticity of the various orbits is treated on. Kepler laid down another law, or rather discovered one, and that was, that the squares of the periodic times of the planets are proportional to the cubes of their mean distances from the sun's centre; and from the law of the squares of the distances it will be seen that all the planets, whatever their mass, would, if at equal distances from the sun, fall to his surface in equal times. This law applies, not only to the planets and comets in their relation to the sun, but to the systems of the planetary satellites, as each is held to its primary by the attraction of gravitation.

Not only does this affect the planets and comets of our system by the mutual disturbance of the different orbits, but the effect of the action and reaction of the attraction of gravitation extends far beyond our solar limits. From certain data, it is almost, indeed quite certain, that the sun himself, with his whole train of satellites, is subject to the same law, and is revolving in space around some centre, which has not yet been defined, located in the vast expanse outside our own atmosphere. The power of analysis as applied to the laws of gravitation can hardly be better illustrated than by citing the case of the new planet discovered by Le Verrier, which was a beautiful illustration of induction from known premises. The only known external planet (the sun being the centre) of our system was Uranus;—the seven elements had been determined and its orbit supposed to be ascertained. Now it must be understood that the real place, or, in other words, the latitude or longitude of a planet or star cannot be determined by observation, as the periods of translation in space are too great; but we may find its distance from the sun. We have stated that by Newton's law all bodies revolving around a fixed point of attraction must describe a line of some conic section; such being the case, all the planets have orbits more or less elliptical, and the sun must be situated in one of the foci of the ellipse, which would of course produce an eccentricity of the orbit. Now, we must first determine the major axis; next, the position the sun takes in relation to the orbit described by the rotating planet, and these two elements give us the form of the orbit. The perihelion as to its longitude must be found, that is the longitude of the point of the least distance from the sun; the inclination of the orbit to the plane of the ecliptic, and the longitude of the ascending node. Here we have five data from which we may determine the position of the planet in space. The period of its revolution around the sun, measured by our division of time, assuming our year as the unit, and the epoch of the node must be determined in order to find the true place of the planet in its orbit at any given instant; these are called the seven elements of the orbit.

In the case of Uranus all these seven elements of the orbit were well known, but the path described by the planetary body did not coincide with the recorded observations; there were some disturbing forces at work that varied the line of motion. Adams in England, and Le Verrier in France, set out to find the disturbing causes. These two astronomers, without a suspicion of the work of each other, determined that outside the orbit of the planet Uranus there must be a body revolving around the sun; as the laws of gravitation were supposed to be as potent in space as on the earth's surface, by analysis the still unknown body was weighed, and what is still more wonderful, its position at a particular minute was determined. Le Verrier, wno first published to the astronomical world the particulars of the sister planet, sent his calculations to the Observatory at Dresden, as there a very accurate catalogue of the stars had been made. His calculations were verified, for on the telescope being directed to that point whose latitude and longitude of the celestial space was indicated by Le Verrier, the planet was found. In astronomy the discovery was an event never before equalled, but it had long been anticipated, as the following quotation from Mrs. Somerville will show. Writing in 1840, she says: "The tables of Jupiter and Saturn agreed most perfectly with modern observation; those of Uranus, however, are already defective, probably because the discovery of that planet in 1781 is too recent to admit of much precision in the determination of its motions, or that possibly it may be subject to disturbances from some unseen planet revolving around the sun beyond the boundaries of our present system. If after a lapse of years, the tables formed from a combination of numerous observations, should still be inadequate to represent the motions of Uranus, the discrepancies may reveal the existence, nay even the mass and orbit of a body placed forever beyond the sphere of vision."

Except the invisibility, the prediction has been verified; and still more our admiration is exercised in contemplating the whole subject of astronomy and the high power of mathematical reasoning displayed by its devotees, in the fact that from the perturbations of the new planet it has been found that another body, still more remote from the sun, belongs to our system. This mutual attraction of the heavenly bodies becomes a very complicated problem to solve when we take them all into consideration; but as they are so remote, and the disturbances so minute compared with the earth's mass and motion, they are hardly of value enough to become the subject of such a tedious and complicated mathematical analysis; but there is a very celebrated problem, denoted the problem of the three bodies, that enables the astronomer to ascertain the motions of translation of the planets. The sun, earth, and moon were the original bodies chosen for the elucidation of the proposition. Suppose the mass of each to be known, the velocities of the original projection into space from three given points as well as the direction given, the conditions of the law of gravitation being that the force of attraction is directly as the masses, and inversely as the squares of the distances, it is required to find by analysis the lines that would be described by these bodies and the point in those lines at any given period. The solution of the question was a triumph for astronomy, and it also was a boon to Horology, for on it depends a correct knowledge of the motions of the objects used in taking observations for time.

Before proceeding to a further consideration of the perturbations caused by the mutual attraction of the planets, we must state their relative positions one to the other, and also to the sun. No two planets move in the same plane around the sun. Taking the earth's orbit or plane of revolution, we find Mercury, Venus, Mars, etc., having planes of revolution more or less inclined to our ecliptic; it follows, then, that at times any one planet may be above or below the plane of the earth's orbit—the sun being considered a fixed point of attraction. This position of the two planets induces a considerable change, not only in the plane of the orbit at times, but in the form; thus, at certain junctures increasing the ellipticity, at others again reducing it. It must be remembered, however much the change, the major axis remains the same; so that if the orbit is increased in rotundity, the earth would have to move through a greater distance in space than with a greater ellipticity, and the rate of the motion would differ materially in different parts of the orbit; thus the inclination of the plane of revolution of the different planets to that of the earth, has a sensible effect on the year, for by observation and analysis it has been found that the orbit of the earth is decreasing in eccentricity by 40 miles a year. There is another disturbance, and that is of the inclination. We can get a good illustration of the inclination, its disturbing forces, and the latitude, if we take two circles or hoops of different dimensions and piercing them edgewise in a line that passes through the centre of each and placing them on a wire as a common centre, observing to keep them concentric—we have a very fair mechanical view of two orbits (we may neglect both the eccentricity and ellipticity). Now if we place the apparatus on a level surface, say a table, we find the two planes of these models to coincide, and the wire centre is the line of the nodes; but if we lift one side of the outer ring and place a rest under it, we destroy the coincidence of all the parts except the two points on the nodal line. We may vary the inclination as much as we choose, and thus show, in succession, the relation of the earth's orbit to the places of the rest of the planets in a very palpable manner. It will be obvious that if the periods of any two planets vary, their relative positions must vary so if the two bodies have started at one of the nodes at a given instant of time, the one whose periodic time is the least will have made an annual revolution and returned to the starting point while the other will have moved in its orbit a space proportional to the periods. Thus if one body, E, has a period of unity, and the other, I, one four times as great, E would have arrived at the starting point while I has passed over only one quarter of its orbit, and consequently is at the highest or lowest point of its orbit while E is at the node; resuming the motion, E will, in one quarter of its revolution, arrive at the same highest or lowest point of its orbit; but during this time I has moved one-fourth of this distance, so that he is one sixteenth of E's period in advance of E; continuing the reasoning, it will follow that there will be a common point in the two orbits where E is above or below I. By the law of gravitation the attraction of the largest mass would tend to lift or depress the smaller from its path; this really occurs.

Taking our simple apparatus, we can get an idea of the latitude of a body. We will suppose E and I again placed on their respective orbits at the same node, and set in motion at the same ratio of periods; as E goes in advance of I, the planes of the orbits begin to separate, and the perpendicular distance of I above the plane of E is the north latitude of I; if below, it is south. The celestial latitude of any body is, then, the angular distance of the body from the ecliptic.

The most interesting aspect of the law of gravitation is afforded in the consideration of the stability of our whole system of sun and planets, with their satellites. Tho subject has been discussed by men whose names are household words in the astronomical world. La Grange first demonstrated the fact, and the proposition and its successful solution won for him the following compliment from Professor Playfair: "a discovery that must render his name forever memorable in science, and revered by those who delight in the contemplation of whatever is excellent and sublime." La Place and Poinsett extended the demonstration to more accurate results.

La Place laid down the proposition that there is a great invariable plane passing through the centre of gravity of our whole system, about which the whole oscillates within very narrow limits; and that this plane will always remain parallel to itself, whatever changes time may induce in the orbits of the planets in the plane of the ecliptic, or even in the law of gravitation; provided only our system remains unconnected with any other. La Place found this plane to be inclined to the ecliptic at an angle of 1° 34′ 15″, passing nearly midway between the orbits of Jupiter and Saturn and through the centre of the sun; the sum of all the inclinations being thus divided by this great plane which may be considered the equator of the solar system. Now as this plane is invariable, it will in time enable astronomers to determine whether our system is connected with any other system. It is highly probable that the sun with his attendant satellites is revolving in an immense orbit around some distant unseen primary, and if so the variation of this great plane after the lapse of ages will give the then living astronomer a clue to the size of the orbit and the distance from the primary.

Even imagination is utterly incompetent to take in distances so vast or masses so great as would pertain to such a system, of which our sun with his train of attendants is but a planet.

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Watch and Chronometer Jewelling.

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NUMBER TWO.

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In considering the making of the jewels from the various materials enumerated in the first article, the reader must bear in mind that much detail, and perhaps repetition, are unavoidable, if the description is to be of use in the practical sense to the artisan, the whole process being made up almost entirely of *littles*; and any essay on it would be incomplete, were we to neglect the little things and motions of the processes. With the close of the last article we had arrived to the manipulation, which we now propose to consider. In order to give some system to the descriptive part, we will take up the subject of the tools used by the jeweller, which are comprised in the following list: First, and most important of all his tools is his lathe; no very complex affair, comprising simply a head, stock, and a mandrel (*well fitted*, with no tremble, and no end shake in its bearings), a common T rest, a driving wheel with stand and its band, and a treadle hung on the outer end and connected with the crank by a leather strap. It is not a very formidable tool, nor is it easily deranged; but in very fine and delicate manipulations it is essential that considerable care should be exerted to keep the mandrel in such a condition, that while it is immovable in a vertical or longitudinal line it is left perfectly free to revolve with the greatest ease; for one of the greatest requisites is speed.

There are three varieties of the jewelling lathe, but no difference in the principle. The English use a small brass tool not more than five or six inches in length, and with a very small swing—the mandrel, being fitted to a steel bushing on its front end, and a pointed centre at the back bearing, is a very strong and substantial arbor, but for good work and durability it lacks length. The small swing of the lathe necessitates a very low rest; but in drilling this is perhaps an advantage, as the operator is enabled to rest his hand on the bed of the lathe, which is quite broad. The band generally used is common catgut, and is unobjectionable in all but that of joining the ends. Now, joining the ends may seem of but little importance, but it is; for a knot in the band is very apt to cause the arbor to "jump," and in drilling a very fine hole the cherished drill (and a good one *is* cherished) is broken. No one but a sluggard or saint could have such an accident happen without an exhibition of impatience. The jeweller in England drowns his sorrow, on such an occurrence, in a quart of ale. The best material for a band is good well-tanned calf-skin; it is easily made, most any shoemaker being able to cut from a small piece of leather a band from fifteen to twenty feet long, and the shred thus obtained may be drawn through any wire plate whose holes are of sufficient diameter; or, in case of the absence of such a plate, a common pinion stake can be profitably used, as the sharp edges of the finished face will cut the superfluous corners from the square leather thread and leave it uniform in diameter and nearly round. It is now rolled between two surfaces, and is ready for use. The most prominent virtues of this band may be summed up as, *first*, elasticity; so that if the driving-wheel is not true, the strain arising from the inequality will not be transmitted to the arbor; *secondly*, it can be easily joined without the formation of a knot; and, *thirdly*, the mice will not eat it; the last may seem trivial, but it has occurred in a large establishment that the depredations of the mice were a cause of serious inconvenience, as well as loss of money and time. The English lathe, as thus described, is a very handy tool in the hands of an operator who has learned the use of it, and got his hand accustomed to the dimensions, but for the general watchmaker it is of very limited value.

The Swiss jewelling lathe is too well known to need any description. Like all other human productions, it has its advantages and imperfections; its valuable points are, that the arbor is longer, projects farther from the front bearing than in the English lathe, and has a much greater swing—thus enabling the operator to use skives and laps of all kinds of larger diameter, and of course more rapid in action; and the lathe itself can be used on the bench for all kinds of watch repairing requiring either the old verge or the Jacot lathe—no inconsiderable advantages; but it has the arbor turned down too thin in the neck of the front bearing, causing a tendency to tremble. In the Swiss style of drilling this is hardly an objection; but it is not good when the English diamond drill is used. The American lathe is a better tool for general work, and can be used for jewelling with all the advantages of the English and Swiss, with none of their defects. As a matter of course, the prime necessity in each is rapid motion. To accomplish this, the driving-wheel is usually of large diameter, but light in weight, as it is necessary to control its motions with ease and speed; the wheel should be well and truly turned up on its face by the hole in the centre, and hung on well-made bearings—not conical centres—as the pressure of the screws that hold the centres has a tendency to spring the shaft in the crank, causing the wheel to "wobble." The advantage of a leather strap is that it is more elastic, and gives less shock to the wheel and lathe mandrel, than if made of iron.

The alcohol lamp is a most important adjunct to the lathe, it being what the screw wrench is to other lathes. It should be small, with the wick tube placed on the side at a strong angle, something like the spout of an ordinary coffee-pot, only it should enter the side at the bottom of the lamp—a small wick, and consequently flame, only being needed. A very pretty lamp which any watchmaker can fabricate for himself, and which is superior to any lamp he can buy, may be got up in this manner: Select a common house britannia lamp, such as are used in hotels for bed-room purposes, drill a hole in the side just above the bottom plate and solder in the hole one of the drawn brass tubes used in the manufacture of the penholder; a common hollow penholder will answer admirably by cutting off its closed end, and this lamp is neat in appearance, and the size of the tube is just about the desideratum.

The tools that pertain to the lathe proper may be summed up as the skive, lap, and chucks; the lap has been described in a former part of this article, and it only remains to treat of the skive and chucks. The skive is nothing more or less than a circular saw, or really a lap; only the thin edge is used in place of the face. It is made from soft sheet iron, planished up true but slightly dishing, and is clamped on an arbor between two flanges which are held together by means of a screw and nut on the arbor; the object of the dishing being to render the part left exposed outside the flanges rigid, so as not to "buckle" when the charging process is being done, or by the pressure of the stone in being cut. Except in the factories, the skive is not much used by the jewellers, their lathes being too small to permit an economical use of the instrument. The lapidary uses it extensively, as he has sometimes large stones to slit, which would be ruined were he to attempt cleavage by a blow. The charging of a skive is a simple operation, yet requires no little skill to effect a good result.

After having trued up the plate, both as to centre and plane of revolution, the arbor is set in motion at full speed; a small quantity of coarse diamond powder in oil is taken up in the hollow of a quill cut something like a tooth-pick. Having a piece of cornelian in one hand, the operator presses it with a gentle degree of force against the edge, and with the other hand he applies the powder as near the stone as convenient, which becomes attached to the edge of the skive, through the viscidity of the oil, and is carried along on the edge until it comes under the piece of cornelian; the pressure of the stone imbeds the particles of the powder in the soft iron. The use of the quill is suggestive from the fact that its shape is all that could be desired, while its elasticity could not be equalled in any other way.

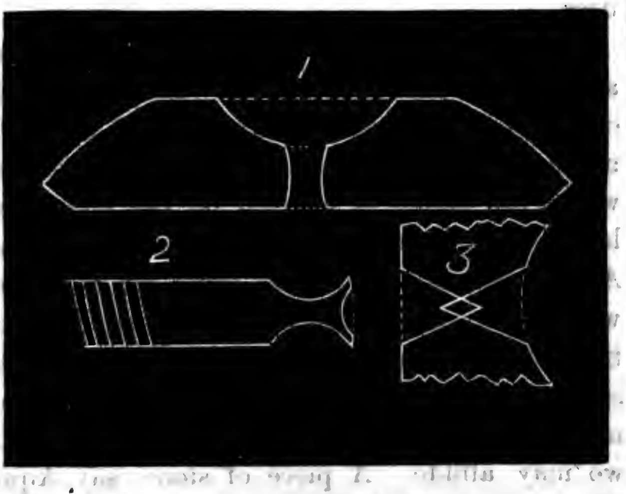
After two or three revolutions, the skive begins to cut the cornelian used as the burnisher; that is of no importance, for a new spot on the face of the cornelian with a fresh charge of the powder, will generally charge the edge with diamond sufficient to do a large amount of work. The object to be slit is held to the edge of the skive by the lapidaries in their fingers; but the small stones used by the jeweller are cemented on the end of a stick, and thus can be applied to the cutting edge with facility, the skive being kept well oiled during the operation of slitting.

For jewellers' purposes the chucks are nothing more or less than short pieces of brass with a screw on one end to join it to the mandrel; it is placed in the lathe as true as possible and then turned off with a common steel graver to any form and dimension.

So much for the lathe and its adjuncts; it would be useless, however, without the two important bench tools—the diamond cutter and the drill; these are made the same way, the only differences being the size and form adapted to their different uses. To make a cutter, the artisan selects a fragment of "Bort" of the size desirable—the form, as a matter of course, being that which presents the best cutting edges and adaptability for being firmly set in the stock, which he proceeds to make in this manner: Taking one of his chucks, he anneals it by heating it red hot and plunging it in cold water, then places it in the nose of the mandrel, turns it off true and drills a hole in the end large enough to receive the "Bort," and deep enough to enable him to have stock enough to hold the diamond. The outside of the chuck is now turned down with a neck just back of the bottom of the recess, tapering the end of the chuck from the bottom of the neck outward to the end; the piece is now ready to receive the cutter, which is placed in the recess in such a manner that it will be larger in the hole than outside; the operator, then, with a pair of plyers, pinches the two sides of the end together on the diamond, the soft brass yielding and taking the form of the "Bort;" in the pinching the whole form of the end of the chuck is changed; it is elongated on each side of the diamond; by pinching with a pair of plyers these elongations, it will be obvious that the stone is bound on the edge of the setting almost as if it were a piece of soft wire twisted around the cutter; the rough parts are trimmed off with a file, the balance of the chuck turned up to suit the convenience of the operator. For additional strength, it is sometimes soldered in with silver solder, which fills up all the crevices, and thus forms a solid bed for the diamond. The drill is made in precisely the same way, the only difference being in size and delicacy of manipulation.

The miscellaneous articles are such as are generally used on the watch bench, such as tweezers, plyers, files, gravers, etc. He uses also pieces of iron and copper wire and of lead in the form of short cylinders, also glass plates for facing, and boxwood for various uses.

The watchmaker is well aware that there are two forms of a jewel: one commonly called a plate hole, where the end shake is made by the shoulders of the pivot, another where the shake is effected on the ends; the latter being accompanied by an end stone. As the process is about the same for both, we will take a common plate hole for an illustration of the making, premising that the description will be interrupted frequently by the necessity of explaining some process to which we may allude. A piece of stone, say Aqua Marine, is selected; if large the jeweller may slit it up by means of the skive, but generally it is broken into fragments; these are sorted for the different-sized jewels it is desired to make. The workman now fits his lap on the lathe, and taking a fragment he holds it against the face of the lap, the end of the finger being protected by a piece of cloth, which is also useful in wetting the lap, as it must not be let to get dry during the operation. In a very short time a flat face is produced on the stone. So far but little tact or skill is exercised, but it is necessary to make another flat parallel to the first; for the object of the whole proceeding is to reduce the broken fragment to a plate of stone, just the thickness of the intended jewel; but this is a nice point in the sense of feel, as the stone is completely hid by the finger and cloth, while being operated on by the lap. Practice alone can enable one to do it with truth and rapidity; a few hints, however, may lighten the task. The finger may be pressed on any side of the stone, being cut; the lap then will cut faster on the side of pressure, and thus a wedging piece may be brought parallel. The experimenter must work very cautiously, not hastening, but examining very often the condition of his work and correcting as he goes along. The piece having been thus reduced to a small slab of stone, irregular in form on the edges, it must be rounded as near a circle as the eye can judge and the means allow, which is done by means of a pair of plyers, nicking off the prominent projections until a small circular disc is formed. This is now in a condition to go on the lathe to be turned into the shape as seen in Fig. 1 in the plate.



Now commences the first operation on the lathe. A chuck is first turned up in the manner illustrated by Fig. 2; the neck there shown is of essential service as it allows the end to be heated by a small flame as the conduction backwards towards the lathe is prevented in a great measure; the hollow in the end of the chuck is made in order to insure and get a bearing surface for the object. The chuck having been thus formed, the operator sits at the lathe in such a position that he can reach his left arm around to the back of the lathe; he now with the lamp gently waving the end of the chuck, touching it frequently with a piece of gum-shellac, and when warm enough the gum will flow over the face of the chuck; the stone is now held over the flame long enough to warm it, and placed against the face, and the flame delicately applied until with the points of the tweezers the stone moves with facility over the face; the lamp is now withdrawn, and, revolving the lathe very slowly, the stone is pushed either way until the piece is centred to general truth. It must be observed that the less shellac applied the stronger will be the cement, therefore a pressure must be exerted against the flat of the stone while adjusting it to the centre.

The work is now left to cool, which it does very quickly and is then ready for turning off. This is done with the diamond cutter—both the cutter and stone being kept wet. The outside edge is turned round, and a slight chamber made with the cutter on the face corner. The stone is now ready to drill half way through from the face side. This drilling requires a few words, as it is a very important part of the performance; the size of the drill and the truth of the centre being the most particular points in any jewel. While the lathe is running, the operator presses his drill against the centre of the stone exactly; it is easy to say he does it, but it has required of him much practice and many broken drills to acquire the tact to discern the accurate centre and plant his drill so that no eccentric motion of the drill can be observed when the lathe is in motion. Again, much judgment must be exercised to drill the hole just deep enough to meet the one to be drilled from the other side in the centre of the stone after the oil cup is turned out. The hole being drilled from the face the piece must be turned on the chuck; this is done by warming the shellac, taking off the stone, and putting the face side against the chuck, observing the same precautions as before.

A new process of centring now obtains. Before we merely observed the general truth; now absolute truth is required. The chuck is warmed until, as before, the stone glides easily over its face; when the rest is fixed near the work and while the lathe is revolving slowly, a piece of stick or the points of the tweezers is gently brought up to the outside edge of the stone; if it projects from the centre on any side, the high side will be rubbed in towards the centre, and a few turns (if the operation be conducted gently) will bring the circumference of the work again in the same centre as it was before being reversed on the lathe; if it is true, it follows that the hole now out of sight is also in the centre, for the hole and the outside were concentric.

There are what are called the convex and concave; these are now to be made; the convex is generally turned up first, and it is important for success that the figure should be nearly true, as it may bother a great deal in forming up for polishing. The oil cup is now to be turned in, which operation is generally done with a smaller diamond cutter; the same precautions given for the large surface must be observed, but there is a greater difficulty in the operation. This difficulty is caused by the tendency of the cutter every once in a while to run over the centre when the bottom of the oil cup is being made, thus creating a tit which is fatal to drilling, as it throws the drill out of centre. The drill is now put in until it reaches the corresponding hole from the other side; the form of the hole which is now pierced through is in section of the form represented in cut No. 3. The jewel, now in a rough state, is in a condition to be brought to a uniform surface on both the convex and concave, for the diamond tool has left rings, and in turning by eye a perfectly true form has not been obtained. This process is effected, first, by a sort of a former, which consists of a piece of brass wire of a diameter considerably greater than that of the jewel; in the end of this wire a concavity is cut, somewhat larger than the convexity of the jewel; some coarse powder being placed in the concavity, it is applied to the stone on the chuck. It is apparent that if held directly against the stone in the centre it would affect only the top of the convex; a wobbly motion is given to the former, so that in the course of a few revolutions of the lathe it has acted on every part of the stone, and in a very short time the surface of the convex will become uniform and of a true shape. The oil cup is treated in a similar manner, save that the former is convex on the end.

Having arrived at the formation of a jewel in the rough, we will leave the subject for a future number. As the object of the article has been to give a practical exhibit of the *modus operandi*, nothing was left but to give such minute descriptions as would enable any watchmaker, by a little practice, to make a jewel for himself, should he be in a position where it would be difficult to obtain the desired article.

The Lathe.

No one tool is of such extensive application as the one we are about to consider; it is in itself the first approximation to the guide principle when used merely as a hand tool, and almost perfection when it assumes the form of the engine and geometric lathe. From the earliest times has it been known, and the potter's throw is the symbol of its antiquity. Could we, at the present day, imagine any degree of civilization without it? Other tools are specialties. The planer, the cutting engine, and all the other forms of labor-saving shaping tools are useless without that master-piece—the lathe.

Its adaptability is so great, that the same principle obtains in boring the huge cylinder of 114 in. diameter, as in making the hole in a balance staff to replace a broken pivot, and differing only in size and appliances; the shaft of a steamboat, and the staff of the most delicate Geneva watch, are each formed and adjusted alike by its aid. In whatever form it may occur, whatever its size, it is always the ready tool, and only one, with which to perform numberless marvels of mechanism.

The Chinese, who, by patient skill of manipulation, succeeds in turning sphere after sphere, one inside the other, from a solid block of ivory, has done the same thing only as the engineer who bores the grooves in the boxes of a propeller, and by the same agency. The watchmaker has a great interest in the subject for almost every step is involved in some way in the operations of this tool. Does he wish to turn out a barrel, face a plate, pivot an arbor, etc., he must have recourse to the lathe.

The earliest form of the lathe in the trade was undoubtedly the dead centre; that is, the object to be operated on was placed between centres that were dead, did not revolve, and the bow was the propelling power. The objections to this need not be here enumerated; they were sufficient to throw the instrument out of use wherever the live mandrel was introduced; but there are some good points about the tool that we are bound to acknowledge, in gratitude for the debt we owe it for the advancement of Horology.

It possessed the element of truth, and it made no matter how coarsely constructed, this truth was not eliminated unless through the entire mismanagement of the artisan; for the centres must always remain the same relatively, whatever may be their position in relation to the lathe bed. Even at this day this form of lathe is used in cotton-mill machine shops, to perform certain kinds of work that require extreme accuracy, such as rollers for mules and jacks, etc., etc. This work, however, is entirely external; the object must first be centred, and herein half the true value of the lathe principle is lost. The watchmaker has, in manifold cases, to work on the inside of an object, and on the face. The set of arbors which, even in the writer's time, were an indispensable adjunct to the dead-centre lathe, give a full answer as to the value of the tool. To the verge, Jacot, the drilling tool, centring tool, and a host of others, we bade adieu when the live spindle was introduced. True, there are those who never learn by seeing what others do, and how they do it; but, like the Italians, carry their grain to mill across an ass's back, in a bag, with a stone slung on one side and the grain to counterpoise on the other. The race, however, is dying out; some converted to the new methods, others passing off the stage, leaving younger ones of more progressive ideas to fill their places.

The live spindle lathe having become the watchmaker's right hand tool, it will be perhaps of some benefit to many to know what lathes are in use, and perhaps there are more who would like a few remarks on the art of manipulating it to the best advantage.

The point sought for in a live-centre lathe is accuracy of fitting, so far as the arbor or mandrel goes; for, unless a certain degree of perfection is attained in this, the most important piece, it is worse than useless, as it not only does not do the work, but leads us astray. This accuracy having been obtained, it matters little what (in a simple hand-lathe with no back centre) the finish or truth of the other parts may be. Taking this point of accuracy in the mandrel as a standard, we will sum up the various lathes now in use among the watchmakers, and investigate the merits of each.

First upon the list comes the Swiss bench-lathe; first, because it was earlier introduced as a general tool into this country. The form is too well known to need description. It is a neat, and, with few exceptions, well-made tool. When purchased, it is accompanied by sundry adjuncts, such as extra chucks, drilling rest (for stone work), screw-plate for fitting chucks to arbors, T rest, etc. The front box for the arbor is so arranged that the upper half may be swung back on a joint, and enable the arbor to be taken out with the least amount of trouble. This plan enables the operator to use a number of arbors without removing the work already on the lathe, and the best of the Swiss tools are accompanied by extra arbors, and it can readily be understood how convenient it may be at any time to lay aside a job without disturbing its truth, and using the lathe for other work, or in fitting two pieces together to have the chance of trying without removing either; this is a very decided virtue. Of the arbor itself, however, we cannot speak in high terms of commendation; it is turned down too small in the neck, where it leaves the front bearing weak in the very place it should be strong, so that the mandrel is very liable to tremble, or even break, when a heavy piece of work is put up, as when a plate or barrel bridge is chucked eccentrically, the centrifugal force of motion of the heavy side causes a sensible vibration in the arbor; it is true this may be remedied by counterbalancing, but this process is tedious as well as inconvenient.

The rest in the Swiss lathe is too large and clumsy, it being held on the bar in such a manner that the centre of the T cannot be passed beyond the centre of the lathe. This must occur in all lathes having a square or triangular bed for a base. The small odd-looking slide rest that generally accompanies the Swiss lathe is of no value whatever to the watchmaker. It is used in Switzerland for drilling holes in stone by the use of the steel drill and diamond powder. Of late years, however, a back centre has been substituted; but it is not true, and even if it were, the base of its support is too small to render it very efficient. Objectionable as are the points we have mentioned, this lathe has been of use to the trade, as it has to a great extent displaced the bow for all work, except perhaps for burnishing pivots, as its cheapness and general merit commended it to favor.

The above remarks apply to the bench-lathe only. The Swiss-universal lathe is, for the purposes designed, a very superior tool; the fitting, as in all Swiss tools, is first class, and generally the face plate not only runs true, but presents a perfect plane, truly at right angles to the arbor. The slide rest is also first class and admirably adapted to the work it has to perform, and is convenient to operate; the fault of the instrument is, that while the head is strong and massive, the bed on which the resistance of the cutting comes is too light, and does not present surface of bearing enough to give a firm and steady base for the slide rest; consequently, when a heavy cut is taken, the rest is liable to chatter. Again, it is very limited in its application to the general work of the repairer, it being a special tool. The face plate being stationary on its arbor, the only uses to which it can be applied are facing and turning out; and even in facing, the piece cannot be faced to the edge, the dogs or clamps interfering, unless the work is cemented on another and larger piece.

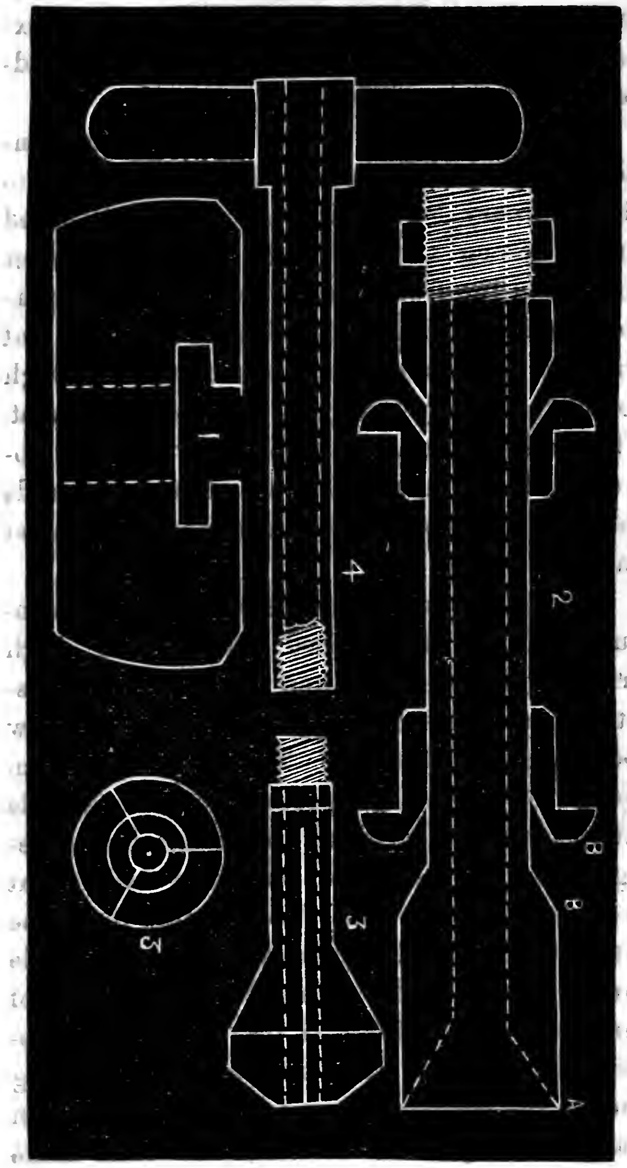
These considerations, conjoined with its high price, have restricted its use generally among the workmen. In the absence of any other, however, it is almost indispensable to the general workman, as there are few, very few, that can face a true surface with a hand tool. The ordinary English universal lathe is also an excellent tool, but is generally used with the hand-rest.

The next in order is the Bottom lathe, undoubtedly a tool superior in every respect to the ordinary Swiss; its arbor is well fitted and is strong and true; the T is of a better form, and the front journal is in better proportion, and runs in a hardened steel bushing; but the nose of the mandrel does not project enough to make it very handy in relation to the rest. This and the form of the bed are the only objections to the lathe. In Mr. Bottom's hands the tool is capable of an almost unlimited variety of work.

When the manufacture of watches was introduced into the United States, the high price of skilled labor, and its scarcity, necessitated a corresponding introduction of new tools and appliances. The most of them being for special purposes, possess but little interest for the general workman; but a design was at last fixed on for a lathe that becomes valuable from the fact that it can be made of general application to the whole range of the trade. The first impression of the watch-tool builder is that watch work requires light tools. This impression is a wrong one, as the costly experience of the old Boston watch factory well attests; the later-made tools possessing solidity and strength between parts. In the matter of truth no other tools are produced that exceed those manufactured in the different watch manufacturing establishments; in fact, there has been created, since the inception of the manufacture, a class of fine machinists that are hardly equalled in the world, whether for fertility in design or skill in execution. The American combination lathe we are about to describe is beyond all comparison superior to any other in use, or attainable at any thing like a reasonable expense. The ease with which work can be held, and taken out, and put back, with an almost absoluteness of truth, is alone a quality that guarantees the above assertion.

The bed of this lathe is of cast-iron, from six to eight inches long, cast hollow and undercut as represented in the sections Fig.

1—planed up on both the upper and lower sides parallel; on the upper, or face side, it will be seen that two chamfers are made on each side, which are also paralled to the face and the planed undercut groove in the centre. The object in having the bed hollow is to allow the bolt holding the rest to pass through and be operated below. The bed is placed on a neat stand, with a bolt passing through it and through the bench, fastened with a wing nut and washer. Though not heavy, strength is acquired by reason of force, and the tendency to chatter is counteracted by the amount of base offered for the head and tail stocks, as well as the rest.



The head stock is very similar to the tail; both are bored and planed up together on the same arbor to the bed, the guide to parallelism being the two bevels on the sides. This style of fitting causes the centres to come in a true line, and that line to be parallel to the base. These are advantages to be found in no other lathe, as a much less strain on a holding-screw will insure firmness, the bearing base being so great.

The rest has a wide base and is held to the bed by a headed bolt resting in an undercut, and is free to move in every direction, and, what is of great importance, may be placed beyond the centre of the lathe; the T is of any form desired, or can be modified to suit any particular purpose. The tail stock is made with two bearings and has an arbor with a taper hole for centres, cutters, dies, or any other tool it may be desired to use, with a binding screw and hold-down bolt.

The head stock requires a detailed notice, as being almost perfection. The mandrel is put in with straight holes, but with a taper bearing to prevent end shake, as may be seen by Fig. 2, which is given in outline and sectional view. The dotted lines, A, represent the interior of the arbor (for it is hollow)—those marked B, the journal bushings; the mandrel is introduced endwise from the front and passes through the back bushing; the bevel for the nose end is made solid on the arbor; that on the back is effected by a ring of steel accurately fitted to the arbor and capable of sliding on it, but not rotating. This description will be readily understood by referring to C in Fig 2. The end of the arbor is furnished with a fine screw and nuts to adjust the end shake. It is to be presumed that the fitting in the bearings is all that modern machinists can effect. It might be supposed, and generally is, that having two through bearings would make it harder to rotate the arbor, but the supposition is a fallacy; the conical bearing being stiffer if the closeness of the end shake is equal in the two varieties. We have said that the arbor is hollow; it is made so for the purpose of applying the spring chuck, of which the reader may gather the idea by inspecting Figs. 3 and 4. The nose of the mandrel having been turned out taper, the chuck is fitted with a corresponding bevel; the chuck is then sawed longitudinally into three sections—the saw cuts terminating at the boss, immediately in front of the screw.

Running through the hollow arbor is a

hollow spindle with a hand-wheel on the back end; the front end is tapped to fit the screw on the chuck, and it will be obvious that if the hollow chuck be put in its place, and the hollow spindle introduced and screwed in its place, the strain will force the cut sections of the chuck to a common centre. This whole arbor, spindle, and chuck, being hollow, a long wire can be introduced; an advantage not to be overlooked, as we may thus turn up a staff, for instance, almost completely, without taking it from the lathe after it has been commenced. The spring chucks are capable of holding various sizes, and greater facilities for shellac work are afforded than by any other lathe.

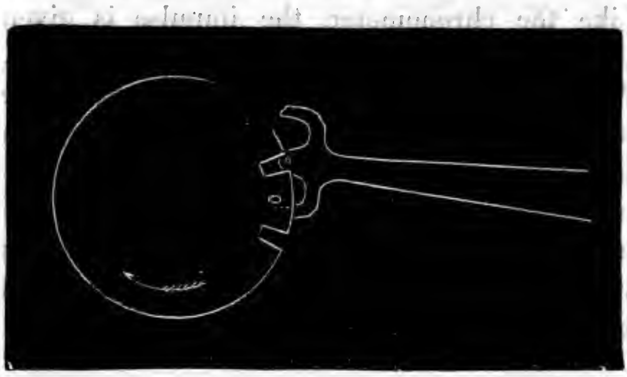
The spring chuck is not confined to the lathe alone, for we saw an article that has been patented by Mr. M. V. Noble, of Elmira, in the shape of a holding-piece for a brace, consisting of two parts placed together longitudinally, bored out to within about a half an inch of the end, and a screw thread cut in the bored portion; the outside of the two parts is turned up with two tapers, so that a ring, when the two are together, may be slid up on the long taper, and thus make the whole, as it were, a solid nut; a hole is bored in the other end sufficiently large to take the shank of a bit. The end of the brace has a square socket to receive the end of the bit, the outside of the end being cut with a thread to fit. The chuck, when screwed on, will look as if it were solid, but on sliding the ring down to the narrowest part the two jaws open wide enough to take in the square on the bit, which now fits into the socket. On sliding back the rings the jaws are again closed, and in consequence of the shoulder in the chuck closing over the shoulder of the square, a few turns of the chuck sets the square firmly and truly in the socket. Altogether, it is the neatest thing we have seen, as it is equally efficacious when applied to the lathe, though it would not be true enough for fine work.

To resume the American lathe. The higher priced ones are accompanied by a spare headstock, fitted up with pump, centre, face-plate, and holding-dogs, together with a slide rest of the most approved style, the dove-tails planed in and scraped to truth. As the sole of the rest is based on a wide surface, and the holddown is strong and powerful, no chattering is observable, even in taking a heavy cut at high speed.

The tail stock, with its centre, is very useful. Drilling, boring, etc., may be done very expeditiously; and turning between centres is practicable.

The space allotted to this article having already been overrun, the further consideration of the lathe and the manipulations must be reserved for a future occasion.

Peabody's Escapement.



In our last number we quoted an article from the *London Horological Journal*, describing a new three-pin escapement, and referred to one invented and patented some years ago by Mr. R. L. Peabody, of this city. We relied, in our reference, entirely on memory, and have found since that it was a two-pin escapement, and combined all the principles of the three-pin, but, from its construction, offered superior advantages for correct performance. It is an improvement on the well-known three-pin English (Savage's) escapement, the only real difference being the use of two slots instead of two pins. These slots are cut on the edge of the roller at such a distance from a straight line, passing through the centre as to make the angular distance from this line equal to from 10° to 20°, according to the proportions of the roller-lever and the movement of the pallets. The pin shown in the roller is the unlocking agent, the impulse being given by the guard-pin in the fork that takes into the slot immediately following the unlocking pin; from the position of the fork, which is represented in the act of being unlocked and giving the impulse, it will be seen that the unlocking is done on the line of centres, and therefore more than one-half of the friction of the ordinary fork is avoided; the pin being in contact with the fork through only 6°, while the pin in the fork takes the slot 40° from where it leaves it, thus extending the impulse over an arc of that number of degrees.

The important facts in the escapement are: first, that the unlocking force is applied at right angles to the line of resistance, and that the impulse is applied to the whole arc of the segment of a circle between the two slots; and again, it will be borne in mind that the impulse is a pin giving its force on a plane, the very reverse of the ordinary fork and lever. Like the chronometer, the impulse is given after the balance has passed the point of repose. With fine and accurate finish and the other parts of the watch in accordance, there can hardly be a doubt of its value as a very superior escapement. Its simplicity alone would recommend it, to the exclusion of an escapement where a wheel of very difficult form to cut has to be used.

Watchmaker's Transit.

Still another transit instrument. The very fact of its production is an earnest that the trade is advancing in the right direction. We call attention to the advertisement of Mr. Edward Prevear, whose instrument certainly gives indication of a thorough knowledge of the science of time. We had a look at the Transit, but it being on a rainy day, we were unable to take an observation, and are therefore not authorized to speak of its performance; but we may say that it is founded on correct astronomical principles, and what is more, can be used by any one at all competent to work up a sum in addition or subtraction.

In ordinary jewelry repairing with hard solder, it sometimes happens that the work will retain a discoloration, even after faithful boiling in pickle. It may be of some advantage to repairers to know that a solution of the cyanide of potassium will render the surface clean, and more readily polished.

Household Clocks.

"Oh! the old, old clock, of the household stock,
Was the brightest thing and neatest;
Its hands, though old, had a touch of gold,
And its chime rang still the sweetest."

It is well that the author of those lines had a favorable opinion and not *my* first impression of the "old, old clock," else the world had been minus one little poem.

I remember, when a boy, of going into the country for a few days, and the first night I had the "best bed" in the parlor. It was a canopied four-poster, and so high that I had to use a chair to mount to it, and, when once in it, was obliged to spread out like a star-fish to keep from sinking out of sight in its feathery depths profound. It was a hot night in August, and for a long time I lay awake, looking at a tall old-fashioned clock that stood in one corner of the room, that in its turn seemed to peer at me, with its dim white face, through the gloom of the room, into which came faintly the light of the waning moon, and whose loud *tack*, *tack*, with a crooning sound occasioned by the clip-wire grating on the pendulum, made me extremely "fidgety," and its harsh discordant bell made sleep impossible; and when at length the morning came, I had a fair look at my old enemy, and I did not like, and from that time I have not liked, those tall clocks, so firmly do first impressions maintain their hold upon us, that although

"Years have sin syne o'er me run
Like Logan to the simmer sun,"

Longfellow's fine poem of the *Old Hall Clock* fails to call up pleasant memories, and I am glad that he made the old clock tell us that

"Forever, never,
Never, forever,"

—will such clocks ever be made.

Notwithstanding what I have written I am an admirer of clocks, and whenever I enter a house I instinctively look for one, and if I do not see its face on the mantle, or hear its cheerful tick from an adjoining room, it seems as if the very person that I came to see was not there. Not long since, I visited at a house where everything in the way of furniture that money could buy was to be seen—yet there was no hall clock. I looked for that ere I had my hat off; a glimpse of the brilliantly lighted parlor, through the half-opened door, made me think surely they have a fine French bronze or ormolu on the mantle, but there was none. Thinks I to myself, there's hardly room among those fine vases and statuettes for a clock, it is in the other parlor. I hurried in there—no clock;—"staggerer number three," as Dick Swiveller would say. To make a long story short, there was a clock in the finely furnished dining-room. I saw it before I was seated at the table and welcomed its homely old Bristol Connecticut face, but it did not look well in that finely furnished room. If the owner of that fine house would purchase one or two fine clocks, nothing would be lacking; and if every one thought as much of the useful articles as myself clock-making would flourish, for I have a clock in nearly every room in the house.

Now a word as to the "looks" of a clock; and I think it should be the aim of the JOURNAI to raise the standard of taste in clocks, so that as the years pass away we shall lose sight of those miniature dry-goods boxes, with pictures of large white houses, amid vivid chrome-green trees, close beside the indigo-blue sea, while a finely japanned red school-house is seen under the yellow branches of a gigantic willow; or, that other abomination, with its representation of a young lady with dabs of crimson on her cheeks and lips, very rank hair, and a purple dress, with a legend at the bottom of the panel informing us that the name of the enchantress is "Ruby Jane." Then comes the little square-toed clock for one dollar, whose usual rate is 70 seconds to the minute, being of the same size and shape as the blocks of wood that little Scotch boys use to block the wheels of heavily loaded carriages in going up steep hills, and are called "scotchers"—and surely those clocks have served to block the wheels of the car of taste for a long time.

Having told what I do not like, perhaps it would be well to say if there is anything in the clock line that does suit. I never tire of looking at a fine French bronze clock, with its beautiful design, elegant dial, and general finish, and I love to hear its musical bell, which tells us so softly and pleasantly that time is passing away. I am aware that there are many persons who cannot afford a French clock; but they may do as I did. I bought one of George B. Owen's tasty native wood clocks—a little black walnut case, very cheap too, and within the means of all; then I bought a little imitation bronze group of a very demure pannier-laden ass, led by a Spanish maiden, which I set on the top of the clock, and it looked very pretty. I liked it, my neighbors liked it—at least they all wished to buy it—and it is one of the few things I ever owned that I could have sold at a profit. But I still keep it, and as a "thing of beauty is a joy forever," it will, doubtless, bring something at some future sheriff's or executor's sale.

But to return to French clocks. Some years since, I strayed into the mechanical toy factory of my friend George W. Brown, in Forestville. I found him engaged in "Yankeefying" those fine bronze clocks, and well had he succeeded. I was highly delighted at the prospect of seeing them upon the mantles throughout the country, but before they were in market I learned with regret that his factory was destroyed by fire; and as I left Connecticut some time after, I lost sight of all endeavors in that line. Since then the various Clock Companies have taken the subject in hand, and are producing almost veritable French clocks, elegant in design, fine dials and movements, etc., for less than one-half the price of the imported clock; so the time has come when we can own beautiful household clocks, to make pleasant our homes.

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We would call attention to a letter from J. F. He makes a proposition of great importance for good or evil to the whole fraternity. The formation of a Watchmakers' Union in the United States would be attended with numerous difficulties—the scattered state of the trade, and the diverse opinions of the members thereof; still, by means of delegated powers, the watchmakers of any section could be represented, and the best interests of the trade discussed. We will not speak of its usefulness until our correspondent, or some one else, sets forth the objects, and some definite plan of action. In the meanwhile, our columns are open for discussion.

Watch Cleaning.

It may seem frivolous to soberly attempt to teach the trade how to clean a watch, but it must be remembered that each one has some peculiarity in his mode of work; they may be better or worse than others; comparison as to the value of any two methods would have to be made in reference to personal peculiarities, for a workman can do a certain amount of work in his own way that it would be impossible for him to accomplish by any one else's method. We therefore offer no apology for giving in answer to a request from a correspondent the method pursued by a first-class workman, as he claims for it superiority to all others.

The best example would be the ordinary Swiss lever as to the true value of the system, for in his hands it becomes a system. The brush, with chalk, whiting or burnt bone, is entirely discarded; the theory being that there is no use in piling dirt on to take dirt off. There is a stronger objection to the use of the brush, for the surface of a watch plate properly gilded is almost as sensitive as that of a dauguerreotype, and it is impossible to brush a new plate with even a soft brush without leaving the marks, or scratching the plate.

In lieu of the brush the workman supplies himself with a dish containing strong alcohol—the stronger the better; also with a piece of old cotton cloth—the softer and the more worn it has been the more preferable. Armed with these and his pegwood he proceeds to take the movement from the case, remove the hands, dial, and face wheels; the last, with the cannon pinion, and the centre-wheel staff, are thrown into the alcohol; he next lets down the spring, then takes out his balance and pallet; from this he proceeds to start all the screws, turning them out in rotation in some certain direction from right to left, or the contrary; with his tweezers he takes out the screws one after another and places them on the bench before him in precisely the same order he takes them out. The object of this careful proceeding is: first, by turning out all the screws at once he has saved himself the duplicate motions involved in laying down his tweezers, and screw-driver alternately—and by preserving the systematic order of his screws on the board he avoids the chance of having to try a screw to see if it fits the hole. The screws having been thus arranged, the clocks and train are lifted out and thrown in the alcohol together with the lower plate, after the end-stone has been taken off; the barrel and bridge is now dissected and the parts also placed in with the train. The spring is then cleaned and laid aside; the hair-spring stud is next pushed out, the end-stone and regulator taken off the cock and consigned to the spirits, together with the cock. While these parts are soaking in the alcohol, the balance is cleaned thoroughly, as is also the pallet. If the oil is very thick and gummy, they may be brushed off with alcohol, but it must be done quickly, as the stones are put in with shellac, and soaking them might displace the jewels. The escapement having thus been cleaned, we commence with the parts in the cup, in this order—first, the balance-cock. Taking it out of the alcohol it is dropped in the cloth held in the left hand, and is then wiped dry; if any little fuzz is left on it from the cloth a fine soft brush may be used, merely to brush, not rub, it off. The end-stone setting and the regulator are now cleaned and replaced on the cock, and, if satisfied with the work, the hole is oiled with the least amount of oil that will fill the hole; the balance is replaced, the stud set well in, and care must be taken to so place it that the coil of the hair-spring falls equally between the regulator pins. The other cocks are taken out one by one, cleaned in a like manner, and placed in order opposite the screw belonging to it; after cleaning, the barrel is sprung, and the bridge cleaned. The steel work is then taken out and wiped dry with the cloth—care being taken not to touch with the fingers any piece that has been wiped, as the alcohol has left it almost chemically clean, and correspondingly sensitive to being marked. The barrel bridge is now mounted with its steel work, and we proceed to clean the train. The brush must be used sparingly, only enough to remove any particles of dirt that the spirits has been unable to dissolve; the pinions are best cleaned with the thin edge of a piece of pegwood. What fuzz there may be on any of the work may be brushed off, as before mentioned. The plate is, or may be, brushed hard with a soft brush, provided the brush is wet with alcohol at the time. After brushing, however, it should be again dipped in the alcohol, and wiped dry with the cloth. The holes being pegged out, the watch is ready to put together. This, however, requires no comment, except to say that you commence in the reverse order to the taking down, putting in the whole train, setting the cocks home, and replacing the screws in their order before taking up a screw-driver.

It will be seen that the advantages of this plan are numerous, whether the quality of the work or the speed is considered; it saves the watch from being scratched, or the gilding rubbed. In Swiss watches the matting or frosting of the gilded work is effected by first depositing a coat of crystallic silver, and then gilding on the frosted surface; and every watchmaker has seen cases where nearly every particle of the gold has been rubbed off the barrel and centre bridge, from the effects of the frantic efforts of some botch to brighten up the gold.

———o———

Correspondence.

Editors Horological Journal:

The establishment of a Horological Journal in this country will be productive of incalculable benefit, both to the trade and to the public generally; *directly* to the trade, and indirectly through that channel to the public. The only wonder is that something of the kind has not been started before. I can only account for the non-appearance of some such journal heretofore, from the fact that American "Watchmakers" are not *manufacturers*, but simply watch *repairers*. And it is a well known fact, that, as a class, they *think* less, consequently *know* less about their own business, than any other class of artisans or mechanics. It is a lamentable fact, but no less true on that account. Of course there are a great many worthy exceptions to the rule. But a small proportion of watchmakers ever read any Horological books, and they have no conception of the business in any of its bearings, outside of what they have seen with their own eyes, or what little knowledge they have gained traditionally.

I hope your journal will have the effect to inspire each and every watchmaker into whose hands it may chance to fall, to become a better *workman*, and to know more of the science of Horology, to say nothing of becoming more familiar with its history. My remarks will hold good more particularly as regards *American watchmakers*, than any others, for reasons which I will presently give.

There are many questions of importance to the trade I would like to see discussed through the columns of your journal, one of which I will mention at this time, viz.: the propriety and importance of the better class of watchmakers organizing some kind of a society, that will have for its object the protection and encouragement of *good workmen.* The country is filled with men calling themselves watchmakers, and many of them manage to obtain good salaries, at least for a short time in a place but most generally they settle down in some town or city and go into the business of repairing watches, on their own account—men that are totally unfit to be intrusted with anything in the way of a timepiece, other than a "Yankee clock," for the purpose of repairing it. The mischief that these so-called watchmakers do is astonishing.

What watchmaker is there who has not often heard a customer say, "Well, my watch kept splendid time until I had it worked on, and ever since *that* time it has been in the shop nearly all the time, and I don't believe it ever will keep time again." The natural effect of which is to make the public distrustful of *all* watchmakers; and if a man has a fine watch, he will not have it cleaned until it fails to perform, and a *good* watch, every one knows, will run from five to ten years without cleaning before it will *stop*, and then, if it falls into the hands of one of these quasi-watchmakers, it will be in a fix by the time he gets through with it, to make a big bill for some careful and experienced workman, who, in all probability will be accused of making extortionate charges, when in fact he does the work at barely a living price; the "big bill" being consequent upon the damage the watch has received at the hands of one of these miserable apologies for a watchmaker.

Now, if some society or organization could be effected that would admit to membership none but good workmen or scientific men, it would be a great protection to them. It would also serve as a sort of guarantee to the public generally, that any watchmaker who was a member of such a society, was competent to do his work properly.

I stated that I could give some of the reasons *why* some of my remarks were more applicable to American watchmakers than to those of other countries. The great cause of there being so many inferior workmen scattered throughout our land, is to be found in the fact that we have no adequate apprenticeship laws. A boy makes up him mind to be a "watchmaker;" he gets a situation in some jewelry store or with some watchmaker, and in course of time he finds that he can take a watch to pieces, clean it and put it together again, when he becomes dissatisfied with his *pay* and thinks he can do as good work as his employer (and in some instances he can); so he makes up his mind in a year or so to "start for himself," and unless he is a "mechanical genius," he will always remain a "*Botch*."

I think it is very unfortunate that we have no laws to compel an apprentice to serve a stated number of years at his trade, and also to compel his employer to learn him the trade thoroughly. In the absence of any such laws, I see but one way that the regular watchmakers have to protect themselves, and that is to organize some such kind of a society as I have indicated. As your journal will be the mouthpiece of the trade, I hope to see something in its columns from some one else upon this subject. It was not my intention to go into any lengthy argument to prove why some such action was necessary, but to introduce the subject to your readers and state some few *facts* that cannot be gainsaid. There are many other reasons that could be brought forward to show why something ought to be done to protect those who have worked hard and faithfully to become master workmen, but I think I have said enough to *introduce* the subject.

The watchmakers of London have their *Horological Journal* and Institute for the advancement of the science of Horology, and benefit of the trade generally; France and Switzerland can also boast of like institutions. Why should America be so far behind the age? We certainly stand in great need of something of the kind. As the system of the manufacture of watches and other timepieces (rather than marine chronometers) is entirely different in this country from that of any other, so will the character of its Horological literature necessarily be different; that is to say, a literature is needed that will be principally devoted to the wants of the watch repairer. That the American Horological Journal will meet this want, long felt, I have no doubt. Furthermore, I predict the future financial success of the Journal, for I hope every intelligent watchmaker throughout the country will become a subscriber, notwithstanding the little interest that has been taken heretofore by them in everything pertaining to their trade.

I will here state that any remarks that I have made that would seem to reflect upon the trade is *only* intended for that portion of it usually known as "*Botches*."

Respectfully yours,

J. F.

Americus, Ga., *July* 5, 1869.

Delicate Tests in Laying the New French Cable.

Messages are sent freely from the shore to the ship, and their receipt acknowledged by a mere indication agreed upon at Minou. Messages are not sent from the ship to the shore unless on occasion of necessity. The reason for this rule is obvious. While a message is being sent from the ship, the cable end must be to some extent disconnected from the instruments which are constantly testing its electrical condition, and thus, during the transmission of a message, a small fault might pass out unnoticed. The shore end, on the contrary, rather aids the tests than otherwise, by sending messages, so all the news is constantly sent on board.

The method of signalling used, is that now universally adopted in working all long submarine lines — the reflecting galvanometer. The principle of this most delicate instrument was discovered a few years since by a German electrician, named Weber. It was then, however, a large machine, and the condensation of all its powers into the smallest and lightest form is due to the scientific research and skill of Sir William Thompson. This instrument consists of a small mirror with a magnet laid across its back, and that the two are very small indeed, may be judged by the fact that both together weigh less than three-eighths of a grain. This infinitesimally small reflector, which is intensely bright, is suspended by a silk thread as fine as a hair, in the midst of a small circular coil of insulated copper wires. Directly a current is sent through this circular coil, no matter how slight, it induces another electric current within its circle, which acts in an opposite direction, and this causes the little magnet at the back of the mirror to turn to right or left, and, of course, to turn the little mirror with its reflecting ray of light with it. By a very simple arrangement this fine ray of light is thrown upon a horizontal graduated scale, about three feet long and three feet distant from the mirror. Thus, when a current is sent through the little circular coil round the mirror, the magnet is acted upon, and turns the mirror with its ray of light—say on the left of the scale in front of it. When the current is reversed, and that is instantly done by pressing a little key in the speaking instrument, the current in the circular coil is reversed and sent in the opposite direction, and this in turn sends the ray of light from the mirror on to the opposite side of the scale to the right. When the ray of light rests stationary on any part of the scale, it means a dot; when it moves rapidly to the right or left, it means so many dashes, according to the distance it goes. Thus the little pencil of light make dots or dashes on the scale, just as the old Morse instrument used to make them in visible ink on paper, and any combination of words or letters, or figures, can be formed and read with the utmost ease by the receiving clerk, who is watching how the light moves and dictating the letters and words it sends. When the cable is at rest, the light remains stationary in the centre of the scale, at zero. When a fault occurs, the loss of electricity is shown by the currents or the reverse currents, turning the light more to the right or left of the centre of the scale than it should do. When a total fault occurs—that is, when the cable has parted—the little ray of light flies off the scale altogether, and is never seen again till the mischief is repaired. So exquisitely delicate is this instrument that most distinct messages have been sent through the whole length of the present French cable with no greater battery power than that afforded by a lady's thimble filled with weak sulphuric acid and water. With the same galvanometer, also, the Malta and Alexandria cable was kept working between Bengazhi and Alexandria, though the copper conductor was stripped of its insulation for more than a foot, and laid bare to the water. Indeed, in this case it was not till all the copper wires were cut through by chafing on the rocks, that communication ceased, and there is no doubt that for weeks it had been carried on by a single strand of wire no thicker than a needle.

It is this reflecting galvanometer which tells with unerring certainty whether or not the Great Eastern is steady. This is easily explained. The vessel now at the end of the cable is, with its coils of insulated wire and iron hull, a mere electro-magnet, so to speak. The course of the Great Eastern is east and west, and therefore at right angles with the course of the magnetic current, which is north and south. Thus every time the ship rolls, either to port or to starboard, a slight current, but still a current, is induced in her vast coils, and thence transmitted through the cable to the shore end at Minou, where it acts upon the reflecting galvanometer, and turns its ray of light a little to the right or left of the centre of the scale, and thus shows in a fraction of a second of time the precise degree and rapidity at which the vessel is rolling.

These deviations from the central mark vary from half an inch to more than an inch each way; the latter, however, is a very extreme range, and one which the Great Eastern has not yet reached, nor, it is to be hoped, is she at all likely to do so at this season of the year. The vessel, however, is seldom so steady as to allow the light to remain unwavering at zero.—*London Times.*

Answers to Correspondents.

W. H. S., Pa.—It would be impossible to answer your queries in short metre. We are therefore compelled to give a somewhat extended account of a new art, or, to say the least, a new branch of a comparatively new art, and we are the more willing to do so as the new branch is undoubtedly destined to work something like a revolution in the electroplating world.

You have asked for knowledge concerning the depositing of nickel by the galvanic force, and what would be its value provided it could be easily and successfully done. To answer such a voluminous (in matter) question, we must first give some idea of the changes that have been wrought in plating within the present generation. The whole value of the art depends on the fact that an oxidizable base can be protected by a metallic coating, having but little affinity for oxygen; the beauty of the article being increased by means of the coating. Silver and gold generally have been the protecting metals, but from time immemorial, iron has been coated with tin, and latterly with zinc—(galvanized iron). Copper was also used on iron bolts, and its alloys are to this day of great importance in protecting iron work from the action of salt water. The mode by which the plate was united to the base at the time of which we write, was either by fusion, or rather sweating on, as when an ingot of copper was cleaned on its side, a clean plate of silver was bound to it, and the two, in contact with borax as a flux or protector from the oxygen of the atmosphere, were placed in a muffle and heated until they were sweated together. Common sheet tin is also another example; the best charcoal sheets, having been cleaned with sand, dipped in acid to pickle, and then in a solution of sal ammonia, are plunged into a bath of melted tin on which a layer of fine charcoal is constantly kept in order to prevent oxidization. The tin readily unites with the surface of iron, and the union is chemical to an appreciable depth. This process has not varied in hundreds of years, and is so simple and economical withal that it is hardly probable that the coating will ever be made in any other manner. Bolts to be coppered or brazed are likewise plunged in a bath of the melted metal. A variety of iron manufactures, as water pipe, sheet-iron, chains, agricultural implements, etc., are at present coated with zinc in a manner precisely like the method pursued in the case of plate tin.

Another method of coating was used in silver work, in which the coating was soft soldered to the base; this has now gone out of use. Gold was used by the method of fire gilding, and for some kinds of work the process of centuries ago is still followed. In the case of silver, tin, copper, and zinc, by the dry method, the deposited metals were as hard as the same would have been if allowed to cool from a state of fusion in an ingot mould; and in the case of the silver fused to an ingot of copper the silver was hardened by the subsequent manipulations it received in the rolling, wire drawing, and swedging. For jewelry purposes gold was applied in the same way as silver, and is still used in that form for filigree wire, plated jewelry, etc.; but for watch work the gold was applied by means of an amalgam on the clean surface of the base, after which the mercury was driven off by heat—an agent, we need hardly say, detrimental to the subsequent accuracy of the work, as warping would be almost inevitable in thin work, like watch plates or wheels, when subjected to a heat equal to the subliming point of mercury.

Many of these processes have been abandoned for all purposes, and the new agent, galvanism, has crowded out most of the old methods. This electro-plating we have styled a new art. We can remember when the only use made of the electro-plastic method was to produce copies of objects in copper, and this as much for scientific research, as for practical utility. To-day, without doubt, the use of the battery for plating is universal in the common pursuits of practical life, so that within a generation an art has sprung up, vast in its proportions, and involving an extensive knowledge of mechanics, chemistry, and electricity.

This art has been brought to a high degree of perfection, and it would seem that nothing more could be desired; but such is not the case. The process is one that plates with pure metal, and the molecular condition of the coat is that of the softest form; thus, even after burnishing, silver is so soft that its surface is scratched, even by the softest and finest polishing material; indeed, its brightest polish may be totally spoiled by the application of a dry, soft cloth. Gold is also subject to the same objections, though we shall seek in vain for anything that will match it in color and permanency of chemical surface. When gold is thrown down by the battery, if the action is too intense, a black deposit is formed, and thus a great difficulty is encountered in the outset in producing a thick coat. Copper, however, can be deposited of any thickness, and is used in printing for copying type, maps, and engravings.

These three metals have hitherto been exclusively used as the coating material. The other metals, as iron, platina, manganese, etc., have been tried, and with the exception of platina, are useless, even if success were attainable, for the tendency to oxidization is too great. There is a metal, however, that possesses the color of silver, but less liable to be tarnished by the action of sulphur or sulphuretted hydrogen. Indeed, except at high temperatures, it has a power of resisting oxygen but a trifle—a fractional degree—less than silver, and is susceptible of as high a polish. To these qualities it adds the still more valuable one of hardness.

Nickel is a comparatively rare metal, and in its properties resembles iron, with which it may be classed, although it is most generally found in connection with iron and cobalt, and the difficulty of separating it from those metals has hitherto been the cause of its high price. It is also a very important constituent of most of the meteors that have fallen to the earth from the outer space. In these meteoric bodies it is always found associated with iron, thus differing from that of terrestrial origin in its associations.

Nickel, when pure, is almost as white as silver, but tinged with a very slight yellowish gray; it is ductile and malleable, and may be forged either hot or cold; its point of fusion is as high as that of eithe pure wrought-iron or manganese; specific gravity (mean) 8.85 Hemmerer, it is influenced in a marked degree, like iron, by a current of galvanism, either direct or induced; it ranks also with iron in the facility with which it takes up carbon, and is capable of being welded. All these properties are so much in coincidence with iron that the two metals are ranked in the same class, the more especially as the chemical reactions are very similar in both metals. In hardness, the nickel is the superior metal, as it is about equal to the hardness of steel, tempered to a deep blue. It is susceptible of a very brilliant polish, fully equal to steel in its hardest condition; but it will not have the deep black polish of the latter metal.

Such are the characteristics of the metal we are discussing. It, like all the metals, is capable of being deposited by means of the battery, and the experiment has been performed numberless times by different chemists; but there has hitherto been a difficulty in throwing it down in mass enough to bear the polishing process, for it must be borne in mind that, unlike silver, gold, or copper, it cannot be burnished to get the surface and polish requisite—its hardness after the deposit being an effectual barrier to any burnishing. The problem to be solved was to deposit the metal by such a uniform current, and by means of such a solution, that there should be no black deposit; black because the metal is thrown down in crystals so minute that they do not present planes of reflection large enough to give distinctive form. The problem has been solved, and, through the kindness of Mr. L. L. Smith of No. 65 Crosby street, we have been treated to a history of its solution. Mr. Smith has for years been connected with the battery in its relations to electrotyping, and having brought his knowledge—the result of long experience and careful study—to the elucidation, he has, as might be expected, contributed to the established success of the process patented by Dr. Isaac Adams, of Boston.

It will need but a brief review of the processes by which silver and gold are deposited from an aqueous solution of the cyanide of potassium, to give an idea of the difference in the process when applied to nickel. While gold or silver is unacted on by cyanogen in the free state, it is readily dissolved, forming a cyanide of gold or silver, when under the influence of the electric decomposing current. This solution is effected at the instant of the decomposition of the cyanide of potassium, and the gold is said to be acted on by the nascent cyanogen. The solution must in all cases be alkaline, in order to attain a perfect result. In this method it is not requisite to have any gold in the solution, except the piece from which the gold is dissolved by the nascent cyanogen. The cyanide of the metal being formed, it is carried over to the other pole, where it is decomposed, and the free cyanogen takes up another quantity of potassium, leaving the gold or silver deposited in the metallic state on the object to be gilded or plated. The solution generally used, however, is a solution of gold in cyanide of potassium, as the nearer saturation the solution may be, the better its conducting power, and the lower the battery power needed. The copper solution is, on the contrary, of acid reaction, being formed by a solution of the sulphate of the oxide of copper.

The nickel would not obey either law laid down for gold, silver, or copper. On the atomic theory, it is certain that there must be a point where the acting and reacting chemical forces, conjoined with electrical, are equal to the amount of electrical resistance in the fluid. Dr. Adams took advantage of what in mathematics is called the path of least action, and the result is the perfection of plating with nickel with the least power of battery and high conducting power of solution.

As before stated, we are indebted to Mr. Smith for a full inspection of the various manipulations, and we must give that gentleman the praise due to perseverance and intelligent direction, for it is a success beyond doubt; and soon the nickel-plated goods will supersede the silver in very many instances, while the valuable qualities of the nickel plating will extend its use to an innumerable host of articles now left plain simply for the reason that other metals present too soft a surface for durability. We were particularly struck with some cutting tools, such as knives scissors, etc.; also a hammer, and it was a reminder of the condition of most of the brass and steel tools on the watchmaker's bench; rusty and tarnished from the action of the atmosphere and the moisture of the hands, they present an appearance the reverse of neatness and accuracy.

The articles, after having been put in the solution and coated, are first dried and then polished on a brush and buff with rouge. The polish thus produced is altogether superior to the burnish polish effected on silver or gold. As the nickel coating thus produced is not so liable to be attacked by sulphur or its compounds, in the wet way, as silver, it retains its polish longer; and its degree of hardness is such that it is difficult to scratch it with the point of a knife. As in plating with other metals, the surface of the object is first cleaned, as near as may be chemically clean, and then placed in the solution for the operation of the battery.

There can be no doubt of the wide-spread value of the nickel-plating; hardly anything can come amiss to its application. We all know the unsightly appearance of plated table-knives after being a short time in use; the black streak along the edges, and on the corners of the back, gives evidence of the worthless character of silver plating for such a purpose. The plated fork is another illustration of superiority. For tools of every description, gauges, callipers, door-knobs especially, and lock attachments of every kind, butts and hinges, sword blades and sheaths, pistol and gun work—in fact, for every purpose, with the exception of spoons and plate for table use, the nickel plating is superior, in beauty, durability, and practical utility, to any other. While at the establishment a piece of plate of pure nickel was presented us. It is about the thickness of stout foolscap paper, and is two inches wide by three long, and presents all the appearance of a solid rolled plate, while it is as hard as ordinary steel. The peculiar properties thus exhibited are in themselves a guarantee for an extensive application of the art to almost all branches of general industry. It would offer the watchmaker, also, a very beautiful finish for movements, the surface being variegated with alternate gold and nickel ornamentation. In fact, it would be hard to know where to stop in the enumeration of the applications to be yet made of this process. From the builder's and ship hardware to the finest and most delicate philosophical instrument, the best process yet before the people is the electro-nickel plate.

H. W. R., *N. Y.*—We have made inquiry as to the chucks. They are to be had only to order. Then it would be necessary to send one of your present chucks, in order to get at the size of the screw. Dennison's work you will find mentioned in the catalogue we have mailed.

M. L. M., *N. Y.*—You will find your request as to watch cleaning complied with in this number. The best watch oil is Kelley's.

D. C. J., *Ky.*—No; unless you had a very large watch-repairing trade. The competition is too great.

H. K., *Ill.*—Not every man can take the true time in comparing the watch with his seconds clock. There must some time elapse between the sight of the seconds hand on the clock dial and finding the place of the seconds on the watch. Grant him quickness of eye; that organ is not perfection in its quickness, and must take time to find its object. Therefore, the general way of comparing the two time-pieces is to rely on two senses—sight and hearing. The clock is supposed to beat seconds, and if a marine chronometer is to be rated, we may, from its having five beats to two seconds, easily divide the seconds of the clock into tenths. The observer counts the clock seconds by the ear, and notes the time of the chronometer or watch by the eye, and thus, without a change of motion, he has made an accurate comparison.

W. C. H., *Ohio.*—The aluminum bronze is all that was claimed for it in the first number, but it is not safe to judge that a metal is free from oxidization in the mouth because it is unacted on by dilute acids in other situations. The fact is that, although chemistry can demonstrate the constituents of the fluids of the mouth, and the action that ought to take place, it unfortunately cannot grasp in the real effects produced when the decompositions occur in the living organism. So, although gold of 18 carats fineness is not acted on by anything but a combination of hydrochloric and nitric acids, it is sometimes attacked by the acids of the mouth. And again, it may be boiled in a solution of cyanogen in water without any effect; but connect the gold with the battery, leaving the other pole in the solution, we shall find the gold rapidly dissolving on completing the circuit. As a base for artificial teeth the bronze would be worse than useless; as being composed of two metals of unequal tendency to oxidization, the galvanic current would cause a more rapid corrosion of the alloy. We will send samples by mail.

H. M. D., *N. Y.*—Tempered hair-springs of every desirable variety can be obtained in this city. Mr. Bottom, Gilsey Buildings, may be addressed on the subject. He is the only maker in this country. His springs are fully equal to the English or Swiss, both in evenness and temper.

G. W. H., *Ohio.*—In answer to the following, we are tempted, from a fellow-feeling, having been placed in the same "fix" ourselves, to give our experience: "How are the holes drilled in the glass backs that come in Swiss Chinese duplex watches? I can drill the holes, but the glass invariably breaks. I don't know how many glasses I have broken, nor the time I have wasted. I dropped the whole matter until I received your Journal, and now will you please give me some information?"

Your glass broke after the holes were drilled because you did not *polish the inside of the hole, and the corners.* Try again, and after the holes are drilled fix up a small grinder or polisher, *smaller than the hole*, and then grind to an even surface with fine sand and water, or emery; this grinder may be of soft iron. Then polish with a wood polisher (boxwood or any other wood hard enough to retain its form). The corners are ground and polished on a conical centre with the same treatment.

C. I. M, *Ind.*—The electric clock as manufactured by the Kennedy Clock Company, has the reputation of performing well, and is a splendid looking instrument. Further can hardly be said unless a full description both of the clock and the principle on which its construction is founded.

A. C., *Conn.*—The best form is the periscopic. You can purchase a treatise on Optics.

A. K. L., *Vt.*—There are no American watches in market in aluminum bronze cases. We will try to give what you wish in the column for correspondents. Much obliged for the kind words.

Ed. Horological Journal:

Sir,—I have had the pleasure of receiving a number of the Journal, and am happy in acknowledging my obligation. I am, however, more especially pleased with the opportunity offered for a free discussion of subjects pertaining to an art to which my whole life has been devoted since a child; and even then I was connected somewhat with it, for my father and older brothers were pinion makers, and worked the long days and short days in a little cottage on the mountain. It was only on rare occasions that my father was absent, and then only for the purpose of disposing of the made work and buying material for work to come. The lessons I received in that little cot were too deeply implanted for me to lose, and with my first memory of the whole trade my mind is chained, as it were, to a pinion. I did not set out to trouble you with my affairs, for, after all, why should you or anybody else have anything in common with my life, except as regards the trade? But I have written thus to rather tender an excuse for the remarks I am about to offer, and to show that I am not wholly unauthorized to speak a few words to the trade at large.

Through the whole of my 22 years sojourn in this country, I have watched the progress of the trade, its extension, and whatever of improvements have been made, and have looked (in vain) for a corresponding progress in the members. The trade has progressed in tools, in a better class of time-keepers, and in some instances an elevation of an artificer above the mere routine of watch repairing. There are many now who not only are watch repairers, and good ones, but are scientific horologists as well. I hail your paper as the dawn of another age; we, the watch repairers, have been too long contented with the mere humdrum of life — the monotonous routine of having always nearly the same day's work before us—work too intricate to allow the mind to wander, and yet not enough to enable the mind to be fully occupied. There are hopes, then, that your Journal may stir up the really dormant talent that for want of exercise lies buried in apathy. I hope you will fulfil your mission by affording the followers of the trade an outlet for the knowledge that they possess, and so setting them to thinking on subjects somewhat higher in science than the mere handicraft.

I have not given all that is in my mind as to the present state of the trade, nor have I time to express my views as to the elevation of the trade; but if you should feel disposed to grant me space, I shall be happy at some time to advance some ideas that I think may be productive of good to my fellow-workmen.

Yours very truly,

NORFOLK, *July* 14, 1869. G. L. DE M.

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AMERICAN HOROLOGICAL JOURNAL. New York: G. B. Miller, 229 Broadway.

WE are always glad to welcome a new journal devoted to any particular art, especially when it has real merit. We know of no arts or trades in which there is more scope for a representative journal than those of watch-making and clock-making. The AMERICAN HOROLOGICAL JOURNAL—if we may judge from its first monthly number just received, and from the prospectus therein contained—proposes to treat the subject both scientifically and practically, from its astronomical bearings to the minutest details of the workshop, and it gives promise of being a valuable addition to our industrial periodical literature.—*American Artisan.*

WE are in receipt of the first number of the "AMERICAN HOROLOGICAL JOURNAL," a new monthly published in this city devoted to the interests of marine chronometer, watch, clock, and mathematical, astronomical, and nautical instruments, repairers and dealers, and the cognate branches directly or remotely connected with these industries. It is a welcome addition to the industrial literature of the United States, and we wish it the success which it merits.—*Scientific American.*

WE are indebted to the two leading mechanical papers of the United States for the above favorable notices of our JOURNAL. We shall endeavor to merit the continuance of their good opinion, and cordially we reciprocate their kind wishes.

AMERICAN
Horological Journal.

VOL. I. NEW YORK, SEPTEMBER, 1869. No. 3.

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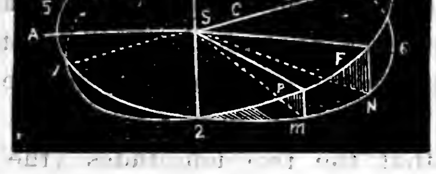
⁂ *Address all communications for* HOROLOGICAL JOURNAL *to* G. B. MILLER, *P. O. Box* 6715, *New York City.*

Astronomy in its Relations to Horology.

NUMBER THREE.

We had occasion to revert to the seven elements of the orbit that are required to be determined if it is necessary to locate a planet in space. The reader may, by means of the following diagrams, get a more comprehensive idea of these elements, and a very slight acquaintance with geometry or geometrical reasoning will enable him to see why they are absolutely requisite. Assume 1, 2, 3, Fig. 1, to be the elliptical orbit of a planet, S the sun situated in one of the foci of the ellipse, and C the centre of the major axis. A is the first point of Aries, as that is assumed to be the point of the vernal equinox; 5, 2, 6 represents the plane of the ecliptic. The elements of the orbit are: First, the major axis, 3, 1. Second, the eccentricity, C, S. Third, the periodic time, or the earth's revolution around the sun, being taken as a unit of time, what is the period in which the observed planet performs its revolution around the same common centre, the direction always being from west to east? Fourth, the longitude of the planet's perihelion, or that point in its orbit nearest the sun, and all the movements of the planet are dated from the longitude of the perihelion, whether for the planet's antecedents or its future positions, thus by an almost direct measurement obtaining the period of revolution. Here are four elements that enable the computer to determine the form of the orbit and the angular velocity of the planet. But it is yet required to find the planet in space at any required moment of time; and, in order to render the analysis complete, that moment may be taken in the past, present, or future, so that the astronomer may know where Saturn was 1000 years ago, its place now, and its position in relation to the earth and sun 1000 years hence. To calculate this problem, we must have the angle contained in A, S, 1; the angle 3, 2, 6, which measures the inclination of the orbit to the ecliptic; also the angle A, S, 2, which determines the longitude of the ascending node—as before stated, the measure of the divergence of the orbital from the ecliptical plane giving the latitude.

FIG. 1.



We have deemed this return to the former article desirable, as it is difficult for those unaccustomed to view an abstract mathematical proposition without confusion, and the elucidation will give some idea of the method of reasoning that enabled Le Verrier and Adams to locate a hitherto unrecognized planetary body to within a very few minutes of space. It will be seen, as we progress, that all this is directly connected with Horology, for the position of a star in space is of vital importance in transit observations. The observer does not have to make the calculations, and, indeed, the observer might be called merely the recorder, for the work is all done in the computing-room, and hence the tables are ready for all.

Taking up the conclusion of the ast article, we would extend our remarks on gravitation if space allowed, but will content ourselves with merely drawing this conclusion.

If it is a fact that our sun, with his train of satellities, is revolving around some primary, we can easily imagine that that premary is again acted on by the same law, and is revolving around some other centre of gravity in space. The deductions could be carried out until the mind becomes completely lost in the mists of the infinite. The only advantage to be gained, therefore, in the consideration, is a conception of the fact that the same law, by the force of which a body falls to the earth, is the connecting tie throughout all space.

In the progress of astronomy it was found necessary to note the position of the stars by some standard points, and we have given one, the latitude; we must then have the other point, and that is the celestial longitude. The reader must bear in mind that this differs in all respects from terrestrial longitude, as will be seen by the following definition:

Terrestrial longitude is the angular motion made by any given point on the earth's surface, from an assumed standard point. Thus, taking Washington or Greenwich to be the point of departure, a star visible in the plane of the polar axis will have an apparent motion westward, and as the earth revolves once in twenty-four hours, and the whole equator contains but 360 degrees, it is evident that the polar plane, which passes through the assumed point, will change its place in relation to the star eastwardly at the rate of 15° each hour of angular motion. The measurement of this angle is taking the longitude, and is of necessity a measurement of time; for, if a star has left the meridianal line of the point of observation, and is observed at another point west of the meridian of observation, the difference of time elapsed gives the number of degrees the earth has revolved during that time.

Celestial longitude is computed from a point in space that has some connection with the earth, and this point is found in the vernal equinox; the angular motion of any celestial body from west to east being estimated from this point. In astronomy, the first point of Aries was the 0° of longitude; but by the different disturbances exerted by other bodies, it has been shown that the vernal equinox is not a quiescent point, and the coincidence of it and the first point of Aries took place some 2253 years ago.

The vernal equinox is represented by the point 1, in Fig. 2, and the line 1, 2 is the line of the equinoxes. In Fig. 3, the 1 also denotes the same point as in Fig. 2; the true longitude is then measured by the angle 1, S, P, the mean longitude by 2, C, M—to find the real place we have recourse to the equation of the centre. By inspecting Fig. 3 it will be seen that the two longitudes (the true and mean) can coincide in two points only, P and A, the apsides or extremities of the major axis, the true place being at every other point of the orbit, either before or behind, in moving from A through the arc A, P, 2. The true place, P, is behind the mean place, M. Following the whole revolution, it will be seen that in the opposite arc, P would be ahead. Now, half the sum would be the mean place of the bodies at any given time. The true measure of the equation of the centre,

FIG. 2.

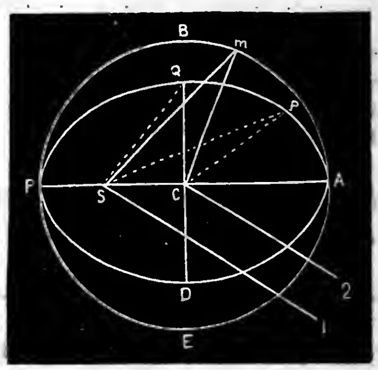
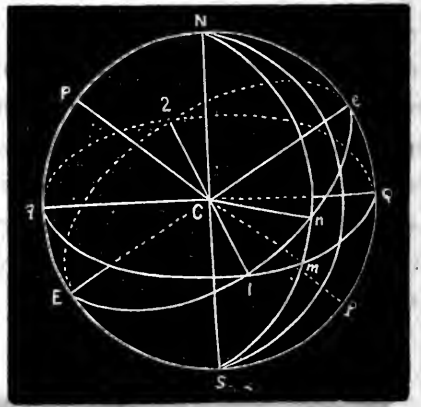


FIG. 3.



then, is the distance C S, which is also the measure of the eccentricity of the orbit when in quadrature. It follows, then, that the place of a planet in its elliptical orbit is obtained by adding or subtracting the equation of the centre to or from the observed mean longitude.

It must be recollected that the consideration of all these qualities is necessary to a full and complete understanding of the modes by which time is accurately obtained, as is done by use of the transit or other instruments, in connection with the tables that have been compiled for nearly every important star, planet, or satellite. Yet, not all the difficulties have been mentioned. The correct observer, in computing his observations, must take into view the distance of the object, its relative fixedness, and the path that its ray of light takes in reaching the observer's eye after leaving the body. Again, we must not neglect the fact that light takes an appreciable time to travel through a given space, and to this fact we must add another, that the earth changes its relative position to an appreciable amount during an observation, however limited in time. We may add one more difficulty in estimating a position in space. The error in an observation arising from this last cause, is designated the aberration of light. Again, it would be useless to speak of getting the longitude by lunar observations, were we to leave out the various disturbances incidental to the moon's path, arising from the reaction of the earth on the moon. It will be necessary, then, to treat of light and its laws pertaining to astronomical research, and it may not be uninteresting to define the method by which the distances of the heavenly bodies are determined. In all cases a ray of light is taken as travelling in a straight line, as it would, provided the medium through which it passes was of a uniform density. Suppose an object —say the pole star—is observed, we should be in error were we to assume its true place to be that indicated by the instrument. Our first object must be to ascertain the distance of bodies from the earth and each other. In mathematics it is demonstrable that any triangle may be measured, provided we have one side and any two angles. Thus, if we have a base that is accurately measured, and the contiguous and opposite angles known, we may ascertain the value of all the other parts. Now, the diameter of the earth is well known, having been determined to within a small fraction of a mile, its equatorial radius being 3,962.824 miles, and consequently the whole diameter 7,925.648. This quantity can be used (the radius as a base of a triangle) in taking the angle that the radius of the earth would make, as seen from the body under observation. This angle, so viewed as from the centre of the moon, or any other celestial body, is called parallax, and by it the distance of the earth from the body may be determined. If we conceive two lines to be drawn from the centre of the moon to the centre of the earth, and to the eye of an observer respectively, assuming the moon to be just rising or setting, we shall have a right-angle triangle, the base of which is the earth's radius; and as this is a known quantity, and the angle formed by the junction of the two lines at the centre of the moon can be measured, we have the three angles and one side—all that is requisite to get the true value of the other two sides of the triangle, and consequently the distance apart of the two centres. The same may be effected by the combined observations of two persons, if the points of observation are on the same meridian and at a great distance apart. In this the horizontal parallax is not used. The two observers take the zenith distances of the object on the same day, at the time of its passage over the meridian. The hour, minute, and second must be the same, as it would the meridian being the standard. This was the process by which, from observations taken simultaneously at the Cape of Good Hope and Berlin, the mean horizontal parallax of the moon was found to be 3.459″. From the explanation of the reasoning on which the computation is conducted, it can be calculated by any one at all accustomed to trigonometrical computation. The distance of the moon, as deduced from the observations, is 237,360 miles. The parallax is equal to the radius of the earth, divided by the distance of the moon (thus $\frac{3949585}{237360}$=parallax); it must vary with the distance of the moon from the earth, under the same degree of latitude, thus proving the ellipticity of the moon's orbit.

It will be apparent to any reasoner that an increase of distance would tend to impair the accuracy of an observation, and when the distances become enormous the errors accumulate so as to render the subsequent computations of but little value. For this reason the parallax of the sun could not be obtained with the same correctness as that of the moon; the slightest error in the observation being fatal, from the great distance. The planet Venus, however, affords us the means of getting the distance of the sun. When she arrives at her nodes (that is, in the same line that joins the centres of the sun and earth), she must necessarily pass over the disk of the sun, and consequently the transit would be visible to an observer on the earth. If the sun and planet had no parallax this transit would describe the same line of passage over the sun's disk, and be of the same duration of time to every observer on any part of the earth. But the earth's diameter is a sensible magnitude when viewed from the centre of the sun, and, therefore, if two observers at opposite points of longitude observed the transit, the lines described by each would be nearer to or farther from the sun's centre in just the proportional difference of longitude. The sun's diameter being so much greater than that of Venus, the time of the transit will be of shorter duration when the line falls towards the edge of the sun's disk than when it falls near the centre. The difference of time is due to the effects of parallax. The motions of Venus and the sun being known, this eclipse of the sun, for such it is, is computed by the same means that eclipses of the sun by the moon are calculated. The ratio of the sun's and moon's distances from the earth at the moment of the transit is known by the theory of their elliptical motion. The ratio of the parallaxes is inversely as their distances; the transit determining the parallax of the sun. In 1769 a transit of Venus was observed at Otaheite by the astronomers attending Captain Cook in his first voyage, the voyage having been projected for the purpose; and it was observed at Wardhaus, in Lapland. The whole time of the transit at Otaheite was about six hours, and that at Wardhaus differed by eight minutes. This difference gives the sun's parallax at 8″.72, but subsequent considerations have reduced it to 8″.6, and the distance deduced is now estimated at 95,000,000 miles.

When, however, the object becomes so distant as not to present an appreciable diameter, or what is the same thing, when the earth's diameter would present but a point if viewed from that object, the two preceding processes of obtaining its parallax fail, and another base is taken, and that is the diameter of the earth's orbit. Great as are the dimensions of this line, it, in its turn, becomes a point when viewed from an object distant 200,000 times greater than the diameter, which is 190,000,000 miles. One star (fixed, we call it) has had its annual parallax thus taken, and the angle under which the diameter of the earth's orbit would be seen, amounts to only 1″, and this, the nearest fixed star, is more than 200,000 times the distance of the sun from the earth, and the star 61 Cygni had been known to have the largest annual translation in space, and accordingly it was assumed to be the nearest fixed body. Arago and Mathieu tried to find its annual parallax. M. Bessel found that the angle having 190,000,000 miles as a base was but 0,33″. Thus, *a* Centauri is still the nearest, for 61 Cygni must be 592,000,200 times the distance of the sun from the earth. This distance may be more vividly realized when we state that the star is seen in the spot where it was nine years and three months before the observation, owing to the fact that a ray of light travelling at the rate of 190,000 miles per second would take that time to reach the eye. The motion of this star is annually 5″ in space. At that distance 1′ of space would require a base of 24,000,000,000,000 miles; then 5′ will gives us 120,000,000,000,000 of miles. Arago says: "And yet we call this a fixed star." The diameter of the earth's orbit is too limited to become a base of mensuration, and we are forced to measure the distance of other stars on the assumption of the velocity of light. This may be, in course of time, effected in the instance of what are called double stars, by finding the difference between the place of the satellite star at opposite points of its orbit; by finding this we may have the diameter of the orbit, and consequently the angle at the centre of the earth which it subtends.

Watch and Chronometer Jewelling.

NUMBER THREE.

The convex and concave surfaces of the stone having been brought up to an even, regular surface, we proceed to polish. It must be remarked that in using the "former" we must not trust entirely to its agency to get a regular surface, for if the jewel is left very rough from the diamond cutter, or the form is very much out of a true circle, the "former" is very apt to make the convex come out of true with the face, and thus render it almost impossible to set with truth in its position in the watch; therefore the workman is very careful to turn off the convex as near the segment of a circle as he can. The same cautions, in a less degree, are to be adopted in forming the oil-cup—not so much for the sake of truth as to avoid the diminished brilliancy incident to irregular form; the light not being reflected in the most favorable directions for effect.

The polishers for all stones as soft as aqua marine are made of lead, used with tripoli and water. This tripoli is a mass of shells, and is exceedingly sharp until it becomes rubbed fine by the friction of the stone on the polisher; then it is capable of producing a very superior polish. The polisher is made of a small piece of lead wire, say an inch and a half long, and of about the same diameter as the jewel, or generally somewhat larger; the end is filed off flat and a concavity formed in it; but, as lead is soft, the workman merely takes the point of a knife or graver and cuts out a conical cavity, as on application to the hard stone the lead will be forced to assume a circular form. The tripoli, having been mixed up in water, the polisher is dipped in the mixture and then applied to the surface to be polished. The friction between the stone and polisher (for the speed must be great) soon heats the stone, and if persisted in would melt the shellac, and thus take the work off the lathe. To avoid this the polisher is held on but a few seconds at a time, the surface of the stone wiped off and examined as to progress. After a few applications the stone will begin to obtain a semi-polished condition, and at this stage the operation will be accompanied by a very peculiar squeal (it can be called nothing else), the indication that a polished surface is being attained. At this point the water dries very rapidly from the tripoli, and increased care is needed to avoid overheating the work. The object being to obtain a finely polished surface and truth combined, the process must be discontinued as soon as the polish is uniform, for then the stone has a true convex, parallel in all its diameters to the face. The oil-cup or concave is treated precisely like the convex, a reverse polishing tool being used, and the convex end of this is generally filed with a coarse file, being held and rotated in the fingers of the left hand. The file marks are of service, as they receive the tripoli, and thus enable the polisher to more firmly hold it. The hand is kept moving in a backward and forward elliptical direction during the whole time; for if the polisher were to remain quiescent, creases would be formed, and thus render a good polish unattainable. When a very superior job is to be done, a piece of boxwood is used, the grain end having been formed to match the stone, either on the convex or in the oil-cup. The slight chamfer on the face of the jewel is now polished with a slip of lead and tripoli, and the stone is ready to be removed from the lathe, to be topped and faced. The oil-cup meets the convex in a sharp edge, and is generally ragged after the polishing of those two surfaces. This roughness is remedied by facing, a process applied as well to the flat surface. The means employed are various, some jewellers preferring one, and others different methods; but the general principles are alike in all cases. There may be used a flat piece of boxwood, planed off on the end of the grain, with the finest variety of diamond powder. This is very effective, and is open only to the objection that the powder is wasted, as it is absorbed into the wood. A plate of a mixture of lead and tin—say half and half—is scratched with a coarse file, and tripoli used as a polishing material. The jewel is laid flat on the metal and tripoli, and rubbed about with gentle pressure by means of a pointed piece of peg-wood placed in the hole, care being had to keep the jewel revolving and changing its position as much as possible. When the tripoli is about dry on the plate the stone will be found polished, but it must be examined at short intervals during the process. This way of facing seems very simple and easy to accomplish, but it will be found to present some few difficulties, the greatest one of which is the liability of the surface to *drag*—that is, small fractures of the face will be torn out, and then the stone has to be faced on the lap again before it can be polished. This is to be deprecated, as the refacing almost invariably throws the jewel out of true with the convex, besides making the finished jewel too thin. The best method for both the ring on the top and the face of the jewel is that in which a glass or stone face, with diamond powder, is used. As the glass or stone faces are of great importance in subsequent metal operations, a very minute description of the mode of preparation will not be out of place, especially when it may be asserted that there is no process so rapid or satisfactory in its results for polishing the flats of steel work. The workman selects three plates of glass—plate is preferred, as it affords a truer surface; but a better choice is to select two pieces of, say the glass plates used for Daguerreotype purposes, and another piece of hard lime glass; the reason for which preference will be seen. Two of the plates are rubbed together with emery, of a grade of from 60 at first, finishing with a grade of 80. The surfaces must be ground until a uniform appearance is obtained. In all cases the grinding plate should be frequently turned around in every direction, and changed from its course at every stroke, as thus only uniformity of surface can be produced with truth. One of the plates is now taken for a grinder of the hard plate; this last must have been ground previously to as near a true plane as possible, which may be effected on a plate of cast-iron, with sharp sand, or No. 20 grade emery, with water. Between the hard and soft plate, emery of 90 grade is used, and the grinding process is continued until the hard glass has a perfectly uniform surface, but it will be found that the grain of the lime glass is much finer than the other plate, which, in its turn, is coarser than the plate that has been laid aside. Could we obtain glass of three unequal degrees of hardness, a better polishing-plate would be obtained. However, we have now three plates of different degrees of fineness. It may be of advantage to reduce the finest plate still more by the use of another piece of glass with the finest washed emery. The coarsest plate is of no advantage to the jeweller, but may be used by the watch repairer for reducing his flat steel work to a fine gray, with a perfectly true surface, by the use of Arkansas oil-stone dust and oil. After washing the oil-stone dust from the piece of work it may be transferred to the second class, using sharp or crocus, with oil; this will give the steel a fine face, with a peculiar—apparently pellucid—polish, but of very fine uniformity. Again washing (cleanliness is all important in polishing), it is taken to Plate No. 3, which will, provided the surface be perfectly clean, give a polish without any polishing substance; but should an exquisite black polish be desired, well levigated rouge, mixed with alcohol, should be used. The ease with which steel can be polished by this process, and the cheapness of the apparatus, recommends the method to any watch repairer. He must, however, be sure that, before using, the plates are free from dust of any kind; and in order to render the finest plate perfectly clean it should be well washed with alcohol, and wiped dry with a very soft, clean cotton cloth. The stone surfaces are prepared in somewhat the same manner as the glasses. There should be selected two stones—say the cornelian red, such as were some time ago favorite stones for breast pins—and any other agate of another color, no matter what—the only care being had that both are uniform, with no striæ or lines of cleavage. These stones are very low priced and easily obtained, and are generally so true that but little labor is to be expended in facing up. The difference in the color is important only from the fact that the two will almost invariably differ in hardness. These two stones are first to be faced down to a true surface on a piece of cast iron, with No. 20 grade emery, with water, and then the two may be ground together with a very fine grade of emery until they touch in every part of the two surfaces; they are then finished with No. 2 diamond powder and oil. One of these stones may be used for facing and topping jewels; the other, for polishing brass settings, as will be described when we come to the metal department of jewelling.

In topping, the stone is laid on the finest glass, with a small quantity of the finest diamond powder, and held by a pointed piece of peg-wood in the hole. The wood must not touch the plate, and must not enter the hole so, but that it can have perfect freedom of motion. A few circular strokes, combined with straight lines, will develop a finely defined circular flat on the top of a stone, having a polish superior to the rest of the surface. The jewel is now turned over on the same plate, and the face polished in the same manner. It need not be stated in lengthy terms that the higher the polish the face of the jewel gets, the more brilliant its appearance when set in the watch-plate.

The jewel has now received all the work necessary to its external form and polish; the hole, however, is as it was left by the diamond drill, with a sharp corner in the centre that must be taken out, and the sides of the hole finished, and the corners chamfered off and polished. This operation is called opening, and on it depends the real working value of the finished jewel. The jewel may be first set or opened before; in either way the process is the same. In opening by hand the only tools used are some pieces of wire, say an inch and a quarter long; these are filed to a long, taper point—the longer the taper the less risk there will be of breaking the stone in opening. The jewel, whether set or unset, is put up on a chuck which has been drilled to a good depth from the end, to allow the opener to pass through the hole, and yet be perfectly free at its point. This opener, generally of copper wire, is dipped in No. 2 diamond powder; then, the lathe being set in motion at its highest speed, the end is introduced into the hole, and the powder begins to cut—the stone being held by the copper wire, which is held lightly in the fingers, and pressed against the side of the hole; for if it were introduced in a straight line with the mandrel, the powder would grind the opener in very much like a screw, and it being taper, the jewel would be split. It will readily be seen that the form of the hole may be made to suit the requirements of the maker—either perfectly straight, taper, or rounded in the vertical sides. The opener is moved backwards and forwards through the hole while the operation is going on, and occasionally rotated in the fingers, the reverse of the motion of lathe spindle, and again must be held in an angular position to the line of the mandrel. This operation is continued with No. 2 powder until the sides of the hole are of the desired form in vertical section, and of a uniform surface. The jewel is now cleaned of the accumulated diamond stone dust and oil, the peg-wood being used for the hole. To clean the surface, the best article is soft new bread, which not only takes off the powder, but effectually takes up the oil, so that the effect of any process may be observed. It is used also by the pinion makers, and all other steel polishing, on account of its detersive quality and the ease with which it may be used. No. 3 powder is now to be used to obtain a polish. In the soft stones tripoli may take its place, used on a copper opener; but the powder is most economical in time. A piece of tortoise-shell, such as a comb-tooth, filed up to a long taper, may be used; or, as is the practice of Mr. James Queen—the best jeweller in the United States, or, indeed, one of the best in the world—a piece of peg-wood answers every purpose, provided the speed is increased. This last process generally leaves the hole of the requisite polish and form. The only thing remaining is, to take off the corners of the hole. This is done by a rounded conical point, charged with fine powder. The corner on the oil-cup side requires but little consideration, but the face side must be chamfered the slightest possible amount, or the bevel may admit the shoulder of the pivot, thus causing a defective end-shake and an increased friction, which might be very detrimental if it occurred in the fourth or scape holes. The jewel is now supposed to be ready to be put in its place in the watch, provided it has been opened to a proper size for the side shake.

The opening of jewel holes is done by the jewel-makers in the American watch factories in an entirely different way, as the opener is not held in the hand, and the speed is increased twofold. The advantages gained are speed and a *round* hole. It is almost impossible to get a round hole by the hand process, especially in an English-drilled jewel. The elasticity of the opener allowing it to follow the shape of the opening made by the meeting of the diamond drill, in some cases the hole will be angular, but with the corners rounded off, at others, of an oval form; this last being highly objectionable, as if the proper side shake is taken from one diameter, the pivot will be too large or else too small. To remedy these defects and still lessen the cost, the jewel was chucked as usual; only the spring chuck was used, and the jewel placed in a setting which was thus in a condition to be held truly both in centre and in plane. On the bed of the lathe is placed another head stock facing the other, but set at a slight angle, which is but little more than that of one-half the taper of the wire; this head stock has a hollow mandrel with a spindle inside that rotates with it, but capable of motion longitudinally.

The wire opener is held by the inside spindle, and the power is applied in such a manner that the spindle, together with the wire, revolves with the same rapidity in a contrary way to the mandrel holding the jewel. One consequence of this arrangement is, that double speed is achieved; another, that, owing to that duplicated speed, the opener cuts away the inside of the hole before it has time to leave its own place, and therefore the hole is round. A common round Swiss pivot broach may be made a good test of the circular truth, for the broach is not round, and were it to be introduced into an angular or oval hole, the high sides of the broach would fill the low sides of the hole, so that rotation of the broach would be impossible; but in a round hole it would make no difference, were the broach five-sided, oval, or of any irregular section; another advantage is, that No. 2 powder is used for opening and polishing at one operation, but the saving of time is the greatest element of value where large quantities of work are to be dispatched. By the old process the jeweller could open about thirty pairs per day; by the new, a girl could open from 125 to 150 pairs in the same time, the work done being of as good quality as that performed by the skilled workman.

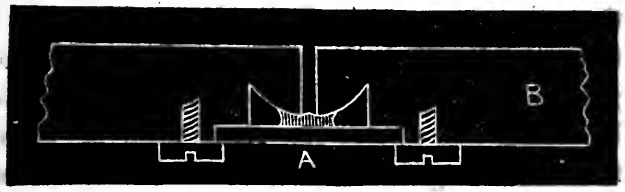
Hints on Clocks and Clock-Making.

NUMBER TWO.

We find it difficult to adhere to the plan we had formed of writing these articles in as light and pleasant a vein as possible in order that some might be induced to read them who were not fellow-craftsmen, because we find ourselves drifting on to dry facts and figures, which in themselves are not enticing, and therefore will be shunned as much as possible; but we would nevertheless urge upon the beginner as well as the more advanced workman, the diligent study of the various text-books, that they may arrive at that excellence that can only be attained by a knowledge of the theory as well as the practice of their occupation.

We consider it very important that the posts or pillars and side-plates of clocks should be made and put together in the most thorough manner; the posts should be turned exact to length, have large shoulders, turned true, so that the plates, when put together without screws, should fit accurately, for if they do not, when the screws are driven, the work will be cramped. We prefer iron for the posts, it being stiffer, and better retaining the screw threads in the ends, which in brass are liable to strip; they are also cheaper, and should be blued after being finely finished, thus presenting a pleasing contrast. The plate screws should also be of steel, with large flat heads, turned up true, and having a washer next the plate.

The plates we have made of various compositions: cast-brass, nickel-silver, and hard-rolled sheet-brass. It is difficult to make plates of cast-brass which would be even free from specks, etc., and we have long since abandoned the use of cast-brass. Nickel, or German silver, makes a fine plate, but it is difficult to drill the small holes through plates of four-tenths of an inch in thickness, on account of the peculiar toughness of the metal. The best material we have ever used is fine hard-rolled sheet brass; it should have about 4 oz. of lead to the 100 lbs., which will make it "chip free," as clockmakers term it, rendering it easy to drill; the metal is so fine and condensed to that extent by rolling, that the holes can be made with the greatest degree of perfection. We remark here, that within our time the improvements in tools and machinery have effected great changes and improvements in clock-making. We remember when it was quite a difficult task to drill the small holes in the plates with the ordinary drills and lathes; now we lay the plates after they are soldered together at the edges (which we prefer to pinning), on the table of the upright drill, and with one of the modern twist-drills the task is rendered a very easy one. After the pivot-holes are drilled, we run through a round broach, finished lengthwise and hardened, which acts as a fine reamer, straightening and polishing the holes exquisitely. A little oil should be used to prevent abrasion. We long since adopted the method of fitting up the pivot-holes invented by Le Roy, a French clockmaker of some note, a sketch of which we give. It is a sectional view at the pivot-hole. It will be observed that instead of countersinking for the oil, the reverse is the case. A is a hardened steel plate counterbored into the clock plate B, and held in its place by the screws. There should be a small space between the steel plate and the crown of the arch for the oil. After the clock has been put together it is laid down on its face or side, a drop of oil is put to the pivot end, and the steel plate immediately put on; and the oil will at once assume the shape of the shaded spot in the drawing, being held in the position at the centre of the pivot by capillary attraction, until it is exhausted by the pivots; the steel plates also govern the end play of the pinions. The pivot ends being allowed to touch occasionally the plates, the shoulders of the pinions are turned away into a curve, and, of course, do not bear against the plate, as in most clocks.



We have used glass plates instead of steel, and like them for some reasons. They are very hard and smooth for the pivot ends, and the state of the oil at the pivots can be seen at any time. We think highly of the arrangement, and clocks fitted up in this manner have been running many years without oiling.

We have made the plates about four-tenths of an inch in thickness, which allows of counterboring in for the plate, and admits of long bearings for the barrel arbor, which are so liable to be worn down in the holes by the weights; and the pivots of the pinions, by being a little longer, do not materially increase the friction.

For the clockmaker's use the next in value to the E wheel-cutting engine is the "pitching" or "depthing" tool, for it is by means of this instrument that the proper sizes of wheels and pinions can be ascertained, and all errors in sizes of wheels and pinions, and shapes of teeth, are at once detected before the holes are drilled in the plates. In fact, this tool becomes for the moment the clock itself; and if the workman will consider that as the wheels and pinions perform in the tool for the little time he is testing them, so they will continue to run during the life of the clock, he will not be too hasty in allowing wheels to go as correct when a hundredth of an inch larger or smaller, and another test, would, perhaps, make the pitching perfect.

There are various kinds of pitching tools in use, but many of them are objectionable for the reason that the marking points, or centres, are too far from the point where the pitching or depthing is being tested, and the slightest error in the instrument is, of course, multiplied by the distance, so that it may be a serious difference. Having experienced some trouble from this cause, we made an instrument on the principle that the marking points, or centres, should be as near the testing place as possible. We succeeded in making one with a difference of only three-fourths of an inch, which was so exact that we had no further trouble. It was made on the Sector plan, but upright, so that the work under inspection, whether wheels and pinions, or escapements, could be observed closely, and with a glass, if necessary.

We intended to have given the subject of pinions, as to size, form, method of making, etc., some attention as an important part of our subject; but we are pleased to see, in the first number of the JOURNAL, the first of what promises to be an exhaustive series of articles on "Pinions" by one who evidently understands it "root and branch," and in leaving the subject out of our article we feel that it is in able hands, though the writer is unknown to us.

In our next we will endeavor to illustrate as many of the various escapements that have been applied to clocks with success as possible, and in connection therewith the subject of pendulums.

The Lathe.

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The modifications that have been made in such a general tool as the lathe, are limited only by the mechanical wants of mankind. There would be something of romance in a full history of what has, in ages past, been done; but, for all that, there have been but few improvements except in the mechanical perfection of construction—the general principles being the same, whatever the work performed. The optical instrument maker cuts his screws on thin tubes with a stationary tool and sliding mandrel. The machinist cuts a screw in the lathe, but he adopts the fact that the tool moves and the mandrel only rotates. In the case of the optician, where the screw is to be cut, the arrangement of the lathe is as follows: a fac-simile of the desired screw is placed as a hub on the mandrel, with a corresponding nut. When the mandrel rotates it must take an end motion exactly equal to the pitch of the lead screw. Now, if the tool is held stationary, the cutting point will trace a spiral line on the article being operated on. The reverse of this is done by the machinist, for he holds the piece in the same position at all times; but by means of a lead screw he is enabled to move the tool in proportion to the velocity of the revolution of the spindle. The ordinary slide or engine lathe is of this type, and the pitch of the screw formed may be varied to any fractional or integral number by the combination of gearing that gives the lead screw revolutions in proportion to those of the object. To calculate what the pitch schould be, it is necessary only to know what the pitch of the lead screw is. Suppose it to be 8 to the inch. Now if the screw revolved equally with the lathe mandrel, the tool will describe a spiral of just the same pitch; if, however, it should revolve twice to the mandrel's once, the pitch would be 4 to the inch, and this may be varied in just the same proportion to any desired end. The rose-engine used by the watch-case makers is a lathe where the line described by the tool point is a copy of some pattern on the mandrel, and which, as in the first-mentioned process of cutting screws, moves the mandrel longitudinally, the tool remaining in the same relative position. The patterns are limited only by the space on the arbor designed for their reception. The engravers use what is called the geometric lathe; in this case the line is produced by the combined action of the tool and mandrel. It is by the use of this tool that the engraving of the die-work, as it is technically called, is effected. Although not pertaining directly to watch-work, it will not be amiss to advert to that class of lathes that turn irregular forms, such as axe-helves, spokes, lasts, etc.

The invention was made by Blanchard, who first applied it to the forming of statues by means of a pattern, thus multiplying the original at a very low cost. In these tools the cutter is movable, revolving on an arbor at a high speed; the object being placed between a pair of centres, that are connected with another pair that hold a pattern, this being in contact with a stationary rest during the rotation at a slow rate of the object and simultaneously the pattern, a vibrating motion is effected, as a matter of course limited in extent by the pattern. This species of the lathe has been applied to the forming and surfacing of piano-forte legs—octagonal forms being as easily produced as those truly circular. A modification of this principle has been introduced into the watch trade for polishing pivots, and for the repairer is superior to any mode of effecting this object. As it can be applied by any ingenious workman who has a lathe, it may be of considerable interest to give a general description; the particulars will be readily comprehended. In the rest there is fitted an extra T, which is centred at the end to receive the conical points of two screws which pass through the base of a small frame, thus allowing the frame a swinging motion; in the frame two holes are bored to receive a mandrel, which holes should be bored parallel to the screws. The mandrel is fitted with a pulley, which receives power from a light counter-shaft placed on the bench, at a convenient distance back from the lathe. The swing has a screw for adjusting it to position, and on the arbor of the swing frame the polisher is placed and turned off so as to run true. The arbor has an end-play to enable the position of the polisher to be changed while it is operating on the pivot. The edge of the disk is used as the polishing surface, and the same description of polishing material and polishers that may be found in the article on pinions in the first number of the Horological Journal, will be applicable. It will be obvious that the edge of the disk may be varied in its relation to the pivot, as may be desired. This way of grinding and polishing pivots and staffs, or even facing pinions, will be found the best for the repairer, and can be adapted by him to his lathe so cheaply that it recommends itself to all who wish to do good work. For conical pivots this would not be so good as using the polisher on the face; the edge being dispensed with in this case, it would be necessary to have the arbor at right angles to the pivot, and the pivot must not point to the centre of the polisher, but must be placed at a chord of the circle, which will effect the same result as the backward and forward motion of the arbor and disk in the first-mentioned process. We have tried the last mode and find a result equal to any produced by the wigwag and straight reciprocating polisher. The only modification to be made is, that in the last method a right angle band will be necessary to transmit the power from the counter-shaft, which is driven by a band from the mandrel of the lathe; and the speed may be made of any degree by a proper selection of the driving pulley on the counter-shaft. This plan could also be used for opening jewel holes, provided that instead of the disk a taper wire was set in the second mandrel and was used with diamond powder. Indeed, there are so many uses to which it may be applied, that it would seem to be a most valuable attachment to the jobbing lathe.

Those who have been in the habit of using the lathe for many purposes, may hardly thank us for minutely describing the various manipulations; but they must bear in mind that the tool has been used to a very limited extent, and again, that very few who do use it are so well posted as to experience its full value. There are many little appliances that the workman can make for himself, costing but a trifle, either in money or time. The general drilling operations, whether a running drill is used, or one held in a state of rest while the piece of work is revolving, are not as a general thing developed by the repairer. We have seen the workman, with a good lathe on his bench, use a pivot drill and bow to replace a broken pivot; his knowledge of the lathe was deficient; had it not been, he would have performed his job in a much shorter time, and in a more perfect manner.

Again, in making the fine pivot drills, the workman in the majority of cases finds considerable chances for the exercise of his patience; he files down a piece of steel wire to almost a point, then flattens it with a hammer to provide for clearance for the drill chips, and then tempers it pretty nearly by guess, and finally sharpens it in the old style by two angles on the cutting faces. The drill thus made may be of the right dimensions, or more probably not; its degree of hardness is a matter of much doubt, and the cutting edge is of the worst form for good work. Another way of making these delicate tools is that in which we have the temper right to begin with, the size accurately obtained, and the steel spared the shock of the hammer blow, in order to get the point larger than the shank of the drill, thus providing a good clearance.

To effect all this the workman may use the round Swiss pivot broach; as they are sold, the temper is always of the proper degree. The operator, having determined the size of the hole he wishes to make, puts the broach in his split gauge, and takes the measure of that part of the broach that is of just the size desired, breaking the broach at that point;

he will now have a taper piece of steel which may be too long for use, but he can reduce the length by breaking off a portion from the small end. This being done, the next operation is to fasten the small end in the end of a brass wire of a proper size, which is done by drilling a hole deep enough to allow the broach to be soft-soldered in, leaving only a short piece projecting from the end of the wire; the soldering can be effected without drawing the temper of the steel, if the flame is applied to the brass at a distance from the steel, thus allowing the heat to be conducted to the solder. The blank is now to be formed into a drill by grinding the two sides of the steel, using two pieces of oil-stone—one a slip, the other an ordinary stone. By placing the steel between the two it will be found on moving the slip that the friction between the two stones has changed the form from the circular to one having two flat sides. The end is now formed by means of the stone, with but one angle for cutting. This pivot drill cannot be used with the bow, and that is in its favor. It can be used as a running or stationary tool when applied to the lathe. Of late years the twist drill for larger-sized holes has been used extensively, and in cases where a spring chuck is used there can be nothing so perfectly adapted for the watch or clock maker's purpose. They are cheap, and what is more, the sizes are exactly the same as Stubbs' round wire, so much used by the repairer. The workman with a good run of trade can hardly afford to make any of his drills above the pivot sizes. The best form of tools used on the lathe is a matter of great importance, and the care and degree of attention the workman may bestow on them will return him ample profit in ease and saving of time. The general tool is the ordinary square graver, and is used in the same style as on the ordinary dead centre lathe. We need not urge the necessity of its being sharp and ground to the correct angle; never sharpen the sides; always grind on the angular surface. There is another tool for centring that is superior to the graver, and may be easily made by the repairer; it is made from a small, flat piece of fine steel, reduced at one end into a tang for the purpose of handling, the other end being filed off from the right hand side to the left, at an angle of about 30°, and being under-cut on both the end and left hand edge, which is straight. This, being hardened and tempered, is the best for centring. It is laid flat on the rest on the same level of the centre; the corner is introduced to the work just a little to the front; the cut being entered, it is only necessary to force the cutting corner towards the centre, and it will rest when that point is attained, for the back part of the cavity thus formed is moving in a direction that allows the cutting edge on the angles to become a stop. Any one who becomes accustomed to this tool will be surprised to find how easily he can centre the end of a staff for entering a drill.

We would be remiss did we not take a paragraph for the consideration of the various chucks that can be used for general purposes, and others that are special in their application. The most simple is the one described as Fig. 2 in the article on jewelling in the last number. The end may be altered to meet the various requirements of diversified work; it may be used to finish screw heads, by boring and tapping, or, with a small tube placed over it, it may be made to take in a staff or pinion. That can be effected by turning the chuck off as nearly parallel as a hand tool can be made to do, and then using a small piece of tubing, a trifle larger in its inside diameter than the chuck. In this case we use shellac as a cement, and for truth make a centre in the chuck. Now, having cemented the tube, so that it is fast, we place the round end or pivot of the staff or pinion in the centre and shellac the whole, tube and all, by the application of heat. This style of chuck is more particularly useful where the wheel or balance is staked on either the pinion or wheel, and the operator wishes to avoid driving them off. In using the tube there will be no difficulty as to coloring the wheel or balance, if the flame of the lamp is kept back from the piece, allowing the heat to be conducted rather than to use it direct.

Another form for screws, say in polishing the points, is to make the end of the chuck with a screw cut on it something like the ordinary Swiss screw-pointing tools sold by the material dealers; indeed, if the repairer should cut one of these off the handle, fit it to the nose of the lathe mandrel, he would have a very capital chuck made very cheaply. In all cases where a large surface is to be left for the purpose of putting up, say a wheel plate, balance, or barrel, the chuck may be made by riveting a plate of the right size on the front end of a small chuck; he may do this in a manner that renders the face of the chuck perfectly true without a subsequent facing off. To effect this, the plate may be filed flat on one side, and may be rendered perfectly a plane by scraping, or even, in this size, by grinding on a true glass plate. This being done, the plate is shellacked up on the face of a chuck that has been previously turned up true on its bearing face—the end being concave, with the exception of a narrow bearing surface. The hole is now bored and a face turned out from the hole to give a bearing for the shoulder of the new chuck to which it is to be attached permanently. The facing from the hole should be made slightly concave, as with a hand tool it is not certain that the shoulder to meet it will be perfectly square. This plate is now removed, and the face side of the central hole is counter-bored, the plate having been rechucked with the reversed side on the chuck. It is now removed, the gum dissolved off by means of alcohol, and a new chuck of a little larger diameter than the faced plane on the back of the plate is screwed in the arbor, and the nose turned down so as to go easily into the counter-bore that was placed out in the back of the plate. A tit or projection is now turned on the end of the chuck, a little longer than the thickness of the plate; the tit is turned to fit the hole perfectly, and is made concave on the end. The plate is now slipped on to the tit, and riveted by throwing or rubbing the edges of the concave into the countersink on the face side of the plate, by means of the burnish. The degree of truth found in the now completed chuck will correspond with the amount of care that has been taken to get the edge of the shoulder in perfect contact with the back of the plate, and the accuracy of the fit in the hole. If the chuck has been firmly screwed in the nose of the mandrel, it may be taken out and replaced without disturbance of truth; but generally it will be found necessary to turn off the face after it has been once removed. This chuck is useful in enlarging holes in balances, wheels, etc., where the circumstances may require such enlargement. There are many such appliances the watchmaker may make without expense and with the expenditure of but little time. The spring chuck is of great value, as before stated, as the length of the wire or work need not be limited, and in many jobs, such as pivoting in French clocks, the work can be done in one-tenth the time that it can be by hand drilling and turning up on centres. The sizes of the spring chucks may be varied for holding face work by turning shoulders out on the face of the chuck, having first put a centre in the hole to close the sections on, so that no great amount of spring will be had when the hole is screwed together. A number of these shoulders, which should be slightly undercut, in order to hold well, may be made on each chuck; and if there are a number of them, the range of sizes may be made very large.

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Solders.

To do a good job of hard soldering is quite an achievement, as its practice involves a great many considerations of chemistry as well as physics. There is no secret in the art, and yet the quality of the majority of the work done in the ordinary stores is so badly executed that it would seem that the art of soldering was unknown. We will leave it to any good workman to say what proportion of the repairs made is either workmanlike or even tolerably well done. A professional jewelry manufacturer cannot be excused for such slovenly work, the more especially when we take in the fact that in a great many cases the repairs to jewelry are positive barriers to any subsequent operations. No doubt this evil has arisen as much from the nature of the jewelry as from ignorance. Let a fine brooch be repaired, it will, in the majority of cases, be found that the repairer has soldered the joint or catch, as the case may be, with soft solder. Should he have heated it too much it will be found very difficult at any other time for even a skilful workman to repair, except in the same manner. In all jewelry that is made with soft solder no other resource is left the workman than to use the same; but in all goods that are originally hard-soldered no excuse can be made for the use of any lead or tin solder. Perhaps there may be a color to the article, which the heat may spoil; if the repairer has no means of restoring that color he will be compelled to use the material that fuses at the lowest degree of temperature. This case is a very common one, and is indicative of the slight knowledge the workman possesses. We will state here that these remarks are not intended to apply to those whose trade is jewelry; they are informed on the subject well enough to choose the proper mode of repairing. The general watch repairer is very often called on to do this kind of work; the repairing of jewelry being a very important and lucrative branch of his business. He should then be prepared to execute all jobs so well that the repairs may not be apparent. If he spoils the color of the work, he should have the means of restoring it; his solder should be adapted to every class of work, and his polishing apparatus sufficiently extensive to enable him to make the piece look like new work—as well indeed as it did when it came first out of the factory.

The prices ordinarily paid for jewelry work are too small, or rather there is but one price for all classes of work, and the cheapest method is adopted, and this fact accounts in many cases for the bad work. This, however, should not deter the repairer from making a discrimination in his prices and doing the work acccordingly.

For the ordinary run of hard-solder work, silver solder, or two carat gold, will be all that is needed. The choice of either will be determined by the color or quality of the goods. There are many receipts given for the composition of these solders, but it requires some knowledge of melting alloys that are to be of a given composition. The workman may, however, make his silver solder with the blowpipe on a piece of coal by alloying, say a dwt. of silver (coin is about right), with about 5 grains of brass. This brass should be common pins, as they have a slight trace of tin added when they are colored, and after the two metals are in a state of fusion a small quantity of tin may be added. When hammered or rolled out, and the surface scraped clean, this composition will be found to melt at a low heat, and run or flow very readily. We have not been particular as to the proportions, as it will be easy enough for the workman to vary them according to the required degree of fusibility. The tin is a very important ingredient, as it renders the solder more likely to flow freely. The use of this solder is attended with but very little risk if the workman has the joints well cleaned and amply protected by borax. It often happens that what are called red gold rings are broken and brought in for repair. They are fusible at so low a degree that they will fuse before the silver solder; still they may be repaired with it in the following manner: Having filed the ends of the fracture true with each other, the ring is closed so as to make a close joint; a piece of the solder, very thin, is cut about the size of the section of the ends, and the joint is now forced open and the piece of solder is placed in the opening; the surfaces having been well covered with borax, the ring is submitted to the heat of a blow-pipe applied with caution—the object being not to fuse the solder—until the operator finds that the solder begins to glisten on the surface, the ring being hardly red hot; it will now be found that a perfect joint has been made without having melted the solder. This is called sweating, and may be followed in all cases where there is reason to doubt the fusing point of the work. The gold solder is used on a much higher class of goods than the silver. Some articles of jewelry are filled with this two-carat solder, the outside being a very thin shell of sixteen-carat gold. In repairing these articles, it is generally best to use the silver solder, though in the case of a ring the ends of the fracture may be prepared as stated in the other case. The lining, however, must be bound with wire to prevent separation. The ring is then heated just enough to melt the contained solder at the extreme ends, being withdrawn the instant the sweating has been discerned. This makes a very neat job, and requires no filing to get rid of the surplus of the solder. There is little to be said as to soft solder except that there are some goods put together with a metal that melts a little above the boiling point of water; any of the ordinary soft solders would be inapplicable in such work. The workman may, however, make a solder by melting two parts of lead with two of bismuth and one part tin; this alloy melts at a temperature of 236° F., and may be used with perfect safety on any filled work, but it does not make a very sound joint; it is used with the ordinary soldering fluid.

It may be of some profit to many to know how to solder rings with settings that may be damaged by the heat. Pearls, enamel, turquoise, and opals are liable to injury, and the taking them out and resetting would involve some time and labor. The work can be done with safety if the workman will bury the part to be protected in a piece of raw potato, placing inside the ring a small piece of charcoal. The soldering may now be done by fusion or sweating, as the circumstances may dictate.

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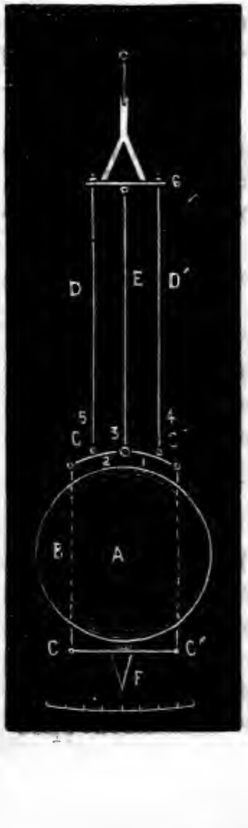
Mason's Pendulum.

The great importance of a perfect system of compensation in the regulator for timepieces has stimulated the exercise of mechanical ingenuity. From the earliest times of horological history, we read of attempts made to find some device that will allow a large range of temperature and yet maintain a constant quantity. Thus, in measuring the bases of angles for trigonometrical surveys, the slightest error in the length of the standard measure was fatal to any accurate calculation of the angle. We all know that metals are expanded by heat and contracted by the deprivation of it. If, then, the rod used for measuring a line was made of metal, the error arising from expansion and contraction would render the survey nugatory. A system of compensation was adopted, and the results have been so satisfactory that in the trigonometrical surveys of Ireland, the same base of 500 feet in length, measured over twice, was found to vary but the .08 of an inch. The system of compensation in this case must have been very perfect, as we may well conceive, when there is taken into account the length of the line, the enormous amount of surface, and the multiplication of the errors in frequent measurements. The idea of the compensation was borrowed from the gridiron pendulum, which, in principle, is perfect, but not so in its application. There are too many joints, or places of contact, to allow all the effects of contraction or expansion to be fully compensated, as some lost motion must ensue—small, it is true, but enough to render its performance unreliable. Harrison's pendulum was certainly a very ingenious deduction, but, consisting as it did of seven alternate bars of brass and steel, with fourteen points of contact, the want of continuity of the metal surfaces at these points of contact was a bar to accuracy. Graham's pendulum, with the mercury jar, is not open to these objections; but as it is very costly, other inventors have tried to supersede it. Of the hundreds of devices, perhaps none have so far succeeded as the device we submit in the engraving. It is the invention of Mr. C. T. Mason, of Sumter, South Carolina, and we may add that he has really taken an advanced stand in making two different metals compensate without the drawbacks incident to the Harrison pendulum. There can be no doubt that, should the leverage between the points of support and the attachment of the central brass rod be adjusted to the amount of the difference of the expansion in the steel and brass, with lost motion accounted for, the pendulum would approach nearly perfection. By inspecting the figure, it will be seen that the compensation is effected by reducing the effect of the expansion of the brass rod. Taking E to be brass of any length and securely fastened to the bar, G, to which also the two steel rods of the same length, D and D, are as firmly attached, when the two metals are expanded the brass will be the longest. There are two levers, 1 and 2, attached at the outer ends, to the top of the stirrup rods; these are



also attached to the brass rod in the centre, 3; the two steel rods are attached to the two levers at some points, say 4 and 5; these points would necessarily be determined by the difference in expansion. They can be changed to or from the centre, so that the adjustment can be made from the rate of running and not from theory. No watchmaker can see the figure without comprehending the whole principle. A pendulum thus constructed would perform certainly better than any Harrison's that could be made, for the accretion of the amount of error in the fourteen joints becomes a complete bar to the correcting of the effect of expansion or contraction.

The Total Eclipse.

A correspondent of the *Journal of Commerce* gives the following from personal observation:

The most brilliant phenomenon which called forth the most glowing and intense description, is the *corona* or halo, which, like a nimbus, surrounds the darkened disk of the eclipsed sun, shooting out long streamers, moving and waving, and sending forth a pale aurora-like light.

Baily's beads, too, have been described as a gorgeous spectacle. They occur just before and just after the totality, when the sun is reduced to a crescent, and the serrated edge of the crescent is almost reaching the sun's edge. Then the lunar mountains have seemed to shoot forward, and stretching over the thin crescent to leave open spaces of brilliant light, compared to a necklace of intensely brilliant diamonds.

This phenomenon was observed by Halley in 1715, and especially remarked by Baily in 1836. The effect is probably to be largely attributed to irradiation.

The feature of the eclipse to which most interest has attached of late years, is the appearance of rose-colored protuberances projecting beyond the sun. They are first seen on the western limb (where an eclipse always begins) just after totality, and later appear on the eastern limb. They bear now the shape of a mountain peak, now of a sickle, now of a tongue of flame. The shade is almost always reddish or pink. These prominences gave rise to many conjectures. They were commonly supposed to be clouds resting on the sun's atmosphere and reflecting his light. The observers of 1868, however, took with them into India the wonderful spectroscope, and the secret of the protuberances was revealed at once. The spectroscope is an instrument by which different sorts of light are examined, and as the luminous vapor of each chemical element has a peculiar light never found in any other element, and never wanting in itself, the presence of any element may be detected by observing its spectrum. But very delicate work it is, this examining and comparing, and wonderfully minute and elaborate are the maps of different spectra, showing hundreds of the most delicate lines, arranged, black bands and light, after the peculiar fashion which may always be identified as its own. Well, the parties of 1868 went into India, turned their tubes upon the prominences so long a puzzle and the source of so many conjectures, and the story was told at once. The protuberances are hydrogen flames burning around the sun. The day after the eclipse M. Janssen, turning his tube where he had the day before marked the protuberances, had the good fortune to find the very flames never before found when the sun was not eclipsed, and for many days he examined and studied them, living, as he said, in a perpetual eclipse. Almost simultaneously Mr. Norman Lockyer, thousands of miles away in England, made independently the same discovery, and examined the solar prominences when the sun was shining brightly.

With these things especially to look for, and with this much knowledge about them, the observers of 1869 prepared for their eclipse at home. Many parties, with better or worse furnishing, stationed themselves along the line of totality, determined to catch the gorgeous sight, and contribute to the knowledge of the interesting phenomenon.

Among the many accessible positions few were more inviting and convenient than Springfield, Ill., and to this place was sent a United States Coast Survey party. The place selected for the observatory is about a mile and a half from the city, near the Water Works. Here a wooden building was erected, and observers stationed several days before the eclipse to ascertain the precise latitude and longitude, take observations for time, and adjust the instruments. The most important feature of the work at this point was to be the photographing of the sun. Mr. Black, from Boston, with an assistant, accompanied the party, and made very careful preparation. He used an equatorially mounted refractor, of about 6 feet focal length. On to the end of this was attached the box for photographing.

The image of the sun is thrown through a narrow horizontal slit cut in wood. Over this wooden surface slides a cover, in which is also cut a horizontal slit, exactly like the other. When the slide is pulled up, the slits do not correspond, and no light can pass. When the plate is ready the slide is allowed to fall, and the photograph is taken in the incalculably small fraction of a second that the narrow slits are in line. Even then the time of exposure is too long for the sun in its brilliancy, though when a photograph is to be taken of the eclipsed sun it was supposed an exposure of ten seconds would be necessary.

The other instruments of the party were a zenith sector; an equatorial, on to which was fitted a dark box into which the image of the sun fell on to a sheet of white paper where all the phases of the eclipse could be observed; marine binocular glasses and the requisite outfit of chronometers. The party was made up of Professor Benjamin Pierce, superintendent of the Coast Survey; Mr. Schott and Count Pourtales, assistants; Mr. Black and several gentlemen from Cambridge, who accompanied the party as observers. Strangers began to arrive in Springfield from all quarters on Thursday and Friday.

The weather was anxiously studied, but Thursday was cloudy and Friday still more thick and rainy. Every one was despondent, and fell to counting the miles he had to come to see a rain storm, for it certainly appeared that little else would offer itself on Saturday.

Notwithstanding, Saturday was clear, absolutely cloudless, a perfect sky in every direction. In the morning, positions were selected and parties made up for different stations in and out of the city, and stained glass was in great demand. It was judged expedient on Saturday morning to detach two observers from the Coast Survey station and send them north, that another set of observations might be secured.

Accordingly two observers started at noon for Bloomington, some sixty miles from this place. We arrived on the ground about an hour before the first contact was expected, and therefore had not much time for selecting a station. We finally decided on planting ourselves on a platform on top of a new building near the railroad station. The men working in the shops near showed a very intelligent interest in the eclipse, and were anxious to assist us in our arrangements. The fires in the shops were covered up promptly, that the smoke might not trouble us, and we were aided in every way.

Adjusting our glass as soon as possible, we began at once to watch for the first contact. The exact time had not been calculated for Bloomington, so that we could not tell precisely when to expect the event. The glass was kept narrowly on the south-west limb of the sun, about 124 degrees from the vertex, and I watched the chronometer. At last the faintest speck was made out at the sun's edge, and "time" was cried at 4h. 6m. 2s., Bloomington mean time. The eclipse had fairly begun; but for a long time the shadow moved very slowly, and no perceptible change was noticed in the landscape, of which we had a very commanding view. The wind was blowing strong from the east, and we were considerably inconvenienced. Soon the large spot on the lower limb of the sun was covered. The hue of the surrounding country began to change. The cusps of the sun seemed cut off, and sometimes the moon's edge appeared to be serrated. We could not notice sphericity of the moon, as has been remarked by others, at this time; nor did the moon's dark limb seem visible, though sometimes we thought we caught sight of it.

The appearance of the sun was of a bright crescent, the widest part or middle of which was somewhat to the left of the vertex or highest point. The light now grew extremely strange and weird. There was a slightly greenish tinge, and the effect on objects was something like very bright moonlight, but it was a much more unnatural light. The shadows were sharp, but very cold, not at all like ordinary sunlight. The effect was very impressive and awing, for a certain indefinable feeling of dread and alarm seized on the mind, and an uneasy consciousness of perfect helplessness. I could see very plainly, however, as yet.

At about two minutes before the totality Venus shone out very brilliantly, immediately followed by Mercury to the west of the sun, and Arcturus was nearer the zenith. Regulus, which we expected to find between Venus and the sun, we could not see.

The effect of the darkness now began to be felt in the town below us. There had been much noise and hammering, shouting, and snorting of locomotives, but this began to subside. The wind also, contrary to our expectations, went down, and a great solemn silence awaited the putting out of the sun. The people in the streets were standing motionless in groups, the poultry were going to roost, a string of ducks were pursuing a slow march across the field home. The whole earth seemed still and frightened. At about 5.06.8 the last ray on the eastern limit was cut off. In a few seconds more I looked up from my paper and chronometer. The sight was beyond language for awful grandeur.

Around the black wafer in mid air shone a brilliant circle of waving, curling light, white, with just a slight tinge of green. Near the lowest point of the sun, and near the middle of the right limb, appeared large prominences shining in the midst of the corona and showing to me a yellowish orange color. I was much astonished at this, for I had not expected to see the solar protuberances with the naked eye, and what else these flames were I could not conjecture. Long streamers shot out from the corona and waved like long arms. Their color was quite like that of the corona, though perhaps not quite so dead a white. The seconds were going fast, and I turned to look around the country. The sight was grand and solemn. The darkness was not very deep – at least I could see with tolerable clearness a bright new wooden shed some thirty-five rods distant, and I think I did not need much assistance from the lighted lantern which stood by the chronometer. Along the southern horizon I saw what seemed like a long low cloud of bright golden color, but there was really no cloud there or anywhere else in the sky. A minute and a half had gone—gone before I thought I had seen anything, so filled with intense excitement was every instant, and I dared not look away from the chronometer longer, for the time of the reappearance of the light was very important. By a great effort I turned away, looked down, and in a few seconds the call of time marked that the totality had passed. The change is sudden and very remarkable; the instant the light reappears a single ray makes all the difference imaginable. The duration of the totality was 1m. 56.1s.

The effects of the retreating shadow were similar to those of the advancing.

The town below waked up from its stillness at the instant the light reappeared, and noises began to be faintly heard, and grew louder as natural day advanced.

Venus still shone and was seen twelve minutes after the appearance of light. We watched the uncovering of the spot—the only one which our instrument would show, and took the time of the final disappearance at 6 hours and 4 minutes. These times are not exact, but are reduced from the readings of the chronometer (which marked Greenwich time nearly), by the best knowledge of longitude that we have, which is not exact.

The eclipse of last year that was of such general interest to the European astronomers, was not of any more importance than the one of Aug. 7. When the results of all the observations have been collated, we may find some novel deductions from the spectroscope into the nature of the substance of the sun. More interest is felt in the late eclipse from the fact that through the whole path of totality the air was unusually clear, and the supposed hydrogen flames were well defined.

Correspondence.

———

The annexed extracts from letters received from Mr. R. Cowles, of Cleveland, Ohio, one of the best Horologists in the North-west, will give some idea of the co-operation we have met since our first number. Mr. Cowles, taking the ground of practicability, has favored us with a short dissertation on Lifting Springs, and has proved the assertion we made a few lines above. The information he gives will be of great value to the trade, as hunting-case watches are the mode. We heartily endorse his process, for we know that it is the one the manufacturers follow.

Editor Horological Journal:

* * * The first numbers are excellent, and if your succeeding ones are as good, *i. e. practical*, I, for one shall be *more* than pleased. I find from my own experience, and from conversation with others, that what is wanted is actual *practical instruction*. My idea is, that a journal of the practices of the best workmen will pay you far better than a scientific theoretical one. Leave the abstruse mathematical philosophy of the business to the mathematicians and philosophers. You can't make a journal that they will read, if you attempt, but you can make one that will be a *treasure* to the uneducated mechanic. No doubt you receive plenty of "*advice.*" Every one has an over-stock to dispose of, and you must take your share. One blessing is, you are not obliged to act upon all of it.

But seriously, you will find a hundred readers who would rather you would tell them the very best way to round up wheel teeth, where you will find one who cares to read about the geometric properties of cycloid or epicycloid curves, and I venture to say that nine out of ten of your readers would rather know how to properly fill a spring box—that is, the proportions between the spring, the arbor, and the space—than to read the most profound discussions upon the *general* philosophy of springs.

* * * Perhaps one of the most vexatious *little* things that irritate a watchmaker is the breakage of lifting springs; after spending valuable time to fit them, and then to have them go "*chick*" the first time the case is shut down, will try the temper of any one except a *good* mechanic. I have failed to get a good temper in them not oftener than one time in ten by the following means: After nicely fitting the spring, and hardening by any of the usual processes, I then wind the thin part of the spring loosely with binding wire till it is about the same size as the thick part, then dip it in any viscid oil, and hold it

in the flame of a lamp till the oil, which the binding wire holds about the spring, is *mostly burned off*, then quench the flame in cold water. I find it much more convenient than burning in a spoon or any other way, and a very certain method. No doubt, others do the same way, or perhaps a better; and there may be others who have worse methods and will like to try this. *My* rule for working has always been: "Try *all* things; adopt that which proves good."

Finally, again let me say you have begun well, and I really hope you may succeed pecuniarily as well.

Very truly,
Royal Cowles.
Cleveland, *Aug.* 10, 1869.

Editor Horological Journal:

Although watchmakers are, generally speaking, but little interested in the laws of the refraction of light, and the science of Optics generally, yet, as every jewelry store keeps spectacles and other optical goods for sale, and as there are many who deal in such goods that have no idea of the importance of selecting spectacles of the *proper focus* for their customers, I thought that one or two articles upon Optics, in so far as relates to spectacles, would not be amiss. I do not intend or expect to write anything for the instruction or edification of a regular optician, but simply to give the uninitiated a few "dots."

I have no doubt but what many of your readers will say that *anybody* can select a pair of spectacles to suit themselves; but allow me to inform them that such is not *always* the case by any means. Any good optician will tell you that *he* can select what is proper for his customers to wear better than the party can themselves. It, of course, requires, considerable experience and no small amount of study to be enabled to do so. As I stated before, my remarks are chiefly for the benefit of those who know but little about this subject, which will be a sufficient excuse for my going into the minor details.

Besides having a good stock of spectacles, a good "optometer," and a "pebble tester," are necessary; or, if not an optometer, a set of "trial glasses." The use of such will be explained presently. Those who have not already done so should provide themselves with a convenient rule or scale, to be enabled to measure the focus of spectacles or eye-glasses. The best and most convenient way I ever saw is as follows:

On the counter-shelf, or other convenient place, at the *end* of the room *opposite* a window, mark distinctly in inches from 1 to 48, counting from the wall or partition. Now to get the focus of a convex ("multiplying") lens, all that is required is to hold the lens or spectacles, so that the plane of the lens will be at right angles to the rays of light coming from the window, and over or opposite the scale; move it back and forth until a distinct and inverted image of the bars of the window, or of some building or tree outside, is formed on the walls; now notice where the glass is on your scale, if opposite or over "20," then your lens is what is called a No. 20, *i.e.*, the focal distance of the lens is 20 inches, and so of any other number.

Every pair of spectacles or eye-glasses should be measured before they are sold, as it not unfrequently happens that one of the glasses is stronger than the other; especially is this the case in cheap spectacles. Such a pair should never be sold, as they would injure the eyes of the wearer.

In order to select a pair of glasses of the proper focus, for any one to read or sew with, for a case of simple *presbyopia, i.e.*, when the point of vision is removed too far from the eye, and hence the difficulty in distinguishing small objects, let the party take the optometer, and with one hand hold it so that the eye-glass is close to the eye, and with the other hand move the slide back and forth on the graduated bar, until he finds some place where he can see better than at any other distance, and the number on the bar, as indicated by the slide, will be the number or focus of glass required.

The optometer is not an infallible guide, especially if there is any complication of diseases of the eye. If, upon trial, you find the number selected does not suit, or, in other words, if the party cannot see to read at about 16 inches from the eye better than at any other distance, you may know that something is wrong; if too close, select a higher number; if the party has, on the contrary, to hold the object too far to see plainly, select a lower number of glass. The above directions are, as I stated, for a simple case of *presbyopia*, in which convex lenses are always required. There are three kinds of convex lenses in use, viz.: plano-convex, flat on one side and convex on the other; bi-convex, or convex on both sides, which I consider superior to any other shape; and the concavo-convex or periscopic, concave on one side and convex on the other; many people prefer the latter shape, but I have found in my experience that they did not give as good results as the bi-convex.

In a case of "amblyopia," or weak sight, the party also needs convex lenses, and by selecting glasses of a proper focus this difficulty can usually be removed, if not complicated with something else; the best way to ascertain the proper focus required is by trial.

The optometer will also be useless in a case of *hypermetropia*, besides in many other conditions of the eye. By hypermetropia is meant that condition of the eye that will not sufficiently converge *parallel* rays of light to bring the focus upon the retina—the focal point falling behind the retina; therefore convex glasses are needed in this case, that, instead of parallel rays from any object coming to the eye, we may have convergent rays. As in *amblyopia*, we find what number is required by trial. There are many other conditions of the eye needing spectacles, which could not be fully explained without engravings, and it would also require several articles of greater length than I intend this to be, to demonstrate those conditions.

The "pebble tester," of which I spoke, can be had from any dealer in optical goods; its object, as its name signifies, is to enable any one to tell a pebble from a glass lens. It is useful in more ways than one, as it not only enables us to keep our stock of pebble spectacles from those of glass, but enables us to detect fraud and imposition in many cases. I will give a case in point. Some time ago one of those celebrated "Professors," the "great Optician and Oculist, direct from Russia," Prussia, or some other foreign country, that are scattered throughout the country, came here and put up at the hotel, and went from house to house with his handbills, professing to sell the ONLY kind of spectacles fit to be worn, viz., some celebrated kind of "Russian" pebbles, that *he made himself*, at *his* factory. His prices varied according to his customers; some he would charge $10 a pair for, in steel frames; others he would only ask $5 for the same article. One gentleman who had bought a pair was telling me what a spendid pair of pebbles he had. I applied the "pebble tester" to them, and was not long in convincing him that his "*celebrated* pebbles" were nothing but glass, and that he could buy the same quality of spectacles for $1.50 at any respectable jeweller's or optician's. The *result* was that this itinerant Israelite of acquisitive propensities never sold another pair of spectacles while he remained in the city, and as soon as he found out that he had been detected in swindling those to whom he had sold his "celebrated pebbles," he left, but not until after some of the parties had made him refund the money which he had so dishonestly obtained from them.

In a future article I will have something to say about near-sighted (*myopia*) eyes, and the proper glasses for them, and how to measure the focus of a concave lens; also, may have something to say about some other peculiarities of that delicate and wondrous little organ, the Human Eye. J. F.

AMERICUS, GA., *August 10th*, 1869.

WE would call the attention of our readers to the very sensible observations of Mr. J. Cross, of Vineland, N. J., as given in the following extract from his communication. The idea he advances is one of much importance to the workman, for in attaining the faculty of getting time by observation of altitudes, he gets not only means of correcting his clock, but acquires a habit of reasoning that renders him a better workman at his bench. The discipline thus applied to the mind is quite as valuable as that obtained by the mere reading of books. The instruments previously mentioned are valuable as supplying a want long felt by those who could not purchase a high priced one:

ED. HOROLOGICAL JOURNAL:

* * * * Your notice of the late improvement in tools,—Dipleidescope, etc., brought to my mind the fact that so few watchmakers avail themselves of the method of computing time from observed altitudes of the sun or other heavenly bodies with the quadrant and sextant and artificial horizon. The advantages of this method are many; I will mention a few: First, the cost of the necessary instruments is small—a good quadrant and saucer of molasses, basin of tar, or other thick fluid, not easily agitated by the wind, costing not more than $25, are all the instruments absolutely necessary, although a sextant and mercurial artificial horizon are better, and a copy of the *Nautical Almanac* and *Bowdwitch's Navigator* contain all the tables and information necessary, and which can be learned by an intelligent person in six hours, if acquainted with the common rules of arithmetic; a little practice with and knowledge of the adjustments of the quadrant would be necessary, but easily attained. Next, the observer is not confined to the time of the sun's passing the meridian, as in the use of meridian instruments; again, the relative motion of the images of the sun in the quadrant and artificial horizon being twice its real motion, as observed by any meridian instrument, it follows that a smaller amount of motion and a corresponding shorter interval of time can be observed by this method than by others founded on meridian passage, etc. Of course the transit, when correctly adjusted in the meridian, possesses advantages over almost any other instrument, allowing, as it does, the use of a powerful telescope. Another advantage of computing time by observed altitude is, it requires no difficult adjustment of instruments in the meridian; and last, but not least, any degree of accuracy almost can be attained by this method, by

simply taking a sufficient number of observations in quick succession, and taking the mean of the whole.

Yours truly, J. CROSS.

VINELAND, N. J., *July* 26.

We can heartily endorse the above remarks of Mr. Cross; he is certainly on the right track, but there can be no doubt that the passage of a celestial body over the meridian, is altogether the best and most accurate method of getting time. The only difficulty hitherto has been to get a good instrument at a moderate price. The trouble of getting the adjustment for meridian is no greater than adjusting the quadrant or sextant for daily uses; it may require for the final result a more patient attention, but so much the better for the watchmaker, as it will educate him up to a higher point.

The former styles of the transit instrument were not only too costly, but were absolutely cumbrous for any but an astronomer; they were too good for the mere purposes of taking meridians, inasmuch as they were capable of doing more than any watchmaker desired or needed. There need not be a word said as to the necessity of having a means for correcting the clock for true time, and we would wish to say to Mr. Cross that an instrument is now offered for sale in New York, with a 10-inch tube, with power enough to give a well-defined disk of Jupiter or Mars. The wires are drawn on glass, which can be adjusted, so no trouble can ever occur from breaking of web or wires. The plane of the meridian can be maintained; while the peculiar construction of the base enables it to be taken in-doors without disturbing the adjustment. The line of vision is reflected at the eye-piece. We have alluded to the construction of the base not without reason, for one of the greatest difficulties of the transit has been to have an adjustable, yet firm support for the instrunent; the finer adjustment for meridian is accomplished by means of a screw moving the V in which the axis rests. It is provided with means of illuminating the wires, and also has a graduated circle with vernier for vertical angles. Altogether it is the best transit we have seen for the purpose of affording a standard of time for the watchmaker.

In the article on astronomy, in a future number, the full use of the transit instrument will be treated of, and the reader will then see how important are the points we have enumerated.

EDITOR HOROLOGICAL JOURNAL:

* * * The suggestion by J. F. in the second number of the JOURNAL, in reference to the formation of a Watchmakers' Union in the United States, for many obvious reasons is a good one. The whole country is so completely flooded with poor workmen, that some plan should be devised whereby the public at large might be relieved from the daring recklessness and total incapacity of that class of men who call themselves watch repairers. A better application would be *watch butchers*.

I have no doubt that it is the experience of all good workmen, that nine-tenths of the heavy charges they are obliged to make on all good watches, is caused by the ignorant and unskilled manipulations of these so-called watchmakers. The people are so grossly imposed upon by such workmen, and by dishonest workmen too, that something should be done to stop this wide-spread evil. Not only are the people imposed upon, but all good workmen suffer directly from the same cause. Watch repairers have got a bad name for dishonesty and incapacity. As a general thing it is too true, but there are many noble exceptions. Now for a remedy.

All the scientific horologists and the best practical workmen should organize themselves, as soon as practicable, into a United States Watchmakers' Union, with some such objects in view, as the following:

1. The protection of the public against incompetent and dishonest workmen.
2. The protection of the interests of all good workmen.
3. The promulgation of a thoroughly scientific and practical horological literature.
4. The passage through the respective State Legislatures of efficient apprenticeship laws.
5. The establishment of Co-operative Unions in the principal cities of each State, thereby saving the profits to the workmen, instead of dividing them with middle-men.
6. The establishment of a uniform price for all specific jobs done to watches and clocks.

The above are some of the objects for which, I think, a United States Watchmakers' Union should be established. In this article I cannot discuss the six propositions advanced, but I hope, by your kind permission, I may be allowed to discuss the propositions in another article.

W. H.

BINGHAMTON, N. Y., *Aug.* 9, 1869.

EDITOR HOROLOGICAL JOURNAL:

* * * * I was most agreeably surprised on receiving the first number, and rejoice to know that we are hereafter to have a journal devoted to our special interest. I hope now that those of us who are entitled to any consideration in the profession, will see to it that the enterprise be well supported, and that an art so justly entitled to a high rank be raised from its present miserable position, so that those who have labored faithfully and qualified themselves thoroughly, may take rank in the world as something more than "tinkers."

I had almost become disgusted with the whole concern, and was thinking seriously of quitting the business and going into something where a man would be acknowledged for what he was worth; but your paper gives me new hope. By all means let us have the society as suggested by your correspondent "J. F.," and make the qualification for membership such that "botches" cannot creep in, and we may then hope to see the line so plainly drawn between watchmakers and "tinkers," that the public may have some means of knowing whom to trust. Who will make the first move?

Yours in the cause,

O. D. BEMAN.

MONTROSE, PA., *Aug.* 12, 1869.

Answers to Correspondents.

M. B. S., *Ala.*—The gilding referred to in the article on watch cleaning, differs from the English or American, inasmuch as that it is matted, as it is called, by depositing the gold on a surface rendered frosted by a deposit of silver in the crystallic form. The other style of gilding is where the matting is effected by means of a scratch brush which dents the surface. This brush is formed of fine brass wire, and generally a series of them is put on a lathe revolving at a high speed. The plate having been first heated to render it soft, is now subjected to the percussive action of the ends of the wire. While the brushes are thus striking the object a small stream of sour beer is allowed to trickle on them, which serves to clean the plate by chemical means as well as mechanical. It is obvious, however, that were the ends of the wire to pass over the plate they would leave only straight lines. To remedy this a block is held just in advance of the object to be gilded; on striking this block the wires are bent backwards; when they pass the block the elasticity of the metal causes them to vibrate forward in advance of the circular motion; by this means the wires strike the plate nearly perpendicularly. The force of the blow causes an indentation of the surface, and the number of such blows being innumerable the surface soon becomes uniformly matted. It is then washed in clean cold water and placed in the gold solution for gilding.

C. M., *Texas.*—You are mistaken as to the mode of painting watch dials. The figures are not transferred from an engraving, as you seem to think; you are right as to the use of the transfer process by the manufacturers of earthen ware, porcelain, etc. If you will critically examine the figures on a good dial you will discover a sharpness of outline that would be unattainable by transfer. The painting is a very simple process, for the figures are rubbed out—that is, a spot of black enamel, ground in a mucilage of gum, is dabbed on the face in a blot at the place the figure is intended to appear. When the gum and enamel mixture is sufficiently dry, all the parts of the blot that do not constitute the figure are rubbed off, leaving the number on a clear, white ground of enamel; the color is then burnt in, and the dial is finished. Like many other simple processes, dial painting, to be well and tastily executed, is the result of care and delicate manipulation, acquired only by application. The circles, minute points, seconds dial, and name are painted in—the very reverse of the other mode.

J. M. O., *Ind.*—If the watch you wish to have make time, be one of the very low class of English levers, the only real standard would be one of comparison. Throw it at the nearest dog you see, and you can ascertain by comparison which (the dog or watch) makes the best time. We would be willing to bet on the dog, giving heavy odds. In sober truth, the class of watch you seem to refer to, surely is made only for perplexing the workman; do not warrant any repairs, for the defects are radical, and nothing short of entire reconstruction can be of any use. To find obstructions in the train you should try each depth by itself, and you may find one that is faulty, or in the trying find a wheel tooth or pinion leaf either too large or too small. The process of repair is to alter the depth, or make the wheel, tooth, or leaf of the right gauge.

P. I., Jr., *Pittsburgh, Pa.*—Your letter is very creditable to you. You must, however, remember that the mere practice of a mechanical trade does not produce the good, first-class workman. There is much more to be learned than the mere manual dexterity, or tho general routine of watch *tinkering*. Spend your leisure time in obtaining a good knowledge of geometry, and acquire the habit of mathematical reasoning by studying algebra. Not this much should satisfy you, as a knowledge of inorganic chemistry and of natural philosophy is almost indispensable. This course of study may seem too much; yet you must reflect that you are an apprentice, and your time cannot be so fully occupied as to debar you from the pursuit of such knowledge as will render the trade a science rather than a sort of hap-hazard handicraft.

S. R., *Maine.*—Your first query covers too much ground to be answered in short metre. The adjustment of expansion balances to temperature depends on too many contingencies, such as the proportion of the steel to the brass, the weight of the rim to the whole weight of the balance, and again the weight and velocity to the tension and elasticity of the hair spring. It will be seen that a full answer would be a treatise on expansion, momentum, elasticity, properties of steel, etc., etc., and a full discussion would occupy the space devoted to a whole volume of the HOROLOGICAL JOURNAL.

W. W. S., *Ill.*—In the remarks we made on the letter from J. F., of Ga., we did not intend to convey an idea of impossibility. The vagueness of plan and the scattered state of the trade were all the hints as to impracticability we offered. Since the first mooting of the idea, we have received communications from almost every quarter, enough to show that there is a strong current of opinion setting in the direction of a watchmakers' Union. We have left the question open for the expression of thought from the trade, as we are to be considered as the medium through which intercourse may be had.

H. B., *Chicago, Ill.*— The JOURNAL can hardly devote an article to such an interest; it is too foreign to Horology, even if some of the productions are incidentally put in requisition as insulators and supports in the electrical apparatus, sometimes used for Horological purposes.

L. F., *Pa.*—Address John E. Hyde's Sons, Maiden Lane, New York city, in relation to the aluminum bronze. Its cost is about $2.50 gold per pound. The Vienna lime may be obtained by addressing Henry Harrison, No. 23 Maiden Lane.

H. M. J., *Ohio.*--There must be some limit to our answers. To give even a synopsis of the facts you ask for would take up nearly a whole number of the Journal. The diameter of a pivot to the balance has been determined by chance, perhaps, as much as by any mathematical reasoning—at least this is the case in the ordinary classes of watches. Within certain limits personal choice has been the guide. In Swiss watches the gauge is $\frac{1}{2500}$ of an inch to the degree, and will run from 7 to 10, or even more, while in the English and American watches the sizes will be found to fall between 12 and 17; in these watches a degree and a half is generally allowed for side-shake.

W. C. J., *Pa.*—The Chinese duplex has a double-pointed wheel troth, the true duplex has a single point. You can see what the effect is, as the staff jewel in either case must be the detent, the slit or notch giving the unlocking.

M. Y., *Ga.*—You are in the true path for the accumulation of knowledge; reason in the same style for yourself. Nothing but over-modesty and diffidence prompts you to restrain the publication of your very able solution of a difficult problem. Will you allow us to insert it in our next, it pertaining to the science at large?

M. B. B., *Iowa.*—Are you certain you have mercury enough in your pendulum jar? From the "symptoms," we should suspect that the centre of gravity of the contained mass of mercury is not high enough. You can ascertain very easily whether such is the fact, by placing any small weight, say a thin piece of brass plate, on the upper bar of the stirrup; though this will not determine where the centre of gravity is, it may indicate where it should be.

F. H., *San Francisco.*—We have taken some trouble to ascertain where in the United States you can get your desired articles, but with no success. We are happy, however, to answer the other query. The true value of the cylinder escapement lies in the fact that the detent frictional surface is very nearly equal in resistance to the impulse; it follows, then, that a considerable variation in the power (mainspring) has but a slight effect on the rate of the watch.

"Troy," *N. Y.*—When you wish to have an answer, why do you not sign your real name? We are at all times happy to extend any information we may possess, and in some cases take considerable trouble to ascertain the true facts; but we do not like to reply to one who does not like to sign his own name to his queries. We have noticed yours more for the purpose of stating our reasons than as a reply.

Miss C. B., *Pa.*—Why should not women become watchmakers? is asked at too late a day. They have been employed for years at all the factories, and we have in our memory one who was very talented in every branch, so far as a mental comprehension of the subject could carry her, but alas! she got married. Do you think she followed the trade afterwards? Not a bit of it; she learned the trade for a temporary pupose, as a means of support. You will see we have no objection to the admission of females as workwomen, but the whole fault lies with the members of the sex.

G. L. B., *Tenn.*—Except the dial feet, there are few watches that have pinned holes, or, to speak correctly, pinned fastenings. The Swiss use screws; so do the Americans in all, and the English in their best watches. Your mistake, as you relate it, has been in using a file that was too sharp, and relying on the cutting plyers for length after the pin has been sent home. Why not try the pin and run your file at the proper place for cutting off? You can break without disturbing the wire in the pin vice.

J. L. *N. Y.*—You will receive the fat rouge you asked for by express. You will find that it is a very superior article for polishing, and at the same time perfectly clean.

AMERICAN

Horological Journal.

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*** *Address all communications for* HOROLOGICAL JOURNAL *to* G. B. MILLER, *P. O. Box* 6715, *New York City.*

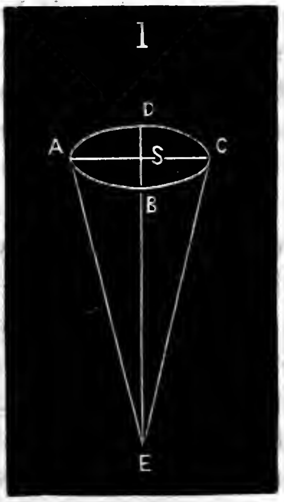
Astronomy in its Relations to Horology.

NUMBER FOUR.

The article in the last number terminated in the consideration of the distances of the fixed stars and the mode of measurement. Though the subject does not bear directly on time, it is so linked in with the whole subject of Astronomy, that a more extended consideration will not be out of place.

Though an approximation has been made to the distance of 61 Cygni, a star of 5.6 magnitude, the result of such an annual parallax is hardly exact enough to satisfy the modern astronomer. The distances of other stars (for instance that of Sirius, the brightest star) are so great that the angle formed by the diameter of the earth's orbit is less than the one-third of a second. The star α Lyræ has no appreciable parallax. It is probable, whatever the degree of perfection to which instruments may be brought, that the distances of most of even the brightest fixed stars must remain forever unknown. The only hope of a solution of the problem lies in taking the velocity of light as a means of measurement. The wave of light propagated from a luminous body undulates in a straight line at the rate of 196,000 miles per second. When it has reached the confines of our earth, however, it is turned out of its course by the difference in the density of ether and the terrestrial atmosphere. The quantity of refraction, however, is so small in relation to the whole space, that it may be disregarded. We have, then, a wave moving at a fixed rate, in a direct line, to furnish us the length of that line. Did we know the instant the wave left the body, and the instant it arrived at the earth, nothing more would be needed, as this is the whole of the problem. This problem may, in the course of time, be solved by obtaining the difference in time it takes a ray to pass from one side of the star's orbit, whose plane is nearly parallel to the plane of the terrestrial orbit. Could we draw that orbit in visible proportions in the celestial sphere, it would appear an ellipse in a horizontal position.

As the star is supposed to be one of a pair called double stars (while their distance is so great that the two represent but one object to the naked eye, they are resolved into two by means of the telescope, one revolving around the other), the central one will furnish us with a point of departure, as in Fig. 1. Let A, B, C, D, be the supposed ellipse, and E, the earth; if, now, we take B as the starting-point of the revolving star, moving towards C, it must follow that the star will be continuously receding from the earth; consequently, increasing the distance, it will appear to take a longer period for the star to arrive at D, than for the time of translation through the other half of the ellipse, D, A, B, to the original supposed point of departure; for the light will take less and less time in reaching the earth. This will furnish the means of



ascertaining the entire distance of both the primary and its satellite. Thus the difference betweeen the greatest and least distance of the satellite from the earth is just the diameter of the orbit, and the difference between the observed times of the two semi-revolutions is twice the time taken for its light to pass over that diameter; the half of this distance being given in seconds and multiplied by 196,000, would give us the diameter in terrestrial miles. Observation gives the position of the orbit, as well as the place of inclination and apparent magnitude of the major axis; that is, we are able, by observation, to find the angle the visual ray across the orbit makes with the major axis, and therefore are enabled to determine the angles that the extremities of the diameter thus measured in miles makes with the centre of the earth. We consequently have the same elements so successfully used in determining the distance of the moon by horizontal parallax; the difference in the two methods being that the bases are in reversed positions to the earth. M. Savary was the originator of this very ingenious method of ascertaining the distance of this class of stars. It must be remembered, however, that time is a very important consideration, as even the shortest revolution known is some 30 years, and a series of observations that must extend over that period would necessarily be subject to many inaccuracies; the success of the whole process, too, depends on the position of the orbit. With these two drawbacks to encounter, it will be a long time before the process is of practical application; there is no doubt, however, of its ultimate success, and that by its means the true distances of many of these systems will be ascertained.

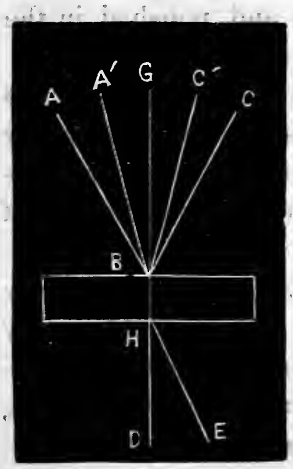
We are not disposed to make any apology for this diversion from the direct relation of Astronomy to Horology, our object having been to give the mode of reasoning by which such distances are measured, and something of an idea of the ingenuity and reflection that have produced such wonderful results. The true beauty of these results can be known only to those who can follow the reasonings of the higher mathematics and mechanics. The general truths and the general principles, however, may be comprehended by many who would not comprehend the most simple equation if put in its algebraical form; and these very minds might be able to find the truth by ordinary reasoning in figures, that would seemingly be beyond their reach if expressed in symbols. The reader will be benefited, even if he cannot follow, at first, the whole train of reasoning; for, by thinking over the subject, his mind will eventually expand so as to take in abstract truths.

It has been stated that light has a measurable velocity, though no attempt has yet been made in these articles either to prove it or show the method of its measurement; and it is necessary to take this velocity into consideration in all observations of angles and distances in space. The study of the laws of light is, therefore, indispensable to a full understanding of the subject of our articles. We should be on a sea of conjecture were we to neglect the nature of light—its refraction, its aberration, and its composition, together with the law of the propagation of its rays.

Light has hitherto been explained on two theories, both in many points coinciding in accordance to observed facts. The oldest theory held that light was the propagation of a material body, infinitely minute in dimensions, and of instantaneous translation in space. This is called the corpuscular theory. There were effects, however, produced by the action of light that could not be accounted for by this corpuscular theory. It naturally would be suspected that these material particles of light falling against the surface of the earth, must accumulate, and finally become visible as a mass, from accretion. Other and more forcible objections finally induced the hypothesis that light was rather the effect of undulations of a very rare ether, which fills all space and permeates all matter. The existence of this ether in space is proved by its retarding force on comets; for one or two of them have had their periods shortened by increased ellipticity of orbit, the result of a retardation in orbital motion. To whatever we may refer the propulsion of these undulations, the theory, of which they are the base, can satisfactorily account for all the phenomena; and therefore, at the present day, all reasoning on light is conducted upon that theory which is called the undulatory. The battle was strongly contested by the adherents of the respective theories. Like all other purely hypothetical reasoning, it would seem that the vehemence and animosity increased the nearer the two agreed with facts; but the undulatory actually kept growing in its accordance with phenomena, until its opponents, drawing off from the contest one by one, left it in the field a complete victor, when Arago and his colleague settled the question by the successful performance of a decisive test, admitted as such by both parties.

It is hardly worth our while to enter into the argument, though much romance is to be found in the early history of the discussion. Strange that mathematical minds could so stray from the realms of reality to adopt the insane, illogical systems of reasoning of the scholasts and metaphysicians.

We shall assume the undulatory theory to be true, and in all the subsequent observations will take it as a sufficient ground to base any explanation of facts observed. Light being the stimulus to the eye in the form of waves, the same as sound is that of the ear by undulations of the atmosphere, the comparison is so close that nearly all the phenomena of light can be explained by the same course of reasoning as those of sound. A ray of light proceeding from a luminous body always pursues a straight line until it meets with some obstacle, and then it is diverted, either by reflection or refraction, and in some cases by both. Suppose a ray of light falls on a plane surface as at B, proceeding from A, it will be reflected from the surface of F, in the line B, C. Now, it is a well-known law that the angle of incidence, A, B, G, is, and must be equal to the angle G, B, C; provided the ray is at a certain angle of incidence all the rays will be reflected at the point B to C; but if the ray proceeded from A′ to B, there would be a distribution of the amount: part would go through F, in the line B, H, thence proceeding in the direction H, E, while the balance would be reflected to the point C′. In all cases it must be remembered that the angle A′, B, G is exactly equal to the angle C′, B, G. This equality of angles is expressed in the rule that "the angle of incidence is always equal to the angle of reflection." This law is good for all surfaces of reflection, for we may consider that a curve is made up of an infinite number of planes, and that from each the same series of rays could not be parallel, for in the curve there could be no planes parallel to each other, however infinitely small we may conceive them. We have in this respect a means of determining the direction a ray of light would take after being reflected; and were all the light incident to a surface to be reflected, the image of an object of observation would have all the illumination of the original. We find that it is not the case, and on inspection we can see that a portion of the light has been absorbed by its passage through the material of which the reflecting plane is a surface. Whether the reflecting material is transparent or not, this effect will inevitably follow. Suppose a transparent medium, a part of the ray will be found to have passed through the medium, but not in the same straight line. By inspecting Fig. 2 we may see that a ray of light propagated from the point A, may be divided into two rays—one reflected to C, the other passing through in a line B, H, and from that point resuming its parallelism to E. Except in the reflecting telescope and the reflected light of the planets, we have but little to do in respect to that part of the ray B, C. It seems, then, that a ray of light must lose unless it falls perpendicular, G, D, to the plane B; but it does lose some, even then, for a plate of even the most transparent glass will not transmit all the light it receives. We, nevertheless, use this deflective quality of light for all instruments, as it plays an important part in all the subsequent observations.



The proposition may be stated in general terms thus: A ray of light suffers a deflection when it passes through two media of unequal density. No body of observation, then, is in the place that it should be if the ray of vision was a perfectly straight line. This is called refraction, and in terrestrial measurements it plays a very important part. We may assign it a very high place in celestial observations when we take into consideration that our atmosphere is about 45 miles in extension from the earth, and moreover that it is of very unequal density in itself; that is, the compression, by its own weight, makes the density diminish from the surface of the earth so much that it is estimated that .9 of all the atmosphere is contained within a space of five miles from the earth. If a ball was let loose from the top of a tower or mountain, two forces would finally determine the course, or rather the path, the ball would take in falling to the earth; if it is dropped, its course will be in a straight line, directed to the centre of the earth; if some propelling power is given it would describe a curve, which, in its turn, would be determined by the amount of propelling force applied in relation to the attraction of gravitation. Now, if we conceive a ray of light projected in space to reach the confines of our atmosphere, we shall find that in its passage through the forty-five miles it will be deflected from its true course; and as the atmosphere differs in a gradual ratio in density, the new line would assume a curve; but as the densities diminish as we leave the surface, this curve would not be an arc of any given circle, and as the visual ray must follow the line in which it meets the eye, we would see the object in the direction of the tangent of the last curve that meets the eye. Such being the fact, it follows that when a star or other heavenly body is projected on the field of a telescope, its observed place is too high or too near the zenith. In Fig. 2, the ray emanating from G will pass in a straight line through the points B, H. The atmosphere is of the same form as the earth; therefore if a ray is transmitted through the atmosphere from any point in the horizon, it will be compelled to traverse the air in the longest line to the earth's surface; but it will also be more deflected than at any other point of passage. Then, to table the amount of this refraction, we should take the horizon at 90° and zenith at 0°; for it is plain that the amount of refraction must diminish from the horizon to the zenith, where it is nothing. Not only is the ray diverted by the air, but the amount of deflection is variable, depending on the temperature and weight of the atmosphere.

Watch and Chronometer Jewelling.

NUMBER FOUR.

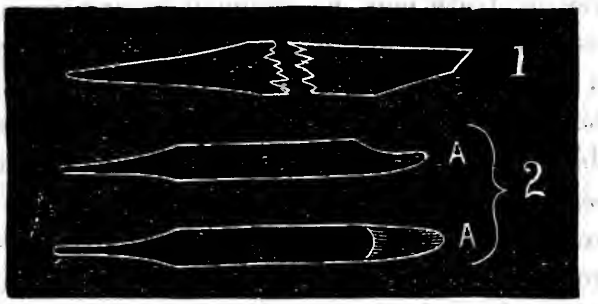
In the description of jewel-making we have taken a soft stone, aqua marine, as the material, and a common plate hole as the form; but there are some slight modifications when ruby or chrysolite is used, and the polishing is invariably done by the use of fine powder. The form of a jewel to which an end stone is to be fitted differs very materially from a plate hole—one side is convex, the other has a plain face and two concaves, the end stone fitting to the convex side. On the whole, however, the process is alike for all kinds of stones, and therefore we need not particularize, but may mention that the jewels for end stones are generally much better made than plate holes, as in chronometers the quality of the work cannot be too good. We might add some few paragraphs on the making of roller jewels, pallets, duplex rollers, etc.; but it is hardly of much importance, for the processes differ only in the shape to be formed—the milling, grinding, and polishing being identical. The English roller pin has generally a flat side, produced very simply, by placing a number of the round pins on a fine-surfaced plate of glass, with a little facing powder; a common cork is now placed on the whole of the pins, and a few strokes of the hand will make the flat surface. End stones are merely turned up on the convex and polished in the same style as the jewel.

We have now followed the stone from the rough up to the finished state, and it is ready to be placed in its seat in the watch or chronometer. This department of jewelling is of more importance to the general watch repairer than the maker, for he frequently has jobs in which a jewel is to be replaced by reason of fracture, or, as it sometimes happens, from its being rough and so cutting the pivot. In such a case if the pivot is repolished it will have too much side-shake. Among some, whose pride of workmanship is of very low grade, it is the custom when a jewel is broken to replace it with a brass bushing. A knowledge of jewelling would break up such a pernicious habit from motives of economy, for in nine cases out of ten a jewel can be replaced in one half the time, and the result will be a good job. Two styles of jewelling are used in the trade: in one the jewels are set directly in the metal of the plate or cock, the Swiss watch being nearly always jewelled in this manner, even in first-class work, and in the majority of English watches the lower holes are thus set in the bar and plate. In the other and best style, the jewels are set in settings, which, having been trued on the outside with the hole, are let in the plate and retained by jewel screws.

In repairing, the Swiss style gives much less trouble than the English screwed jewel-setting, for if the watchmaker has a fair stock of holes he can hardly fail to find one of the number of very nearly the size of the original; such a one having been selected with reference to the size of the hole as well as to the seat, the workman, having removed all the fragments from the jewel seat, carefully rubs back the burnished edge of the seat; he now places the stone in the seat, being very careful to have it have an even bearing; then he burnishes the edge back again over on the face of the jewel. This operation can be performed in one-half the time it would take to fit in a bushing, lay off the depth, drill the hole, and free off the face to get a proper end-shake. The same thing, it is needless to say, can be done in English work, but there is a difficulty, as the setting is generally stripped very close to the stone; this renders the size deceitful, for if the jewel is very thick in the convex it will apparently fit, when in fact it may be too small. In cases where a jewel is to be replaced in a screwed seat, it is best to make a new setting; as in that way the workman may true up the hole perfectly—a matter of no small consideration, for many of the holes purchased of the material dealers are very considerably out of truth.

The first step in jewel-setting is to select the jewels in reference to the size of the holes and pivots; this is generally done by trial, or the workman may open a hole to the right size should he have none that are right. Opinions as to the proper degree of side-shake are somewhat diversified; and again the same degree would not be advantageous, as applied to the whole train; and again, in English watches wheels and pinions are very frequently seen out of upright, which condition would render a larger degree necessary, or the pivot would bind on opposite corners of the hole. As a matter of course, no wheel should be out of upright; but this fact is discovered in a large proportional number of English levers. This want of truth is sometimes a great annoyance to the workman, especially in repairing; for he must cut out the holes in the plate to receive the jewel-settings from the centre of the pivot-hole in each plate; were they true he could upright the frame, and cut the holes by taking but one centre, and without removing the pillar-plate until the job is finished. In sizing the holes for the pivots, unless the workman has had some considerable experience, mistakes will very often occur, even with brass holes. A gauge can be made that will give the sizes with great accuracy, provided a good split-gauge is at hand; it will require some little trouble to make it perfectly true, but a sufficient degree of truth may be attained by any one accustomed to the use of the file and split-gauge. In the first place, a piece of good wire (steel) about 3½ inches long is filed as nearly as possible to a regular taper, ending in a fine point. This may be rendered a true taper if the workman will get a machinist to plane a groove with a diamond-shaped tool in a block or bar of steel; he can get the requisite taper by elevating one end of the bar when in the plane this steel should be hardened to the highest point. The needle now may be filed up in the taper groove thus planed; the sides of the taper will be straight lines, and the truer the face of the block the truer the lines. The large end of the needle is now inserted in a small block that is fitted to a bar of brass, and the small end projected through a small nozzle at the end of the bar; it will be understood that the block and needle are free to move on the bar. If, now, we make the nozzle a stand-point we may, with the split-gauge, place the needle, and consequently the block, at any degree marked on the gauge which rests against the nozzle; the degree may be marked off on the longitudinal bar, and thus a mark corresponding to every degree on the gauge may be made on the needle-bar. The longer the taper the more delicate the instrument will be.

This mode of mensuration for the side-shake has an additional value, inasmuch that it habituates the workman to use known quantities, rather than trust to the rule of thumb. The split-gauge that is the basis of measurement is easily obtained in a form that combines the whole range of watch sizes, from the finest pivot to the largest watch-glass. We now refer to Dennison's combined gauge, an article indispensable to every watchmaker, who may, by it size wire or plate to all the sizes indicated by any Stubbs' gauge, also the diameter of wheels and pinions most perfectly. The price is very moderate, when the wide range of sizes is considered.

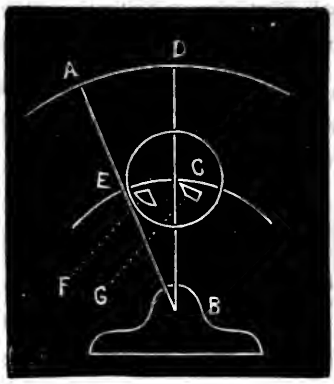


The side-shake having been determined, the first step is the setting There are a few small tools used in this operation that are worthy of an illustration. The Figs. 1 and 2 are respectively a cutter and burnisher. As a matter of course, the sizes are arbitrary, in order to suit all kinds of work. Fig. 1 is the general form of the cutter for centring, made of flat steel, and ground in the form represented. To make a proper concave seat for the jewel, the corner should be slightly rounded The Figs. 2 are the burnishers, not only for jewelry setting, but extremely useful in a variety of the ordinary watch repairs—made of common Stubbs round wire, the end being first turned up round, and a flat filed on one side; the corners are rounded off, and a tang forged on the other end. The acting end is now hardened, and then drawn soft from the tang to about an eighth of an inch from the point. The rubbing surface is now to be made uniform with oil-stone powder, and then finished with rouge, until a high polish is effected. While using, a piece of sole leather is found valuable to preserve the necessary surface. It, like the cutter, is put in a good handle, and forms, as said before, a handy tool on very many occasions, such as setting stones in jewelry, etc. These tools having been provided, if the operator has no spring chuck, he screws a piece of brass wire in the lathe mandrel, and drills a hole in it, first centring it with the sharp cornered tool No. 1 in the cut. The hole, of course, is smaller than the external diameter of the jewel to be set, and the shoulder turned in is to be of the exact size, leaving it with a bevel for the convex of the jewel to rest on. It will be obvious that, if the jewel is not true on the convex, the plane of the face will not come true when rubbed in; if it does run out the burnisher is liable to slip off and break the stone. The shoulder having been cut, the jewel is now introduced, and, in order to make it stay, is slightly wetted. The setting is turned off at a slight bevel with the true face, and by means of the burnisher the edge of this bevel is rubbed down on the slight chamfer and face of the stone; the burnished edge is polished by means of a piece of cork, dipped in rouge, and applied during a few revolutions of the lathe.

In this operation nothing but a hand tool has been supposed to have been used. If, however, a large number of jewels have to be set, it would become tedious as well as unprofitable to set them by hand. This was more especially the case in the inception of the watch manufacture of the United States. A large number to be set and but few to do the work, it became a very perplexing problem to do the required quantity in the old style. Mr. E. Howard, one of the proprietors of the Boston Watch Company, comprehended the difficulty, and set his active mechanical brain at work to devise some way by which the jewel might be set true without skilled labor. And here it will not be out of place to pay a tribute to Mr. Howard for the services he has rendered to Horological pursuits in the United States. We will not point to the Horward & Davis clock—is it not seen wherever time is of any importance?—but the firmness, sagacity, and almost intuitive knowledge of mechanics that he possesses will not be fully understood for years; and yet to no one man are the United States so much indebted in so far as the manufacture of watches is concerned. We remember the dark days of its history, when the infant was unable to walk—when everything was to be almost, as it were, created; even those who were to do the work had to be educated. Perhaps as good a pun, or play on words, was never made than by Mr. H., when, in explaining before a committee the hard lines the Company had passed through, one of the gentlemen remarked: "Why, Mr. Howard, you ought to be knighted!" "Why," said Howard, "I have been '*be-nighted*' for the last three years." But it was not so easy a task to navigate the watch factory through the stormy financial seas. In the mechanical parts, however, Mr. Howard was triumphant; not that he invented even a tithe of the processes and tools, but he had the sagacity to appreciate the value of any plan which might be submitted, and he had the firmness to carry out the idea, in the face of all the opposition of those who should have aided—indeed of the absolute treachery of those in his employ. We do not assert that he was the entirety of the watch making, but we will assert that he has done more than any other one man to bring the watch manufacture to its present high standing in this country. With this passing tribute we will rest at present, but shall, in a future article, give the reasons, *in extenso*, for our assertion.

We take the more pleasure in thus recognizing the worth of one of the earliest pioneers in watch work in the United States, from the fact of having been in his employ for some time, and having had the opportunity to notice, not only his general kindness and true-heartedness, but that strong mechanical will that, while it criticised unmercifully any plan offered, was always open to conviction on a reasonable demonstration.

Mr. Howard *did* invent the SWING REST, and as the principle is founded on true geometrical premises we will try to give an outline of its general construction—premising that the point of departure is in every case the absolute geometrical centre of revolution of the mandrel of the lathe, and also that in this case the spring-chuck is used in connection. As handy as the shellac may be, it is expensive, when the operations are repeated an infinite number of times. The setting is a piece of punched brass, a little larger than the size required when finished, and is held in the jaws of the spring-chuck as any other piece of work, by the external circumference. A hole is drilled in the blank first, and then a cutter, represented at F and G, in Fig. 3, is used for getting the true size of the jewel. Let C represent the centre of the lathe-mandrel, and the circle a hole we wish cut in the metal held in the chuck. Now, if we make a rest to carry the cutter, hanging on a centre at a point below C, say B, with the cutter at E, it is evident that the point or cutting edge of the cutter will preserve its relation to the circle, however far we may swing it from the centre, C but in all cases C and E are equally distant from the point B; if, now, we continue the lines B C to D, and B E to A, the arc between the points A and D is twice the arc E and C; but when one side of the circle, of which C is the centre, is cut away, the diameter of the hole will be increased by twice the amount of the cut; therefore, if B A should be moved towards D, until it coincides with B D, and the edge of the cutter point F coincides with C, the whole axis of rotation would be in the same straight line with the cutter. Now D being stationary, and A movable, if an object, say a jewel, is laid on the arc A D, it will measure its own diameter in the cut at the arc E C. As a matter of course it will strike the reader that the distance B C, or B E, must be exactly equal to C D, or E A. The line D B represents a solid part of the rest, while A B is a frame pivoted to the rest at B, and is movable forward, that is, toward the workman; the tool is held by means of a spindle moving through the frame at E. This rest is not confined alone to jewelling, for it can be adapted to every variety of watch repairing, pivoting, polishing, or facing, and might be applied to any existing lathe with the most gratifying results.



Watch Dials.

In no one particular has so much improvement in the general appearance of watches been effected as by the really elegant hard-enamelled dials of the present day. Any one, by referring to an English or Swiss watch, even of superior quality, that was made thirty years ago, will be struck by the inferiority of the dial to those now placed on even the cheap class of watches. The most beautiful are undoubtedly those on the first quality English watches—the painting equalling the Swiss, while the surface has a softness of tone that renders the figures perfectly distinct when viewed at any angle. The American watch is, in this respect, in advance of the Swiss, and is fast rivalling the English.

The chief points of excellence to be sought in a watch dial are an even surface and uniformity of tone, combined with a granular appearance, something like the exterior of an egg-shell. The painting is distinct and not glassy, and baked in, to leave the corners as perfect as possible. The great defect in the Swiss dial is the glassy surface, as it interferes with a good view, unless held in certain directions in relation to light. However, no one can fail to admire the dials of Swiss make, even those on the cheapest class of work. The whole process of making is exceedingly curious—requiring tact, judgment as to the rates of expansion and temperature, and no little artistic skill to paint in the figures, etc. The base on which all hard dials are enamelled is copper, rolled as thinly as possible consistent with strength, and, for reasons given hereafter, must be perfectly pure, or at least should be, if we wish to get a uniform tint or color on the surface of the enamel. This copper plate is next cut into sections, so as to get the different bases for the various-sized dials. In the foreign way the circular disks are cut out by pattern, as the diameter, greater or less, of each watch movement may vary from others; but in the American watch, the sizes being determined, the dial copper blanks are punched to the right gauge, allowing for the small rim that is turned up on the disk, in order to hold the enamel. This rim is made either by burnishing the copper over a block with a hand tool, or it may be drawn up in a swidging punch and die—the last being the best, but limiting the number of sizes; the centre and second holes are now punched of the proper sizes, and the edges drawn up from the back to form a rim, to answer the same purpose as that on the edge of the copper.

The dial feet are put on the back by solder that is but a little easier fused than the copper; the feet are cut off from the wire, and one end squared up so that it may stand alone when placed in its position on the copper blank. This soldering is done entirely on the back, in order to keep the front of an equal quality of surface metal. It is obvious to any one accustomed to soldering, that there can be no certainty as to the exact position of the feet after being soldered. In the English or Swiss watch this variation of position is not of much importance, as the dial feet holes in the plate are made to accommodate the position of the feet; but in the American system, the dial feet holes in the pillar plate are the points of departure from truth in all the subsequent operations on the movement, therefore their position *must* be always the same; no more, if as much, latitude being allowed than in planting an accurate depth. In the earlier stages of the manufacture of watches in the United States, the dials were imported from England, and the above difficulty was encountered at every step.

Well do we remember the efforts made to remedy the trouble, such as sending to the dial-maker in England a form with the holes correctly drilled; that failed, for the workman *broached out the holes to fit the feet.* Next, a steel form was sent, hardened to the highest degree, to prevent the broaching process; it availed nothing, for with a mechanical sagacity, almost equal to that possessed by an angle worm, the workman drew the temper, and again resorted to the broach.

Thus it became an absolute necessity that the dials should be made in the factory; and necessity, as ever she must, triumphed, and now the American dial will bear comparison with the best made.

The copper base is now cleaned of its oxide, and is ready for the reception of the enamel. As a broken dial is past remedy, the watchmaker can have no interest, save a desire for knowledge, to inquire into the minutiæ of enamel; still, to know the whole range of his trade is the duty of the artisan, and we therefore deem it worth while to give a somewhat extended description of enamel and its mode of application, together with a few remarks on its chemical relations.

The composition of all enamels is that of glass, and a good treatise on that article would give the reader a comprehensive idea of the material used for dials. There are some few distinctions, arising from the low point of fusibility, and the large amount of metallic bases used to give the requisite opacity and body.

Silex is the acting agent in all glasses, and chemically unites with the various bases, the same as any other acid. It seems strange to view common sand as an acid; but such it is. Silicic acid, which in contact with metallic bases, such as potassum, sodium, lead, tin, and arsenium, and subjected to a high degree of temperature, attacks the bases and forms silicates. The action is very energetic and the resulting salts are with the greatest difficulty decomposed by any ordinary chemical process. Enamel is composed of such salts as the double silicates of potash and soda, and also of lead and tin, and a silicate of arsenic.

It is made by introducing into a crucible composed of a highly refractory clay, proportional parts of finely powdered quartz, potash, soda, tully powder (lead and tin), and arsenic, and the crucible is now exposed to a high degree of heat. Fusion takes place, and after arriving at the liquid condition the whole mass is in an active state of ebullition, resulting from the chemical changes. Oxygen being set free in large quantities, after a while the combinations are effected, and the whole settles down to a quiescent liquid state. The crucible is now withdrawn from the furnace and its contents poured out on an iron plate, where it cools in the form of an irregular circular disk. As to the proportions used, little need be said, for every enamel maker has some favorite formula of his own, which he strives to keep secret. We may observe that they will be determined by the fusibility it is desired to have, and the peculiar surfaces required, while colors are obtained by the same agents that are used in any glass staining. We have mentioned that the face surface of the copper base should be of uniform purity of metal, and it should be perfectly and chemically clean, as silicic acid attacks the oxide of copper with nearly as much avidity as that of lead, and were the surface oxidized, the enamel would take up the oxide when it is fused on the base. As the figures and names are fused on the surface of the white enamel, it will follow that the fusibility of the colored enamel must be much below that of the ground on which it is fused.

The cake of enamel is now ready for use, provided it is not found on trial that the chemical action has been incomplete. And this is no uncommon case, for when baked on the copper the apparently homogeneous enamel will be found to have held in suspension metallic lead in very small particles, and these, when exposed to the baking heat, are again acted on by the free silicic acid, and the result will be yellowish spots, more or less in number, on the surface—one only spoiling a dial. This may be remedied by boiling the powdered enamel for some time in nitric acid, and then washing in cold water until all traces of the acid disappear. The dial-maker generally pulverizes the enamel in an agate mortar, lest some extraneous substance should be added. This powder is not fine; indeed it is washed in water in order to get the coarse grains separated from the dust; the coarse variety being used for the face, while the fine is applied to the back. The workman keeps the powdered material under water, and applies it to the copper in the form of a paste, using a common spatula for the purpose, and with which he very carefully fills the cavity formed by the raised edges; the superfluous water is allowed to run off, and it is still further dried by means of a clean towel. Much experience is needed to judge of the proper quantity, and also to spread the enamel paste evenly. The whole is now set one side to dry, when it is ready for the muffle, which is nothing more than a miniature oven, placed at the point of greatest heat in a furnace, exactly like that used by the artificial teeth manufacturer. At first sight it would be thought that a number might be baked at once, but it is not so; for, during the whole time of baking, the dial must be kept in constantly changed positions, and in effecting this the workman displays a tact that can be acquired by long practice only. A pair of spring tongs about 5 feet long, with narrow points, and a small block of fire clay, shaped like a half sphere, and placed in the muffle at the point of most intense heat, are all the tools he uses. The copper, with its enamel, is carefully taken up by the tongs and placed upon the little block; the action of the heat is closely watched, and on the first appearance of fusion the tongs are again introduced, and the dial is rotated on the block in accordance with the uniformity of the fusion, which is effected in a few moments, when it is withdrawn and laid on a ring of fire clay to cool.

The dial now presents a somewhat uneven, glassy surface, which is removed by grinding by hand with a stone of a coarse sharp grit. It is now ready for the operation of painting. Here again tact is required, and a person watching the operation would admit the truth of the assertion; the rapidity with which the operation is performed, and the procision of the lines, render the process of interest. The dial painter has before him a small revolving table, divided and arranged like the index plate of a cutting engine. Across the table, but not touching it, runs a bridge, the straight edge of which passes directly through the centre of the table. The black enamel which is to be used is ground up fine and mixed with a mucilage of gum, thus forming a species of water color. Having placed the dial on the table, truly central, he covers those parts of the surface on which a figure is to be placed, with the gum and enamel; thus there will be twelve daubs of a brownish black paint, large or small, according to the space to be occupied by the figure; the paint is now allowed to dry to such a consistency that it will cut smoothly, when the painter, with a point of bone or ivory, rubs out all the superfluous color, leaving the figure in strong contrast with the white face of the dial. The name and circles, also the minutes and seconds marks, are painted in with a small brush. The dial is now ready to be again fired, in order to give a fused face to the ground surface, and to attach the color. When the dial has been sufficiently heated, it is cooled off gradually, when it will be found that the brownish black has become a perfect jet. The dial now has the copper edge gilded, and it is ready to be put on the movement. If, however, it is desired to have a sunk centre, or seconds, there is another and very tedious operation. A number of dials, perfectly plain, but much thinner, are prepared from the same enamel, in order to furnish the stock for the sunk part. The true dial is now placed on a block with a centre that takes, say the seconds hole; this centre is in line with the grinding tool, which is nothing but a short piece of copper tubing, fitted to a revolving spindle. The edge of the copper tube is notched slightly, in order that it may hold the emery used in grinding through the enamel to the copper base of the dial; the pressure on the grinder must be light, owing to the fragile nature of the material. When a circular groove has been ground to the base, the dial is reversed and a similar groove is made through the enamel, on the back. The face of the dial is now covered with varnish or wax, and a wall of wax is built up around the groove to furnish a sort of cup, which is filled with nitric acid.

The copper is eaten out by the acid, and the dial is cleaned, and the edge of the enamel surrounding the hole is polished with tripoli and water. The false dial is then turned up and fitted to the hole from the back, and then cemented in with bleached shellac. In polishing the edge, great care has to be observed that the enamel may not be chipped. The whole operation is one of great delicacy, and the number of good sunk dials obtained is small in proportion to the number broken in the attempt.

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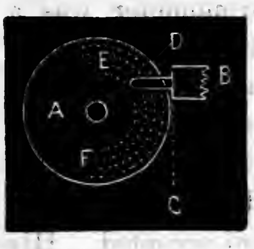
Solders.—In the article on soldering we neglected to mention the fact that very fine and elaborate work is effected by using solders of different degrees of fusibility; for instance, a plate is soldered on with two carat gold; on that, another piece with silver, and so on; each subsequent solder being more fusible. In this manner jobs may be repaired that it would be impracticable to do by any other process.

Pinions.

In the ordinary style of English work, the pinion leaves are polished with a straight motion of the polisher by hand—the polisher being held in a frame that permits longitudinal and vertical movements, but not lateral. In fact this is the mode of polishing adopted in even the very best work. It will strike the repairer that it is very unsuitable for his purposes; but there will be found in the article on the lathe in the last number a small apparatus that may be easily applied to any lathe, and what is more, is within the power of any workman to adopt. The swing in this case would be used for pivot, staff, and face grinding and polishing. As a matter of course, the face work is done by the face of the polisher instead of the edge, though, if set at right angles to the line of the staff, it should face the ends of the leaves as well as polish the staff, simply by a species of slide motion in a line perpendicular to the axis of the mandrel on which the polisher is swung. In this case the edge of the iron disk would do the facing, while the staff would be finished on the flat. Now, a very slight motion of the disk would change the relative positions in a much greater porportional degree than could be done by means of a rectilinear polisher.

We give a small diagram that explains our meaning. Let A be the polisher, with the pinion B E chucked in the lathe mandrel. Now, if while the polisher A is in motion, it should be vibrated backwards and forwards in the line C D, it will at no time be in the same relation to any point on the pivot E, for it being placed in the chord of the arc measured by the intersection of the line C D, therefore the full conditions for good polishing will be effected. It must be understood that a polisher, however well made, will leave the surface of the polished work uneven, if the relative positions are not very frequently changed. For this reason, in polishing the inside of watch cases, the polishing buff is made to revolve backward and forward as often as possible in relation to the speed of the lathe mandrel. From the difficulty of obtaining this desired change of position, it is troublesome to get a good polish on the pinion leaves by means of circular polishers; it might be done, however, if the whole frame was carried on a slide over the pinion, with just vertical motion enough to give a slight difference in the pressure. The parallelism of the leaf would not be so perfectly attained as by a straight polisher carried in a guide frame. The watchmaker may, in a general way, on steel work, make himself independent of the tool store, if he will only reason upon the various things to be done, and make occasionally a small tool, such as a little centre milling tool for male centres, one for centre drilling; and even if he has nothing but a common head centre lathe, he may still apply the same principles—not so handily, it is true, as on the going mandrel. The best material for grinders and polishers is, for the first, soft iron, and type metal for the last. We say type metal, for it is easily obtained and wrought. The watch repairer should not be content with the faces left on finished Swiss or English pinions, but should finish them up, if for no other purpose than to show that he is a good workman; but there is a real practical value to a well-finished face, as it does not draw the oil off from the pivot by capillary attraction, as it would if the surface is left rough. That this would be the case, any workman may decide for himself if he will let fall a drop of oil on a plate of polished glass and another on a ground surface. The oil on the rough face will be found to spread over the surface, while the clean surface of the polished glass will retain the oil in a globular form, from the attraction of cohesion in the particles of oil predominating over that of the faces given by such a perfect surface.



As to the proportions of pinions to the wheel teeth and the diameters, we hardly deem it within the scope designed in the article on the subject. There is no one in the trade but has at some time or other been called upon to put in a new pinion. Now, the object was to give some hints that might lessen the labor and perplexity attendant on such an operation, by giving the processes in vogue. The mathematical relations can hardly be considered of any importance, unless we went into a discussion on the theory of wheel teeth, mathematically considered. In so much as pertains to the mechanical manipulations, all has been told that is of importance to put the workman on the road to reasoning out his proceedings when he wishes to do a good workmanlike job.

Edmond J. Dent.

We can hardly look back into the past history of Horology without every once in a while finding the above-named gentleman in some way or other playing a very important part. His clear mechanical perceptions and true mathematical reasoning prevent our being astonished at the very important niche he occupies in Horological memory. It was on the eighth day of March, 1853, that his spirit left the shores of time to investigate eternity. He was born August 19th, 1790, being therefore 62 years of age at the time of his demise.

The services rendered by Mr. Dent are not to be estimated solely by his mechanical execution, but should be valued by the vast amount of good done in calling out the purely scientific reasoning faculties of those engaged in the watch trade, or, more properly speaking, in Horology, which in England at that time, as well as at the present, was not confined to the mere mechanical craftsman. E. B. Denison, Q. C., and Mr. J. M. Bloxom were actives members of the Horological Institute, while other distinguished names were on the rolls. It is not to be wondered at, then, that Mr. Dent received so much encouragement. He may be said to have lived in a transition stage of Horological science, and he led the movement.

Mr. Dent was not at first intended by his people for the watch trade, but a natural impulse decided his future career—one again of the many thousands that have had their whole terrestrial course determined by their own predilections. The Bros. Callame were at that time in full operation in Castle street, Longacre, and they manufactured with much celebrity what were called "repeating motions," under the instruction of Mr. Rippon. Mr. Dent became a very fine workman. During the period from 1815 to 1829 he was constantly employed by Messrs. Vulliamy & Son., and Messrs. Barrand & Son. His knowledge of the chronometer was widely extended under the tutelage of the last-named firm. Eaneshaw had set him the example that if he would succeed he must become a practically skilful workman. The example was not lost, for so assiduously did he labor at his craft that work was soon intrusted to him on his own account. The full meaning of that fact can only be appreciated by taking into consideration the great difficulty there always is anywhere, and in particular in London, to induce the public to try a new-comer in the trade, against old and well-established names; and at this time Dent was struggling against Horologists whose reputations were deservedly high. His high attainments were recognized by the Admiralty and the East India Company, and he had the high honor of being called on by the Royal Observatory, at Greenwich, to change the escapement of the transit clock that had been supplied by Hardy. A new Graham escapement was put in, and the working gave the highest satisfaction to the Astronomer Royal.

In 1829 he placed on trial at the Observatory, the chronometer "Dent, 114." The superior rate of going was a guarantee, not only of his skill, but of his future success, and from this time "Dent" on a chronometer was a warrant for good performance. At this time Arnold, a very celebrated maker, was in business in London, but his attention was more particularly directed to theoretical investigations. Mr. Dent was offered a partnership in this establishment in 1830, and accepted. His whole time was devoted to the direction of affairs in the workshop, while Mr. John Arnold resided in the country, engaged in chronometric experiments.

It was but a few years before the reputation of the firm of Arnold & Dent was of the very highest character. During these years Mr. Dent had not been idle. His attention had been called to a cheap and convenient method of obtaining time by transits of the sun.

Mr. J. M. Bloxom, a barrister in good practice, invented the Dipleidoscope, and had taken out a patent, but assigned it to Mr. Dent. This instrument was perfected and made by Mr. Dent, and for close approximation it has been found to answer nearly as well as the transit.

But we are also indebted to Mr. Dent for some very valuable observations on hair springs. Steel, gold, and palladium were successively experimented on. Scrimgeour, of Glasgow, had invented, in 1828, glass hair springs; to these Mr. Dent paid great attention, and his observations led him to have a high opinion of their efficacy—requiring, as they did, such a small range of compensation. Mr. Dent was not content with pursuing these investigations merely for his own advantage, for he gave his results to the world in his tract on the Dipleidoscope in 1843, in sundry communications to the British Association, and in a masterly paper on secondary compensation in the Nautical Almanac for 1833. In 1838 he laid before the British Association his observations on the mercurial pendulum, using a cast-iron jar. This particular mode of compensation was invented by Mr. Jones, of Charing Cross, and was adapted by Mr. B. L. Vulliamy to the clock in the transit room at the Observatory of Dr. Lee, at Hartwell. With this improvement, Mr. Dent instituted a series of experiments on the additional compensation required for the pendulum spring, and which had been noticed by D. Bernoulli as early as 1717, and fully confirmed by Berthoud in 1763; it was on this that Loseby founded his experiments on the additional compensation.

Mr. Dent was active in the dissemination of what new discoveries he might make, by lectures before the Royal Institution, the United Service Institution, and by papers published in the Transactions of the Royal Astromomical Society, and he was gratified and honored by a vote of thanks from the Royal Irish Academy, for his valuable services in the determination of the longitude of Dublin, as well as of Armagh. Again, in 1843, the Emperor of Russia ordered a gold medal to be presented to Mr. Dent for amount of good rendered to commerce by his chronometers.

In 1840 the firm of Arnold & Dent was dissolved, and Mr. Dent established himself near the old locality. With such a reputation as he then enjoyed, there could be no doubt of pecuniary success. Accordingly, the business became very lucrative, so much so as to induce him to open a depot in Cockspur street and another in the city. Mr. Dent had placed the chronometer (114) on trial in 1829, and, as said before, the result was so satisfactory as to establish him as first among the makers, four years after he announced his theory of secondary compensation; that theory has been corroborated as to truth since then, too thoroughly to leave any doubt as to its correctness. Now, we may know the value of his investigations, if we see what really double compensation is. If a chronometer has been adjusted to a mean temperature between certain points, it will be found to lose when the temperature is much in excess of that used in the adjustment, and the same effect is produced if it falls below; that is, the instrument will lose in its rate out of its normal temperature of adjustment. Again, if the instrument is adjusted to extreme degrees, the resulting rate will be a gain when in mean. Mr. Dent, reasoning on the subject in the Nautical Almanac for 1833, says: "The diminution of force in the spring proceeds uniformly in proportion to the increase of heat, and may therefore be represented by a straight line inclined by some angle to another straight line, which is divided into degrees of temperature. But the inertia of a compound balance, such as I have described, cannot be made to decrease quite as fast as the heat decreases, and therefore its rate of variation can only be represented by a curve, and can therefore only coincide wlth the straight line representing the variation of the force of the spring in two points—either the two extremes or the two means, or one extreme and one mean. In other words, the compensation can only be exact for some two temperatures for which you may choose to adjust it."

As the preceding states the case very completely, it would be of little use entering into the mathematical discussion so elaborately worked up by Denison. Mr. Dent's records at the Greenwich Observatory are not to be lightly estimated. Denison, in his work on clock-making, makes the assertion that in general the best chronometer is not equal in performance to a good astronomical clock—that is, in steadiness of rate. Denison even includes some turret clocks in this category of high rate. Now there can be no doubt of the severe tests given the chronometers on trial at the Observatory, and it has been only a few years back, comparatively, that the extremes were so widely separated—say 100° of temperature; and though a few were equal to the clock rate in the trials of mean temperature, Mr. Dent only succeded in obtaining the best rate under the new regime—namely .54 sec. per day. Mr. C. Frodsham was next best, his recorded rate showing a variation of never more than .57 sec. These rates, it must be observed, were taken from the trials at Greenwich, with the full difference of extremes equal to 100°. Mr. Dent did more than merely make a good chronometer; he himself invented automatic tools, by which to lessen the cost. But still more ingenious was the simple method of simultaneously effecting the primary and secondary adjustments of compensations within the ordinary range of temperature; but it was not capable of standing so wide and artificial a range as that which the Observatory requirements demand of an instrument.

Mr. Dent, however, owes his reputation not more to the chronometer improvements than to those he introduced into the clock manufacture; and into his department of Horology he dropped quite without his own consent—certainly not with any intention. The Royal Exchange had determined to have a clock, and, to make sure of its quality, the Committee consulted with Mr. Airy, then Astronomer Royal, as to the requirements necessary to be demanded for such an instrument. Mr. Dent put in a bid for its construction, his calculations being based on co-operation with other turret clock-makers. In this he failed, and was forced to seek the aid of M. Wagner, of Paris, then a very distinguished manufacturer. Here he was successful, and from this moment he might consider his troubles ended; but a new difficulty interposed: the custom-house regulations were such as to compel him to rescind his contract with Wagner. With his accustomed determination, Mr. Dent now got up new machinery of the best construction, and did build the clock for the Royal Exchange, which was approved by the Astronomer Royal. Mr. Dent now had a workshop within which he felt able to carry out the turret clock business to a great extent. He not only reduced the cost, but equalled in quality the Paris turret clocks, which at that time were the best known. As late as 1851, Mr. Dent received the Council medal, class X. R, for a large turret clock. In 1852, the order for the much praised and much abused Westminster clock was issued, and given to Mr. Dent. He did not live to finish it, but had the gratification to see the success of a new gravity escapement, invented by Denison, in which "the pendulum, weighing 6 cwt., is kept going by a scape-wheel, weighing little more than a half an ounce."

The compass, also, was an object of Mr. Dent's active inventive mind, and his method of hanging one that should not be disturbed by the action of a heavy sea or firing of heavy guns.

The period of Mr. Dent's useful career was now drawing to a close; thirty-eight years of active inventive life were quite enough to enfeeble his physical powers. He had associated with some of the best minds of the Horological world, had enjoyed the esteem and highest respect of those associates, and in 1853 yielded up a well-spent life.

The fact that such a man has existed is of no small importance; he is a representative point in the past, and we must all reverence his memory.

Eclipse and Shipwrecks.

"During the twenty-four hours of that disastrous day (the 7th of August), four fine sea-going steamers went to pieces in the fog on the Atlantic coast—three off Newfoundland and one off Savannah. In each case the query arose, How came the vessel to be so far out of her course? It is not easy to answer it without supposing the ship's compasses to have been useless. For nothing is more common than for a sea-going ship to run through fogs as dense and continuous, hardly deviating from its course a hundred yards in as many hours. Such a coincidence of disaster, therefore, in so many first-class steamers, commanded by officers of skill and experience, and furnished with the best appliances known to the science of navigation, seems to negative the theory of simply bad steering, and to excite the suspicion of a magnetic disturbance of the ship's compasses. Comparing days and dates, we find that the variations from the true courses very probably took place at or about the time of the eclipse of the sun. We all know that the latter event produced great atmospherical changes, and a rise and fall of no less than 40 degrees in as many minutes. The magnetic currents may have been influenced by these sudden changes of temperature."

The above, from the *New York Times*, suggest thoughts that will hardly rest satisfied with the mere reading. Four ships already heard from on that day—and who can tell how many more will be recorded?—have gone the way of shipwreck from defective courses, as indicated by the compass. We would hardly be justified in assuming it to be a mere coincidence, that two ships were wrecked on the same coast on the same day, the fog only being an element of error. As the editor says: Sea-going ships do and have been run in the densest fogs. The magnetic disturbances incident to changes taking place on the surface of the sun are well known, as the following facts will show: Two independent observers, at different points, on the same day, and same hour and minute, while noting the sun's disk, were surprised to see the actual commencement and progress of a sun-quake. Dr. Wollaston thus describes what we have demonstrated sun-quake:

"I once saw, with a twelve-inch reflector, a spot which burst to pieces while I was looking at it. I could not expect such an event, and, therefore, cannot be certain of the exact particulars; but the appearance, as it struck me at the time, was like that of a piece of ice when dashed on a frozen pond, which breaks in pieces and slides on the surface in various directions."

Now, what he has thus described was exactly what was seen by the two observers. When the returns of the various magnetic observations, taken at many different parts of the earth, were inspected, it was found that on that very day and hour and instant of time, a magnetic storm had swept over the face of the earth. We need not be surprised if we find an astronomer asserting that such a coincidence of facts indicates the magnetic influence of changes that take place on a portion of the sun's surface only, for we must recollect that the spots observed on the sun are of a magnitude that makes our earth, in comparison, but an atom. Some idea of the dimensions may be had by a consideration of the following items:

"One measured by Pastroff in 1823 had an area four times larger than that of our earth. In August, 1859, a spot was measured by Newall, which had a diameter of 58,000 miles, a length exceeding more than seven times the length of the earth's diameter. But spots even larger than this have been observed. For in June, 1843, Schwabe measured a spot which extended over a length 74,816 miles. The spot was visible for more than a week without optical aid. On March 15, 1858, the observers of the great eclipse saw the moon pass over a spot which had a breadth of no less than 107,520 miles. In the same year the largest spot of any whose records have reached us was observed by many persons without telescopic aid. It had a breadth of upward of 143,500 miles; so that across it no less than thirteen globes as large as our earth might have been placed side by side.

But we need not go back to past years for the records of spots of tremendous dimensions; within the last six months gaps have opened in the sun's surface which will bear comparison with the largest that have yet been observed by astronomers. Mr. Browning, at a late meeting of the Royal Astronomical Society, exhibited a picture of an enormous spot bridged over by two strange streaks of light, formed, as it seemed, of interlacing flakes of a somewhat lengthened figure. An aggregation of clustering spots observed by the same astronomer was found to have a length of 97,700 miles and a breadth of 27,130 miles."

Changes taking place over such large surfaces, even at such an immense distance, may well be expected to exert a great influence on the condition of the earth's magnetism; but one may not depend entirely on supposition. There are concomitant facts which have been observed times enough, and through a period long enough extended, to raise us above the science of probabilities. In the discussion, we need not inquire into the material of the sun's mass, nor need we consider the constitution of the photosphere, but may assume that the earth is a body in a state of transient magnetic induction.

Mr. Barlow, whose researches into the subject of magnetism, and consequently of polarity, give weight to his opinions, has proved that the magnetic power of an iron sphere is in the surface only; his next step in the investigation was to find the action of the surface of an iron sphere, while in a state of transient magnetic induction, on an astatic needle; that is, one insulated from the action of the magnetic force of the earth itself. M. Poisson corroborated the facts deduced, by a very masterly analysis, and, furthermore, M. Biot confirmed them, so far as the theory of magnetic induction is concerned, from Humboldt's observations. It is hardly necessary to give a full description of the various experiments, but one is so striking that a resumé will not be out of place. Mr. Barlow constructed a wooden globe with a spiral groove cut on its surface from pole to pole, in which a copper insulated wire was coiled. When a current of electricity was passed through the wire, an astatic needle went through all the phenomena exhibited by the needle on the earth's surface. Now, electricity can be produced by heat as well as by motion, or active chemical combination, and if the wire was duplicated, and formed of two metals, say bismuth and antimony, the exposure of any part of the surface of the sphere to heat, would set into activity an electrical current that, by induction, would affect the astatic needle, as in the first experiment.

If we apply the facts to reasoning on the magnetic relations of the sun and earth, we may easily imagine that the earth is a sphere magnetized by the sun by induction; and we are sustained in the supposition by the ascertained fact that the moon is acted upon by the earth in precisely such a manner. This fact being then taken for granted, we might expect that, the moon being between the sun and earth in a straight line, some magnetic disturbance of the needle would take place; that is, the combined effects of the sun as a direct magnet, and the moon as an inductive, similar to the effects of position in spring and neap tides, where the attraction of gravitation is modified by the sum or difference of the relative masses, distances, and position of their bodies. We can conceive this the more readily as the facts go to indicate that a magnetic storm was in progress from daylight in the Pacific Ocean until sunset in the Atlantic, on the 7th of August last. At all events, there can be no doubt as to the fact, that the compasses of four ships were in fault, and time may bring us such numbers of corroborating cases as to reduce the question to one of certainty.

Correspondence.

The following letter from Wm. Bond & Son will explain itself. We had, in some of our queries, one relating to the spring governor for equable motion in equatorial instruments. We applied to Messrs. Bond & Son, and the result was their very complimentary letter. We received it too late to get an illustration of either of the escapements (gravity), but we feel under obligations to the Messrs. Bond for their kind response to our inquiries, and we hope to furnish our readers with some valuable articles from this source. In the next number we shall be able to give the two escapements, together with the theory. The horological student can hardly go astray when he seeks information from these gentlemen, the introducers of the "American system" of observation, for they are as highly distinguished for their attainments in *practical* as well as theoretical Horology

BOSTON, *Sept.* 7, 1869.

ED. HOROLOGICAL JOURNAL:

SIR,—Your favor of the 6th instant in relation to the driving clock of the Equatorial at Cambridge is received.

The beautiful performance of that clock is due entirely to the spring governor invented in 1850 by the late Richard F. Bond, for the purpose of obtaining a uniform rotary motion to the cylinder of the chronograph, or electro recording apparatus.

The clock which was sent out with the equatorial was regulated by a fly, and was so irregular in its action that it was found impossible to use the telescope for photographing the moon and stars, owing to its jerking motion. In consequence of this, we applied to it a new gravity escapement and spring governor, similar to those on the chronograph, and with such good results that since then several other clocks have been altered in the same manner, and Messrs. Alvan Clark & Sons, for several years, have used the spring governor entirely, to regulate their driving clocks of equatorials.

There has been no description published of the spring governor, except a short account in the Annals of the Observatory, a copy of which we send you, and have marked all the passages which bear on this subject. The engraving of the chronograph, however, is from the first one made, and they have since been much improved, the pin escapement being replaced by a simple gravity escapement, of which I enclose a sketch.

The performance of the spring governor as a regulator of rotary motion is best shown by letters which we have in our possession, and of which we enclose copies. We also send you a description of another escapement invented by Mr. R. F. Bond, which may interest you, and there are others of which we should be happy to give you sketches if you would like them.

We have been waiting to see a copy of your Journal before subscribing; we are much pleased with the appearance and contents of the number you have kindly sent us, and shall be happy to furnish you with any information in our power, which you may think of interest to your readers.

Yours very truly,
Wm. Bond & Son.

Cleveland, *Aug.* 29, 1869.

Mr. Miller.

Dear Sir,—Your Journal continues very good; but didn't you put on the "soft soap" rather *thick* in my case? I still have a little fault to find, not with you, but with the author of the Lathe. He is too *timid*, too afraid of giving the *minutiæ*, all the *little* instructions, and seems inclined to apologize because he don't describe great things instead of little ones. Can't you make him, and all your correspondents, understand that they are writing for those who *don't know*, not for those who do know? I will hazard the assertion, that those who are "up" to all these little "dodges" are the very ones who will rejoice that some one has the talent for imparting, in a plain, distinct manner, the method of doing *little* things, and of making those *little* appliances, scarcely deserving the name of tools, which it has taken them the best part of their lives to study out.

The greatest good these minutely descriptive articles which you publish can accomplish, is to save the young mechanic years and years of hard labor and hard study, for before he can become an expert he must find out more or less of these *very little things* by bitter and dear-bought experience; and if he can be put in the possession of the experience of gray-headed men, for 25 cents per month, it ought to add at least ten years to his *working* life.

I commenced writing you to ask the "Lathe" a few questions, which I think very many readers would like answered. The answers could as well have been embodied in his article in a few words, if he had not presumed too much on the knowledge of his readers; we don't all know as much about the lathe as he does.

1*st*. He ought to have given a simple drawing of his swing frame attachment for the lathe; something in the style of those astronomical drawings; they are not expensive, and as good as any.

2*d*. The size and thickness of the polishing wheels should have been given; it would have saved, to the novice, a great loss of time and labor in experiments, for he has no information whether to make them an inch or a thirty-second in diameter or thickness, and "Lathe's" experience in that matter could have been given to hundreds of workmen by a single scratch of the pen.

3*d*. A diagram of the centring tool would have been of great benefit to the inexperienced. He says, "there are many little appliances that a workman can make," etc. Now those are the very things we wish to know. "Lathe" has, probably, spent years and years in finding out "those little appliances," and if he should give one, two, or three articles minutely describing them, he would deserve, and I am sure receive, the thanks of thousands of workmen who are inferior to himself in that department of the craft. His directions for making pivot-drills are worth the price of the Journal for a year, although he omitted one important thing—that is, he ought to have told what degree and in what direction the angle should have been formed at the end of the drill; so he says the "graver should be ground to the correct angle." Why didn't he give the correct angle? Two or three words would have done it, and many would have been benefited—none injured.

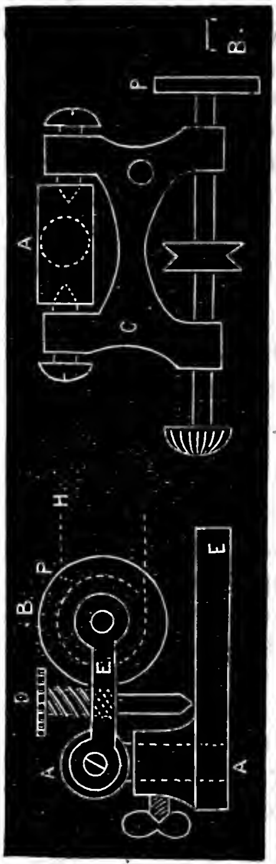
The person who writes the articles on jewelling has got the *hang* of the thing, and by following out his plain directions any person can do the thing described. Please give your latheman a "jog" in the direction I have tried to point out.

I have another "dose" for you as soon as I think your stomach has recovered from this. I don't think you need to publish *this;* it will do *you* more good than it will the *public*.

R. Cowles.

We publish the above, although there is an implied prohibition as regards such a course. The author of the articles on the lathe tells his own story, as follows:

There was a timidity about so very minutely describing the processes on the lathe. We will, however, try to make our meaning understood, if the readers of your Journal can possibly get up the patience to read an article made up of so many little things. We will strive to make up for the deficiency in future by some articles on bench tools, and devoted to little things in general. In the present number we will try to meet the positions taken by Mr. Cowles, in their order.

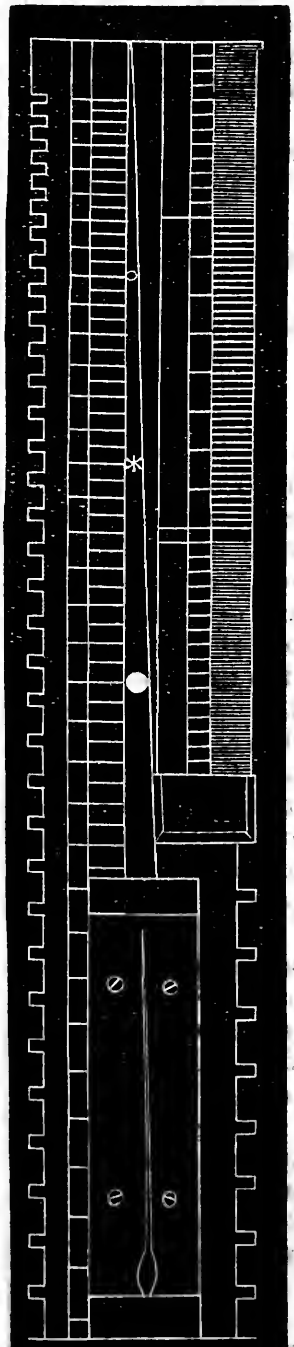


1*st.* The swing-frame attachment is well exemplified in the diagram given. A very lengthy description is hardly demanded, as the first glance should give the idea, and enable any one with an ordinary share of mechanical reasoning to make, or cause to be made, one in proportion to his lathe, both as to size and adaptation. Let B represent the geometrical centre of the lathe mandrel and E the rest and hub, for the reception of the ordinary T, in place of which, in the new arrangement, a T with two centres is substituted, as will be seen by reference to A; the swing, C, may be of any dimensions that the lathe is capable of taking, for in every case the centre, B, and its height above the lathe-bed, will be the point of departure; the stop screw, D, enables the workman to bring the polisher, P, as near as he chooses to the centre, B. The small arbor on which the pulley and polisher, P, are hung, is parallel, and passes through straight bearings, so as to be capable of an end motion, in order to polish. A further description would be useless, so we pass to a consideration of

2*d.* The polisher may be anywhere from one-half to three-quarters of an inch in diameter, and should not be over three thirty-seconds of an inch face, and may be made of sheet-iron, and should be turned up when on its own mandrel, running on its bearings.

3*d.* A diagram of the tool mentioned as the centring tool will be found in Fig. 1, of the article on Jewelling in this number. That author has of it the same opinion as "Lathe." The angle of the end is not of much importance, so that it does not leave the cutting corner too pointed for strength. The angle for the cutting edges should be about 60° with the upper face, and this will be found the best angle for any purpose where a good cutting or drilling tool is sought to be made. The pivot drill should be ground up with angles of 60°, with the axis and the cutting edges the same with the face.

We spoke of the use of the split-gauge, in connection with the drill. We have thought it best to give an illustration of Dennison's gauge, made by Palmer, Batchelders & Co., of Boston, and which answers every purpose of the watchmaker. Now, many of our readers may be familiar with the instrument, but we will venture to say that not one in ten has a gauge of this description on his bench. The rule of guess has been the most prevalent source of error in the manipulations generally practised in the repair shop. We need, then, offer no apology for giving the gauge so prominent a place; aside from the mistakes it often enables the workman to avoid, it is useful, inasmuch as, the habit of measurement once acquired, he will seldom rely on the law of guess. In the accompanying illustration no attempt has been made to give a perfect representation of the gauge, as it actually is brought into the market; the description will, however, give an idea. The outside edges are made up into sizes for plate, main springs, square wire, etc. Now, it is of some importance for-



one to know that a main spring is of the right width, and also whether it is equal in its measurement. There is also a graduated scale for glasses, dials, and any part of watch material that exceeds—say an inch and one-half; still another gauge is found that gives a standard in reference to the measurement of pinions, verges, etc. The steel gauge is figured on the front, though it is really on the back, and is used for the dimension of pivots.

Taking it altogether, there can be no tool so useful to the repairer, if he wishes to work by rule, instead of the "rule of thumb."

And one who tries to write a full descriptive article of the processes he performs every day at his own bench will find that his labor increases, until he feels that he becomes tedious from repetitions. It is that delicacy that in general prevents an author from giving those little things that seem so perfectly obvious. In a subsequent number there will be found an article that will suit the readers of the JOURNAL if the details of the trade are of so much value to one who has practised the trade so long and successfully as we happen to know Mr. Cowles has done.

"LATHE."

NEW YORK, *Sept.* 16, 1869.

ED. HOROLOGICAL JOURNAL:

Hand in hand with that high degree of mechanical skill exemplified in the construction or repair of fine time-keepers, and which commands the respect and admiration of the novice and the expert, one would always expect to find a similar scientific skill, enabling the artist to determine accurate time, in order that his own mind, if for nothing else, should be satisfied, beyond a doubt, of the results of his patience and skill. It is hardly asserting too much to say, that one is not fairly entitled to call himself a master of the art of Horology until, in addition to making a machine that shall keep time, he can at least use another machine for taking time, thereby testing the accuracy of his work; nor can he reasonably expect to make a very profound impression on the mind of his patron, unless he shall set before him some accurate standard of comparison. An inexpert workman would not be likely to wish to have his work tested by a correct standard; his interest lies in the direction of an uncertain standard, and the more so the better for him. On the contrary, a skilful artist need not, and does not, fear the closest scrutiny, due allowance being made for the small inaccuracy inherent in all time-keepers.

It should therefore be the aim of every dealer in, or repairer of, watches, who aspires to win a well-merited reputation, to not only be able to turn out good work, but to have such a general good repute for accurate time, that he can command the confidence of the public in this matter.

Some, in a praiseworthy effort to supply a good standard for the comparison of watches, have gone to considerable expense in obtaining fine chronometers or regulators for this purpose; but though something of that kind is, to a certain extent, indispensable, yet it does not reach the difficulty. Something lies still back of that, for the question arises, what shall the chronometer or regulator be set by? And if set correctly, there is no assurance it will remain so, for nothing is better known than that no time-piece is absolutely perfect; a daily rate, so small in these time-pieces as to be a quantity not worthy of notice, when the amount for one day is considered, causes in time an appreciable error, and oftentimes surprisingly soon. A friend suggests that watchmakers in general would probably be satisfied if they knew the error of their clocks were not more than a quarter of a minute, and would not alter a regulator for that amount; but the man who makes no account of a quarter of a minute will pretty surely soon be detected in an error of a minute, or more—a discreditable amount, which he cannot be made to publicly acknowledge. If, now, he sets his clock right, then every good watch being compared with it, apparently "jumps" the contrary way. Should the watch happen to have been compared with some other standard also, then it becomes manifest where the trouble lies, and the watchmaker must either make a humiliating confession of his error, and thus lower himself in the esteem of his patron, or the latter must be satisfied, whether he asserts it or not, that the former is unworthy of confidence. In this picture, many a watchmaker will see his likeness reproduced with unpleasant fidelity.

The remedy for this uncertainty is within the reach of all; but whatever the particular method employed, the principle must rest on the observation of heavenly bodies; the movements of which approach near to perfection, and afford a certain standard by which to measure the inaccuracy of human mechanism. Among the most simple of these is the establishment of a noon mark, which indicates the passage of the sun across the meridian; but, like the sun dial, on account of the difficulty of obtaining a sharply-defined shadow, is very inaccurate, and unworthy of use by a watchmaker. The Dipleidoscope rests on the same principle of obtaining the meridian passage of the sun, but is open to the objection that it cannot be set up independent of having correct time. A better method is with the quadrant or sextant, the latter being the more accurate instrument. A description of these instruments, and the manner of using them, may be found in any work on Navigation; but while the problem by which any given case is worked out is highly scientific, the results, in practice, are not sufficiently uniform to satisfy any one desirous of accuracy. Notwithstanding the scientific character of the work involved in the use of the sextant, yet the method of its use at sea being reduced to a practical rule, even very illiterate persons are often enabled to use it, mere reading and writing being all that seems to be required to obtain the results requisite for navigation.

Undoubtedly the best and most accurate method of obtaining time is with the transit instrument; but its use has hitherto been too much prevented by the unfounded assertion that it required considerable scientific attainments on the part of the observer, when, in fact, it requires far less study than to obtain a knowledge of the sextant from the descriptions in the books, while the time occupied in taking an observation, and the figures employed, are far less than with the sextant, and much more readily understood.

Your correspondent, Mr. J. Cross, in your last number, helps in his way to perpetuate this false notion, and seems to endeavor to reconcile watchmakers to the use of an inferior method, by raising the old hue and cry about "difficult adjustment," etc., and also enumerates some "advantages," as he calls them, which the sextant possesses over the transit instrument.

It is hardly worth while to discuss this part of the subject, further than to suggest that a few minutes at noon can generally be spared much more easily than a longer time between eight and nine o'clock in the morning, the best time for the sextant; also that the relative increase of motion of the images of the sun, arising from the use of an artificial horizon, does not give an advantage over the transit, though what Mr. Cross probably means is, that it has an advantage over the use of the natural horizon at sea. The power of the telescope of the transit makes the apparent motion of the sun across the field of view more rapid than as seen with the sextant; consequently the contacts may be observed more nicely, and as to taking the mean of several observations, the average of ten intersections may be used in a solar observation with any ordinary transit. As to the matter of cost, a fair quality of new English sextant cannot be had for less than $75 or $80, and it would seem better to pay $40 or $50 more and get something far more accurate. If Mr. Cross takes an observation daily with his quadrant, and assumes it to give, in each case, a correct result, he must make his clock appear to run with gross irregularity. On the contrary, if he has a clock which runs pretty uniformly, daily observations with his quadrant must show a great want of uniformity in their results. Which horn of the dilemma does he take?

Yours, etc.,
HOROLOGIST.

ED. HOROLOGICAL JOURNAL:

Myopia depends upon the fact that the refracting power of the eye is increased above the normal standard, or that the antero-posterior axis of the eyeball is too long, so that parallel rays, or even not sufficiently divergent rays, are brought to a focus *before* the retina. A person with such eyes is usually termed near-sighted. To find the spectacles suited to such a condition of the eye, we have to select *concave* glasses, because they make the rays of light *diverge;* and if we select those of a proper focus, they will bring the focus back to the retina, and enable the wearer to see the object he is looking at, clearly and with distinctness.

The quickest way to find the number or strength required is to let the party try on a pair, and if the print of a newspaper or book looks *smaller* than it really is, you may know that the glasses are too strong. Then select a higher number; if he has to hold the object too *near*, you may know that they are not strong enough. If your stock of concave glasses should be small, and you have some strong concave glasses, let the party put them on, and then, in connection with them, try convex glasses of different numbers, and when you find any combination that suits, measure the convex glass, and put that down—which we will suppose to be No. 24, which we will call $\frac{1}{24}$. The concave glass being measured gives No. 8, which we will call $\frac{1}{8}$. As the concave 8 is too strong, we must deduct the convex from it—*i. e.*, from 8 take 24, or $\frac{1}{8} - \frac{1}{24} = \frac{1}{12} =$ No. 12 concave glass required; but that we may be positive that we are correct, place weak convex glasses, then weak concave glasses, before the No. 12, and if the party cannot see any better with either combination than without them, we may know that he is properly suited. But suppose we find that with concave glasses No. 12 he can see better if we give him concave No. 60 (in connection with No. 12); then we must add the two together, and we have $\frac{1}{12} + \frac{1}{60} = \frac{1}{10} =$ No. 10, the number required. It is always advisable to select as *weak* a pair of glasses as we can that the party can see well with. If, for instance, the party can see but little difference between No. 16 and No. 18, give him No. 18, and so on. We often meet with persons who can read distinctly at the proper distance, yet for distant objects they require concave glasses. This peculiarity has led many to suppose that they required convex glasses. In such a case, adopt the same method for finding the proper glasses, only letting the party look at distant objects instead of near ones. We sometimes find those who may require a different glass to see at a distance than they do to read with. In this case a stronger glass is required for distant objects than for near ones. A person may be both myopic and presbyopic—that is, he may require concave glasses to see at a distance and convex glasses to read with. This peculiarity is by no means common. There are three kinds of concave glasses in use, viz.: Plano-concave—flat on one side, concave on the other; biconcave—concave on both sides; and periscopic, or convexo-concave—concave on one side, convex on the other. Of course the radius of concavity must be less than the radius of convexity.

To get a focus of a biconcave glass, the same rule or scale that is used for measuring convex glasses can be used; but instead of the image of the window, tree, or other object, passing *through* the glass, and being formed on the wall, it will be *reflected* from the *surface* of the glass. Now, by holding a piece of white paper in *front* of the glass, and moving it slowly back and forth, you will find a point where a clear and distinct image of the object will be formed on the paper. The paper should be held so that the top of it and the top of the glass are about on a line, horizontally; for if the paper is held too high it will obstruct the rays of light, if too low, it will not receive the image. Now, suppose the glass, a double concave, to be six inches distant from the paper when the image is clear and distinct, it will be a No. 12—*i. e.*, its focal distance is 12 inches. If a plano-concave, same distance from the paper, it will be No. 24. In other words, multiply the apparent focus of a biconcave by 2, of a plano-concave by 4, to find the focus. Another method, and that usually employed, is to have a convex glass of every number put into a strip of wood—say twelve in each piece, made by boring holes about $1\frac{1}{4}$ inches in diameter through two thin pieces of wood just wide enough to cover the large round glasses; one of the pieces can have the holes chamfered, or felt can be laid in. Put your glass in and screw the two pieces together; now, by passing a concave glass in front of the different glasses, you will find one that will be neutralized by the concave glass. A No. 10 concave will completely neutralize a No. 10 convex, and so of all other duplicate numbers; that is, the two together will appear to be one piece of plain glass—a test of which is, that if we look at one of the vertical bars of a window through them, it remains perfectly immovable when the glasses are moved to and fro. If the glasses do not neutralize each other, the bar will appear to move in one direction or the other; if it appears to move in the same direction that the glasses are moved, the concave glass is the strongest; whereas, if it moves in a contrary direction, the convex glass is the strongest. The strength of convex glasses can be found in the same way. The strength of a convexo-concave glass is found by neutralization.

The directions that I have given in this and the preceding article will enable any one of ordinary intelligence to select glasses of the proper kind and strength to suit most of the cases brought to notice. There are other peculiarities of the eye that need different kinds of glasses from either convex or concave; in which case it is best to direct the party to a regular optician, as it would not pay, ordinarily, for any one else to keep a full line of cylindrical and prismatic glasses on hand. In astigmatism, the state of refraction is different in different meridians. It may be normal or emmetropic in the horizontal, and myopic or presbyopic in the vertical, or *vice versa*, or diagonally, in which case cylindrical glasses, either simple or in combination with convex or concave glasses, would be required. Prismatic glasses are used in muscular asthenopia, or "squint." To make this latter subject alone intelligible would require a long article; and for any one that feels an interest in these peculiarities, I would advise them to procure some suitable books upon Optics. Before closing, I would say to those that are troubled with being near-sighted, that they ought to wear glasses, especially if they are very much so, otherwise they may lose their sight altogether, as the constant strain of the accommodation, as it is called, has a tendency to cause the retina to separate from the choroid. I would also say, for the benefit of your customers, urge upon them the great necessity of not only getting glasses of the proper focus, but of the best *quality*; those where the glasses are clear, ground true, and well polished. J. F.

AMERICUS, GA., *Sept.* 6*th*, 1869.

MEDINA, OHIO, *Sept.* 4, 1869.

ED. HOROLOGICAL JOURNAL:

DEAR SIR,—We feel it a duty to tell you and your readers how much we like the JOURNAL. The instructions in regard to making small drills is alone worth many times the subscription price. We can now make drills as fine as we like, and each one we should have pronounced priceless had it been given us before we knew how easily they could be made.

We think we have made a little improvement, viz.: using German silver hollow wire, drawn very small, to solder the drills into to hold them by. It can be made very cheaply, and is quite stiff, even when very small. We feel like saying "many thanks" for that idea as well as many others.

In regard to lady watch repairers, we would say that we employ several in our business, and have one that devotes her time particularly to that department. For neatness, both in tools, materials, work, etc., we think ladies have a natural gift, and all must admit the great importance of perfect cleanliness in all operations pertaining to watch-work. For delicacy of touch, care to avoid accidents, etc., we have yet to find one of the sterner sex that would suit us as well as a lady. We might add that the person mentioned has had several years experience in mechanical work in our manufacturing department before taking up watch-work, which was, perhaps, a very material advantage.

We have many times observed—and who has not?—the want of order and cleanliness about the watch-repairer's bench, and have thought that nothing would so well supply the deficiency as the hand of a woman that was sufficiently acquainted with the implements to avoid making mischief.

With our best wishes, we remain,

Respectfully yours,
A. I. Root & Co.

Answers to Correspondents.

G. H. D., *Me.*—The rotation of the major axis seems to puzzle you. The following diagram may let light on the subject:

S representing the sun, the line A′ P′ is the major axis of the ellipse, marked in full with a dotted line. Now, we may imagine any fixed point at a distance, but in the same straight line. If in relation to that point the axis A′ P′ should change, having S as a centre of revolution, the direction of A′ P′ would, in time, become A P, and the angle A′ S A would be its angular motion; this motion continuing, in the course of 109,830 years the major axis, A′ P′, will again be in a straight line with the fixed object we imagined. This is called the motion of the apsides.

A. G., *N. Y.*—We do not pretend to answer questions purely mathematical, but you say you are learning the watch trade and have also a liking for algebra and its style of reasoning, and that you are studying it on your "own hook." Now, as we would like to help any one aspiring to perfection in the trade, and believing you are on the right course, we will give you a solution of the equation that you say has been a nightmare for a long time:

The equation is

$$\sqrt{x} = \frac{8}{x} - \frac{7}{\sqrt{x-2}}$$

Clear it of fractions, and for simplicity substitute P for the $\sqrt{x}$, then

$$\sqrt{x} = P$$

and the resulting equation will be

$$P^4 - 2p^3 - 8p + 16 = 7p^2.$$

Now if you add $9p^2$ to both members you will have

$$P^4 - 2p^3 + 9p^2 - 8p + 16 = 16p^2.$$

Extract square root and

$$P^2 - p + 4 = 4p.$$

Transpose

$$P^2 - 5p = -4.$$

Extract root

$$P - \frac{5}{2} = \sqrt{-\frac{16}{4} + \frac{25}{4}} = \sqrt{\frac{9}{4}} = \pm\frac{3}{2}$$

Transpose

$$P = \frac{5}{2} \pm \frac{3}{2} = 4 \text{ or } 1.$$

as you may take the plus or minus sign. But

$$P = \sqrt{x} = 4 \text{ or } 1.$$

Then

$$x = 16 \text{ or } 1.$$

You might have solved it by the Diophantine analysis very elegantly, and we shall leave that solution to you, hoping you will apprise us of your success.

C. A. F., *N. J.*—The surface of the glass polishing plate must have been too coarsely ground; it acted exactly as a coarse file.

The abrasion should be carried to that point where the glass is nearly transparent—not quite so. If you attempt to *polish* on the surface alone you will be disappointed, but a very fair job may be thus done. You must use some intermediate substances that will deaden the cut of the glass or stone surface, say rouge. To levigate the rouge you may first mix up a quantity, say one quarter of an ounce, with four ounces of water, and let it settle for four or five hours, then you may pour off the supernatant fluid, and after it has become clear by precipitation, you will find a very fine uniform rouge at the bottom of the vessel; this is one way. You may attain the same result much more perfectly by elutriation by having three or four vessels in a row, communicating with each other, being one elevated in regular succession above the other. The water and rouge is placed in the highest, and then a stream of water allowed to flow in it. You will readily see that the finest particles will settle only in the lowest vessel. Sharp is a grinding material, and almost any material dealer can furnish it.

Jas. Mc., *Me.*—You may be able to do all you say; set a jewel, put in a fine staff, or compensate a balance. What then? There are plenty here with but a limited amount of work to do, men who have been in the trade for years, after having served apprenticeships in England, Switzerland, or the United States. You may judge, then, what would be your chances, were you to come to this city and compete with these workmen, whose reputation for good and reliable work has been fully established and widely known.

You are just of age, you say, and are ambitious to distinguish yourself. Admitted; but can you afford the time and money to enable you to succeed in such a strife, where the competition is so great? Stay in the country, where you are not lost in the great desert of city business; there you can establish a reputation and make it lasting, while it affords a fair remuneration for your time, talents, and labor.

E. L. M., *Ohio.*—You have sent us a drawing of a very fine bench, and were each watchmaker to take the same interest in his conveniences for working, there would be fewer botches. Can you expect this, however? The same causes produce like effects, and when you see a workman careless of his tools, you may argue with full conviction that he is also careless in his work. We admit the most of your premises in your remarks on the comparative value of the different lathes in market. You must, however, be aware that one may become accustomed to a tool, and with it do better work than with any other form or modification.

E. N., *Conn.*—You need not be alarmed about admission into any Watchmakers' Union Society, or anything that can be called an association. When a man attempts to get a knowledge of given facts from sheer love of it, he will generally get a long start ahead of those who go into the thing simply for "learning a trade." Horology is so intimately connected with the repairs and adjustment of astronomical instruments, and as well the mathematical reasoning incident, that you may rely upon being a chosen candidate in any society whether you have served an apprenticeship or not.

H. E. W., *N. Y.*—We refer you to the article on Dial Making in the present number. You may rest assured that from the nature of the case no repairs can be effected in a broken dial or other kind of enamelled work. The dial might be re-enamelled, but the process would cost too much. A ring or watch-case may be treated in the same manner; but here the whole value does not, as in the dial, consist in the enamelling.

W. A., *Ill.*—The test you mention for diamonds, as distinguished from paste, has gone the rounds of the papers. How many people do you think have the patience to take a stone from the setting, then boil it in nascent fluorine, *i. e.*, flour-spar and concentrated sulphuric acid? or how many druggists in the United States keep on hand the hydrofluoric acid? The test is worthless except in the laboratory. Hardness is the true standard; for any diamond, of whatever color, water, or form, will cut or scratch a ruby or sapphire; nothing else will.

A. H. J., *Iowa.*—We cannot answer. Were we brokers, and, as such, received a commission, we might reply to your query; but then we should not be connected with the Horological Journal.

J. H. L., *N. J.*—Your letter was handed to a party who will probably attend to the matter. The difficulty you find in polishing the bevel on the inside of the jewel setting is due to the fact that it should not be polished by any abrasive process. A full description of how it may be done will be found in the next article on jewelling.

J. A. D., *Vt.*—There can be no doubt that a decimal system of weights and measures would be altogether convenient, as it would save so much in computation. The French system has proved very easy of adoption by the general public. It was our intention to give our readers an article on the subject in the current number, but the author was unable to finish it in time. It will appear in the November number.

M. G., *Ala.*—We can sympathize with you on the dulness of trade, for it must affect us as well as yourself. Your idea of a Horological Institute is worthy of publication. Will you allow us to publish your letter in so far as it relates to the Institute?

A. I. R. & Co., *Medina, Ohio.*—We are having compiled a complete catalogue of all books pertaining to the watch and jewelry trade; it will appear in our next number. The prices will be appended.

L. C. V. S., *Pa.*—The tool you describe, as having been invented for drilling, has been in use for many, many years.

AMERICAN

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CONTENTS.

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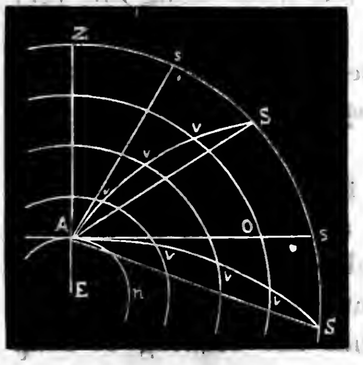
Astronomy in its Relations to Horology.

NUMBER FIVE.

To comprehend the real importance of the effect of refraction on the results of an astronomical observation, we must take into consideration the fact stated in our last article, that the density of the atmosphere is not uniform, and therefore the line described by a ray of light will not be in the arc of any given circle; true, it would describe a circular path, but each arc is the part of a circle having a very different radius from any of the others in the same path. This can be illustrated if, in the following figure, we imagine the point E to be the centre of the earth, while the lines exterior represent the different strata of the air. Let A be the observer's place on the surface of the earth, and S some star on the same meridian, but at an immense distance; the ray that comes from the star is supposed to meet the surface of our atmosphere at the point S. Now, if the light proceeded in a straight line it would meet the observer's eye at A, and appear in its real place on the celestial sphere; but when it strikes the air it is first deflected to v, and again in a curved line, v V, to A. Now, the tangent of the last curve is the straight line in which the star will be apparently located; that tangent will be A s, so that the angle contained in S, A, s, is the true measure of the refraction. Taking, in the figure, the line H, A, O, as the horizon, to the observer at A it would appear that an object that really was situated at S′ would appear as just rising in the horizon at s; at the same time the straight line A S′ would seem and really does cut the surface, so that, were it not for the refraction, the star S′ would not be seen; but the angle S′ A′ s' is greater than S A s, and, as stated in the last number, this angle of refraction must diminish as the object approaches Z, where the angle is 0°. It is obvious that this change of value arises from the difference of the distance the ray traverses in passing through the air. It has been found that an object 10° above the horizon will be refracted in its approach to the zenith very nearly as the tangent of the angular distance from that point. The constants for refraction are varied, however, in a more marked degree by the conditions of the air as shown by the barometer and thermometer; thus the quantity of refraction at equal distance from the zenith varies nearly as the height of the barometer, assuming the temperature to be constant, which it never is, and the effect of the variation is in all cases to diminish the refraction by 480th of its true value for every degree of increase in temperature. The sole effect of refraction is exerted in the meridian, therefore in transit observations it may be entirely neglected; but where time is taken by means of altitudes, the allowance must be made, and in all astronomical observations the results are not considered reliable below 15° of the horizon.



The laws governing the source of so much error were investigated by Dr. Bradley, who formed a set of tables. He observed the zenith distances of the sun at his greatest declination, and also the zenith distances of the pole star at its greatest meridian elongations, and added the four quantities, which must be equal to 180°, minus the amount of the four refractions. Taking their zenith as 0°, and having a base, it was easy to assign the law of the variation by theory. Thus the mean horizontal refraction he found to be=35′ 6″, while at the altitude of 45° it is only 58″.36. The effect of refraction in observations was noticed by Ptolemy as early as the second century, but Astronomy was then not equal to the task of determining the true value.

Upon the property of light thus called refraction depends the whole value of astronomical instruments, in all of which the lens comes into use, either for the observation of a celestial body itself, or for reading off the distances indicated by instrument. The laws of refraction, insomuch as they are applied in the construction of such instruments, hardly need be explained here, as in a subsequent chapter all that need be said will be in connection with the transit and quadrant. There is a subject connected with refraction, however, that is a fine illustration of the reasoning used in astronomical research. If we allow a ray of light to pass through a prism of glass we will find, on letting it fall on a sheet of white paper, that instead of there being a round spot of white light, a parallelogram is formed, not of white light, but composed of colors in the following order:

Red,
Orange,
Yellow,
Green,
Blue,
Indigo,
Violet.

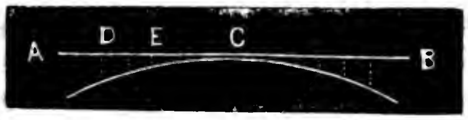
The image they cast on the white screen is called the spectrum; the form of which, its size, and the peculiar relation of the space occupied by the different colors, are destined to become very important agents for discovery in Astronomy, as, from considerations founded upon the spectrum, it is believed that the material of which the sun is formed may be yet analyzed, and the constitution of his whole body be nearly determined. The decomposition of light is of importance, as it has been found that the spectrum is affected, not only by the angle, but by the material; and this knowledge is taken advantage of in order to render the object-glass of the telescope capable of refracting a ray of pure white light, at high magnifying power. Were the two segments of a sphere which joined together to be made of only one kind of material, it would be impossible for the eye to receive the image of an object without its being surrounded by colored fringes that would render the definition very confused. Now, if two glasses of different refractive power are placed together in order to form one lens, the rays that have been decomposed by the biconvex lens are recomposed by the other, thus enabling the eye to get a ray of natural light. These glasses are called achromatic, from the fact that they give no accidental colors to the objects viewed. The decomposition of white light was one of the highest efforts of Sir Isaac Newton's profoundly mathematical mind; his genius not only discovered the law of refraction, but enabled him by actual experiment to measure the lengths of the different colored rays.

Newton had observed that the pellicle of a soap bubble gave all the colors of the prism, and the question came up—why? In pondering on the subject he decided that it was owing to its thickness; and it will occur to every one who has in his boyhood used a clay pipe and soft soap in solution, that he found the drop at the lower side of the bubble to give a red ray, while in the centre it would be violet. It was while using this very simple apparatus in his invstigations that a frequent passer by, seeing Newton busily engaged in blowing soap bubbles, asserted that no one but a fool or lunatic could amuse himself in such a frivolous way. But the pursuit was too far above the comprehension of the spectator, and we can only imagine what his astonishment would have been had he been convinced that the blowing of soap bubbles was in future to give a correct definition of the laws of light. In observing the different colors in the thin film of soap and water, he was led to connect the fact with the dispersion of the rays by means of a prism; he had a clue to the color, but why should the different rays be given by reflection? Newton could only assign, what has since been substantiated, that the color depended on the thickness of the film. Now, it will be obvious that the sides of a soap bubble are thinner than the bottom, where, by the force of gravity, the greatest amount of material is collected. We must first premise that in the reflection one part of the ray is from the exterior surface, the other from the interior; if, then, the thickness of the film was a fractional part of a supposed undulation, no light would be seen—a black spot, or ring, only being obtained. If, then, we assume a wave of any certain colored light—say red, to be equal to X, then at any part of the film that also is equal to X in integral numbers, we should have only red light reflected, as no other colored ray has the same value. By the table it will be seen that the undulation of the extreme violet is the shortest, and extreme red the longest.

Table of Dimension of Undulations.

Color.	Length of Undulation in Parts of an Inch.	Number of Undulations in an Inch.	Number of Undulations in a Second.
Extreme Red....	0.0000266	37640	458,000,000,000,000
Red.....	0.0000256	39180	477,000,000,000,000
Orange...	0.0000240	41610	506,000,000,000,000
Yellow...	0.0000227	44000	535,000,000,000,000
Green....	0.0000211	47460	577,000,000,000,000
Blue.....	0.0000196	51110	622,000,000,000,000
Indigo....	0.0000185	54070	655,000,000,000,000
Violet....	0.0000174	57090	699,000,000,000,000
Extreme Violet....	0.0000167	59750	727,000,000,000,000

Newton had not this table of measurement, but he furnished the means by which it was computed. Thus, if a plane is supposed to touch a sphere, it can come in contact at only one point; from this point the distances between the sphere and plane will be in some relation to the diameter of the sphere. Or, to give it more sufficiently, let us suppose the line **A B**, in the **Fig.**, to be the representation of a tangent. We shall have the distances between the plane and sphere constantly increasing in some ratio that we may easily determine, if we know the radius of the sphere. Arguing on these premises, Newton placed a plane of glass on a lens, and found in the centre, as he had anticipated, a black spot, owing to the interference of the rays. Now, if between the two glass surfaces there should be a distance that was an even measure of any wave of colored light, that color will be shown at the spaces that are equal, or in an even ratio, say 1, 2, 3, etc.; but at the space which is a fractional part of the wave, the ray of light will disappear from interference, and a black ring will be formed. The experiment is simple, and any one can try it; the effects are more striking if a ray of homogeneous light is used. The reason why the ring is of an increased brilliancy is owing entirely to the fact that the eye receives the wave, doubled, as it were, on itself; that is, with an equal motion the wave must meet the eye at the same time that the lens-reflected ray has. But it must be remembered that the wave will arrive at 1, 2, 3 . . behind the wave that reaches the eye from direct reflection; but as it corresponds in time, the light is clear and definitely impinged on the retina. But if the distance is such as to render the refracted wave fractional to the other, an interference in the lengths of the wave would take place; that is, a part of the wave would overlap a part of another, and thus destroy any light that falls on the spot. Knowing the focus of the lens, we can easily ascertain the lengths of the wave from their colors. The exceeding minuteness of such quantities is an apparent bar to one's studying the subject; yet it is within the comprehension of any one who can reason. We must, however, leave this branch of investigation, for it is in itself so interesting that we should wander off the path we laid down, to treat of Horology with Astronomy. We can



hardly part with the subject of color without stating the very interesting fact, that in the spectrum we have mentioned there are rays emanating from the sun, not visible to the eye: and the whole success of photography depends on the rays that are not shown in the spectrum. These are called actinic rays, and their effects may be observed in many ways other than in the strictly photographic processes—say in the crystallization of camphor in the druggist's jar. Now, we know that gum camphor will sublime and then condense; but were there no actinic rays, the vapor would condense equally on the sides of the jar; but it does not. The place of deposit will be found, by any observer, to be invariably in the line of the light: and this effect would be had were the jar to be so placed that the light does not fall on it; for if the actinic rays just beyond the visible spectrum are allowed to fall on the drug, this effect is produced; and again, in the photographic processes, there are rays used called chemical, that are interesting, but hardly within the province of Horology

If we suppose a ray of light to emanate from any luminous body we trace its path in a straight line; but from the effects of refraction, we have proved it to be curved, and in the case have assumed that the luminous body and the observer's eye remain in the same relative positions. In the case of an observation on a fixed star, only one of the positions is fixed. By the motion of the earth in its orbit the observer is continuously changing his relation to the object. If he is approaching, the object will be seen always a trifle in advance while the contrary would hold were his course from the object. Now, if the telescope were directed to the star in a straight line with the ray, and parallel, the ray would fall on the side of the telescope, instead of directly on the line of collimation of the instrument. This is called aberration of light, and though small, an account of it has to be taken, both in the observation and the subsequent computation. This demonstration of the aberration of light has confirmed the undulatory theory, and moreover established the fact that light is not instantaneous; that it takes an appreciable time for a ray to accomplish its passage.

This, one of the most beautiful propositions of Astronomy, was established by a Danish astronomer (Roemer) in 1675, and was first suggested to him by some very singular disagreements in the real and computed positions of Jupiter's moons.

Galileo, by the use of the telescope, had discovered that the most magnificent planet of our system was attended by satellites. This discovery was of the highest importance to Astronomy; indeed, it forms an epoch, for it furnished a means for the astronomical determination of longitude; in other words, the determination of time. In order to give a true idea of the subject, it will be necessary to give a general history of the Jovial system.

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Watch and Chronometer Jewelling.

NUMBER FIVE.

It must be remembered that the jewel thus set is in the piece of brass wire that forms the chuck; it will therefore be necessary to cut the wire off, in order to obtain the required depth of setting for the thickness of the plate. This is accordingly done, and the jewel, with its setting, is reversed on another chuck, whose face is smaller than the face of the stone; therefore, when the stone is trued up by its own centre, the outside of the setting may be turned off to the size of the largest diameter of the hole in the plate, and the face of the setting may be made parallel to the face of the jewel. The jewel and setting, thus far finished, are now ready to be put in the plate. The lower holes have already been set in the bar and pillar plate, so we must sink the upper hole in just far enough to allow the pinion a sensible motion endwise, which motion is called the end-shake. To get the proper end-shake, the jeweller now reverses the setting and jewel on a chuck face, a trifle larger than the setting; thus he has the jewel with the face out, as when he set it. He now turns a shoulder on the setting that just fits the smallest diameter of the hole in the plate, and tries the setting in. If he has set the lower holes with reference to the level of the face of the upper holes to the lower side of the potance plate, he may leave the face of the jewel just level, take it from the chuck by a sudden jerk of the plate while the setting is in its place, and try his pinion in by putting it in its place and placing the two plates in their true positions. If, now, he has in his judgment too much shake, he chucks up the jewel again and takes a slight chip off the shoulder, and continues this tedious operation until he has succeeded. But, suppose he gets, by accident, no shake at all, he will burnish the edge or corner of the shoulder down, and thus raise the face of the jewel in the plate. This pernicious and very unworkmanlike way is not to be commended; the setting should be made anew, for the hole requires a good square face to rest on—not the sharp edge of a burnished rim of brass. The getting of the proper degree of end-shake is a very delicate matter. When we add to the difficulties already described the fact that the plates hardly ever go together alike in the separate trials, for it would be too much to screw together the plates every time he tries the shake, therefore he will judge by the pressure of his finger and thumb, and still find himself mistaken when the watch is finally put together. In nine cases out of ten in such a condition of affairs, the workman will "bump" the plate, in order to remedy the defect. Even in some high grades of English levers, the watchmaker may detect that the finisher has "bumped" the plate to get the proper degree of end-shake, rather than take a small amount off the pinion shoulder in case the shake was too large, or reset the jewel were the shake too close. While this style of jewelling may not affect the owner of a watch, it is perplexing to the repairer, who, on taking down and putting up the movement, finds that he has again to adjust, by *bumping*, the mistake of the watchmaker.

The ordinary course of jewelling in England renders it almost impossible to make correct shakes without subsequent adjustments, for the watches are jewelled in the grey, or before gilding, and in the process of gilding the plates are annealed, thus warping them out of the truth, or position in reference to which the jewels were set. Now, the only true plan on which any screwed jewelling should be done is, to jewel after gilding. The watch may be all set up and put in running order before a jewel (except the cock and foot holes) is put in; then it may be taken down and gilded; then the jewelling may be done with a certainty of the parts coming together with the same regularity as a well-made steam-engine. Again, in brushing the plates for gilding, the sides, or at least one edge of the hole in the plate, will necessarily become burred up, and the jewel, when replaced, will be found not to go to its place truly, in consequence. True, it is much more trouble to jewel after gilding, as the plates are liable to be scratched or even tarnished by frequent handling; but it should be understood that watchwork in all cases requires care, and no excuse can be had for any scratching by any one who professes to jewel a watch.

In the English mode of watch-finishing and jewelling, the end-shakes are invariably attempted to be made in relation to the level of the plates. The whole process, as there carried on, is one of unmixed stupidity; not in so much as to the quality of the work when done as in the mode of doing. The general operation is for the frame maker to send the frame to the finisher in the following described condition: The plates are put together and pinned or screwed; the train, with barrel and fuzee and motion work, together with the potance and cock, are in readiness for the finisher. The pinions and arbors are left long, and, in order to put the frame together, holes are drilled in the plates for them to pass through. These holes are not planted with any reference to accuracy in the matter of depth, and are as large as the largest parts of the respective pinion staffs and arbors. The first thing for the finisher's consideration is to get the lengths between shoulders in relation to position. These having been marked, his next step is to bush up all the holes, stone off the plate, and then proceed to lay off his depths. After having turned up and finished all the shoulders and pivots, according to the marks made on the train, the new holes having been drilled in the bushings and the escapement put in, the watch is inspected; and if the depths are correct, the plates and train to be jewelled are sent to the jeweller. He turns out *the plugs* that had been put in by the finisher and replaces them by jewels; but it sometimes happens that the frame maker has made the hole so far off from depth that the true hole for the pivot will fall outside the bushing; in this case the jeweller has no other choice than to cut out the plate to the full diameter of this eccentric bushing. It will be seen at once that all this work on the bushing is not only utterly lost, but a positive injury.

The jeweller having set the faces of his jewels level with the surface of the plate, the end-shakes are supposed to come right; the frame is now sent to be gilded, and, as said before, this process is almost fatal to the preservation of the correct shake.

In the American companies the shoulders are all finished to gauge, and at one time the jewels were set in the pillar plate in the Swiss style, with their faces level, the shake being got by the greater or less sinking of the potance plate jewels in the plate. As the distance between shoulders was intended and supposed to be equal, there would have been but little difficulty, provided the conditions were fulfilled; such, however, was not the case. The height of the pillars, the warping of the plates in gilding, and the difference that is inseparable in the dimensions of a number of pinions, conspired to prevent, by the accumulation of the errors, the result that otherwise might reasonably have been anticipated.

Where so many watches were to be jewelled per day, it became a very important matter to diminish the repetitions of manipulations that so seriously retarded the work. The only method that could be devised was, to make the work self-measuring; that is, cut the shoulders on the jewel settings by the lengths of the pinions, when they absolutely gauge the depth of the shoulder. The principle of self-measurement in work was never better shown than in the end-shake tool now in use in all the factories. A brief description, in words alone, will answer to enable the reader to comprehend the tool, and the principle on which it is founded.

If a cutter were made to cut the shoulder, and at the same time a stop that rested on the face of the jewel, it is certain that the shoulder would always be of the same depth. Now, if the stop were made variable in relation to the cutter, it is equally evident that the shoulders could be varied at will. The next step in the process of reasoning was, to devise some means by which that stop was varied in exact proportion to the length of the pinions. But here was another difficulty—the pillars cannot be exactly equal in gauge, and the shoulders cut in the plates were widely astray from equality. Whatever care might be exercised in the use, even of the best appliances, an error would always creep in. Here, then, were four measurements to be effected by one tool, which at the same time was intended to cut the work exactly to those measurements. The difficulties will be the more readily understood when the fact is considered, that the measurement is so small—being in most of the train not over one and a half degree, where the degree is only the one-twenty-five-hundredth of an inch; and that the mere fact of a few degrees of difference in temperature applied to the instrument would invariably either take up the allowed amount or double the shake.

No one can fail to appreciate the difficulties that must be encountered to avoid so many causes of error. The simplest form will be conceived if we should take a hollow arbor, terminating at one end in an adjustable cutter with a square corner, the other end being furnished with a small hollow nipple, just the size of the largest shoulder cut in the plate. Running in this arbor are two small spindles, meeting just in the centre where the ends of the inside spindles correspond to the exact length of the outside arbor. Now, if any size was placed between the two centre ends, the inside spindle would be increased in length by just the size added. The upper plate is first jewelled with the faces of the stones just level with its under surface; as a matter of course, the depth of the shoulder in the plate is of no importance. The lower plate is now cut out from the dial side for the jewel setting, with a shoulder for the reception of the jewel. The plates are now screwed together, and the two arbors are applied to it—one on the outside, with its tit or nipple resting on the shoulder in the hole of the pillar plate, the other passing through and resting on the face of the jewel in the upper plate. A pinion, the one designed for the place, is now put in between the centre ends of the inside spindles, and the stop pushed back in relation to the corner of the cutter. It is evident that the inside spindle, lengthened as it is by the distance between the shoulders of the pinion, must now be a measure of the difference between the stop and the corner of the cutter; and therefore, if the cutter, with its stop fastened to it securely, be brought up to a jewel in its setting while it is revolving in the lathe, a shoulder will be cut on the setting just deep enough to allow it to enter the lower plate sufficiently to make the distance between the faces of the two jewels exactly equal to the gauge between the shoulders of the pinion. The end shake can now be definitely made by increasing the length of the stop portion of the inside spindle, as it would lessen the depth of the shoulder on the setting. The object of the above description has been to give a general idea of the principle. A minute description of the tool would imply the necessity of drawings, and as the information would be of little use, except in a factory, we deemed it useless to give it, our object being only to show the principle of direct automatic measurement. In practice, the tool was found capable, with care, of doing the work of a dozen men, with a degree of accuracy never attained by hand. Great care is, however, required in its use, as the slightest pressure or change of temperature will alter the result.

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There can be no better schooling for the apprentice at the watch trade, than to attempt to lay off geometrically, the various parts of the watch—first, in single parts; then in combination, say a wheel and pinion, preserving the relative proportions with the greatest care; also the various escapements—their different positions while in action or in repose. The pursuit of such knowledge as he will have to acquire, in order to get a satisfactory result, will afford him not only pleasure, but reward him in after life, by making him a better practical workman; it may not help his "tact," but will give him enlarged ideas.

Decimal and Metrical Measurement.

Although the French have adopted the metrical division, and subdivided it into the decimal, it does not follow that we should blindly take as "authority" the standard which by law is recognized in France. The whole thing is in its infancy, and as there are considerations to offer on either side of the question, we will state the gist of the argument, pro and con. In doing so we will not go on the assumption that the decimal system is the metrical, for the very lowest orders of the Chinese, from time immemorial, have been in the possession of the "Sampan" (the common Arabic "Abacus"), that was used in times of which history has not cognizance. The Armenian, as well as the Chinaman, used the decimal, and in Hindostan, for ages, 10 has been a sacred number. We cannot, in fact, date the advent of the decimal as we can that of the metrical system. Yet the discordance in weights and measures made it necessary to obtain some unit as a standard of measure. The object sought to be achieved was not a trifle; indeed it extended into every walk of life, and was a source of constant litigation and social trouble.

The fact was, and somewhat is still in existence, that in France there was an endless variety in weights and measures. A man knew nothing about the boundaries of his land, or the weight of his hay, if measured or weighed by standards of any other province than his own. When the Revolution of 1790 swept everything before it, the different denominations that had been in use were abolished, and the pseudo government decided for a decimal system.

The next step was to get some standard of mensuration, and it was decided to take, in preference to the length of a pendulum vibrating seconds, the chord of an arc the forty-millionth part of the quadrature—that is of 90°. A commission was appointed, which, after investigating the whole subject, appointed two of its members, MM. Delambre and Méchain, to measure an arc of the meridian between the parallels of Dunkirk and Barcelona; having ascertained the value of this arc, it would be easy to compute that of the entire meridian. These gentlemen made a very satisfactory measurement, but not exact enough to be taken as a standard. They were not alone, however, for the following table will show what care was taken to insure a true result:

Where the Arc was Measured.	Lat. of Middle of Arc.	Arc Measured.	Measured Length in Feet.	Mean Length of the Middle Lat. in Feet.	Observers.
Sweden........	+66° 20′ 10″ 0	1° 37′ 19″ 6	593,277	365,744	Svanberg.
"	+66 19 37	0 57 30 4	351,832	367,086	Maupertuis.
Russia........	+58 17 37	3 35 5 2	1,309,742	365,368	Struve.
"	+56 3 55 5	8 2 28 9	2,937,439	365,291	Struve & Tenner.
Prussia........	+54 28 26	1 30 29 0	551,073	365,420	Bessel & Bayer.
Denmark........	+54 8 13 7	1 31 53 3	559,121	365,087	Schumaker.
France........	+44 51 2 5	12 22 12 7	4,509,832	364,572	Delambre & Méchain.
America........	+39 12	1 28 45	538,100	363,786	Mason & Dixon.
Rome........	+42 59	2 9 47	787,919	364,262	Lacaille Casini.
India........	+12 22 20 8	1 34 56	574,318	362,956	Lambton & Everett.
Peru........	− 1 31 0 4	3 7 3 5	1,131,050	363,966	Lacondamine & Bouguer.
Cape of Good Hope...	−35 43 20	3 34 34 7	1,301,993	364,060	Maclear.

These measurements were taken with the utmost care, and with all the fidelity that such men generally devote to a subject of so much importance. Various countries commissioned them, and they were supplied with the very best instruments attainable, while every facility that would tend to a successful result, was afforded. It was from the observations, measurements, and deductions from these results that the French Government established the "mètre," which is equal to 39.371 English and 39.3685 American inches. The French law, passed in 1795, enacted that there should be but one standard of weights and measures. The linear dimension of the metre was to be taken, and in order to preserve this measure, the law further enacts: "It shall be a rod of platinum, on which the metre, the fundamental unit of the whole system of measures, shall be traced. This rod, made by the order of the Government, is still preserved with the greatest care at the Hotel des Archives at Paris. The Bureau des Longitudes and the Hotel des Monnaies possess accurate copies of the original. At the same time the French Government was not unmindful of the importance of a unity of standard among nations. In 1821, John Quincy Adams, then Secretary of State for the United States, made a report to Congress on weights and measures, in which he describes the presentation of the standard metre, together with a kilogramme of platinum, which were deposited in the archives of the Government. Two standard metres of platinum are at present preserved at the apartments of the Royal Society at Somerset House. The whole idea of a perfect system of measurements, as a matter of course, involved the fact of national agreement in some one recognized standard, which should not only be constant, but easily regained in case of loss. In all this the French philosophers and statesmen have acted with a cosmopolitan generosity that should be appreciated.

This fundamental measure of linear dimensions is multiplied and divided by 10, the divisions being denoted by prefixes for the multiples taken from the Greek, and those for the divisions taken from the Latin, thus: metre, decimetre, centimetre, etc., and for the multiples, metre, decametre, hectometre, etc. The following table gives the measures with their corresponding values in English lengths:

French.		English.
Myriametre......	10.000	6.2137 miles.
Kilometre	1.000	0.62137 "
Hectometre	.100	0.062137 " = 328.833 ft.
Decametre	.10	393.7 inches.
Metre	1	39.371 "
Decimetre.......	.10	3.9371 "
Centimetre.......	.01	0.39371 "
Millimetre	.001	0.039371 "

This linear unit, its multiples and divisions, taken in the squares and cubes, gives the superficial and cubic standards, and therefore of capacity. For weights, the process or deduction is more intricate. A cubic centimetre is accurately filled with pure distilled water at 60° F., and the barometrical reductions are allowed, to date it at the level of the sea. The weight of this quantity of water under these conditions is taken as a standard of weights.

The "gramme," as this standard is called, bears the same relation to the sytem of weights as the metre does to that of length. The prefixes are the same, as the table will show.

FRENCH.	NO. OF GRAMMES.	ENGLISH.
Millier	1,000,000	2,204.6 lbs.
Quintal	100,000	220.46
Myriagramme	10,000	22.046
Kilogramme	1,000	2.2046
Hectogramme	100	0.22046
Decagramme	10	022046
Gramme	1	15.432 grains.
Decigramme	.1	1.543
Centigramme	.01	0.154
Milligramme	.001	015

The measure for capacity are regulated on the same scale; the litre being taken as the standard unit. The whole system, then, depends on the accuracy of the standard unit, the metre, and that again is dependent on the correctness of the results obtained from the twelve measurements of the arc of the meridian. It may, without doubt, be questioned whether, with so many probabilities of error, the metre could be restored should, by any accident, the original and copies be destroyed. The decimal system, however, having been taken in connection with the metre, the combined standard and system obtained the sanction of law, and at the present time the majority of the continental nations are using the French system—Belgium, Holland, Germany, Greece, Switzerland, Piedmont, Sardinia, Tuscany, Portugal, and Spain; but this is applicable more particularly to coinage.

Another, and really the most important consideration lies in the fact of the invariability and easy reproduction of the *standard unit* in any system. If such a standard has been attained that its reliability is insured through all time, no question exists as to the best system. The number 8, and again 12, have been each proposed for divisors. That there are some advantages belonging to each, is undeniable. If we attempt to divide a line, we will invariably find ourselves taking first one-half, quarters, and eighths—the division being much easier than by thirds or fifths, and consequently tenths. Again, if we have a square piece of paper we may divide it equally into halves, quarters, etc., by folding simply; in fact, nature has seemed to furnish the factor 2 as an almost universal divisor; and as it forms the lowest square, except one, we may by the folding process extract a square from a square; but it would be very difficult to get a roof, or square, of the factors 3 or 5. Joiners, carpenters, machinists, etc., almost invariably use a division founded on 8—as $\frac{1}{8}$, $\frac{1}{16}$—though of late years the closeness of the work required in the machine shop has compelled the introduction of the tenths.

Suppose, however, that 12 should be taken as a basis, the strongest argument in its favor would be the number of factors entering as divisors, say 2, 2^2, 3, 2×3. In this case the fractional parts might be avoided to a greater extent than in the decimal division, having a greater proportion of aliquot parts. Again, the radius of the circle is equal to the chord of one-sixth part of the circumference, and in the whole circle the constant 360° has more factors integral than any number below it; this division of the circles by multiples of 3 is as old as record can show of human calculation. The French attempted to make the circular division 400, but it is evident that this number does not answer the purpose so well as the other, so that we may reasonably expect that 360 will be our circular division, whatever changes may be wrought in the linear; the more especially as the number has been used so long in Astronomy, Geometry and consequently Geography.

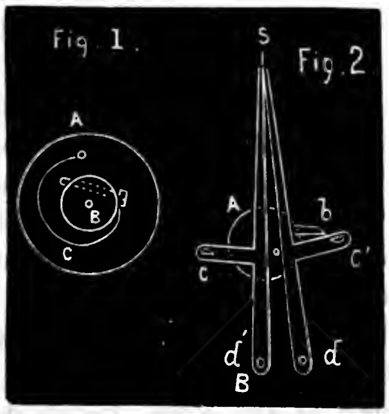
The whole reasoning, however, in favor of either modulus, falls when we consider the ease in computation afforded by the decimal, and therefore we shall consider the point settled in every respect but the standard. Richter, in Cayenne, discovered that his pendulum did not vibrate seconds; that the length of the instrument had an influence was well known, but it was a point of the greatest interest to find out why a pendulum that vibrates seconds at Paris did not do the same at Cayenne. It was found that the form of the earth caused the variation. The subject was subsequently taken up by Christian Huygens, and he proposed to make the length of a pendulum vibrating seconds the standard unit. Now, to get the real length for vibrating seconds, various considerations are to be taken in view, for though it seems to be simply a matter of course, it really is a difficult problem to solve. Indeed, for two hundred years no pendulum has been made or measured exactly, that beat seconds at given points of latitude. The word "exactly" is to be taken in the strict mathematical sence. As on the earth's surface the force of gravity varies according to latitude of elevation or depression—that is, the distance from the centre—the mathematical length of the seconds pendulum must remain in doubt. But the question is, to ascertain if it cannot be determined with more accuracy than the length of the metre; if it can, then it will be the best standard unit, for it may be found if lost, with more ease than the metre. Capt. Kater's experiments, which were carried out with skill, care, and patience, gave the length of a pendulum vibrating seconds in vacuo at a temperature of 60° F. at the level of the sea at 39.1393, at the Greenwich Observatory. By Act of Parliament this was taken as the standard unit. From this it will be seen that the British standard differs from the French by only the 0.2317 of an inch. The United States having taken that measurement as a standard, we can make the division decimal, and then the only difficulty lies in the fact, that there is a want of commensurability in the two systems.

We have given as full an account of the Metrical System as is compatible with the scope of the JOURNAL; therefore, if our readers wish for further information, we will refer them to the various reports of the Commissioners on Standards of Weights and Measurements from 1833 to 1840. Also to the various reports from Commissioners appointed by Congress to establish a Standard Unit.

Gravity Escapement.

To the watch repairer the clock escapement that beats the most distinctly is the most valuable, presuming it to keep a fair rate. The Astronomer, however, strives in certain portions of his work to get rid entirely of the dead beat, for he must have continuous motion if he would keep a certain celestial point on the wire of observation for any length of time. This may be well understood if the reader will reflect that an equatorial having been brought on a star, the position must be preserved, regardless of the earth's motion on its own axis. Now, if the power that turns the equatorial should be regulated by a pendulum vibrating seconds, at every beat the motion of the equatorial would be arrested, and there would be an error in the observation and the subsequent computations. At the Harvard Observatory there is an equatorial of 27 feet 2 inches in length, that weighs between two and three tons, with an object refracting glass of 14.95 English inches effective aperture, and alone weighing 47 lbs., and this vast body has to be moved with an equable motion for a space of time, say two hours, during which no interruption of the motion should take place. It will be obvious to the reader that a pendulum beat would have interrupted the motion 7,200 times during the two hours, and without some modification the pendulum would have been inadmissible. The driving clock had been furnished with a gravity escapement somewhat after the Denison plan, and was as perfect as a clock could be made at the time for the purpose. Mr. Bond, however, was not content; the revolution of such a mass as the great refractor on its equatorial axis was more than the instrument was calculated to effect. The proposition was, to allow the movement to be controlled by the pendulum, and yet have a continuous motion of the train. To explain his invention, for such it really was, we must first give an idea of the gravity escapement, as distinguished from the Graham dead beat. We will take it for granted that all our readers are cognizant of Denison's gravity motion, or, as Mr. Bond would have called it, the "Isodynamic," that is, an equal force or equal power escapement. Now, in this peculiar escapement the power applied has no relation to the power that moves the pendulum. We may do what we like with the clock train, make it coarse or fine, if only we give the pendulum the same amount of power with each impulse. We know, however, that a body falls the same distance, whatever may be the size, in the same time, provided we make the due allowance for resistance of the atmosphere; therefore, if we give the pendulum a constant force, whatever it may be, we should reasonably expect that the arc of vibration would be the same, other things being equal, and we would not be disappointed were it not for the fact that temperature, friction, resistance of the air, and the imperfections of mechanical arrangements all combine to prevent an equal amount of vibration in any pendulum, however correctly made, or patiently compensated. We may, however, take into account that errors will exist in any escapement where the force applied to moving the pendulum is derived from the direct impulse of the tooth of the escape wheel. But if we should apply that force, by means of a certain constant weight, falling independently of the clock train, at regular intervals, we should have a motion not influenced by any irregularities in the clock motion or escape wheel. This desideratum is almost achieved in the gravity escapement; and we have had the favor of a drawing of a new single-toothed wheel escapement, of which we give a description with an illustration, together with another isodynamic escapement that comes to us from another source, and which we think will commend itself to Horologists from its simplicity and perfect immunity from the tripping that has hitherto been the greatest fault of the gravity escapements.

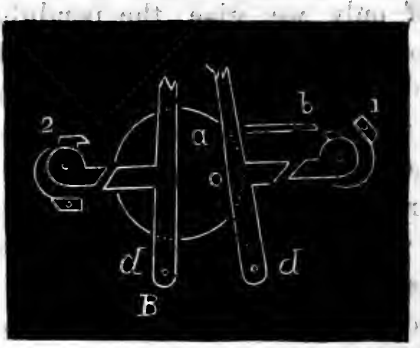
In connection with gravity, Mr. Bond very happily used the principle of the ordinary maintaining power as used on the fusee, in the English style of watch and chronometer, to effect the continuity of motion. The diagrams, though not in exact proportion, will illustrate all the principles on which the escapement is founded. The first diagram is intended to illustrate the continuous motion. Suppose the escape wheel, A, to be loose on the pinion staff, B, if now a spring, C, be connected with it and the staff, it is evident that the pinion will rotate until the whole tension of the spring is taken up; then the wheel will commence its revolution, but while the vibration is being consummated the wheel, being dead beat, is arrested, and the whole train would be in repose; but the spring allows the pinion to keep on in its rotation, thus again winding up the spring connecting the pinion with the wheel. Thus, supposing we have a dead beat, the whole train would be in continuous motion while the escape wheel was at rest. This, in the ordinary clock for Horological purposes, would be of but little consequence; but it must be borne in mind that the astronomer wants, not only the instrument with which he takes an observation, but the one by means of which he records the passage of a star, to be as nearly automatic as possible. The self-recording apparatus was devised for this purpose, and is now used as the base of all astronomical record. If we take a cylinder, revolving somewhat like the barrel of a common automatic organ, and on its surface paste or attach in any manner a piece of paper, and a style were to trace a line, it is obvious that the line would be a true circle, at least as true as the cylinder. If we moved the cylinder endwise in the meantime, the style would describe a spiral. The same effect, however, would be produced if the style were moved at an equable and proportional rate in the direction of the axis of the cylinder, the same as the tool and slide-rest are moved in the ordinary screw cutting lathe. If we knew the exact rate of rotation of the cylinder (say one minute per revolution), we shall know that the line described by the style represents one minute of time. By the peculiar arrangement



of the electrical current the circuit is broken every second, lifting the style so as to leave a break in the otherwise continuous line; then, if an observation is commenced at any particular recorded time, the seconds elapsing until the star, or object to be observed, comes on to some definite point in the field of vision, are shown by the breaks and may be counted off with ease The second, or part of a second, that the object is to be recorded is marked off on the cylinder by breaking the circuit. When the paper is unrolled from the cylinder the time may be read off, by means of a scale, to the hundredths of a second. But it is needless to go into the detail of the means by which such a desirable result is accomplished; we are interested in the gravity escapement, and the means for continuous motion alone. Fig. 2 gives the new single-tooth wheel with the detents on the pallets. The plan is obviously simple, and if the train is in perfect order, probably there would be no tripping to the escape wheel; but it will be equally obvious that in proportion to the force applied to the train, will be the shock of the detent leg of the escape wheel on the opposite locking jewel on the pallet.

In this diagram, the escape wheel is represented by A, having but one pin for the lifting, and one long leg, *b*, for the locking; C C are the detent, and *d d′* the unlocking jewels; P being the pendulum rod. The action may be explained thus: Having S as the point of suspension, if the pin, A, revolves it will lift, or throw from the vertical, the unlocking pin, *d*; but the detent leg of the escape pinion rests on the locking jewel, c′. When the arc of vibration is about being completed, the pendulum rod abuts against the unlocking jewel, *d*, thus raising the locking jewel, C, until the leg, *b*, is liberated from the detent. It will be seen at a glance, that in its motion in the arc of vibration the point C′ must raise the leg, thus on this side of the escapement produce a recoil on the escape wheel. The escapement is simple, however, and the force is nearly isodynamic, taking into consideration the friction of the pin of the escape wheel.

Another modification of the gravity escapement is shown in the diagram. The relative parts are the same except that the detents are independent of the pallets, as may be easily comprehended. The wheel being A, and the long locking leg *b*, each side of the pallets, and attached to the plate by bridges, are two bell crank detents, 1 and 2; the motion of the pallet lifts 1, and thus will unlock the long leg in *the direction of its own motion;* the leg, *b*, has a slight projection in front, not shown in the diagram, while the bell crank lever, 1, has a corresponding projection behind: and thus when the escape wheel is locked the two projections are in contact; on moving the detent the projection of the leg of the escape wheel passes behind, *i. e.*, towards the centre of motion of the detent, 1; on both sides of the escapement, the locking levers may be held to their places by springs, or counter weights; the action would be more positive and certain with the springs. The mode of opening the locking on 2 would be of the simplest form, as it acts precisely where the least force is required to unlock, the form of the inclined plane giving the desired form. In combination with the spring governor, or fly, this escapement should perform with wonderful accuracy, with a certainty of not tripping.



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The white substance the repairer finds in the polished steel work, as it comes in the form of material, is nothing more than anhydrous lime, and preserves the polished surface from tarnishing. The theory of its action is based on the known fact that dry oxygen has no effect on steel; in connection with aqueous vapor, however, it readily attacks. The lime being anhydrous, it attacks any watery vapor that may gain access to the package—thus really straining, as it were, the air of all its aqueous particles. After being kept a long time, the lime would become of no utility, as it becomes hydrated, and then its hygrometric property is lost. The repairer would do well to remember this fact.

Watch Repairing.

NUMBER ONE.

The object of the following series of articles is to give to the trade instruction on not only the truly theoretical, but purely technical art of watch making and watch and clock repairing. There has existed a vacuum that these articles are in a measure intended to fill up. The work by Reid was, and is to-day, a standard on the Watch as it existed in his day. Probably the theory was as well understood then as now; but the mechanical operations have been so much improved within the last forty years, that Reid is of very little use, except for the theory of a train. If a work is intended to reach the workman at the bench, and be of any use, it must combine the lowest as well as the highest branches; he must be offered the small things that, in the daily routine of watch repairing, are of so much importance.

In preparing these articles the author has had in view the immediate wants of his readers, and he feels justified in assuming that he knows them, as he was once in the country repair trade, remote from a city, and in a situation where a work of the kind we propose to publish would have been hailed with delight.

We will imagine a good workman, even in a small country town, with a limited stock of tools, and still smaller stock of materials. He finds that a pallet jewel has got loose, or some ignorant workman has so topped the escape wheel, and altered the escapement, that it is almost impossible to make the watch keep decent time. What, then, shall he do? If he puts in a new escapement entirely, the cost will be more than the customer is willing to pay, and he must, in such a case, "botch" up the work, and, it may be, succeed in ruining the watch; he certainly will do so if he attempts to do any repairs with the hope of a good result, at the ordinary price of repairing. Again, the writer felt the necessity of offering a knowledge of the "little things" that go so far toward the making of a good workman, to the young men who are now learning the trade. We must say a few words as to our shortcomings in these articles.

It will be apparent to any watch repairer that an article on the subject of watch repairing, if it enters at all into details, must necessarily be one of constant repetition; not that the subject is limited, but for the reason that one process so runs into another that it seems to be telling the same story over as we progress in the delineation.

The need existing for the series of articles we contemplate is well shown in the correspondence we have had with the repairers from Maine to Oregon and Michigan to Florida. The numerous questions asked as to the smallest trifles (the watchmaker would call them), and the suggestions offered, indicate to us that a work on mechanical manipulations, as applied to the watch trade, would be of importance to the whole Horological community.

There are workmen who stand in no need of a work of such minute detail as to what they know, and they may feel disposed to undervalue the knowledge sought to be conveyed; yet they cannot help recollecting a period in their lives when they would have given much for just such a resumé of the work at the bench as this is intended to be. There is not extant a work that, like Hollzapffel's Mechanical Manipulation, applied to general mechanics, is directly applicable to the watch and jewelry trade. We may regret the fact, but of all the works in existence, not one treats on the smaller things—that is, the constant affairs occurring in the ordinary routine of watch repairing.

What would a learned discussion on the subject of the lever escapement amount to to the man who is repairing the ratchet work on the barrel, or replacing a new centre pinion? The polishing of a square on the barrel arbor may be of more importance to one individual than the most perfect mathematical demonstration of all the escapements. In springing, the watch repairer very frequently has trouble that might be avoided, provided he had the smallest hint from some one who has learned by experience the best method of springing. The man who prides himself on the fact that he can learn nothing from others has a perfectly just estimate of his own abilities, and he can learn nothing, simply from a deficiency of brains.

It is the same old story, that the world was wiser hundreds of years ago than now; as if the accumulated wisdom of ages, added to the person's own individual experience, did not furnish a better basis of knowledge. There is no one man that possesses all the knowledge that is so very useful at the bench, and it must be remembered that there is no one who cannot give some information in regard to his mode of doing certain work, even to the best workman. He may tell many things of no interest, perhaps, to some individual reader, and yet interest a hundred others. Inevitably, the story of a monotonous occupation at the bench must be somewhat stale to him who has wrought at the trade for a number years. This fact constitutes the very first difficulty in treating the subject as minutely as it really should be treated, for there are many, very many, who have had only the education in the trade that an ordinary country jobbing shop could afford. While the proposed articles are intended expressly for such, the author has a consciousness that even the skilled workman may find in them something that will not only interest, but instruct him. With these preliminary remarks, we shall launch out on the subject of watches and clocks, and the repairs of the same.

The very intense ignorance of the watch-carrying public is a source of great annoyance to the repairer. Good, bad, or indifferent, as the case may be, each owner seems to think that the repairer should make it keep time—a result the *timepiece* was never *intended to accomplish*; and we speak from experience when we state that a hasty judgment in regard to the performance will, in some instances, give the workman more trouble than the whole value of the cost of the repairs. That the ordinary Connecticut clock keeps *time*, on the average, is taken as a standard by which the commonest English lever is rated, and, unfortunately for the repairer, the clock is the best timepiece, and thus he will be blamed for work that he, or any one else, in no possible way could improve.

The young man who, having worked at the bench three or four years, starts for himself, say in a place remote from the centre of trade, will occasionally overreach himself in his eagerness to acquire trade, by heedlessly taking in jobs that he has not thoroughly examined, and therefore has no just data on which to found a price adequate to the time and labor he must necessarily bestow on the work. The work of ordinary shops, at the present day, is remedied easier than in former days, from the fact that the general run of watches are Swiss. Once in a while the repairer is called upon to tinker up a poor quality of English watch, made in Coventry, that no skill can make run well; the labor bestowed on it is wasted, and both the customer and workman are disappointed. There are in the Swiss cheap watch some points that a repairer may well take heed of, as his time is of some value. It is to be remembered, also, that the class of watch purchased in different localities will vary with the means and knowledge of the inhabitants. In a Broadway store one may see every variety of watch, from the highest to the lowest, while in some repairing stores only the very best class of work is brought in. The object of the present article has been to bring before the minds of our readers the intention we have in the forthcoming series, and we must ask the reader to use his own judgment in the reading, for there is no one but can add something to the general stock of knowledge.

Precious Stones.

The article on jewelling, in the first number, gave a slight synopsis of the materials used in that branch of the watch trade. As it was technical in its scope, we have thought it worth while to give a resumé of the precious stones used in ornamental jewelling, premising that it is not intended to be exhaustive. As articles for personal adornment, they have been worn from a very early date, though it would seem from a description of the priest's plate containing the emblematic stones to represent the tribes, that at that date they were used more in the representative form than any other. Jewels were long ago known in the East—indeed almost before history began—and the Oriental gem is to this day considered superior to one from any other part of the world. They were viewed among the Easterns as talismans, and were prized more highly for that supposed quality than for any other value. This belief in the inherent virtue of precious gems descended to a late date, even in Europe. Superstition has now been banished on the subject, and gems are now being prized for their qualities of hardness, color, refractive power, and capacity of receiving a fine polish. In all these qualities the diamond stands pre-eminent, and therefore it is the most highly prized gem throughout the world. It takes its name from the Greek *Adamas*, and was called the *Alamas* by the Orientals, from whom the Greeks derived their first knowledge, although the Syrians are alleged to have known it anterior to the Orientals, though the supposition is somewhat apocryphal, as all the evidence goes to show that its first discovery was made in Hindostan. The stone was held in high esteem from its imputed quality of preventing mania, and as an antidote to poisons.

The reader must not suppose that the appearance of these ancient stones was of the wondrous beauty and brilliancy of the modern cut stones. In those days they were worn in the rough state —that is, the real diamond. Among the variety of gems mentioned by Pliny he cites the Indian as a true diamond; the others, from his remarks, we are led to believe were merely quartz crystals that undoubtedly attracted the eye by their beautiful crystallization and brilliancy. The extreme hardness of the diamond prevented its being cut by the ancients with the mechanical appliances at their command. Indeed, it was not until 1476 that Lewis Van Berghen invented the process of cutting the stone, by means of its own powder, on an iron lap. The cutting process, as a matter of course, lessens the weight of the stone; but when the work is done in a superior manner the value is increased, though the diamond, in the process, may have lost one-third, or even one-half, of the original weight.

Thus we may state, on the authority of Feuchtwanger, that the following table shows the cutting loss on some remarkable and well-known stones:

	ROUGH	CUT.
	Carat.	Carat.
Regent....................	410	$136\frac{14}{16}$
Grand Mogul.............	780	$279\frac{9}{16}$
Kohinoor..................	$186\frac{1}{2}$	$82\frac{12}{16}$
South Star................	$254\frac{1}{2}$	$124\frac{1}{16}$

It will be unnecessary to enter into the chemical constitution any more than to state that it is composed of pure carbon, and Sir Isaac Newton, long before its true constitution was known, stated his belief that it was combustible, founding his opinion on the high refractive power of the diamond crystal. It will be of more importance to pay attention to the qualities sought in the gem, as the value depends as much on them as on the weight. The color is first looked at, the pure, limpid white being the most highly esteemed, and the most valuable. The other colors are black, brown, yellow and grayish; but another variety, the muddy blue, is of value; the others are prized according to their cut and general appearance.

The color must be pure, clear, with great transparency, and should be perfectly uniform throughout the stone, as the brilliancy of the light refracted will be in proportion to the transparency and uniformity. On these two last-mentioned qualities very much of the value depends; for clear, perfectly homogeneous stones, without flaws, are ranked as diamonds of the first water, while a stone may be clear and limpid and yet will be rated as of the second water if it should be marked by flaws, or cloudy spots, apparently in the stone. The third water stones include all those that are colored steel gray, black, green, blue, or even a limpid stone may be so injured in the cutting, or have striæ. To distinguish the color and general internal structure, it is customary for the dealers to breathe on the cut stones; the condensation of the water so diminishes the reflection of light that the eye is enabled to penetrate the interior.

Although a very costly stone, the diamond is by no means rare, for it is found in a great number of localities, widely separated, on the face of the globe. While the original place of discovery is not definitely known, there are good reasons for believing that Hindostan produced the first. "Rich as the mines of Golconda" is the old comparison. The richest beds are at the present day the mines of Roal Corda, at the junction of the rivers Binnah and Restua, and those of Golconda, in the neighborhood of Pannah. The island of Borneo also furnishes this gem. One owned by the Rajah of Mattan is classed among the giant stones. Prior to 1728 the diamond market of Europe was exclusively supplied from the mines of Hindostan, but at that date the precious gem was found in Brazil, the discovery being made accidentally in the refuse matter from the gold washings. A person detected the valuable nature of some of the pebbles, collected a large number, and sold them on his return to Portugal, realizing a large fortune. In 1730 the Government took possession of the mines, and they are now worked exclusively by the State. On account of the competition in the market, caused by the supply from Brazil, many very ancient beds in Hindostan were abandoned. Russia has contributed a number, the first being found by Humboldt and Rose, in 1829, on this side of the Uralian mountain range. Diamonds have been found in the United States—in North Carolina and Alabama, and it has been asserted that the territories embraced by the Rocky Mountain range have also produced some specimens. Within a very few years some very fine stones have been found in South Africa, on the course of the Vaal River, some seven hundred miles above C petown; one of these specimens was sold for £4,000.

There is a peculiar species of the diamond called the conglomerate, which seems to be a mere transition from the crystal, though one fact has been observed that would warrant a suspicion that it was carbon in the process of crystallization. The fact rests on the many forms that have been found. It may occur in rounded masses, or even angular; the surface is black, resembling the peculiar coke formed in the retorts in the process of distilling coal. The interior, however, is somewhat crystallic, and has all the properties of the common diamond, and, from its low price, it is used extensively in the mechanical arts. If it be a change from the crude carbon to the crystal, there may be some truth underlying the superstition of the Hindoos, who assert that the diamond grows, and that, although the mine may become exhausted, a rest from the search for fifteen or twenty years will result in a fresh crop. We can know nothing of the chemical changes in the relation of the atoms that take place in this supposed transformation, though we have some analogous facts in relation to the transformation of carbon in the cases of plumbago and anthracite coal. The presence of hydrogen in the bituminous coal is enough to distinguish it from pure carbon; in the plumbago the miners and manufacturers frequently find pieces that seem to have arrived at a condition of incipient crystallization.

Suggestions by Practical Workmen.

Under this heading we shall insert anything of value that may be contributed by practical men, whose observations on any subject of practical application we should gladly hail; the JOURNAL having been instituted as an organ for the trade, we hold that all are entitled to a voice.

We reserve the liberty, however, of condensing, wherever in our opinion the subject matter will allow of condensation. Also, we claim the right to reject whatever may not in our opinion be useful to the trade.

STAKING ON WHEELS.—I do not know whether my plan is unique or not; it is certainly original with me, so far as I use it. I had an old Swiss upright tool with two centres. I took the two parts asunder, and bored out the lower hole so as to fit in a die; of the dies I made a number of the same sized holes, graduated as in any pinion stake; in the upper spindle I bored a taper hole, to which I fitted a number of staking punches. You will readily see that the staking in this tool can be done truly, and with no chance of breakage or canting the wheel over, as the punch must follow the guide formed by the upper hole of the upright tool. I have applied this tool, with different adaptations of punches and dies, to many other purposes. If you think the communication of any value, I will give you a further description.

W. C. M.

NEW YORK, *Oct.* 1.

IT IS AN EXCELLENT PLAN for every watchmaker's apprentice, to count the teeth and pinions of every clock or watch train that comes in their hands, and record the numbers in a memorandum book, which every one should have at hand. They will sooner or later be repaid by losing a wheel, and finding without trouble the numbers of the teeth and pinions lost, by referring to their memorandum of various trains.

R. C.

LIFTING SPRINGS are often broken, and the watchmaker has none of the right size and has no time to make one out-and-out. He can mend the old one and have it just as good as new, by placing the broken parts together, and binding them firmly to a piece of coal, and soldering them with 18 carat gold. It requires a strong heat and plenty of borax; then finish off nicely, harden and temper in the usual manner.

R. C.

CLEVELAND, *Sept.* 29.

MR. COWLES' method of tempering a lifting spring is good; but I think my plan is better, but not original with me. After I get the spring fitted, I draw-file it, then harden it in *oil*, then put it in a "spoon" and cover it with sweet oil, hold over a lamp until the oil takes fire, passing it over the lamp at intervals to keep it burning, and let the oil *all* burn out. I adopted this course ten years ago, and since that time I never have had but *one* spring to break, and that was on account of the steel being so coarse aad poor. The *kind* of oil may have had something to do with my uniform good luck, viz., sweet oil.

J. F.

AMERICUS, GA., *Oct* 6*th*, 1869.

WATCH CLEANING.—The method of cleaning watches as laid down in the August number of the JOURNAL, entitled "Watch Cleaning," will do for *new* work, but not for the class of work that usually comes to the hands of the ordinary watch repairer. A watch that has been used for some length of time not only becomes dirty, but the oil becomes thick, and from being in contact with the metal for some time, the plate and wheels become stained, and the usual method of cleaning is to use the brush and chalk, which of course scratches the plate and tends to wear off the gilding. Now, instead of using the alcohol first, as you suggest, if you will thoroughly wash the plates, bridges, wheels, and all the steel work (that does not contain any jewels that are fastened in with shellac), with soap and water, rinsing well with clean water, *then* put the different pieces into your alcohol, and proceed as you have indicated, your watch will be *clean*. If any stains should remain on the plates, they can readily be removed by a solution of cyanide of potassium. Great care must be exercised in using it, however, to avoid the greater evil of removing the gilding, which it will do if used too strong or allowing it to remain on the article too long.

In using the soap and water, you will find that by adding a little aqua ammonia it will prove of great benefit in expediting the removal of dirt and stains.

J. F.

AMERICUS, GA.

Correspondence.

We had designed in this number to give some plan (not our own) for a successful initiation of an Institute. We find, however, that the very collecting of the opinions that have been advanced, and putting them in some order of classification, is a task of no easy accomplishment. As we have received the following from J. F., the first proposer of the whole plan, we think we shall do the subject good service by submitting it for consideration. We cordially agree with him in his opinions, as to the wages and prices of work; these must regulate themselves. We also give the views of a correspondent from this State. It will be seen that there is a diversity of opinion. We must demur to the seven years' apprenticeship idea, for it ties the brilliant genius to the same anchor to which the dullest brain moors itself.

ED. HOROLOGICAL JOURNAL:

I see that my suggestions in regard to the watchmakers of this country organizing some kind of a Society or Union for their mutual benefit and protection, meet with the approval of all who have expressed themselves upon this subject. I was confident that such would be the case; it now remains to be seen, what we can do towards perfecting or at least putting the idea into some tangible form. As I introduced the subject to your readers, they may wish to know what I would have done. I will simply state that I have no settled plan or line of action that I can present, but will give some general ideas that meet with my approval; not but what some one else can suggest something far better, but to put the ball in motion, it is necessary for some one to give it a push. I think the best place to *organize* is New York city, as it is undoubtedly the centre of the trade. There are more good workmen there than in any other one city in the United States, and there are a great many others that go there every fall to buy goods; furthermore, the Horological Journal is published there, which will of course be the mouthpiece of the Society. For these, and various other reasons, I think that New York would be the place most acceptable to the majority of the trade, as a sort of "Head Centre;" and the fall of the year the best time to meet, say about the 1st to the 10th of October, every year. No one should be admitted to membership that was not either a scientific Horologist, or a good workman (either qualification should be sufficient to guarantee his admission). Other scientific men should be admitted as honorary members at least. The *test* for membership would of course have to be made by the Society, which, in my opinion, ought to be strict.

There should be some definite time agreed upon as to how long an apprentice should remain with his employer before he was qualified to work as a journeyman, and if we could not get the different Legislatures to pass some adequate apprenticeship laws, we could by our united action accomplish all the benefits that such laws would otherwise give us. As for instance, let every member agree that he will take no one to learn the trade who will not bind himself to remain the specified time. Let his name be entered upon a Register kept by the Society for this purpose, stating the time, place, who with, etc. When he has completed his time, his employer can give him a certificate to that effect, and endorsed by the President of the organization, if thought advisable. Let him be examined and admitted as a member also. If, on the contrary, he fails to remain his full time, the President or Secretary should be notified, that the proper entry should be made in the Register; and each and every member should agree never to employ such a party, nor in any way recognize him as a watchmaker. If we would all carry out in good faith something like the above, we would soon be able to separate the "wheat from the chaff." We should of course exert ourselves to induce the different Legislatures to pass some uniform and adequate apprenticeship laws, and I have no doubt but what we would be seconded in our efforts by other Unions; for it is to the interest of *all* mechanics that something of this kind should be done.

In connection with this Union, I would suggest the propriety of local or State organizations, that could meet as often if not oftener than the general or central Society, and at such times as would not interfere with it. The Presidents of these State organizations to be Vice-Presidents of the central organization.

I am in hopes that we may not only succeed in effecting a permanent organization as indicated above, but that we may in time accomplish something else of equal importance, viz., establish a Horological Institute, which would be, if properly managed, of incalculable benefit to the rising generation of watchmakers. Let Horolgy be taught here as a science; have large working models of each and every separate part of a watch, and other timepieces; the different kinds of escapements, etc.—let them be fully understood. Geometry, Algebra, Draughting, Astronomy, the use of the various kinds of instruments for taking the time, etc., should be taught.

If, after an apprentice had served his time, he could have the benefit of even but a few months in an institution of this kind, and he was possessed of any mechanical genius at all, he would be able to not only fully understand any horological instrument, but would be able to repair it properly. It might be made obligatory upon him to remain in the Institue a definite length of time, at the expiration of which to be examined, and if found worthy, to receive a "Diploma." The public, as you see, would be protected from being imposed upon by the numerous "botches" that now screen themselves from detection. By some such rigid appprenticeship system, we would not have so great a number of workmen, but would have a far better class, and their services would always be in demand, and at lucrative wages.

In connection with this, I would notice a proposition from your correspondent, "W. H.," viz.—"in saving the profits to the workmen instead of dividing them with middle men." I think that the subject of wages, etc., is something that should not be brought up, as the Society would soon be divided into two parties, and could not fail but produce ill feelings, and do, no telling how much, injury to the cause, as our Union or Society will be composed of both the employer and employee. The laws of supply and demand will always regulate the price of labor, and more especially does this hold good in our trade. His sixth proposition, if adopted, must also prove of incalculable injury to some, whereas it could not benefit any. In some parts of the country it costs a man two or three times as much to live as it would do in some other section. Now, see the utter imposibility of "the establishment of a uniform price for all specific jobs done to watches and clocks." It would not only be well enough, but advisable for each city or State as the case may be, for their own benefit, to establish a uniform price for work. I have always advocated this; but to make the rates of one section of the country the same as those of another, would simply be out of the question, and I have no doubt but what "W. H." will agree with me, when he gives the subject a little reflection. The prices for may "jobs" are entirely too low in some sections; but that is occasioned by some botch putting down the pricc, and as a great many people will patronize the man who charges the least, the good workman is compelled to reduce his price, although there is no comparison between the work done by the different parties.

Please tell your proof-reader the next time the word plano-concave occurs in my MS., to put it so, not make it "*plaud-concave.*"

J. F.

Americus, Ga., *Sept. 6th*, 1869.

Ed. Horological Journal:

The appearance of my article in the third number of the Journal, on the formation of a Watchmaker's Union, is a guarantee that I may discuss through the Journal the six propositions therein stated. I thank you heartily for the privilege, as what I may say upon those propositions may call forth other ideas from different minds upon the same subject.

First, then, on "The protection of the public against incompetent and dishonest workmen." Premising that a Watchmakers' Union is to be established, a competent committee might be appointed, whose duty it should be to test the qualifications of any applicant for admission to the Union—the qualifications necessary, to be determined by the convention which forms the Union. These qualificatious should be, first, a well established moral character. Second, and ability of such a type as will enable the possessor to adjust any standard escapement upon correct scientific or mechanical principles. He should also be able to renew any piece of work, that may be needed in any given case, as good as the original, and in accordance with the quality and excellence of the machine. A correct statement of the mechanical principles of the four principal escapements extant, namely, the Chronometer, Duplex, Lever, and Horizontal, should be required of each applicant for admission to the Union; or, at any rate, what constitutes an accurate adjustment of these escapements. If he or she can pass such an ordeal, admission to the Union should be allowed. If not, then the applicant should wait until his or her attainments come up to the standard established by the Union.

The names and residence of all who are admitted into the Union upon these conditions, should be made public through the Horological Journal and other periodicals or papers to be determined upon by the Union.

By establishing a plan like this, it will be seen at once that the people would be protected against incompetency and dishonesty.

It is equally obvious that the seond proposition, namely, "The protection of the interests of all good workmen," would be attained by the consummation of the first; because work would inevitably fall into their hands, and the people would be willing to pay, according to my experience, whatever one's ability or skill may be worth.

This leads me to the fifth proposition, namely, "The establishment of Co-operative Unions in the principal cities of each State, etc." I know the difficulties to be encountered here; and the chiefest of the chief is *selfishness.* But it seems to me that this propensity need not be paramount; that it might be reduced to reasonable subordination, within any circle of intelligent, christianized watchmakers. Half a dozen such men might form themselves into a local Union in any city, and agree to work a certain number of hours per day; hire an honest book-keeper, whose duty it should be to receive and deliver work and keep the accounts of the Union. Let each invest a certain share for the purchase of materials, and when the profits of the Union should be such, after concurrent expenses are paid, as to warrant an investment in watches, clocks, jewelry, etc., then invest, each putting in an equal share. Then hire an honest, competent salesman to attend to customers, etc. This, it seems to me, is not only a feasible, but a simple and practical plan. In fact, it is nothing more nor less than a copartnership upon equal terms. The supreme advantage being, in a pecuniary sense, the aggregation of the entire profits to the Union itself, instead of being divided with middle men.

"The establishment of a uniform price for all specific jobs done to watches and clocks," might be done through the U. S. Watchmakers' Union. A committee might be appointed to determine what each specific job is really worth, and that price could be equally the standard for New Orleans as for New York or Chicago. For I do not believe, outside of evidence, that living expenses, shop rents, etc., are so materially different as to debar the adoption of a uniform price list.

"The passage through the respective State Legislatures, of efficient apprenticeship laws" could be done by showing the legislators the necessity of such laws. The legal obligations should be mutually binding upon the employer and the apprentice. The former should be obliged to teach the apprentice the trade, provided he have the native ability to acquire a knowledge of it; the latter should be obliged to serve at least seven years. No matter how fine a mechanical brain a young man may possess, I hold that he cannot become a finished workman in less time than seven years. But who is to teach apprentices the trade? The majority of employers nowadays are not practical workmen; they are simply capitalists, having little or no direct interest in the labors of the shop. Upon whom, then, shall the reponsibility root of teaching the trade to apprentices? This is one phase of the question, which some one, in a future article for the JOURNAL, may endeavor to discuss. It is evident enough that employers, as a general thing, are not competent to teach the trade. And a great number of those who profess to be practical employers, are nothing but botches. Again, I ask, who shall teach apprentices the trade when effcient apprenticeship laws are obtained? I count it an easy matter to obtain the laws, but not an easy matter for apprentices to obtain proper instruction.

W. H.

BINGHAMTON, N. Y.

EDITOR HOROLOGICAL JOURNAL:

To ascertain the rate of a clock or chronometer: *First.* Procure a good telescope, as powerful as can conveniently be wielded by hand, with an eye-piece having no possible side-shake, and an aperture as small as clear vision will allow. *Second.* Select some firm wall of a building (if brick or stone, the better), ranging in a southerly direction, in which can be clearly seen some well-defined perpendicular corner of another building, tower or spire (if perpendicular); then to the northernmost corner of the first-mentioned wall, firmly attach two hard-wood strips of board in such a manner that their distance apart shall be a little less than the length of the telescope, and their outer edges absolutely perpendicular, and their respective widths such that when the telescope rests against them its line of collimation will accurately range with the before-mentioned corner of a building, tower or spire. Then on a clear night, with the telescope resting firmly against said strips, note the instant some particular star drops behind the corner of the before-mentioned house, tower, etc., and on the following or first clear night thereafter repeat the observation, carefully noting the time; then to the time of the last observation add three minutes and fifty-six and six-tenths seconds for every day that intervened between the observations; then the difference between the result and the time of the first observation, divided by the number of days intervening, will be the daily rate of the clock or chronometer whose time was observed. The same result may be obtained by noting the instant a star falls behind the ridge of some distant building, in a westerly direction, with the telescope resting on two immovable horizontal supports, accurately ranging with the said ridge; then working as before. But the result by this last method might be slightly affected by variable refraction, which is sometimes considerable at very low altitudes.

Allow me to correct a few erroneous inferences of "Horologist," in his notice of my communication in the third number of the HOROLOGICAL JOURNAL. In my claims for the quadrant and sextant, I excepted the transit, as possessing superior advantages to almost any other instrument, by reason of its superior telescopic power. I did not refer to the sea horizon, as "Horologist" supposes, but to the double motion of the sun's images, consequent upon the double reflection, as an advantage in favor of the quadrant and sextant over other meridian instruments. As to his question, "which horn of the dilemma does he take?" (previously assuming gross discrepancies must appear between the running of my clock and the result of daily observations with the quadrant), I will say, that although I use a sextant for its superior convenience, yet a single observation may be made with a correctly graduated quadrant to within two seconds of the truth, by using a good telescope, which can be had of the opticians ready to clamp to the quadrant in place of the sight vane; for by slightly advancing the index of the quadrant to a particular division ahead of contact, and then carefully noticing the contact as it arrives, as correct an observation may be taken with it as with the sextant, notwithstanding its finer readings. I heartily accept the conclusions of "Horologist" in favor of the transit, if a *portable* one can be had, possessing all the advantages claimed for those made by Messrs. Bliss & Co., as advertised in the HOROLOGICAL JOURNAL. I notice that some of their patrons, however, state they have tested the transit with the sextant, and found it correct—showing their confidence, after all, in the sextant; and I further notice that officers and others of the United States Navy are required to work to tenths of seconds when using the sextant.

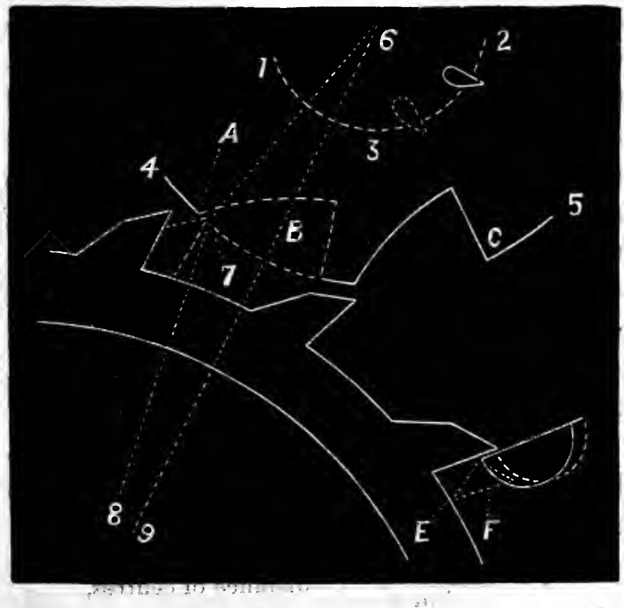
Yours truly, J. Cross.

Vineland, *October 4th*, 1869.

——o——

Answers to Correspondents.

F. B., *Pa.*—Your letter comes only a few days after we had been consulted on a pocket chronometer that was badly "sick," and the symptoms were identical with those afflicting your patient. It would persist in *tripping*, especially if the slightest amount of increase of vibration was given. In this case, one tooth of the escape wheel would sometimes miss the locking jewel, and thus the tooth that should be in repose for the next impulse would fall on the roller, and on the return vibration would take the impulse pallet on the one-half vibration.

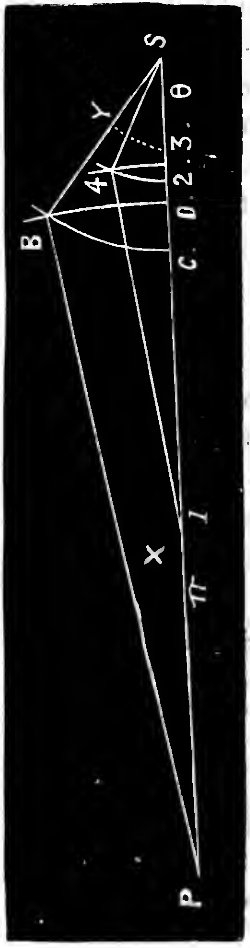


The above figure gives a rudimentary idea of the relative positions of the several parts of the chronometer escapement. No proportion has been cared for in the illustration, as the only object was to show you clearly what has happened in the tripping, and what damage may be done to the staff, wheel tooth, or escape wheel pinion. The full lines are intended to represent the parts in true position thus: 6 is the balance staff; 4, B, C, 5, the impulse roller; the dotted lines 1, 3, 2 being the discharging roller. The corner C is the impulse pallet, while B is the same after the balance has vibrated in the direction 5, and is on its return. The dotted point 7 is the tooth in contact with the roller at any time when the point A is in advance of the wheel tooth in the direction B, C. The locking jewel, whose locking corner is E, is shown in the two positions as traced by the dotted lines, and F is the same corner when the wheel has tripped. Taking the full lines alone, the drawing shows the escape wheel with the tooth on the locking jewel at the point E. Now, if the point of the tooth misses, the condition would be as shown by the dotted lines, the detent jewel resting on the back of the wheel tooth at F, and the other tooth is pressing upon the roller at A. But the direction of the roller is towards 5, and the wheel towards E; the whole force of the main spring then is exerted to throw the wheel pinion and balance staff apart, and as the angle 6, 7, 8, is very large, the force is exerted nearly in a straight line in the same manner as in the toggle joint at the nearest point of greatest pressure. The weakest part then would give way unless the shakes were out of all proportion, in which case the wheel would trip at least two teeth and then lock. In the case as shown, the wheel tooth is crowding on the roller, and the vibration of the balance towards 5 would therefore be lessened; on its return it lets off the wheel at A, and the consequences are that the impulse pallet meets the wheel in full motion while it is going in an opposite direction; the shock is strong enough sometimes to break off or bend the lower pivot, and this effect is also produced by the contact of the tooth with the edge of the roller. The main causes to be assigned for the trip may be, either that the locking spring is too passive, does not drop to its place at once, or the locking face of the jewel may not be in the same line with the face of the tooth, and therefore the spring is crowded off when the tooth takes the detent.

To enumerate all that might produce the fault, would involve too much time and space, therefore we will leave you to reason out the rest.

B. B. H., *N. Y.*—Before we answer the query: "Why is a watch with a short lever less liable to '*set*' than one with a long fork," allow us to ask whether you are sure that it is a fact, as implied in your question. The anecdote of Charles the First and the Royal Academy is a strong reminder that men, wise ones too, may reason on and assign theories to account for "facts which never happened." We see every day Swiss movements with a straight line escapement, where the pallet staff is planted outside the balance, with a long fork counterbalanced, performing with a certainty of action, and with no symptoms of "set." Had the question been asked in relation to watches of that kind that *do* "set," we should have given as the reason, that the fault was not in the length of the fork, but in the want of proportion between the length of the fork and the radius of the circle in which the ruby pin moves. In many of the fine Swiss watches, the proportion observed we have found to be as high as 6 to 1; and it is evident in such a case that the impulse would be weaker than with a shorter fork; but to compensate, the unlocking is performed with more ease by the ruby pin.

An inspection of the relative proportions in watches of the best Swiss make, will show that the difference is confined in a narrow range. In order to demonstrate the matter, the annexed cut, showing two forks and rollers, will be useful.



Let P S be the distance between centres, P being the pallet staff and S that of the balance; one fork and roller is indicated by letters, the other by figures. Now, if we take the pallet angle of motion at 10°=x and the roller angle at 40°, the point B will be the limit of action of the impulse pin; the curve B C representing the path of the pin, and C S the radius of the circle, the first step will be then to determine the distance of centres. The general rule may be expressed thus by Algebra:

If we make

P S = π, distance of centres,

and

P B = F, length of fork,

then

$$\pi = \frac{\text{F Sin. }(x+y)}{\text{Sin. }x}.$$

In the case stated we have

$x = 10°$, Pallet angle.
$y = 40°$, Impulse pin angle.

Assuming the fork to be unity, we may make the following equation, taking one half the angle—that is one side of the centre.

$$\pi = \frac{1.\text{Sin. }(20^\circ + 5^\circ)}{\text{Sin. }20^\circ} = 1.234.$$

which would be the distance of centres. These angles being given, it is required to find the parts. Now, the calculation of the whole length of the fork depends on the fact, that the proportion is in an inverse ratio to the angles described by the fork and impulse pin. In the case under consideration, if the impulse angle is 40°, and the pallet 10°, the length of the fork would be $\frac{40}{10}$=4; that is, the fork is four times the radius of the impulse pin's circle of motion. The numbered lines and angles in the diagram are based on 8° of pallet motion, and an impulse angle of 30°; then the impulse radius would be to the length of fork $\frac{30^\circ}{8}$=3.75. On reduction, if we assume the fork to be unity, the impulse radius will be 0.266, and the distance of centres θ=1.2581, the difference between the two being 1.258—1.234=0.024.

Now if these proportions, as laid down in the following general formula, are observed, the conditions will be the same.

$$\pi = \frac{\text{F Sin. }(x+y)}{\text{Sin }x} = \text{distance of centres,}$$

and

$$\frac{y}{x} = \text{D P, the length of the fork,}$$

and

$$\pi - (\text{D P}) = \text{Radius of the roller circle.}$$

The proportions in the English watches are somewhat different; in the Frodsham ranging from $3\frac{3}{7}$ to 1, to $2\frac{1}{2}$ to 1; the last we think too low, although the watches cannot be charged with "setting." If it is a fact that with the same proportions and an equally well made pallet and wheel, the long lever is more liable to set than the short one, it can be attributed only to the power necessary to overcome the inertia, or the force required to move the fork in addition to that required to unlock the arm of the pallet. Probably in the long fork the shakes of the pivots would have to be much closer, in order to get the same effect of the roller pin in unlocking. The long fork is generally a straight line. Now, from the very position, the fitting of the pivots (escape wheel, pallet arbor, and balance staff) would have to be made more accurately than in the side lever; for with a shake that allowed 1° play to the pallet angle, it can be proved that the loss would be as 1 to 4 on the impulse; that is 25 per cent. loss of power. A long lever fitted in such a way might be more liable to set than a short *side* pallet and fork.

However, until the fact implied in your question is well established under the conditions we mention, we will answer that the long fork is *not* more liable to "set" than the short.

If you will give us any evidence of the existence of the subject of your inquiries, we will try to sum it up and give the reason, if we are able.

D. W., *Mass.*—There are really few good treatises on watch making or repairing. Reid's work is but a compendium of the abstruser questions involved in Horology; it is really of no use to the repairer. It does tell about the various escapements, the form of wheel teeth, with the geometrical data on which these forms are founded; it give also the relative sizes of the wheels and pinions; but for all that, at the bench the workman will find it of the very slightest value. Denison can tell all about bells and his quarrels with Prof. Airey and others on the Committee. in the construction of the celebrated Westminster Clock. So far as watch repairing is concerned, there is absolutely nothing that is valuable to the earnest inquirer.

Holtzapffel, of London, wrote a work on mechanical manipulations that would be of important service to any one wishing to improve himself in the trade; but the ideas would have to be deduced from his own reasoning. The work costs $27, and embraces a range of subjects extending through every trade.

Another, again, by Miss Booth on the Watch, which is a mere rehash of Reid, Denison, and a description (feeble) of the American Watch Company. Piaget, of this city, has also written a good work for those to whom it was addressed. He gives the popular mind a good idea of how to use and how to avoid abusing a watch.

Undoubtedly the best work on the lever escapement, of every variety, is the one written by Morritz Grossmann, a very celebrated watch manufacturer at Glashütte, near Dresden. It is a Prize Essay, and certainly deserves the name; purely theoretical, it still affords the reader a knowledge of the mathematical principles on which the lever escapement is founded. The work, in English, is for sale only (in this country) by Mr. Chas. Wm. Schumann, Nos. 48 and 50 Nassau street, New York. We can cordially endorse a work that, like this, thoroughly exhausts the subject in a masterly manner.

J. B. M., *N. H.*—Sunk seconds dials are fastened, not only with the shellac, but we saw one yesterday in which the enamel on the back of the true dial had been ground off from the copper, which of course was then left bright, and the small plain piece of enamelled dial was ground off the face, leaving the copper projecting; then, when it was placed in, the two copper surfaces were in contact, and the enamel on the backs of the two dials not being cut out or turned off to the same size, a small circular space was left between them. This space was now filled with fusible metal, which soldered the two faces of copper, and made an even surface on the back. The whole thing is much neater than any of the English or American sunk dials, and is more durable, as alcohol will not affect the joint.

O. B., *Wis.*—It would be impossible, in such an article as Astronomy in Relation to Horology, to give all the processes and reasonings by which the results were attained. You ask, "why the orbit must be an ellipse." This was Newton's demonstration, and subsequent observation has proved the truth of Newton's solution. Thus, it may be reasoned, when two forces exactly equal are exerted on a body in lines at right angles, the resultant must be a true circle. Now, if we consider one force to be equal to 1 and the other to the square root of 2, the resultant will be a parabola; if more than 1 to the square root of 2, it will be a hyperbola; between the proportion of 1 $\sqrt{2}$ it will be an ellipse; and as this proportion exists between the tangential force and the attraction of gravitation of the sun, Newton was authorized in his statement

B. F. B., *Ga.*—You will find the method of compensation you describe in Denison on Clock Work. It will not work in practice, from what the astronomers call the *residual errors.* The temperature of the lifting bar will not always be equal to that of the pendulum rod; so there would creep in an error. Again, the slot through which the pendulum spring must move can never be close enough to hold it to the centre of vibration. It has been tried thoroughly, and failed.

A. K. L., *Vt.*—What could you gain? You lengthen the fork, but we can see no compensating advantages, as you would be compelled to counterbalance, and then the fork would be so heavy as to cause a great loss of power from inertia.

A. & Bros., *O.*—No contrivance has yet been devised by which a pendulum spring can be attached to a balance that gives any certainty as to the first results.

R. P. S., *Ohio.*—You can obtain good diamond powder in this city from the glaziers' diamond makers, as genuine, at least, as any imported.

AMERICAN

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CONTENTS.

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Astronomy in its relations to Horology.

NUMBER SIX.

It has before been stated that Kepler demonstrated a grand law of motion among the planets, "that the squares of the times of all the planets are proportional to the cubes of the distances." The Jovial system offered a fine object by which to ascertain whether the same law held good as to the planet and its satellites as well as to the sun and his attendants. If, in the demonstration, it was found to be the case with Jupiter and his moons, there could no longer be a doubt of the law's being general, whether applied to the primary and satellites, or the secondary and its moons. The elements of the Jovial system were also favorable, as the following table will show:

In taking the mass of Jupiter the millions are shown by a², being a×a, or 1,000×1,000

SYNOPTIC TABLE.

Of the Elements of the Primary.—a = 1,000.

Distance from the sun	5,202×95a²
Mean sidereal period in solar days	4,332,584
Eccentricity of orbits in decimal parts of semi-axis	0′,048
Inclination of orbit to the plane of the ecliptic	1° 18′ 51′ .3
Inclination of its equatorial plane to the plane of the ecliptic	3 5 30
Inclination of polar axis	86 54 30
Mass, sun being unity	$\frac{1}{1\,047\,871}$
Density, earth being unity	0.24
Diameter	90,734
Diurnal rotation	10h. 29m. 17s.

The distance of Jupiter from the Sun, as given in the table, is 494 a² miles, and if the Sun, Earth, and Jupiter be considered in the same straight line, the distance of the latter from the Earth is about 490 a² miles; this enormous distance is somewhat compensated for, in observation, by the immense diameter (90,734 miles) of Jupiter, and though his moons are of small size compared to their primary, they are really bodies of great mass and dimension, as we show by the table:

Elements of Jupiter's Moons.

	Mean App. Dia. as seen from the Earth.	Mean App. Dia. as seen from Jupiter.	Dia. in Miles.	Mass.
I....	39″.91		90,734	10,000,000
1....	1.105	33″.11	2,508	0,000,173
2....	.911	17.35	2,068	0,000,232
3....	1.488	18.0	3,377	0,000,885
4....	1.273	8.46	2,890	0,000,427

It will be seen that only one of these satellites is less in diameter than our moon, which is 2164.6 miles, the others being greater. The mean distance of the moon from the earth is about 238,793 miles. The moons of Jupiter revolve around their primary, at the tabulated distances.

	PERIODIC TIME.	DISTANCE FROM PRIMARY.
	D. H. M.	
1..............	1 18 27.53	262,202
2..............	3 13 14.36	453,670
3..............	7 3 42.33	680,505
4..............	16 16 31.49	1,361,010

The conditions afforded by the three tables are rendered still more favorable, as the planes of the orbits of the moons have but a slight inclination to the equatorial plane of their primary; which last is, by the table, only 3° 5′ 30″ to the ecliptic; but Jupiter's orbit is nearly parallel to the ecliptic, differing only 1° 18′ 51″.3, and this combination of positions affords the observer on the earth a view of the moons' motions in a plane always nearly in the ecliptic. The following are the orbital inclinations of the moons to Jupiter's equator:

	°	′	″
1	0	0	6
2	0	1	5
3	0	5	2
4	0	24	4

Nothing could be more favorable to a demonstration of Kepler's law either in the primary or satellite.

To illustrate this law, we will give a numerical statement of two of the moons. We will take Nos. 1 and 3; the proposition being that the time of either, and the distance of both, being known, the periodic time of the other will be found by the application of the theorem.

Thus the periodic time of No. 1 is 1 d. 18 h. 27.53 m.=2547.53 m.

The distance, 262.202.

The distance of No. 3, 680.505.

Then by the theorem

$$(\overset{\text{M.}}{2547.53})^2 : (262.202)^3 :: x^2 : (680.505)^3.$$

The reduction of this proposition gives the equation

$$(2547.53)^2 \times (680505)^3 = x^2\,(262.202)^3.$$

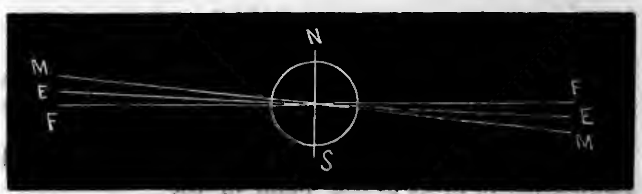
That is, the time of No. 3 is found to be, by the reduction of the equation,

$$x = \sqrt{\frac{\overset{\text{M.}}{(2547.53)^2}\,(680505)^3}{(262202)^3.}} = \overset{\text{M.}}{10062.33}$$

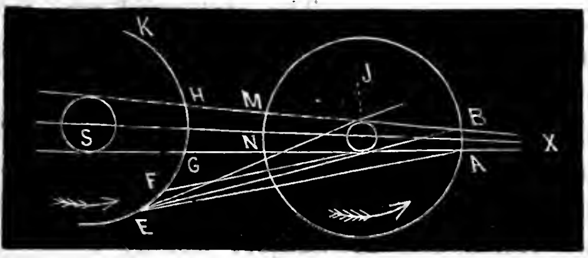
We leave the reader to obtain the value of x, and it must be understood that the exercise will more than repay the trouble; as the numbers are not absolutely correct, the value of x, perhaps, would differ from this, but the result will be close enough to convince the computer that the great law of Kepler gives the time as observed. It was a severe test, but the law has been found true, not only of this system, but subsequent observations have proved its extended influence into space.

To demonstrate this law, was not the only purpose to be subserved in studying the Jovial system; its great importance in obtaining terrestrial longitude was of still greater value to the practical wants and occupations of mankind. The relative motions of the two bodies, Jupiter and the earth, and planes of the orbits of each, were of the most favorable kind. We have shown by the table that the inclination of Jupiter's orbit is but 1° 18′ 51″.3 to the ecliptic, therefore at any point of the earth's orbit, the observer would have to allow but little for Jupiter's latitude. The periodic time of the earth is about 365 days (we use round numbers to avoid too much complexity), that of Jupiter is 4,333; so that the excess of Jupiter's period is equal to 4,333—365=3,968; now, during one complete revolution of the earth, Jupiter has advanced but the $\frac{4333}{365}$ part of his orbit; so it will be seen that he has moved in space but a small amount relative to the line that joined him with the earth and sun; the earth will have to advance through an arc equal to $\frac{1}{365}+x$ of a whole revolution before the bodes are in line; x representing the advance that Jupiter has made in his orbit while the earth was making up the difference in the motion; and it is evident that when the earth has passed through x, the slower planet has passed through $x—x'$; this will imply that the earth will, in the course of its revolution, overtake and pass the line of conjunction.

This will be better understood, if the reader will take a watch and observe when the hands come together on the dial, also when they are in a straight line in opposition. The motions of the hands are peculiarly illustrative of the relative motions of the planets, as 1 to 11.8 nearly; the watch motion being 1 to 12. From the fact that the two orbits are nearly concentric, it follows that the numerous eclipses of Jupiter's moons can be observed both when in conjunction and opposition. As before explained, the moons are observed passing before and behind Jupiter's disk, in straight lines nearly parallel with the plane of the ecliptic, as by the diagram, which



represents by E E the plane of the ecliptic; M M, the plane of the moon's orbit, and F F, the equatorial plane of the primary, N and S being the polar axis. It will be obvious that a body passing from E to E″ must be either projected on the disk or be eclipsed by the planet. But the satellite may be observed sometimes to be eclipsed by the primary when it is not in a straight line with the earth and sun, as may be seen by the following diagram:



It must be premised, before explaining the cut, that the mass of Jupiter is small when compared with the sun, and as the masses are as the cubes of the diameters, the reader will readily conceive that the sun's mass is as $(882,000)^3$ to $(90,734)^3$, leaving the ratio of $(\frac{1}{1047.871})$. But again, the enormous distance of Jupiter from the sun prolongs the extent of his shadow in space. Let S be the sun and J the planet; then by the diagram it will be seen that the lines of light passing by the limbs of Jupiter would terminate at some common point in space, say X. If now we suppose the earth to be in any point in its orbit, say E, it is evident that the observer could see both lines of the shadow cast by Jupiter in space. The planes of the four orbits falling so nearly parallel with the plane of the ecliptic, no moon could make a revolution without suffering an eclipse; the observer at E (supposing all the bodies to be moving in the direction of the arrows) would see the moon, A, enter the shadow, and it would disappear and would emerge at the point B. As the motions of the moons are well known and tabled, we have a means of determining the position at any time by comparison of the observed times of the eclipses which must occur to the then interior satellites at every revolution; while it very rarely happens that the fourth escapes an eclipse, from reason of the greater obliquity of its orbit. But the entrance of the moon into the line of shadows is not instantaneous, as it has a sensible diameter; so that the time elapsing from the first perceptible loss of light will be exactly equal to that the satellite would take in describing an arc around Jupiter equal to its own diameter, as seen from the centre of the primary. As a matter of course, the same thing is applicable to the emergence; but this makes no difference in the calculation, as the diameters are well known. Now, if the immersion and emersion is observed with the same instrument, and by the same person, the full interval will give the times, and the mean the precise moment when the satellite is on the line S, J, X; that is, when the centre of totality has taken place. Now, as the periodic times of the earth and Jupiter are well known, and the synodic elements of Jupiter's moons tabulated, there is no difficulty in predicting the occurrence of an eclipse; and on these tabulated predictions was based a system for longitude. It is true, the whole theory has given place, first, to the theory of lunar culminations, and last, to the relief of Astronomy, of the electric telegraph.

It often occurs that Jupiter's moons, without being eclipsed, are hid from the terrestrial observer from passing behind the body of the planet; in the diagram let E be to the west of the planet, and then the moon *a* and *b* will, in its progression, pass on beyond the line that determines the extreme limits of the shadow (or umbra) to the east. During the progression of Jupiter in his orbit and the moon in hers, the earth has also moved in space. Let us take the amount as between E and F. Now, it is evident that the line from the point F extended to the west side of the planet will reach the point B. A glance will show that on its departure (we mean the satellite's) from the point B, the moon will be obscured by the body of the planet, so that really an eclipse by the sun and an obscuration by the planet are not synonymous. If we follow the planetary motion we shall find that all the eclipses take place to the westward of the planet when the earth is in its orbit before opposition to Jupiter. Again, as the earth progresses in its orbit, it must at some time come, as demonstrated before, in a line with the earth and sun. Thus these eclipses will become confounded, not only with the shadow of the planet, but in the occultation; and thus it happens that at some periods the eclipses and the occultations must occur in the proportions expressed by the equation

$$T = \frac{sd}{a-b}$$

where *d* represents the whole revolution, and (*a*—*b*) the denominator. Taking the watch hands again as the illustration;

$$T = \frac{60}{1-\frac{1}{12}} = \frac{12.60}{11} = 65\tfrac{5}{12}.$$

As this is a general formula we need not extend it. Now suppose we (we refer to the centre of the earth) were to observe the eclipse of one moon on March 21st, and again on September 21st, it will be evident that the distance of the point of observation would be 190,000,000 of miles farther than at the subsequent observation. There was a discrepancy in the observed times of the eclipses and the calculations. We have before stated that a Danish astronomer (Rœmer, in 1675,) had discovered that light required some time to travel; however small the amount, still it was a quantity. Now, on observing the eclipses that take place when the earth is nearest Jupiter he found that they had occurred *too soon*, and he also found that when the earth was the most remote the events were *too late*. Why? To the philosopher this was inexplicable until he remembered the immense distance intervening as a difference—one hundred and ninety millions of miles. He attributed it to the progression of light, and assigned that it took 8m. 13s.3. for light to reach the earth from the sun; in fact, it was demonstrated that the time required for the differences was 16m. 26s.6.; and as this was the whole minor axis of the earth's orbit, it follows that it required one-half that time for light to reach the earth from the sun.

A very slight calculation will enable the reader to ascertain that the figures would require the velocity of light to be reckoned at something like 194,000 miles per second. The figures given were so extravagant that the theory was with difficulty received. Bradley, however, by his discovery of the aberration of light, confirmed the theory proposed by Rœmer, and Fizeau has since found by the principle invented by Mr. Wheatstone, that the velocity of the wave is equal to 194,600 miles per second. Wheatstone's priciple was by the difference of the arcs described by a reflected spark of electricity by means of a mirror revolving with great rapidity while the current was passing through a determinate number of miles.

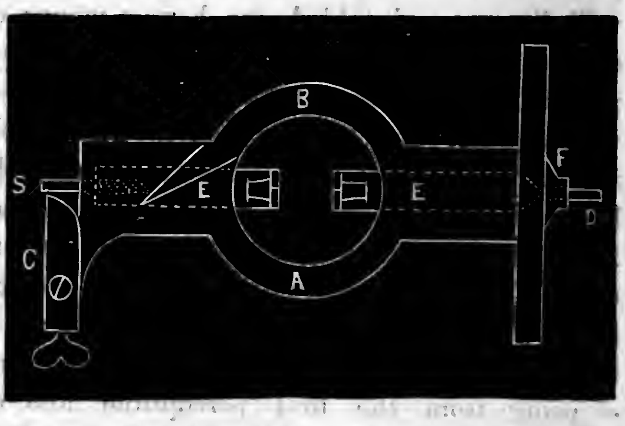
Watch and Chronometer Jewelling.

NUMBER SIX.

In the last number it was stated that the end-shake tool would be of little use anywhere save in a factory. The statement was true. On reflection, we have concluded that the principle on which the tool is founded is capable of too extensive application to the ordinary repair shop, to be passed over with a merely verbal description. We have, therefore, considered the subject worthy of a more extended description, and illustrated by a diagram, and we do this the more willingly as the idea may be very much enlarged in its application to small tools. The following facts warrant us in our assertion:

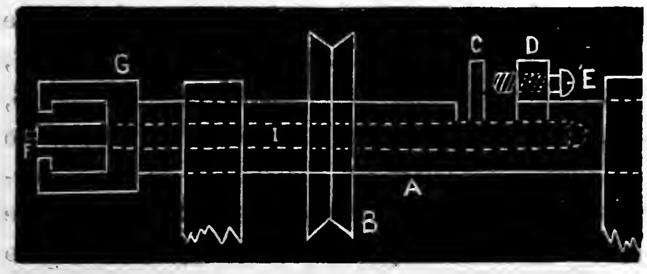
The principle of self-measurement was carried out in topping off the settings level with the plate, and also in countersinking the jewel screws. The use of the principle enabled the movement to be jewelled after gilding with as much ease as it had been done in the old style. We have, for the sake of further illustrations, given the two diagrams that show the whole philosophy of the tool. It must be remembered, however, that the diagrams are not intended as working drawings, and many parts are left out that are important in the real instrument. Enough is shown, though, to enable any one to comprehend the reasoning on which the tool was founded.

On reference to the last number the reader will find that two spindles are mentioned—in fact, three; for the inside spindle is made of two pieces meeting in the centre of the hollow space cut out from the centre of the outside spindle. Let A represent the hollow arbor at the centre B; it is expanded so as to leave room for the largest wheel intended to be used. The two inside spindles are indicated

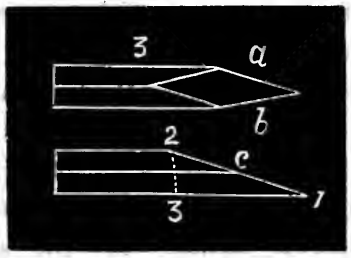


by E, the ends S and D being reduced to gain room; the end S is let into E by means of a fine screw that enables the operator to lengthen or shorten the absolute lengths of the two. C is the cutter, adjustable for diameter. On the centre ends of the spindles, E, a plate is fastened, with a V cut in the upper edge, and the spindle ends are slotted, 1 and 2, in order to furnish room for the pivots. It will be obvious that the shoulder must rest solidly against the end of E. By looking at the drawings the reader will see that if the two Es are closed together in the centre at B, the ends S and D would be exactly equal to the whole distance C and D + the amount of end-shake to be left. The screw, G, serves to adjust the cutter to the right diameter of the shoulder on the jewel setting. There can be no mode of mensuration more accurate, for it is evident that the distance between the two ends of the Es will be the exact length of any pinion put between the Vs, and thus the full distance between the shoulders is self-measured. In letting in the screws the heads were self-measured, and let in flush with the plate, without a burr, and with sufficient bite on the setting to prevent any looseness. While the countersinking was being done, the settings were prevented from turning by an ingenious system of clamps that enabled the stops to reach the plate and yet hold the jewel firmly.

The following diagram will give an idea of how the automatic system may be applied to tools on the bench, to enable the repairer to perform his work without trial.



If we suppose A to be the outside spindle, running in two standards, 1, 1, and to be driven by the pulley, B. We have a good external view on the end of A; at G is a frame let on to the end of the mandrel, free to rotate, but perfectly solid so far as an end motion is concerned, and thus it happens that the mandrel, A, will revolve inside the collar, G. While the whole frame connected with G will remain motionless, as the mandrel, A, has an end long motion at will, and G is permanently fixed, G will move with the mandrel, A, endwise. The mandrel, A, is hollow, and one side has a slot cut, through, which a piece, C, projects, that is firmly fastened to the inside, I. Screwed into the outside spindle is the leg, D, through which an adjusting screw is tapped, in order to make the contact perfect when the cutting lip, F, is exactly level with the stop face of C; if, then, anything to be measured were placed in the space between the point of the adjusting screw, E, and the inside face of C, the cutting lip of F would project from the stop face of G by just the thickness of the article to be measured, or rather that is intended to measure itself. In some of the common polishing and facing tools that are on the watch bench, this principle might be introduced to advantage; the more so, as any repairer could make a tool for use either with the ordinary lathe or the bow. There is one thing that renders the principle of advantage, and that is its certainty. We have supposed the jewel set in the plate with the proper end-shake; the next step is to counterbore for the jewel-screw heads. As the screw holes are drilled a slight distance from the hole in the plate, and the countersink cuts with but one lip at a time on the jewel setting, it will be seen that the countersink has a tendency to turn the setting around in the plate, as if it were a toothed wheel, and the cutter a pinion of one leaf; to avoid this in the grey work, the settings are cemented in by means of shellac—some using it in solution of alcohol, and others by heat, the same as in cementing up the work on the chuck. We would condemn this last, as the heat has too much tendency to warp the plates, and thus destroy the very work the jeweller has been so long engaged in perfecting. It is absolutely necessary, however, that the settings should be firmly set in the plate, and held while the countersinking is going on, as the leverage between the tit of the tool and the outside corner of the cutting edge is so great, that the setting is almost sure to be rotated unless very firmly fixed. Where the movements are jewelled in the grey, the whole plate, with the settings, screws, and all, are first filed down to a level and then stoned, the screws and settings taken out, and while the plates are sent to the gilder, the jeweller proceeds to give that exquisite polish generally observed on the jewel setting, both on the top and in the chamfer cut down to the convex of the stone. It would be a mistake, however, to apply the word polish to the chamfer, for there is not the first process of polishing applied to effect the result. The whole point consists in the condition of the cutting edges of the tools used in cutting away the superfluous metal from the setting. There have been many devices for the shapes, and many more to render polishing possible, but it will be found to be the only really practicable process, where the graver point or cutting edge is brought up to a grade of polish equal, if not superior, to the polish sought to be obtained in the setting.



We will suppose that we take a common steel graver, "Stubbs," and on grinding off the point at the angle 1, 2, 3, say 30°, being careful to leave the plane represented between A and B perfectly level, we may proceed to finish the two edges, A and B, up to a point that shall be equal to the finish we desire to produce in the cut of the setting. At this point we must diverge from jewelling to a somewhat different branch of watch-work, but which, in its turn, demands the very same conditions. We refer to the engine-turned work on the ordinary case, as well as the best class of work offered to the public.

We would premise that in this case we are speaking of how the polish on the barleycorn is effected. It is done entirely by the cutting edge of the cutting-tool, held in the slide rest. The value of the tool depends on equal angles and perfectly polished cutting edges. Another point is to be considered, and that is that the brilliancy of the polish would be much affected by difference in the angle at which the light is reflected, and thus, on the best class of watch-cases the cutting edges of the tools are made at an angle of 30° on each side of what the machinist might call a diamond point; but the angle made from the bottom should be 60°. Hollzapffel constructed a tool called the Goniometer, that was intended to furnish the workman with a positive mode of getting the proper angles with certainty. This instrument is founded on the same principle that is employed in determining the angles of crystals. The whole science of cutting a gem depends entirely on the angle in proportion to the refractive power of the material, and just the same with the brilliancy of the barleycorning on the watch-case. Other things being equal, the angle of the cutter that gives the best reflection of light will be the best for brilliant effect. Now, in what is technically called "stripping," the angle at which the bevel is cut has much to do with, not only its own brilliancy, but adds largely, when well done, to the lustre of the stone. The graver, as generally used by the jeweller, is of the more importance, as he has to judge of the effect from personal experience.

We wish, then, to make an edge on the graver that shall be able, with careful manipulation, to make a clean, polished cut. If any of our readers have been in a machine-shop, and observed the operator in the act of turning off a shaving from a piece of wrought iron, with the aid of water, he will comprehend our meaning of a polish cut. The jeweller, after having ground the point of the graver to the angle we have indicated, 30°, proceeds to put on this face between A and B, as fine a polish as can be effected on any piece of steel. No pains are spared to make it perfect; and as it is important, not only to the jeweller, but the general artisan, we will give a minute description of the process.

Depending somewhat on the habitat of the workman, he may use emery, oil-stone powder, or what is much better, sapphire pulververized and floated off, to get the various degrees of fineness, as is done with diamond powder. As the oil-stone dust is within the reach of every watch repairer, we shall take that as the modulus of operation. We will then suppose that the workman has the glass plates, of which we have in a former article given so minute a description; if he has not these, he may use with advantage a piece of the ordinary bell metal that has been brought up to a surface by grinding on a cast-iron face, with sand and water. After a fair surface has been obtained, the face is roughed up with a sharp file, in order to hold the finishing powder in the grooves made by the teeth of the file. It will be seen what importance may be attached to this form of surface, when we come to treat of setting the diamond end stone, so much used in the best class of watches and chronometers. At all events, the bell metal surface must be so prepared that the polishing material may in every case be retained by the vacant spaces. Great care must be exercised in grinding the face of the graver, if the true level is attained. Assuming that the grinding plate has been well prepared, the first material used after the grindstone, will be the oil-stone powder, in oil. It requires a steady stroke and hand to keep the graver at exactly the same angle, and if it is not so done, the subsequent polishing necessary will be impossible. After the face of the graver on the angle has been effected, it remains to finish the two other sides that constitute the cutting edges. In this consists the real difficulty, for if the smallest deflection takes place in regard to a *perfect plane* meeting the angle of the plane side, the edge will not be perfect for cutting purposes. In such cases, the graver is laid flat on the face of one of the sides and ground down until the edges meet; but the surface of the two sides where they meet the edges of the angle should be a *perfect dead level.* In fact, the finishing the graver will require some considerable practice. After the edge has been rendered perfectly uniform, it is polished up with first sharp, and then by means of a boxwood slip, used with the Vienna lime. If after the boxwood and line you find the edges of the graver gives a sensation of roughness to the finger-nail, it will be necessary to again grind the graver and again go through the same process of finishing. There can never be a certainty of a good edge on any new graver only after the temper has been ascertained.

Diamonds.

Since the article on diamonds was written, news has come that the precious gem has been found in Australia—that land of wonderful boudoir birds, duck-bill, amphibious fishes (onythorynchus), kangaroos, and monstrous nuggets of gold—and it is further stated that the fields discovered have thrown Golconda and Roal Corda in the shade. If one-tenth part of the various reports is true, diamonds will become far cheaper than the ruby, and as low as a fine aqua marine. It is reported that one has been found the size of a lemon. This mode of comparison is certainly very crude, like the old phrase, "as big as a piece of chalk." That diamonds have been found in Australia is beyond a doubt, and as the same geological formations exist in California, we may expect, at no distant day, a discovery of the precious stones in that region. Should the great expectations as to the richness of the diamond fields of Australia be realized, it would be hardly worth the while of any one to pick up a diamond, except for sale as mechanical appliances.

We may easily suppose that, in case the dream of the old alchemists were realized, the price of gold would become lower than that of iron; for one has no intrinsic value, save as a general standard of value, while the other is so intimately interwoven with every pursuit of human life that we can hardly conceive of civilization without it. Liebig has said that the amount of soap produced in any country is the standard of civilization, and soap involves the free use of sulphuric acid, the production of which may be limited by circumstances. Now, if gold were easily produced by transmutation, and the process were well known, the precious metal would become a very inferior one, and in point of fact fall even below lead and tin, from its non-applicability to purposes of common use.

The diamond may have been found in the extreme abundance asserted in Australia, but the same result must follow that attended the introduction of the Brazilian stone on its first discovery and its sale in Europe. In fact, the incredulity as to the value of the reputed diamonds from Brazil, on their first appearance, was so great that the first stones had to be sent to India, and thence imported as Hindostan stone. It sold well then in Amsterdam—then, as now, the great mart for diamond-cutting and sale. When, however, they were recognized as real stones there was no question of the great fall in price, and, as before stated, some of the oldest mines in Hindostan were abandoned. The same result must follow if the Australian field prove so productive as reported.

There have been very many experiments to produce the gem artificially; the basis of all the reasoning being that carbon, as the only constituent, may be made, by artificial means, to crystallize in the diamond structure. Like the search for the philosopher's stone and the elixir of life, the efforts have as yet all proved abortive, although every once in a while we hear through the papers that some professor has succeeded in forming diamonds directly from the carbon. As the subject, like alchemy, has a romance attached, it may be of interest to our readers to give a slight resumé of the attempts, together with the results.

There could be no incentive more powerful offered to the inquisitive—and more the avaricious chemist—than the difference in the relative value of gold and the diamond. The dream of transmutation having had its day, there came in, when the really true theory of chemical research was dawning, a strong desire to imitate nature in all her phases. The only question, said the philosophers, is to convert the common carbon into diamond. It semed so simple, so different from the theory of transmutation of the metals, that even the really scientific world would look with a longing eye to a process whereby a Kohinoor could be produced—say from a bushel of charcoal—and experimented. Numerous as were the attempts, none have yet succeeded; and there is a strong doubt whether the crystallization of carbon can ever be effected, if we consider that M. Becquerel has found that crystals formed rapidly are generally imperfect and soft, and that years of low, constant voltaic action were required for even a moderately hard substance. Now, if Becquerel's statements are good, and we have no reason to doubt them, it must have required ages to have formed the diamond. There may be a process of crystallization, however, of which science has as yet no cognizance, by which the time of perfection may be shortened. It will not be out of place to give some of the experiments.

Newton expressed a conviction that the diamond was combustible, deducing his conclusions from its high refractibility; afterwards it was successfully oxygenized, thus proving the correctness of his views.

The first successful experiment for the combustion of the diamond was made by the members of the Florence Academy, in 1694, and was effected by the rays of the sun, concentrated by a concave mirror. Having thus established the combustibility, and therefore the constituent, the next obvious step was to rearrange the particles so as to produce the solid diamond, as it were, by synthesis. The first obvious direction was towards the fusion of carbon (charcoal), and allowing the fused mass to slowly crystallize; probably the experiment would have been successful, provided it had been fusible. Dr. Hare, of Philadelphia, who first used the oxyhydrogen blow-pipe on a large scale, tried to fuse mahogany charcoal that had been made under circumstances that precluded the idea of any foreign substance. Under the heat by which he had succeeded in fusing some four or five ounces of platinum, he was enabled to obtain some globules of a crystalline nature, but subsequent analysis proved them to be silica in the fused state. In his experiments the Professor used the intense heat caused by the combustion of oxygen and hydrogen. As the proper proportion to produce the most intense heat is exactly the proportion found to exist in water, water was formed by the combustion; which fact may have very seriously interfered with his success. The intense development of caloric attendant upon the interruption of the voltaic current suggested the use of that agent, and it was found that two boxwood charcoal points, placed in connection with the battery, and separated enough to break the circuit and yet permit the current to pass, would exhibit a spark of sunlight brilliancy, attended with the most intense heat; it was also found that on continuing the current, even with the same voltaic force, the light diminished as well as the heat. On examining the points of charcoal, a small transparent bead, resembling glass, was observed, and the natural inference was that the carbon had been fused and the hard globule was the resulting crystallized diamond; but it was the fused silex that is contained by all carbon, in the form of charcoal.

Plumbago being a perfectly pure carbon, unadulterated by anything, save perhaps a slight trace of iron, held out the strongest prospects of success. Professor Silliman succeeded in producing from it several small globules that really had all the characteristics of the genuine diamond. But all the specimens, both from charcoal and graphite, were found by Arago to polarize light at a different angle from the diamond. A French chemist, whose name has escaped our memory, reasoning on the deposition of crystals under the voltaic current, attempted to convert the conglomerate carbon into crystals. The highest point of his success was only to obtain on the opposite electrode a powder that under the microscope gave fine crystalline forms. Some was sent to the gem cutter, who, on using it as he was accustomed to use the ordinary diamond powder, pronounced it diamond.

M. Cagriard de Latour, supposing that he had the true theory, pretended to have discovered the ingredients (?) for the production of diamonds; but the imposition was detected by M. Thenard, who found the crystals to be merely silicates, and Arago detected them by means of polarized light. The various devices that have been employed to crystallize the carbon have hitherto failed, and it is probable that nature's process will ever remain as profound a secret as vitality, or the cause why bodies take some definite forms that never occur in any other. This leads to the consideration of the crystalline forms.

Though we have stated that the chemistry connected with the subject would be passed over, we must, in order to give an idea of crystallization, go somewhat into chemical detail, inasmuch as by no other means can we get the requisite data on which to found a theory. Assuming that the general theory of chemical affinity and cohesion is somewhat familiar, we will not attempt an exposition, but take it for granted that though we may imagine the ultimate particle of matter to be infinitely small, yet it still exerts the same force in proportion to mass of attraction; that is, a tendency to attract other ultimate particles for which it has an affinity. If the particles were of indiscriminative form, the result of an aggregation would be a mass having no regular form, as the particles would be deposited indiscriminately; but we find that there is no substance yet known that under favorable circumstances does not arrange the particles in regular order; and these are so well known that in the chemist's view they become tests of objects of inquiry.

The conditions that determine the form of aggregation of these particles are not understood, but must be various; but a broken crystal will assume its correct figure if returned to the mother water, as it is called. Now, we may state it as a law, that crystallization is the effect of the molecular attraction, regulated by certain laws, by which each atom of the same kind of matter unite in regular forms. Suppose we dissolve a piece of alum in pure water; in the solution we should never detect the alum from its crystallized form, as the water has separated the ultimate particles so far that they become invisible—the chemical properties remaining the same; if the water is evaporated, a series of crystals will be formed identical with those previously dissolved, and these crystals will invariably assume the octahedral form. Of all these there will be some that, while preserving the same general angles, the corners will be imperfect. An immersion in a stronger solution is all that is required to make the crystals perfect, and this may be extended farther; for if a perfect crystal be broken, either of the fractured parts may be repaired by simple immersion in a more saturated solution, aided by rest and time. If, however, any disturbance occurs, the crystals form so small that they can be seen only under the glass. This is the case with the common salt (chloride of sodium), the solution of which, when evaporated, gives large cubes of the salt, but when evaporated by ebullition, gives the common fine salt seen on our tables.

Whatever cause may interfere with the process, the *form* is always sure to reproduce itself. We must argue, then, that the fundamental form determines the form of the subsequent crystal; if the crystal is a cube, as in the galena (sulphuret of lead), or iodide of potassium, we shall find that in pulverization the powdered particles are still cubes; and by parity of reasoning we conclude that, reduced as they may be beyond the reach of the microscope, the original form of each particle remains the same. This will be found to be the case invariably until the microscope has failed to enable us to distinguish the form. There are, however, some substances that, on crystallizing, take the same forms, and they are isomorphous; but even in these cases there seems to be a different arrangement or aggregation of the interior particles, for, from the motion of polarized light through rock crystal (silicic acid), we find that an extremely small change is produced sometimes in two crystals having externally the same forms, and the carbonate of lime shows above an hundred different forms. If we assume the primary molecule of any one substance to always be of a determined order of crystallization, it will be hard to reconcile the discrepancies observed in aggregation. In determining the forms, water enters largely, and we are not yet certain that the diamond is not affected by its presence. Most substances, in crystallizing, take up a certain quantity of water, and this seems to be chemically combined, not mechanically; thus the MM. Haidinger & Mitscherlich found that the water sometimes must give the peculiar determination to the constituent molecule. Except we receive this as a fact we cannot account for the apparent anomaly of the same substance crystallizing in different forms, as in the case of seleniate of zinc, which is capable of uniting in three different proportions with water of crystallization, and these three different combinations furnish as many different forms of crystals.

We may cite many other instances of substances that seem to have changed their primitive molecular shape; thus sulphate of soda crystallizes at 90° F., without water of crystallization, and combines with water at an ordinary temperature, but forms a very different crystal. Not only this, but it seems that a crystal already formed may, in course of time or by the action of heat, become disintegrated, and the interior structure so changed as to be hardly recognizable, while the external form remains the same. Constant vibration, as in the case of the railroad car axles, may afterwards change the internal structure without any obvious change of the external. We must conclude that heat has a great influence on the ultimate form, for Professor Mitscherlich found that a prismatic crystal of sulphate of nickel, when exposed to the active ray, was so far changed as to internal structure that the interior crystals were octahedrons, with square bases. Although these facts may not apply particularly to the precious gems, we cannot lose sight of them, for the whole subject of crystallography is founded on the internal changes that occur in solid bodies. Our whole idea of mobility is centred on gases and fluids, but we may be well be astonished when we find that the most solid bodies are in motion internally. From Sir David Brewster's observations we may infer that the cavities found in all stones are the result of decomposition and subsequent internal change of structure.

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Watch Repairing.

NUMBER TWO.

The first requisite the repairer needs is a good bench, conveniently arranged for laying away both tools and materials. The best bench we have ever used was a single white seasoned pine plank, say one and a half inches thick by twenty inches wide; the length will be determined by the conditions of the window at which the work is to be done. We are speaking now of a good bench, within the reach of any one. When there is a desire to have the surface level, the plank may be gained and battens let in before the top is traversed by the plane, which will insure it against warping. After the top has been made perfectly level by traverse planing, it should be smoothed off with sand paper, and then varnished with three or four coats of gum shellac varnish, which will give it a fine surface that is not liable to absorb oil, thus preventing the top from presenting the unseemly appearance caused by oil and dust;

and washing with soap and water is practicable, thus enabling the workman to always have a clean bench upon which to do his work.

And here, in the very initiation of the subject, we cannot fail of doing the apprentice a benefit by urging upon his attention the necessity of absolute cleanliness in all his work; an attention that will, during a very few years of active work, more than repay whatever little trouble it may involve; the habit once acquired will never be abandoned. The top of the work-bench having been prepared, a small bead should be braided on to the front edge and a flange on the back and ends. The proper height for most artisans is about thirty-two inches, and this height allows of a good-sized driving-wheel for his lathe, if he contemplates mounting one on his bench. The supports should be firmly fixed to the floor, and for the sake of rapid work, a nest of shallow drawers should be suspended beneath the bench, on the right hand side of the workman. These can be made, and divided internally, as the circumstances may dictate in reference to convenience and durability—the partitions being thin and the spaces adapted with care to the various small tools and the material boxes. With a bench thus arranged the workman can do a larger percentage of work than where he relies on the bench for a depository of all the tools.

No one can fail to be struck with the tedious searching for some tool among the mass of stuff lying before the workman that happens where the no system of order is observed. Directly in front of the artisan, and under the bench, should be a drawer with a tin bottom, being pierced in the centre with a number of fine holes, under which a tin bottom is fitted like the top of a blacking box. The object of this arrangement is to catch any filings or chippings of work in silver or gold. Some little distance below the gold drawer a frame should be fitted on runners, and have a bottom of strong leather (good sheepskin is well enough), the object being to afford a depository to catch any article that may drop from the bench. The workman will soon get into the habit of drawing the "skin" out every time he sits down before he attempts to execute any work. Any watchmaker knows the vexations attending the dropping of a screw, wheel, or any small article where he is compelled to get on the floor and institute sometimes a laborious search, which, in many cases, proves unavailing to restore the lost article. These accompaniments to the bench may be made as taste may incline, but we should recommend that neatness in the arrangements should be observed, for any man can work faster and better at a well-arranged, neat, and clean bench, than at one of the slouchy, dirty things too often seen, that look like twin brothers to a jobbing locksmith's bench.

If the workman determines to mount a lathe, it should be placed to his left, far enough to enable him to work with plenty of room at the ordinary repairs, and yet not so far off that he has to move his seat any distance, or get up in order to use the lathe. Thus much for the bench. We have been more minute than may be considered necessary, but when the fatiguing nature of the work is considered, any mode of shortening the duration is of benefit.

The next important point is in regard to tools and material, and no consideration of price should be regarded in getting the very best of both. It must be well known to every jobber, that he is often offered tools that, if good, are far below a fair price; the same with material, and if he happens to be remote from a dealer, he may cheat himself by attempting to save a dime in his purchase, for it is a rule that the price bears a certain relation to the quality. For instance, there are both Swiss and English tools of the very best quality, but they are high. Now if the workman should reject one of these, and choose a pair of plyers, for instance, he is more than likely to get a malleable cast-iron tool, simply case-hardened, liable at any time to fracture, and this may happen at a time when its use is imperatively demanded. The same may be said of the hollow pin vice and pin tongs. One of the most important tools on the bench is the vice. Formerly the common vice was the only one in market, but of late years there have been introduced into market various forms and patterns of parallel vices, some having a moving jaw to hold taper or uneven objects.

The Swiss and Americans are the principal producers. Of all the styles, we give our preference to the smallest-sized Parker vice, with an adjustable jaw, and capable of being revolved on an axis to any angle convenient for working; it is made of cast-iron, with steel-faced jaws, planed on and tempered equal to the best Stubbs. The Swiss parallel vice is made apparently of very coarse steel, left generally so hard that the jaws are very liable to fracture when pinching hard with a light bearing. On all accounts, the American vice is the best; while its cost is not much higher than the Stubbs' Cotter vice, and not so high in price as the Swiss parallel. One should be chosen that closes evenly in the jaws, and we prefer a perfectly smooth face to the steel, instead of one cut in file teeth. As for all the ordinary work in the watch or even clock repairing business, the bite will be sufficient to hold the work without marring.

The vice should be firmly screwed to the bench, at a convenient distance to the right of the workman, and should be furnished with a pair of false jaws made of, say hard sheet brass, and so fitted that they will slide on—not drop on—and when they meet they should be filed down to sharp joining corners. Sometimes in operating on work constructed from soft material, it is advisable to mount the vice with wood or lead false jaws, or even a strip of hard leather may be used, one on each jaw; this material serves admirably in cases of gilded work, etc. Another very important adjunct on the bench, is a first-class oil-stone; it may be Arkansas or Turkey, though we prefer the former. Like all other parts of the bench appliances, it should be kept clean, and should never be used without oil, as the particles of steel are apt to stick in the face of the stone, and thus leave places of no action; the same thing as occurs to the machinist's files, called "cat faces." If the workman has a lathe, he may easily attach a small Arkansas stone to a chuck and use it as a grindstone, either on the edge or face. In fact, for getting the correct angle and flats for cutting tools, the circular grinder is infinitely superior to any other tool, as the object to be sharpened may be held in one position while the grinder is doing its work; whereas, in using the flat stone, and moving the object, neither the parallelism nor angle can be maintained, owing to the motions of the hand and arm. For fitting up very fine drills, the circular cutter is of the greatest utility, and may be made to supersede entirely the straight stone, from the accuracy with which the work can be done, and the delicacy of touch the workman has in doing the abrasion.

The oil-stone has been cited as a sharpening tool only; the bench should be furnished with appliances for flattening both steel and brass work, for bringing them to the grey, and for polishing. As these conveniences can easily be made by any intelligent workman, we shall take great pains in our next to give a full description of both tools and processes.

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Emblems.

Emblematic jewelry is undoubtedly one of the first forms under which articles of ornamentation were made—perhaps not so much as "things of beauty," but as devices that might serve for recognition in the absence of the higher art of writing. From the earliest times recorded in the Pentateuch we have the precious stones used as emblems, and by the following list it will be seen that time as well as tribes were represented:

Jan	Hyacinth	Dan.
Feb	Amethyst	Gad.
March	Jasper	Benjamin.
April	Sapphire	Issachar.
May	Agate	Naphtali.
June	Emerald	Levi.
July	Onyx	Zebulon.
August	Carnelian	Reuben.
Sept.	Chrysolite	Asher.
Oct.	Beryl	Joseph.
Nov.	Topaz	Simeon.
Dec.	Ruby	Judah.

In course of time there sprung up societies that assumed to themselves distinctive emblems, and were somewhat astonished at the various rich and highly-wrought—artistic at that—specimens of Masonic and Odd Fellows' emblems in every variety—onyx, jasper, diamond and ruby—that we saw in the drawers of the safes of Mr. W. A. Hayward, No. 208 Broadway. There was no end to the display, and there were some cut stones that deserved the rank of being in an artist's studio rather than in the gloomy recesses of a chilled iron safe. The stock of other goods were in keeping, and we especially admired a fine style of new designs that is as applicable to the general wearer as the square and compass is to the most devoted son of the Order of Masonry.

Balances.

A correspondent in the present number details very minutely his mode of forming a compensating balance. It will be seen that he solders the two metals together, thus introducing a third, whose compensating rate must be taken into consideration. And again the question comes up, what influence over its own rate of expansion does it have on the other two? We have never believed in the soldering process, for the causes we have just stated, though we are well aware that there are first rate Horologists that take the process into favor, and a good balance is claimed to be the result. The difficulties attending the making of the ordinary expansion balance have induced many and various experiments in order to cut the Gordian knot in the way of cheap and good manufacture. It would seem that the quality of the steel has a very important bearing toward obtaining good results where the brass is melted directly on the base. The plan of turning up, truly, small cylinders of steel, and after the brass has been melted on, of turning off the brass truly from the original centres, and then cutting off the combined metals into disks of the proper thickness, has hardly been a success. The tension of the brass has a great tendency to spring the cut ends of the rim outward, however carefully the rim may be cut. This effect, the English claim, is much more apparent with cast than where blister steel has been used. Accordingly, the English practice is to use blister steel exclusively. But even this precaution does not give a true circle after cutting, and the adjuster is compelled to give the truth of circularity by bending with the plyers, a process that certainly is hardly suggestive of fine work.

When the brass has been melted on the steel, the internal structure will be in exactly the condition left in cooling. As brass, however, contracts more than steel with equal changes of temperature, it follows that, in cooling, the brass must contract on the steel, thus leaving the outside metal in a condition of tension exactly as the outside of an unannealed glass article is—in a condition of constant strain on the particles of the interior that have cooled so much slower. Glass, however, can be annealed, for the reason that the material being uniform, except in the fact of tension, the continued action of the heat allows the particles to assume the conditions best suited to an equilibrium. In the balance this resource is cut off on account of the unequal expansion of the two metals, it being definitely understood that any substance expands more in direction of its fibre than in any other. The result of the rolling would be to make the brass perfectly uniform, and with a tension that would have an equilibrium on the cutting of the rim. The small ends of the cylinders of steel on which the brass would be cast afford a means of escape for the expansion of the metal by rolling. We will revert to this again, as a plan has been suggested that may enable the compound balance to be made so that on cutting the rim the true circle will be preserved, and no subsequent bending needed.

Not only should the contact of the two metals be perfect, but it is a *sine qua non* that the line of juncture should be concentric with both the outside and inside faces of the rim. To secure this, it is necessary that the steel shall not alter its form. It is not exactly a question of poising, for the form, in order to preserve the true equipoise, must be so perfectly central and equal in radii that no change of momentum at any part of the rim can take place on increased or decreased vibration; this result can be attained only by achieving perfect truth in centring, and an equality in the radii.

In the English process the button of steel is bolted down and the brass melted on the steel. The centre is found, and subsequently the arms are filed out after the rim has been turned up; it is then, after the time screws are put in, cut; but, as said before, the cut ends will spring out. By the use of the blister steel it would be possible to make a balance that would not change, provided it were made in the style described—that of melting the brass on a cylinder and then rolling the brass in order to get a perfect uniformity of constitution of the brass. This suggestion is founded on the fact that rolled brass is much more uniform than cast, and the rolling process would tend to make the brass fibrous in the direction of its desired expansion.

Electro-Metallurgy.

NUMBER ONE.

The subject of electro-metallurgy is quite as important to the Horologist as to the general artisan, for he has to use, in his every-day practice, articles that have been modified in some way by the agency of electricity—a name derived from the Greek *electron* (amber), which, when excited by friction, was capable of acquiring properties entirely foreign to it when in a state of rest. The name has been made the cloak for every ignorant pretender to science, as he generally could give a full explanation to any apparent anomaly in science by attributing it to electricity. There can be no doubt of its extensive influence, and if we should call it a force of unknown origin, pervading all space and material, we probably would give the best definition we have. Silent and inoperative when undisturbed, it assumes very marvellous properties when interrupted in its own course. It is an agent imponderable, that pervades all substances—the earth, water, and air; but it does not change the volume or temperature of any substance. When in the passive state, its existence cannot be detected; but if, as said before, it is interruped in its course, the effects may be violent and destructive. Yet a study of the laws of this agent has enabled man to control the erratic exhibitions of its power. When what is called frictional was the only modification of the force known, there were some very curious phenomena attending thunder-storms that made a very close thinker, Benjamin Franklin, suspect that the two forces were identical.

In 1746 Dr. Spence had given lectures on electricity as then produced, by means of friction, on a non-conducting cylinder; the very curious effects produced were in Franklin's mind identical with the atmospheric disturbances that take place during a thunder-storm. His thoughts were directed to the subject by a channel of reasoning that may be popularly expressed in the following proposition:

All bodies in nature have a certain quantity of electricity, which might be diminished or increased at will, by abstraction from one and addition to another body. If the body was deprived of its natural equivalent of the force, he considered it to be negatively electrified; and the reverse he determined was in a positive condition. If, then, he depleted one body by drawing off its full complement of electricity, he could easily change the various relations so as to induce all the various results exhibited by Dr. Spence. He found that his theory was corroborated by his experiments, and his next step was to establish the identity of the ordinary machine electricity with that of the air. The points of resemblance between lightning and electricity were to him the great stand-points, and the disparity in the effects was even skilfully accounted for on a reasoning something like this: "If two gun barrels, electrified, will strike at a distance of two inches and make a loud report, at how great a distance will ten thousand acres of electrified cloud strike and give its fire, and how loud must be that crack." This was in a paper dated November 7th, 1749; and as if to show that that reasoning on the subject was equivalent to actual experiment, he goes on to account for the crooked and waving course of lightning, showing very conclusively that the same course existed in regard to the electric spark. Again, he reasons "that lightning like electricity, dissolves metals, burns some bodies, rends others, strikes people blind, reverses the poles of the magnet, and destroys animal life."

How, then, should he prove the identity? We will quote from a biographer: "It is true that at first a high tower was obviously the apparent agent or instrument of illustration. He walked abroad, but found there was the only one that could be possibly useful; here again he was disappointed, as the time of its completion was then very uncertain. There was not a single building then in Philadelphia that he could by any possibility use. One day the philosopher was taking a thoughtful walk, watching, as was his custom, everything, and turning it to a philosophical account, when his attention was attracted to a little boy, who, with great glee, had got his kite standing." Here was the key-note, and the old man philosopher was taught a lesson by the boy, that the easiest method of reaching the clouds, was a kite. Home went the sage and constructed a silken kite, with an ordinary hempen string. On the approach of the next thunder-storm he anxiously went into the fields, accompanied by his son, and, perhaps thanks to the youth, he was successful in raising the kite.

It can readily be felt by any one with what impatience he watched the string on that memorable day of June, 1752. He had attached to the string a common key as his receiver of whatever electricity he might obtain from the clouds; this key he insulated by attaching it to the post by a silken cord. The experiment seemed to be unsuccessful, and Franklin was about to abandon the whole thing, when he casually observed that some of the hempen fibres were diverging from the string; this convinced him that success was at hand, as the theory on which he had proceeded would indicate exactly this result. He applied his finger to the key and received the welcome shock—a biographer says, the most welcome rap of the knuckles that man had ever before received. When the rain came on, and the kite and string became saturated, the conducting power was highly increased, and Franklin was enabled to obtain every practical demonstration of the identity of the frictional and aerial fluid; and subsequent experiments showed that the same laws governed the one as well as the other.

This simple experiment with a kite, string and key, solved the great physical problem of the day, and we need not be too sparing of the praise we accord to the man who, by an inductive process, so beautifully succeeded in the solution. At all events, Franklin achieved a merited scientific immortality, for he deduced from his experiment that some safety might reasonably be expected from the electric fluid if a good conductor was so placed as to receive the charge before the adjacent parts could be affected; and the world has been benefited by the result, in the ordinary lightning-rod.

Franklin received his reward, even in life, by the extensive fame attending the announcement of the experiment. In Europe, where the papers relating to it were speedily translated, he was regarded as an eminent philosopher. The Royal Society made him a member, remitting the usual fees, and transmitting him a full copy of its "Transactions," and, in 1753, with the Sir Godfrey Copley gold medal together with a very complimentary address.

Electricity may be called into action by mechanical means, by chemical action, by heat, and by the ordinary magnetic force, and differs in its manifestations according to the mode by which it is produced. Hardly any motion or contact of bodies can occur without the development of a certain amount of electricity, and we need not feel astonished at this fact if we accept the final opinion of the most advanced philosophers, who claim the mysterious force to be identical with light, heat, and magnetism. Various circumstances go strongly to confirm the opinion that it is the vibration of "that subtle ethereal medium that pervades all space, being in a very highly elastic condition, and which is capable of moving, with various degrees of facility, through the pores of even the densest substances." While Franklin adopted the theory of two different fluids, subsequent investigations have shown that, though all the phenomena exhibited by this wonderful force may be explained on his hypothesis, there are strong reasons to believe that the results are due to a redundancy in one object and deficiency in another. Those that are + are always said to be positively electrified, and *vice versa*.

Substances in a normal condition neither repel nor attract any other substance, and it is to be assumed that the great law, that action and reaction are equal, holds just as good in the case under consideration, as in all the other operations where its value is understood and taken into consideration in the computation. It follows, then, that the attractive force is exactly equal to the repulsive at equal distances, and when not opposed they must coalesce with great rapidity and violence, thus producing the characteristic electric flash and explosion—the animal economy feeling it not only by sight and sound, but by a shock of the whole nervous system. It follows that one kind of electricity cannot be excited without at the same time causing the other to manifest itself. Suppose a glass rod to be rubbed with a piece of silk, we have in the glass just the quantity of electricity it originally had, plus that which it has taken from the silk, which in this case would be negative.

We have before observed that no motion of a body could take place without a disturbance of the electric equilibrium, and never before were we so thoroughly convinced as at the Fair of the American Institute. By the politeness of Mr. Harris, the exhibitor of the splendid 80-horse power engine, constructed on the principle of the Corliss & Nightingale, we had the opportunity to sit by the side of the 24-inch rubber belt; our hair was soon straightened out, and on inquiry we found that the motion of the belt was sufficient to produce a negative condition that, on the presentation of the thumb nail, caused a continuous flow of electricity for from three to four inches. Mr. Harris, who had already discovered the fact, had got an insulator made from a common sarsaparilla bottle, a piece of cork and copper wire. Without touching the belt, a full charge could be got by those joining hands, and a good spark obtained.

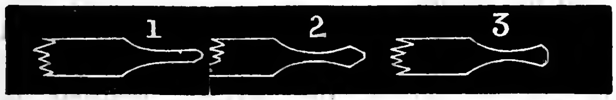
This, however, is not equal to Faraday's experiment in which he demonstrated that a body could be electrified by induction; and as the subject of induction will form a very important consideration in the subsequent investigation we may as well here advert to it. If a coil of insulated wire is connected with a Leyden jar, it seems that the coil becomes nearly as perfect a magnet as a piece of soft iron that is exposed to the influence of a perfect magnet. But it seemed that a current of this mechanically excited electricity, although of very short duration in its effects, would affect the direction of the needle, which had been quoted as an example of constancy. In the course of the investigations that followed Franklin's experiment, many things hitherto misunderstood were accounted for. There are some substances that transmit the electrical wave more readily than others; again, the power of retaining the accumulated force varies even in the same substance with the form, as it is found that a sharp point will more readily part with its electricity than a spherical form. But as the laws that pertain to mechanically produced electricity are almost identical with either magnetism or that involved by chemical means, we shall defer a further consideration of them until in the next number we treat of the immediate object of our articles—Voltaic Electricity.

It might not be out of place to give, before we leave the subject of mechanical electricity, some idea of a few of the most prominent phenomena attending its evolution, and the results of the discharge that takes place when two bodies are approximated differently electrified, as, for instance, in the case of a cloud and the earth, which possesses a powerful electric tension, while the atmosphere is, when clear, almost always positive. The atmospheric electricity is generally supposed to arise from the enormous evaporation going on at all times from the earth's surface. M. Pouillet has demonstrated that the evaporation of pure distilled water is not attended by the evolution of the electric force, but that the full effect is produced only when the water holds in solution some foreign bodies, such as common salt or salt of lime, or, indeed, any substance. The character of the electricity evolved in the evaporation is modified by the nature of the article held in solution; thus he found that when the water contained lime, say in the form of chalk, or any other solid alkali, the result was negative; but, if a salt, like chloride of sodium, was held in solution, the electricity was positive; and, arguing from these facts, it can be assumed that the ocean is the great source of atmospheric electricity; and this again accounts for the great frequency of thunder-storms in the tropics, the high mean annual temperature producing an excessive evaporation from water containing common salt in solution. M. Bequerd, however, has shown that electricity is developed whenever the ordinary arrangement of the molecular condition of bodies is deranged by any cause whatever; it follows, then, that the vast chemical changes taking place on the surface of the globe must occasion many great modifications in the electric condition of the atmosphere. The very forms of the clouds seem to be determined by the electric force, for they have been determined to be hollow vesicles coated with the fluid.

Suggestions by Practical Workmen.

Small Drills.—In making small drills for pivoting, the most serious mistake is generally made in the selection of the steel of which they are to be made; a due regard to its quality would in a great many instances insure good results. If the amount is very small so much the more need of being particular as to the quality, for if a poor Swiss broach is taken, there may, and undoubtedly will result a spoiled staff or pinion, which otherwise might have been made as good as though never broken.

A good drill can be got by using a bit of English steel (Crocker's or Huntsman's), or even a French graver. The diagram No. 1 will show the form of the drill as given by a conical pivot file or a bird's tongue file, of say No. 6 or 7, so as to have it smooth and conical; this form is given it in order to have the greatest possible resistance to pressure; the point should be spread by a slight blow of the hammer, using a round stake (not on a sharp corner as is usually done), and the form will then become that represented by Fig. 2.



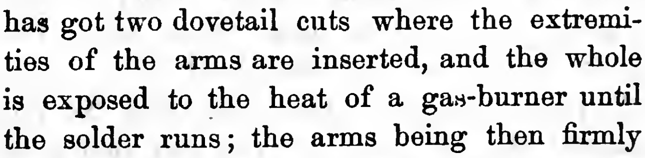
To get a good temper it is necessary to use only a piece of raw potato or apple, while for very hard drills, beeswax, or, in extreme cases, sealing wax is far preferable. The flame of the alcohol lamp should be as small as possible, in order to secure the requisite tenacity and compactability of the steel, it becoming very brittle from the loss of all its good qualities from too excessive a heat. Fig. 3 shows a drill finished on the Arkansas stone that will, from its form, withstand the pressure required to drill in hard steel. On these drills I use only a common screw collet; but there is something particular in the use of the bow, as but a third or one-half turn should be given until the drill, by heavy pressure, has taken hold; then the bow may be used to its full extent, but with a slow motion, for otherwise the friction is apt to draw down the temper of the steel in the drill; and even when used with foot lathe the same precaution must be had to prevent softening or breaking of the drill.

It is a matter, of course, of vital importance to have a good centring, or drilling and centring tool combined, for if the point from which the drilling commences is not truly in the centre, the pivot that is repaired will be eccentric, and there will be more labor and time expended in repairing the fault, than in making or replacing a new staff or pinion.

F. W.

N. Y. City.

Compensating Balances.—Very few pieces in the watch have been studied better and deeper than the balance producing the compensation by the changes of diameter according to the amount of heat in the temperature. The vast amount of work required to cut the arms out of the solid steel, and the difficulty of soldering together two rings of different metals, and consequently of different dilatation, induced me to use a different way of making these balances. By this process, the steel and brass are soldered when in a flat state; then nothing prevents the free dilatation of the brass; and the arms as well as the outside ring are found, by means of a die, in a punching-machine, thus avoiding the tedious process of cutting the arms out of the steel stock. The brass and steel are first rolled to the proper thickness, as illustrated in Fig. 1. Between them is inserted a very thin sheet of silver soldering, and the whole is bound firmly with binding-wire. The hub has got two dovetail cuts where the extremities of the arms are inserted, and the whole is exposed to the heat of a gas-burner until the solder runs; the arms being then firmly fixed to the central hub, a mill cuts the excess of stock on every side, then the balance has got the shape of Fig. 1. Next, the balance is put in a die, and a single blow will give it the form of Fig. 2. Half of the thickness of the arms is cut off on the top of the balance, and stoning and polishing will give



the *coup d'œil* to the piece. Screws or sliding-pieces may be used as weights. This new way is very cheap, and makes an expansion balance as good as any. I used it first in the new chrono-lever watches of the Mozart Watch Co., in Ann Arbor (Mich.), and the result was as good as could be expected. The drawings, as furnished, are not in any correct proportion, but serve to illustrate the idea.

E. S.

Hudson City, *November*, 1869.

How Vexatious to drop a small article and spend a quarter of an hour of valuable time in a fruitless search for it—getting on your knees, dirtying your pants, growing red in the face, partly from your inverted position, and partly from anger. All this may be easily avoided. Thus:

First, sweep very clean every nook, and corner, and crack about your bench and window, then get a pound or two of putty (no matter "what's the price of putty"), and a few strips of nice soft pine, then putty up every crevice that is large enough to conceal a jewel screw; the large cracks stop partially with bits of pine and finish with putty; don't miss a single place. The whole job won't take you longer than you will be searching for a lost second-hand, and then when anything *does* drop, you can find it in a moment by sweeping your floor with a little broom brush.

R. C.

Composition pin tongues are always so soft for about one-third their length above the joint, as to give no satisfaction in use. It is occasioned by the wire becoming annealed in soldering on the joint. A very simple, easy way to harden them again is to fasten the joint in the pin vice, then hold firmly, *near the point*, with the plyers, and twist the pin around (by the vice) till you feel that it is sufficiently stiff. This will leave twist marks (gradually diminishing toward the point) which can be entirely burnished out, leaving a firm, stiff, well appearing pin tongue; 'tis very quickly done—try it.

R. C.

Cleveland, O.

Correspondence.

Worcester, *Nov.* 1, 1869.

Editor Horological Journal:

"Pioneer," according to Webster, is one that goes before and prepares the way, and makes such observation as may facilitate the progress of those that may follow. Many a man has dug his way West under the severest trials and hardships, and secured a home for himself and family, without doing anything for those that follow than simply to observe the climate, soil, and means of support. This is of no small account, inasmuch as it enables his followers to prepare themselves so as to avoid the difficulties which he encountered. It is just so in mechanical pursuits. It is not very often that the inventor, or projector of a new business reaps reward for his toil and labor, but those that build on his failures and avoid his errors.

These remarks are made in view of an article recently published in some horological journal, in which the writer credited the Waltham Watch Company as being *the pioneers* in watch-making in this country. I would not rob that Company of one jot or tittle or praise that is due to them for their efforts, which have been crowned with such great success. But while I award to them all due praise, I would not withhold the same from others, who long preceded them, and did for the time, and in their times, as successfully engage in the business as the Waltham Company, though under far less favorable circumstances. I refer to Luther Goddard, of Shrewsbury, Mass. He was brought up a farmer, but early in life meeting with an accident which prevented his following that occupation, he turned his attention to mechanical pursuits. He was a man of great ingenuity and perseverance. In about 1780 he commenced making the old-fashioned brass clock, of which there were very few in the country at that time, except those of English or German make, and bearing a high price. The way in which he first commenced I cannot now tell, but know that he made many clocks of excellent quality, many of which are still in existence amongst us, and keeping good time. One of his clocks, which is still in the neighborhood of his old home, is of remarkable character. It runs a week once winding, and shows the hour, minute and second, day of the month, age of the moon, strikes, and plays seven tunes, on the Sabbath playing a psalm tune (old Amherst). This clock, to my personal knowledge, is now in good condition, except some slight derangement in the musical part. After a few years' continuance in the clock business, Mr. Goddard commenced making watches. In this he labored under great difficulties, having no practical knowledge, and for the want of proper tools. The first difficulty he overcame by employing foreign workmen, the second by making the tools himself. But with all the difficulties that surrounded him he bravely contended, and succeeded in making a much better watch than was then in general use. He made everything pertaining to the watch in his own shop, except the dial and main-spring. His watches were mostly of the verge escapement.

He had two sons, Parley and Daniel. These he brought up to the watch business. In 1817 he moved from Shrewsbury to Worcester with one of his sons, leaving the other in Shrewsbury, where he still continued the business. But few were made by the old gentleman after his removal to Worcester. In 1824 the old shop in Shrewsbury was abandoned, and Parley moved to Worcester and took his father's interest with Daniel, and the old gentleman retired from the business. He died in 1842, aged eighty years. The sons continued the business in Worcester for a number of years, making some, but mostly importing their movements from England and France or Switzerland, and making the cases at their own shop in Worcester. These men of whom I have spoken were practical watchmakers, and, with the help they employed, made many hundreds of watches, which are still scattered over the country, fair time-keepers.

Now, I would ask if the Goddards are not entitled to the credit of being pioneers in watch-making in this country, as well as those who commenced some fifty or sixty years later. There were others who were nearly contemporary with Mr. Goddard in watch-making—Josiah Wheelock and Moses Morse, of Sutton, Worcester County. They not only made the verge watch, but levers, and other escapements that were original with them. It was Messrs. Wheelock & Morse that invented and made what was called the patent vertical watch. It was afterwards copied by the Swiss, and such alterations made as brought it into disrepute. As originally made, the impulse was entirely on the pallet, with rather a slow motion. The Swiss altered it so as to have the impulse on the escape-wheel teeth, with a quick motion. The effect was, more friction and less power on the last action. As a time-keeper, it was much superior to the verge. I have now one of their old movements as originally made. I have also another of their old movements, which was invented by them. It has two escape wheels, acting alternately on a flat side of the balance staff. It was very simple and a good timer. All the watches made by Wheelock & Morse (except the verge) were without chain and fusee, the barrel acting direct on the centre wheel pinion. There are still others whom I might mention, who were about the same time engaged in making watches in New England, though not to the extent of the Goddards or Wheelock & Morse. I have referred to the above prominent ones to show that the Waltham Company were not the first to make watches in New England.

W.

Answers to Correspondents.

A. E. P., *Cal.*—We print your query, as it strikes home to hundreds who are anxiously trying to solve the same problem. Suppose we reason on the facts that history gives us, and then perhaps we may offer the solution.

QUERY: "I would like to ask now, if there is no way to get the meridian line accurate enough for all practical purposes in regulating a watchmaker's 'Regulator,' without going to the expense of a hundred dollars or more for instruments? It is an expense that many situated in country towns are not able to incur, and do not feel that their business would warrant; still they would like to *know* pretty near how their time is going."

The eclipses taken at Babylon some 2000 years before the advent of Christ, certainly were not taken with either a Troughton & Simms transit or equatorial; how then can a date be assigned to the time of the alleged eclipses, unless the observations were based on some determined point of time?

Hipparchus, who lived some 128 years before Christ, discovered the effect of precession of the equinox on the longitude of the fixed stars, and his data for calculation were founded on observations taken by Timocharis, 155 years before. We cannot suppose that he had a first-class instrument or all the appointments of either the Greenwich or Harvard Observatories. Again, if we take Ferguson, with his string of beads, we may comprehend with what poor utensils a man may make good observations and get good results in computation.

In your query you ask the same solution that the Arab effected 4000 years ago; not, it is true, to a fraction of a second, but close enough for us to detect an annual variation of only 0.045 of a second. As this process was purely mathematical, and depended on the fact of a fixed point for observation, we may copy the ancient's example and obtain equally good results, if not better. We do not feel like going into a general discussion of the subject, but, as we stated in the beginning to the answer to your query, there are hundreds who want the same information you are seeking. There was one Omar, who lived in the city of Babylon, and was a good astronomer; he observed a number of eclipses, and we cannot suppose that he had any of the modern appliances for taking observations; for all that, his correctness is in the same proportion as the truth of work done on the old hand lathe compared with that done on the best engine lathes at the present day.

M. Biot found that the observations were correct; at the time they were taken, however, refraction was not so well understood, and there is an error in the zenith distances. We may cite the tables of the East Indians of Jupiter and Saturn, who had determined inequalities in the mean motions of the two planets in that portion of their periods when the apparent mean motion of Saturn was the slowest and Jupiter's the most rapid. The cycle embraced in this inequality is some 918 years, so you can see that without instruments there were people in old times who could take time. A still more delicate test is afforded by the Indian (East) lunar tables, in which the accelerations of the moon were carefully noted, and by that fact La Place proved that the compilation must have been done in the second century after Christ.

Connected with the method of ancient observation, we can hardly refrain from citing the case of the Pyramids of Egypt, as an illustration of the accuracy that may be attained even without instruments. When the great Pyramid of Gizeh (about 4000 years before the present epoch) was built, the longitude of all the fixed stars was less by 55° 45′ than it is at the present day. If, then, we calculate where in the heavens the polar axis continued would fall, we should have to assign it a place near *a* Draconis—within 3° 44′ 25″. Although this star is now of only the fourth magnitude, it was then, as we know by indisputable evidence, the most conspicuous of all the circumpolar bodies; therefore the ancients considered it their pole star, as much as we consider the bright star of the lesser Bear our true indicator of the true North. The latitude of Gizeh is 30° N., and therefore the altitude of the polar star must have been 30°; but as its distance was 3° 44′ 25″, it will be plain that at its lower culmination the angle subtended would be 30°—3° 44′ 25″; equal to 26° 15′ 35″. Colonel Vyse ascertained that of the nine Pyramids still existing at Gizeh, six have the narrow passages intended for entrance inclined at a mean of 26° 47′. Two other Pyramids at Aboussier have an angle of inclination of 27° 5′ and 26°.

We can hardly conceive that so remarkable a coincidence could have been the result of chance, especially when we take in view the astronomical facts connected. We can only suppose that the then pole star was used as a point of observation, and that the lower culmination was used as a standard for the meridian line.

But we have to consider your query. How can it be done? We will show you; but as a starting-point, we must premise that you understand equated time and have a nautical almanac, or if not, you may obtain one from H. H. Bancroft & Co., San Francisco, as they are empowered by the Coast Survey for the sale. Next, you must ascertain the longitude of some place near to you; if in the same meridian, so much the better, as your watch or chronometer will not vary much in travelling from the place to your own station of observation. The latest determination of longitude at hand gives San Francisco at 122° 26′ 8″; there may have been more recent results, and you may easily obtain what information you wish at the office of the Coast Survey in that city. Assuming that you have the preliminary astronomical requirements, we proceed to lay down the mechanical, easily enough obtained; but we must premise that the results will not be as accurate as those obtained from a good transit instrument. You will find some building, possibly your own, at one corner of which you may obtain a north and south straight line; to this corner you may attach two pieces of tin, each of which has a fine slit punched in it, and the tins are to be so arranged that the slits will be perpendicular to the horizon.

This may be effected by means of a plumb bob and fine white thread. You will arrange the two pieces at about one foot apart, bringing the openings as nearly as possible in the line of the meridian; that is, true north and south. Now, if you can have the patience to get the light of the north star through the two slits, you will be within (depending on the moment of revolution) say 1° 23′ 58″ of the true north. Now, as the earth revolves it will give an apparent motion to the pole star of 2° 47′ 56″, and you can readily perceive that there must be four points of greatest diameter, two of which will be in the meridian line and two on the horizon; if, then, you take from the almanac the period, or rather time, dating from Greenwich, you can add the distance or difference in longitude west, and find the moment when the greatest elongation east or west will take place on any selected day, or you may take the time of the vertical culminations by observing them through the two slits. As there must be two appearances of the star through the two apertures during the twenty-four hours, you will have a positive guide to determine your meridian. Having adjusted your two sights for the pole star, nothing prevents you from reversing your position, without any change in the instrument, and determining a transit south of your place of observation.

The slits in the tins should be long enough to give you a chance for a vertical angle of 23° 30′ from the zenith, or the point directly overhead. Now, you may observe from one side, say looking north, the pole star, and on going to the north side you may see the passage of any well-known star over the meridian. You can very soon get used to this sort of observation, but we warn you in advance that you cannot locate a star or the sun (for which you will have to use a colored glass) within two or three seconds; but it will make no difference if you merely wish to get your clock rate.

W. W. S., *Ill.*—In melting gold, the operator must *clean*, as it is called, the alloy. Now, however fine you may use the materials intended for alloy, chemical union does not seem to take place except under certain circumstances; and until such an union is effected, it is hopeless to expect that either the rolls or hammer can be used without fracturing the edges of the ingot. Perhaps the best way of arguing the question will be to take an example in which we will be supposed to use not only pure alloy, but filings, scrap, sweepings, and so on. We wish then, to run it down; if we would reduce it to twenty-four carats we must quartate the whole mass by adding three of silver to one of the supposed gold alloy; and then, after melting, dissolve it in nitric acid, depositing the silver by means of common salt, forming chloride of silver. In this process of wet reduction we have yet to melt down the gold, and even now must proceed to the furnace, or rather forge, with the oxide of gold we have obtained by the wet process. Here we shall obtain only a button, which may be hammered or rolled, or used for combination with other metals. This is the process observed in the Mint. With the manufacturing jeweller, however, this gold has to be alloyed down to 12 carats, and sometimes even as low as 8. Now comes in a question of melting, and this we propose to discuss in answer to your query.

Suppose, then, that we have a given weight of gold, say in the proportions you have given, 480 grains coin, 90 grains of pure copper, and 50 grains of silver. Our course of procedure would be to put the whole mass in the crucible at the same time, and with a flux of carbonate of potash (pearlash) melt the whole down until a good button is formed. You will now take a clean crucible, and placing the obtained button in it, you will proceed to melt down; if you add a very small amount of nitrate of potash (saltpetre) you will, on watching the fusion, find on the surface of the melted metal, exhibiting the most active ebullition, streaks of red, white, blue, and gray, following in rapid succession; there will come a time, if you do not urge your fire too hard, when there will come a brilliant *flash* on the surface of the metal; when once seen, the appearance will never be forgotten; and you may rest assured that when that appearance is gained, the ingot will be soft under the hammer, as well as in the rolls. As a matter of course, it will need annealing, for no metal will stand the severe change of structure incident to rolling without it.

If you will try the above-described process, yo will, in two or three trials, succeed; but the case may be different if you attempt to melt down refuse filings, scrap and sweepings. We have been writing only on the case you presented; that is, pure coin, pure copper, and pure silver. Now, we will take the filings alone, as they should always be melted down separately from the scrap. You must, be supposed to have removed every trace of free iron, by means of the magnet; as a matter of course, any iron in alloy with the gold will still remain, and you may find that the resulting button is incapable of being wrought under the hammer, or in the rolls. This iron and the other foreign substances must be removed, and in this case by the dry method. The process is simply to intimately mix the filings with pearlash and introduce the mixture into a good clean crucible. It is almost impossible to melt the mass down for working purposes at the first heat, for you cannot *clean* the alloy (we do not mean refine). The button thus obtained will in general be hard, and crack under the hammer; to render it fit for working, it will be necessary to clean it in the way we have indicated, and if the *flash* does not come on, you may add more and more saltpetre, and stir the whole mass with a long splinter of charcoal, in order to effect the more intimate action of the nitrate of potash on whatever impurities may be in the metal under operation.

The chemical nature of the changes that take place in the melting are not understood. We can only infer that the amount of heat, and continuance, have a very important bearing on the success of the operation, for if we overheat a piece of clean gold, we shall find it brittle when we come to work it. When, however, the *flash* makes its appearance on the surface, you may conclude that the button is soft and tenacious. As the button, or ingot, was got from filings you will have to refine, if you wish to obtain a standard carat. To do this you will have to ascertain, as nearly as possible, the standard of the ingot, and then quartate; that is, add three times the estimated weight of silver, remelt, roll down into a thin ribbon, and then submit it to the action of nitric acid, which will dissolve out the silver, leaving the gold in a skeleton form.

Perhaps a better process would be, in fact, to dissolve the original button, after having been rolled, to facilitate the operation, in a mixture of nitric and hydrochloric acids, and then precipitating the gold in the form of the black oxide, which can be melted down within $\frac{98}{100}$ fine. You will find no difficulty if you will take a sample from your gold draw and try to reduce it to workable shape. If, however, you should find the gold irreducible, you may calculate that there is some of the platinum metals, as iridium, osmium, etc., where the presence of a very minute amount of either is fatal to any good results. You may get a good melt on the first trial, if you introduce into the fused mass a small quantity of tin (block tin), which, from its affinity for all the platinum metals, takes up whatever may be of the iridium, etc., and renders it oxidizable under the influence of the nitrate of potash used in the last melt.

If you will watch the fused mass while in the crucible, and note the peculiar appearance it assumes when *clean*, you will never again fail to bring down your ingot to a rolling condition.

C. S., *Sixth Ave., N. Y. City.*—To give the "very best count of the teeth of wheels for a chronometer," would be simply impossible, from the fact that the size, and the purpose to which it is to be devoted, will determine the count. We give you a table of the train in one of the best made chronometers, the details of which were furnished us by the kindness of Mr. John Bliss, of the firm of John Bliss & Co., the reputation of whose chronometers can be offered as a guarantee of the correctness:

Fuzee (main wheel)…………………	90
Centre Pinion………………………	14
Centre Wheel………………………	90
Third Pinion…………………………	12
Third Wheel…………………………	80
Fourth Pinion………………………	10
Fourth Wheel………………………	80
Escape Pinion………………………	10
Escape Wheel………………………	15

Mr. Hotchkiss, the very celebrated maker of tower clocks, some years ago adopted the theory that a large wheel, with high-numbered pinions, was the best for anti-frictional purposes, and he certainly was not unsuccessful in the application of the principle. We give in connection, the calibre of the Frodsham movement (lever):

Main Wheel	72
Centre Pinion	12
Centre Wheel	80
Third Pinion	10
Third Wheel	75
Fourth Pinion	10
Fourth Wheel	63
Escape Pinion	7
Escape Wheel	15

In the Frodsham chronometer movement the train is the same, except the fourth wheel, which is 80, and the escape pinion of 8, with a wheel of 15; this being due to the difference of the escapements. As we have given the trains of the best make, we can hardly go into any more minute dissertation.

P. I., Jr., *Pa.*—Your inquiry is only a repetition of many others that have been made as to the American combination lathe; as to where they can be purchased, etc. Again, the same inquiries have been made as to the Dennison gauge. We will answer you at length, as it will serve for the others. They are both manufactured by Palmer, Batchelders & Co., of Boston, and all orders addressed to them will be promptly attended to. The price of the gauge is $5. They are also sold by Messrs. Waaser & Lissauer, No. 52 Nassau street, corner of Maiden Lane, who also keep a large stock of fine tools and materials. Their stock of Swiss rounding up tools, universal lathes, and cutting engines, is unsurpassed, either for completeness or quality. We were very much pleased with the style of micrometer they exhibit, as the fact is an indication that watch-work has ceased to be guess-work.

After all said, the true man for the selection of a good tool is one who knows the application thoroughly to which it is to be devoted. They are thorough workmen themselves, and therefore we are not surprised at their having so fine an assortment of tools and material in their establishment at No. 52 Nassau street.

You wish also to know the best method of making a conical pivot. If you will refer to No. 4 of the HOROLOGICAL JOURNAL, you will find a description of a polisher that, if rounded on the edge, would finish up a conical pivot; it occurs in the article on Pinions. The previous forming—that is, turning up to form—is a matter for the "tact" of the operator.

G. B., *N. Y.*—Your inquiry was very pertinent, when in the article on the Metrical System we neglected to show anything as to the sizes of watches, as designated by (lignes) lines. We will try to make up the deficiency by giving a table that very nearly expresses the relations between the French line, the English inch, and metre. There is one thing in the line that is a very strong recommendation, it is very nearly equal to the intervals of all the English sizes of watches. By the table you will be able to determine any number of Swiss lines in an equal value either of the English inch or French metre.

We cannot fail of being astonished at the very close approximation. In the first one-thousandth of an English inch it is equal to a little less than the eleven-thousandth of a French line, and this is a very close approximation to one-tenth. We have carried this table out to 21.39295 lines in order to embrace every or nearly every sized Swiss movement.

English Inch.	Millimetre.	French line.	English Inch.	Millimetre.	French line.
0.001	0.025399	0.011260	0.1	2.5399	1.12595
0.002	0.050798	0.022519	0 2	5.0798	2 25190
0 003	0.076197	0 033779	0 3	7.6197	3.37785
0.004	0 101596	0.045038	0.4	10.1596	4 50380
0 005	0.126995	0.056298	0.5	12.6995	5.62975
0.006	0 152394	0.067557	0 6	15 2394	6.75570
0.007	0 077793	0 078817	0 7	17.7793	7.88165
0 008	0 203192	0 090076	0.8	20.3192	9.00760
0.009	0.228591	0.101336	0 9	22.8591	10.13355
0.01	0 25399	0.112595	1 0	25 399	11.2595
0.02	0.50798	0.225190	1.1	27.9389	12.38545
0.03	0 76197	0 337785	1.2	30 4788	13.51140
0.04	1.01596	0.4503 0	1 3	33.0187	14 63735
0 05	1.26995	0.562975	1 4	35 5586	15 76330
0.06	1 52394	0.675570	1.5	38.0985	16 88925
0.07	1.17793	0 788165	1.6	40.6384	18.01510
0.08	2.03192	0 900760	1 7	43.1783	19.14105
0.09	2.28591	1 013355	1.8	45.7182	20.26700
			1.9	48.2581	21 39295

P. & C., *Ind.*—There has not been and never can be a tool for the making of case springs that will fit any case; you can make a milling tool for yourself and put it on your lathe, but would not a file be the best? We must suppose you have a forged blank to work on. In case-making establishments, in which they make a number of the same sized cases, they may go to the expense of getting up forms and dies for the forging, but you will readily see that in a number of sizes these tools would be of little use. We saw a few days ago a device in which the lip of the lifting spring was made movable, thus (if the curvature is right) allowing it to be adapted to any case without making a new screw-hole in the centre of the case. We do not vouch for its success, but it is the nearest approach to fill the want you feel.

S & P., *Ill.*—We do not know of any party in New York, the United States, or Europe, that manufactures and sells spectacles in the way you suggest. Allow us to ask, could any one, on such principles, sell goods so that you could resell them at even a decent price? If the manufacturer makes an article he most certainly calculates on getting a fair price, for cash. What, then, must he charge to enable him to meet the contingencies of such a loose mode of doing business as your query would imply?

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⁎ *Address all communications for* Horological Journal *to* G. B. Miller, *P. O. Box* 6715, *New York City.*

stronomy in its Relations to Horology.

NUMBER SEVEN.

Whatever may be the advantages offered for the determination of longitude by the positions of Jupiter's moons, we have to admit that the observations are subject to too much uncertainty for ordinary purposes, either on land or sea; the length of the intervals, and the great distances, offering alike obstacles to accuracy. Still it is indispensably necessary to find some means of determining longitude (time), on which, not only the geographer can rely for his station longitude, but on "which the navigator can securely stake, at every instant of his adventurous course, the lives of himself and comrades, the interest of his country, and the fortunes of his employers." This means of ascertaining the longitude is afforded by lunar observations.

The moon, being the nearest and most conspicuous body vissible from the earth, has always been the most closely observed of all the celestial objects. Several circumstances concur to render her motions the most interesting and at the same time the most difficult to investigate. In the lunar theory more importance is attached, for the reason that lunar distances are the very best data for longitude, and therefore for time. It was long before the apparently erratic movements of the moon were fully comprehended or tabulated; the ordinary disturbances that occur between planet and planet hardly express the relations of the moon to the earth, for the sun, notwithstanding his immense distance, has a compensating influence by reason of his enormous mass. The moon, then, is influenced, not only by the sun, but the earth being nearest, and the law of action and reaction being good, the earth has by proximity a stronger hold than the sun, but not strong enough to prevent disturbances in the ordinary motions of the moon, arising from the attractive influence of the sun.

Owing to these two disturbing causes, the motions of the moon are more irregular than any of the planets, and yet have been reduced to as precise a demonstration as any problem in astronomy. The fact that the position of the moon, at any moment, can be ascertained in relation to the stars in their positions at any time, is a point from which longitude can be ascertained with a degree of precision that is unattainable by any other means, save a good transit. We give a table of the moon, as it will be necessary to refer constantly to the facts.

Synoptic Table of the Moon.

Mean distance from the earth				237769.44 miles.
				d.
" Sidereal revolution				27.322
" Synodical "				29.531
Eccentricity of orbit				.5
				d.
Mean revolution of nodes				6793.391
" " Apogee				3232.577
" Longitude of node at epoch....	13°	53′	17″	5
" " Perigee	266	10	75	
" Inclination of orbit	5	8	39	96
" Longitude of moon at epoch ...	118	17	8	3
Mass, the earth being 1				0.011346
Diameter in miles				2164.5
Density, earth being 1.............				0.55654

Again, as has already been stated in the course of these articles, the path of the moon's orbit is influenced not only by the earth itself, but by its form and constitution. Thus the protuberance of the earth at its equatorial diameter determines various changes in the moon's motion, and the same result obtains, by reason of the increased specific gravity of the earth towards its centre. These would so naturally interfere with the direction of the path of the moon in her orbit as to draw the attention of even the earliest observers.

The earth, however, does not move always in the same line of orbit, for though the major axis must remain the same, the minor axis of the ellipse may be changed; and as for ages the minor axis has been being shortened, the combined influence of the earth and sun has, in strict accordance with theory, increased the motion of the moon in her orbit.

The theory of the acceleration is founded on the following considerations and facts: For ages past the ellipticity of the earth's orbit has been decreasing, and it can be proved that the greater the eccentricity of the orbit the greater is the disturbing action of the sun. In the whole solar system, as we have before stated, planets disturb other planets; but in our calculations of the lunar motions we are compelled to assume the sun, by reason of his mass and proximity, to be the great source of all the lunar perturbations; and thus it follows that on a decrease of the eccentricity the earth would have more influence over the moon's motion. Now, as the eccentricity of the terrestrial orbit has been diminishing for hundreds of centuries, the earth's attraction for the moon has exerted a force stronger than that of the sun's proportionally, and the velocity of the moon in her orbit has, in consequence, been on the increase. This change in velocity was noticed in very early ages, and as the same cause continues to exist, this increased motion, called acceleration, will be extended to future ages, until the eccentricity of the earth's orbit ceases to diminish, or, in other words, comes to its minimum; after which the moon will be retarded in her orbit from age to age.

The secular acceleration is now about 11″.9, but its effect on the moon's place increases as the square of the time. The secular diminution in the eccentricity of the earth's orbit has not altered the equation of the centre of the sun by eight minutes since the earliest recorded eclipses, but it has produced a variation of about 1° 50′ in the moon's longitude, and of 7°12′ in his mean anomaly, which is its angular distance from the perihelion, supposing the moon to move in a true circle. The true anomaly is the angular distance from the perihelion in its elliptical orbit. The disturbing action of the sun on the moon is equivalent to three forces; and the distinction must be borne in mind, if the reader wishes to get a comprehensive idea of the lunar motions. The first force acts in the direct line joining the sun, moon, and earth, and diminishes the attractive force of the earth for the moon. To explain the second will involve some little consideration on positions—relative, of course. By looking at the table the reader will see that the mean inclination of the moon's orbit to the plane of the ecliptic is 5° 8′ 39″.96. Now, depending on the earth's place in her orbit, the moon will present to the sun an object to be drawn perpendicularly from its orbit. The other direction of force is purely tangential, tending to alter the motions in longitude, while the action of the sun on the plane of the orbit disturbs her latitude; in other words, tends to bring the plane of the orbit nearer or farther off the ecliptic.

The perturbations thus caused by the combined action of the sun and earth are precisely similar to those occurring among the planets; and the best demonstration of the effects of gravitation was afforded in the celebrated problem of the three bodies—the sun, moon, and earth. When the line between the three bodies is straight, the superior attraction of the sun tends to diminish the eccentricity of the moon's orbit in conjunction and opposition, thus making it, at those times, more circular; while the very same cause at the quadrature tends to make the orbit more elliptical. This well known inequality is called Evection. The whole period of this perturbation is less than thirty-two days. Now, even in this "equal inequality" there are some considerations that, in the construction of lunar tables, have to be taken into account. Thus, were the increase and diminution always the same, the Evection would depend only on the distance from the sun; but the value of the variation will, in a great measure, be determined by her (the moon's) distance from the perigee of her orbit.

This Evection was detected by Ptolemy, in A. D. 140; but all the ancient astronomers assigned to the orbit of the moon too great an ellipticity. It must be remembered that the chief aim in the observations of the moon at that time was purely in regard to the prediction of eclipses; and as these can only happen when the satellite is in conjunction or opposition, the eccentricity would be materially diminished at the time of observation.

We have often stated in the course of these astronomical articles, that a body revolving around a common centre, influenced by the two forces (tangential and gravitating), would describe an ellipse; the degree of eccentricity being determined by the distance of the centre of attraction, and the original impulse given to the body. This last is called the tangential force. As an ellipse has two diameters, we, as in the demonstration of the revolution of the major axis of the earth's orbit, would expect the orbit of the moon to be more elliptical, and attended by more disturbances, than in the case of a planet.

If the orbit of the moon is an ellipse, it is evident that there must be two points in the orbit that are nearest the earth. We may infer, then, that the line of the two nearest points must follow the same general law of the revolution of the major axis. This motion of the minor axis is called the motion of the apsides, and it may be very beautifully illustrated by a very simple mechanical contrivance, that shows very finely the mode in which orbitual motion is carried on under the action of central forces, according to the situation of the revolving body. Fourcault, in France, has demonstrated the revolution of the earth, by means of a pendulum vibrating in the same place; now, by means of a rotary pendulum we are able to prove to the most uneducated mind that an ellipse must be the result of the rotation. It must be understood that the most perfect freedom of the planetary bodies cannot be obtained with the apparatus we are about to describe.

Let a leaden weight be suspended, by means of an annealed iron or brass wire, in such a manner that the point of support is firm, and the weight free to revolve in what should apparently be a circle around the point of suspension. We will suppose the apparatus well put up. Now, if we attempt to give it a circular motion, we will find that if we give the pendulum a slight motion we will, if the weight be heavy, by placing a paper beneath it, and affixing a pencil to the bob, find that the path the pencil traces will be an ellipse, which has for its centre the point of suspension. The major and minor axes of this ellipse will change but little during a long time, though the friction of the air and rigidity of the suspension wire may diminish the dimensions and eccentricity. Suppose, however, that we incline the weight from the vertical to an extent of 15° or 20°; we shall find that the former continued direction of the major and minor axes no longer subsists. Both will be seen to shift their position with every successive revolution, and always the advance will be in the direction of the pendulum's rotation.

This advance will be found to be in an uniform and regular progression, and after a time the two axes will have entirely reversed their relations; thus giving a good visual idea of the moon's motion, and also the changes that take place in the position of the apsides. Another form of this mechanical illustration may be introduced by substituting, in place of a weight simply, a hollow space attached to the weight with a very small orifice, being filled with very fine dry sand; it will be found that the scattering of the sand on any surface directly beneath the revolving pendulum will describe an ellipse, and if the same amount of force is applied the revolution of the apsides will be found to be demonstrable physically.

This illustration of a mental structure, if we may so speak, by purely mechanical means, shows the simplicity with which great astronomical truths can be exhibited, open to the comprehension of those who are totally unaccustomed to the method of mathematical reasoning or astronomical research.

We should not have dwelt so much on these perturbations had we not considered that a knowledge of the lunar tables and calculations was an important part of the study of Horology.

Watch and Chronometer Jewelling.

NUMBER SEVEN.

When the temper has been found right, the graver used for a stripping tool should be used solely for that purpose, as by its use for other objects the very fine edge so necessary is completely destroyed. This tool is not alone used for stripping the jewel setting, but the dirt cups on the barrel arbor and centre staff also owe their exquisite polish to the finish of the cutting tool. The jewel screws are, as before stated, counter-bored and set, when, on stoning off, the plate, including the top of the settings and the screw, is removed; the jewels, with their settings, taken out of their seats, and the tops, after the stripping, are ready for polishing. Nothing in watch-work can excel in beauty the fine finish that is given to these tops. The method of effecting it is so applicable to wheels and any other small brass work in the watch, that we shall not apologize for the minuteness of the following description. In the articles on the lathe, in preceding numbers, a process was detailed by which a few glass plates might be used, and the mode of preparing the polishing surfaces was fully set forth. It will be very tedious and difficult for the repairer to get just the exact degree of surface; but he need not despair, even if he fails in three or four trials.

What is still better, as stated in the article on the lathe, is a stone surface, the stone being a homogeneous agate or cornelian; it is necessary to have two stones in order to get the required surface, which may be attained by the use of emery, but the result will not be so good as it would if diamond powder were used. The nature of the polish produced by means of the abrading surfaces is somewhat, if not exactly, like that produced by the action of the burnish file on steel, only the polish is much more exquisite, and can be done with a great deal more expedition. The polishing surfaces having been prepared according to the method explained under the head of "The Lathe," they should be wiped very clean with a cotton cloth and alcohol, in order to remove every trace of oil that may by accident have got on the face from contact with the fingers during the manipulations required in the preparation. The jewel setting, or other small brass work, after having been stoned down to a level on a piece of fine Scotch or blue stone, is placed on the polisher, with the stoned surface in contact; it being premised that any traces of the stone dust have been previously washed off. Now, with a piece of clean cotton cloth covering the end of the finger, the work is moved with considerable pressure over the surface of the polisher. The work must be examined after every four or five motions, to ascertain whether it is polished; for if the process is continued too long the brass will be found to clog up the fine grain of the polisher, and a new cleaning will be requisite. We may mention here that where the stone or glass plate has become uncerviceable by reason of the brass adhering to it, it may be cleaned very rapidly by means of a drop or two of nitric acid, then washed in water, and afterwards thoroughly dried. As a matter of course, this plane cannot be adopted when the jewel or end stone projects above the top of the setting. When this is found to be the case the workman may be sure either that the stone is too thick or that the end-shake is too great.

In most of the first-class watches, and always in marine chronometers, the cock is jewelled with a diamond end stone, the setting of which requires great skill if a perfect job of work is desired. The first and most important point to be looked after (the face of the stone being all right), is to set the diamond in the steel perfectly level. As the setting is of steel and the diamond generally irregular in its form, the burnisher is of no advantage, and the workman is compelled to use other means.

Fitting a piece of soft steel wire to his lathe mandrel, he drills a hole in it endwise, just large enough to take in the stone, whatever may be the differences in its different diameters. This hole is rather a concave cavity, against the walls of which the convex surface of the stone rests. This end of the steel chuck is cut off at a suitable distance, to give the correct thickness after finishing. The cavity having been cut a little deeper than the whole thickness of the stone, the face will fall below the steel, which is placed on any block of metal, and the diamond introduced, and with a small steel punch and hammer the workman closes the steel gently over the edges of the diamond's face. In this operation the utmost care has to be taken to keep the face perfectly level with the face of the setting.

After the stone has been fastened in by means of the riveting process, the workman proceeds to flow, by means of fusion, brass around the diamond, in order to fill up the vacant spaces not touched by the stone, by reason of its irregular shape and the fact of its being cut in facets. The soldering being completed, the face of the setting, solder and all, is filed with great care down to a level with the face of the stone. It may be ground on a glass plate with oil-stone powder, but the grinding must be done with the greatest caution or the whole will be out of flat. The stone, with its setting, is now chucked up on the lathe by means of cement (shellac), with the face side on the chuck, and the workman trues it up by means of the outside, as by reason of the brass filling the cavity he is unable to get it true by the centre. The next step is to turn out, in the form of a bevel, all the superfluous brass and steel down to the diamond, and the tyro will find it a very difficult matter to do this apparently easy job.

The difficulties arise from the very irregular shapes in which the diamonds occur, and the hardness of the stone, the corners of the facets taking off the point of the graver almost as fast as they can be sharpened. The brass must be picked out of the irregular faces of the stone, and the great effort is to remove every visible portion of the brass from the cavity, and at the same time bring a true bevel from the edge of the setting down to every part of the diamond, regardless of its great irregularities; this bevel circular surface must be true, and, in order to achieve the subsequent polishing, the angle of the level should be a perfect straight line, though in some diamond covers we have seen the surface rounded, polished, and then blued. With a very large diamond this mode produces a fine effect. The usual course of polishing, after a true surface has been attained, is to use a small copper grinder with oil-stone powder; the subsequent surface is got with the usual polishing materials, such as sharp and rouge. We have seen a much more exquisite polish obtained by means of fine diamond powder, the tool being nothing more than a common piece of soft iron—say an old horse nail.

The outside of the setting will have its shape determined by the circumstances of the case, and is polished while in the lathe in the same manner as all other steel work; but as the steel setting is soft, there cannot be obtained the fine deep black polish generally found on the steel work of the best class of watches, and particularly of marine chronometers.

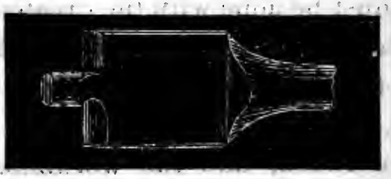
The necessity of having the surface so truly level will be seen readily, if the reader will for a moment reflect on the mutual relations that exist between the pivot, jewel hole, and face of the end stone. Thus, if we suppose the face to be inclined at any angle, the tendency of the pressure of the pivot will be to crowd it to one side of the hole constantly; in fact, it would have all the effect on the action that a close hole would, and that, too, without any compensating advantages.

The small steel collet seen around the fuzee arbor, is polished in ths same manner, though, from the absence of any obstructions in the centre a rounded polisher can be used that acts exactly the same as the one used for the oil cup of the ordinary jewel, and, as the steel can be hardened and tempered, the degree of finish is limited only by considerations of cost and the requirements of the class of work to which it is to be attached. These collets are generally screwed on with the heads of the screws holding the piece down by means of a small flange that is turned on the outside of the piece; sometimes the steel is set, counter-sunk in the plate. The screws, in this case, are rarely countersunk, the steel being so very hard in proportion to the brass, that the countersink tool is almost always broken; the conditions of an uniformity of metal being absolutely requisite for truth.

This brings us, before we take up the subject of jewel screws, to consider the drilling, counter-sinking, and tapping of the jewel screw holes. The American plan, the plates all being alike, is to drill the holes by the aid of a templet, and where the work is jewelled before gilding, of tapping the holes. This practice is not, in the eyes of a good mechanic, the best that could be adopted, for it will readily strike the reasoner that, in counter-sinking, the tit of the counter-sink must necessarily injure the integrity of the thread; and of all the screws in a watch, the jewel screws are the most liable to strip. The English, having no determinate sizes, are compelled to lay off the jewel screw holes according to the circumstances; and, no doubt, some of our readers have been struck with the dissimilar positions laid out in watches of the same manufacturer. Thus he will find in one three screws to one setting, while in another he finds three screws holding down two settings. It is, perhaps, of no account so far as the general public are concerned, but the watchmaker suffers when he comes to repair; for, if the three screws have not equal bearings, the watch repairer will be very likely to tilt one or the other of the holes, and thus make a bad side-shake.

There can be no doubt that the best way to lay off the holes would be to make the settings, if possible, of the same size, and then fit in a steel plug having a very wide flange; through the flange a series of holes at regular intervals are to be drilled, and this may be used as a templet. The holes should be drilled small enough to allow the tap to give a full thread, as, when the counter-sink is made, but little stock remains to hold the screw. Again, the slight burr caused by the drill in passing through the plate on the other side, should be taken off as nearly even as possible, with the object of leaving as much stock as possible for the thread.

The jewel screw holes having been drilled, and the settings in their place, the next step is to counter-sink for the jewel screws. If the work is gilded, great caution must be used in order to avoid any burr around the edges of the counter-sink. We have seen workmen who set the whole plate together with the jewel and setting upon the lathe chuck, and with a cutter used on the rest, made the recess—the centre being obtained from the hole to be operated on; but the same object may be attained by using a counter-bore, made in the best style, and run at a very high speed. The most ordinary mechanical mind will comprehend that the counter-boring should be done previous to tapping, and therefore we shall assume that position understood. To make the tool for letting in the screw heads, it is necessary to put up in the lathe a piece of steel wire, and turn down the end with a "tit" of just the size of the hole in which it is intended to be entered. The shoulder, as a matter of course, should be perfectly true and square, and the outside turned off to the accurate size of the head of the screw that is to be put in; the workman, in every case, endeavoring to get the sizes of the heads the same. The really best form of a counter-bore for gilded work, to be used with high speed, is illustrated in the drawing. The spiral form given to the clearing portion of the tool will enable the chip to roll out of the hole without marring the edges. This tool may be made in the form of a twist drill; that is, the cutting lips may be formed in the same manner, and this gives, provided the groove is sharply undercut, a means by which the chip may come out without touching the edge of the counter-sink; the form compressing the waste material to the centre.



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We were shown a very ingenious device by which a clock dial could be placed in the window to indicate time, without showing any movement. A simple stud is placed in the centre of the glass dial, which is divided for minutes; a hand, with a very large hollow knob, counter-balanced perfectly, moves on the stud, and in this hollow knob a watch movement is put with a counter-weight on the hour hand. Any one can see the result; the revolution of the counter-weight on the hour hand will cause the minute hand to revolve in correct time.

Diamonds.

All crystallized bodies are formed up so that a line of cleavage may most always be found; that is, there is always some direction in which the crystal will split easier than in any other. This line of cleavage is determined very much by the form of the crystal, though each substance has its own peculiar manner and direction of cleavage. For instance, there are hundreds of forms of the carbonate of line which split in six-sided figures (rhombohedrons), and the angles invariably measure alternately 105°.55 and 75°.05, to whatever extent the division may be carried. We must assume, then, that the ultimate form of the carbonate of lime is a rhombohedron, which is a body bounded by six plane surfaces; the opposite planes being equal and similar rhombs, parallel to one another, but not equal, and the angles subtended by the planes are not right angles, as before stated. We are forced to the conclusion that carbonate of lime has an ultimate atom of this form, from the fact that every form of crystallization attending the multitudinous varieties of the carbonate of lime may be built up by using these six-sided solids, in the same manner that children build houses with miniature bricks.

If we fuse a quantity of cyanide of potash the result will be, apparently, a homogeneous mass that presents no trace of crystals; under the microscope, however, the particles will be found to have arranged themselves in a definite order, and the chemical constitution cannot be determined solely by the form, though the crystal becomes an important evidence in corroboration, when other indications are observed. The diamond, as well as other gems, notwithstanding its great hardness, has determinate forms of crystallization; the most common being an octahedron, composed of two four-sided pyramids united at their bases.

It will not be expected that we should go into a full essay on the science of crystallograhy, and we may here leave the subject, referring the reader to any of the works on chemistry, or what would be better, to works devoted to the technicality.

The diamond is interesting for its value and its hardness; and, as matter of course, the difficulty of working it is in proportion to that hardness. As this last quality is a good test of the various gems, we will give the general plan on which the comparisons are made. If we assume the diamond to be the hardest substance known (as it is), we may make up a list of the gems in the following order

Diamond,
Sapphire,
Ruby,
Chrysoberyl,
Spinelle,
Topaz,
Emerald,
Hyacinth,
Essonite,
Garnet.

These are all harder than the ordinary rock crystal, or quartz. The following named stones are softer :

Rock crystal,
Amethyst,
Chalcedony,
Cornelian,
Agates,
Opal,
Chrysolite,
Lazulite,
Obsidian,
Turquoise.

The fluor spar, malachite (an ore of copper), and jet, are all extremely soft; yet it sometimes happens that the malachite has imbedded in its substance pieces of pure quartz; this renders it somewhat difficult to be wrought, although it is in itself so soft.

The consideration of this quality of hardness naturally brings us to the mode of cutting the diamond, the hardest substance known. As stated in a former article, the process was invented in 1456, by Ludwig Van Bergen, and consists in using the " diamond to cut diamond," and from that date the art has progressed to very near perfection. The various steps are all included in cleaving or slitting, cutting, grinding, and finally, polishing. But these do not comprise all that calls for the exercise of skill in the diamond cutter; he must know, before proceeding to operate on the stone, the exact nature of its internal structure; for the stone may be laminated, or have small fissures, that, after much labor has been bestowed, render the gem liable to crack, or at least injure very materially its value. To get this knowledge of the interior structure, he immerses the diamond, or indeed any other gem, in a quantity of clear Canada balsam, or in any other volatile oils, such as sassafras, etc.; the capillary attraction fills up any minute fissure that may extend to the surface, and by the difference in the refraction of light the defect is discovered.

Though so very hard, almost the first tool generally used is made of steel; advantage being taken of the fact that most diamonds have lines of cleavage. Octahedronal stones are the best suited for this purpose, and the object is achieved with general success; but it is evident that where the risk of spoiling a fine stone, whose value is great, is so imminent, the workman very carefully examines the object to be subjected to this cleaving process, and stones that are too valuable to allow of the risk are formed into shape by sawing with diamond powder and soft steel wire, or else a skive. In cleaving with the steel tool the stone is imbedded in the ordinary lapidary's cement, consisting of a mixture of rosin and brick-dust, intimately combined by heat. The part to which the tool is to be applied is cleaned of its coating and a scratch made across its face with another diamond, having a sharp, cutting edge; the tool is now applied to the groove thus made, and with a sharp blow the stone chipped off; this, as a matter of course, leaves a plane surface, and, in order to get the ultimate form, the above process is used to get each plane in succession.

The whole object of the diamond cutter is to get a regular form, to take off as little of the stone as possible, and make the form so as that the action of light shall have its greatest possible effect. There are many considerations that must determine the workman's decision as to the form he intends to make; a small flaw near the surface must be removed, or the value of the beautiful gem would be lessened. The removal of such flaws becomes of prime necessity, as, from its high refractive power, the stone, when finished, shows the slightest blemish, and this is magnified and shows plainly on every facet. The high refrangibility prevents the operator from always correctly deciding whether or not the flaw is in the interior or on the surface. Mr. Mawe says, "a person with a correct and well-practised eye may often purchase to great advantage stones which appear to be flawed quite through, but are in fact only superficially blemished."

The workman has also to take into view the desirableness of cutting the stone so as to get the greatest breadth, or *spread*, as it is technically called, after he has taken off all the flaws. In the choice of the cut he must be guided somewhat by fashion's demand, for the ordinary tastes of the public must determine the ultimate value of the jewel; and therefore the best artisans in the diamond-cutting trade decide the form, number of facets, and so forth, by the eye, rather than by the old mathematical rule. But the workman must also determine which are the hard points and select the facets accordingly; for the hard points are the angles on the original octahedron, and it is necessary to cut directly across these, or the force required to polish may tear up the thin laminæ that face the soft side. This fact accounts for the great difficulty that has been encountered in the application of steam to this very tedious process; and yet it would seem that with a good lap the artisan might hold his diamond with as much precision as by the old hand process.

Assuming that the stone has been cleaved to the satisfaction of the operator, the next step is to bring the facets up to a true level. To effect this, the stone is cemented with shellac to a stick, and another stone is similarly treated, with the two pieces over a box with a bottom to catch any dust that may come from the abrasion. The only difference in the setting is that the cutting tool has its solid angle; that is, its hardest part operating directly on the face of the cleaved diamond. There are two upright iron standards on each side that may be called "gim pegs," such as the lapidary uses to get the angle of the facets. It will be readily seen that the abrasion must be a work of patience as well as skill, in order to get just the proper plane for each facet. As each face has been thus laboriously made, the stone is successively changed to present other parts to the action of the cutting diamond, and each having been operated on, the stone is now ready for the polishing of the facets. Its appearance at this stage of progress presents, under a magnifying glass, "ragged, rough edges, and a broken foliated surface, with a glistening lustre on those facets that are nearly in the direction of the *natural laminæ*, and on the other facets a more even surface, but of a dull, opaque, grayish white color."

But it must not be supposed that this process constitutes all that the workman has to do; he is compelled to observe, at intervals, what effect the style of cutting is producing. The diamond having been brought up to the condition we have described, we will proceed to give an idea of the polishing, which in itself is exceedingly interesting, without any view of the great difficulty attending the extreme hardness In the articles on Jewelling, the nature of a mill has been demonstrated; but in the diamond polishing, the same means are not of value—the polishing mill being of cast iron, about fourteen or fifteen inches in diameter, and revolves horizontally. This mill is, as may be readily conceived, placed on an upright arbor, and the power so applied as to give a high speed to the lap. Radiating grooves of very shallow depth are now made in the true surface of the lap. These are made by the Dutch workmen by means of a very fine-grained sandstone, but might be made easily enough by means of a good graver, or even the planing tool. They must not be too deep, as the facet to be polished must in all cases be longer, or rather greater in its longest axis, than the interval caused by the grooves which serve to retain the mixture of oil and diamond powder used in the charging of the plate.

If the stone, during this grinding or polishing, should change its position, it is evident that no flat or plane surface could be produced. The more ordinary gems, even the sapphire, may be held by the ordinary cement used by the lapidaries; but in the case of the diamond, some better hold must be had of the stone to insure parallelisms. To effect this, the workman uses what is technically called a *dopp*, which is nothing more than a copper cup about three-quarters of an inch in diameter and about the same in depth. This has a stem of four or five inches in length, and in order to prepare the *dopp* it is turned inside and then filled with ordinary soft solder, which is projected above the edges of the cup, in a conical form. The apex of the cone thus formed may be easily softened by heat, and the diamond enclosed, or rather set in such a way that any facet on which it is proposed to operate may be exposed. The diamond having been set in the soft solder to the satisfaction of the workman, the stem is grasped in a wooden clasp, that, resting on two edges at the other end, is kept in its radial position by means of an iron peg fixed to the bench just at the edge of the lap. It will be seen that this arrangement gives a freedom of motion to the holding arm that could hardly be attained otherwise. When the stone in the *dopp* is ready, the whole apparatus is applied to the bench with the stone resting on the lap. The holder is weighted down to give the required amount of pressure, which must be graduated so that the heat caused by the friction may not melt the solder, and thus unset the stone; which event is a serious trouble, involving not only the chance of flawing or breaking the stone, but the diamond being so hard, it tears up the face of the lap. The lap is run at a speed of about two hundred revolutions per minute, and is supplied with the diamond powder and oil from time to time, as, in the judgment of the operator, the work requires it. The work is very slow—a single facet sometimes requiring four or five hours; this is somewhat compensated by the practice of placing three diamonds on the same lap, attended by but one workman. We hardly need to mention that in every stage of the proceedings, the utmost care is taken to preserve any dust or pieces that may be abraded.

Happy New Year.

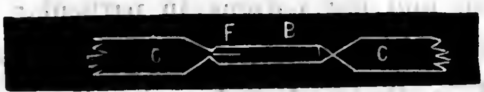
With the opening of the new year we cannot but wish to each and all of our subscribers a "Happy New Year." We feel the wish as well as express it, for in the initiation of any new project, especially a journal, there are so many discouraging incidents that the liberal support we have met with we cannot fail to appreciate. We can, then, with a good hearty will, in our seventh number, wish the trade in general, and our patrons in particular, a continuance of whatever of good they may have had in the past, and a diminution of whatever of evil. In fact, with thanks for the past and anticipations for the future, we wish you all a

"Happy New Year."

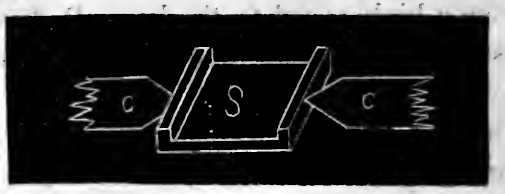
Watch Repairing.

NUMBER THREE.

We will suppose that the artisan has got his bench perfectly arranged, and is ready for work. He will find that in his odd moments, when not fully occupied by custom work, he may successfully make many small tools that can seldom be found in the stores of the material dealers; for he may, with the use of a little shellac, work up his squares or arbors, as well as the flats of the steel work that he may be required to replace or even repair. Let us take the ordinary dead centre lathe—the common verge, as it is called—and we can, by a few appliances, make it quite as useful as the ordinary vice, and the work can be done much truer than by any means that can be employed on the vice; and for this reason the watch repairer should have a common steel lathe, dead centre, or some other appliance to answer the same purpose, and he will find that he can save a great many hours' labor, and do much better work. We will illustrate, for instance, the value of such a pair of centres. Let it be supposed that we desire to finish up the square on a fuzee, or barrel arbor; we may find some difficulty if we attempt to file the sides of the square flat. Even if we achieve this feat, we shall find that, instead of perfect flats, we have rounded surfaces, if we have depended entirely on our hands to do the work. Suppose, however, we place an arbor between a pair of dead centres, allowing it no end-play, but perfect freedom to revolve. Now, if we have, in the first place, made a flat on the sides, we may apply a file to the surface thus made, when it is swinging between the centres: and it is obvious that the surface will follow the direction of the instrument, whether a file or polishing tool. The small cut will give an idea of the application, and may suggest many more that at the bench will be very valuable.



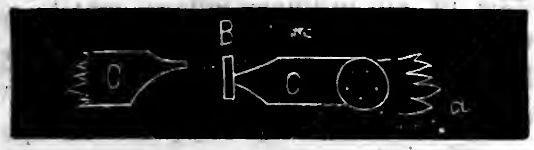
The two centres, C, are supposed to be fixed in their respective places, while the arbor, B, is free to revolve, and the square, F, can be finished up with perfectly flat sides. The file being applied to the flat, F, the freedom of motion will enable the article to meet it at any position the hand of the operator may move it; and in polishing, the value of the process will become more apparent, for it cannot have escaped the notice of any workman that, though he may have filed a surface flat, he invariably rounds it in the polishing. Where thin work is to be done (brass or steel), a small attachment may be made to the lathe by any workman, such as is given in Fig. 2—C being, as before, the centres, and the brass cradle being swung between them. If the piece to be filed is shellacked on the surface, S, it is evident that if the work has been in the first place started right, the work will accommodate itself to the file at whatever position that may assume.



This form of tool may be used for almost every part where parallelism of the two sides is required, and the file will leave a flat surface. The reader must have observed the sharp corners and beautifully level surface given to the polished sides of the Swiss wheel, and that, too, of those occurring in a very low class of watch. It is to get just such a surface ready for the final polish that the watchmaker may use the above.

This little attachment is so easily made, and so obviously useful, that we shall expect to hear of its adoption from many of our subscribers who have not been in the habit of using it. Let the conical holes for the centre be deep enough to prevent the work and tool being thrown out of the lathe by the use of the file or polisher. In small steel work it is invaluable; as the flats of the barrel work, and so on, may be filed, stoned, and finally polished, without removal of the piece. The workman may make the swing of any size and length to accomodate the dimensions of the pieces he wishes to work on, and as the thing is so easily made, he may have a number of different sizes and depths. In planting the centres on which it is to vibrate, it must be taken into consideration that the nearer the line of the centres the surface to be worked, the truer will be the work, as it will vibrate much more more easily than when the surface falls below the centre.

Other attachments will suggest themselves to the workman if he will study the capabilites of the tool as an instrument to be used in the vice for various purposes; and we will give one or two examples that will open the way to a full comprehension. We predicate, however, that the repairer has no standing lathe; that is. he must use a dead centre tool. If he is in the vicinity of a machine shop, he can very cheaply obtain a few spare centres, and on the ends turn up a button, somewhat like the figure.



By drilling a series of holes around the common centre, as shown at A, he will have a back rest with which he is enabled to true up any pivot or staff; the holes must vary in size and be chamfered until the chamfer forms a very thin edge, with the back of the button, B. It will be at once comprehended that the back spindle must be elevated, or rather thrown above the centre by as much as the holes are from the centre. With a few spare spindles, the repairer can make for himself a great number of small conveniences that cannot be purchased.

The very making of such tools will be a source of profit, indirectly, as the maker will, by the exercise of his mechanical powers, find some relief from the monotony of watch repairing. Every workman is familiar with the Jacot lathe, and where work is to be done on the dead centre principle there is nothing better; but it is confined to a very small class of work, and therefore not so well adapted for general purposes as the ordinary lathe, with the attachments we have spoken of. The depthing tool is all-important, and the new beginner, when he has a good watch down, should always spare time enough to try the depths with the tool; the practice will familiarize him with the standards of depths adopted by the best makers.

There is a very ingenious use to be made of the depthing tool somewhat aside from the object for which it was originally intended. Suppose we wish to top a scape-wheel with pointed teeth. We first place on one of the common arbors sold in the stores, a small hub of bell metal, and then turn it off true and parallel on its own centre. This arbor, with its hub, is swung between one pair of centres in the depthing tool, while the scape-wheel is swung by its own pinion in the opposite; and it will be seen that the hub may be brought in contact with each tooth successively. With a bow, and a small amount of crocus and oil applied to the hub, the topping can be done with a degree of precision not attainable by any other means.

In purchasing the depthing tool, it should not be taken for granted that the tool is true; it should be tried, and if on trial the marks made by the four centres do not correspond when they are projected to their full length, and again when closed, the instrument may be considered defective and unreliable—in fact, worse than none at all, as it is so apt to betray the workman in a very important item of watch repairing. The workman would do well to attach to the depthing tool a small right angle made of a thin piece of brass, and screwed to the side of the tool in such a manner that, with a notch cut in the upright portion, he can get a species of banking pins when he is examining the depth and action of a scape-wheel and pallet, in case either have to be replaced. This banking piece is of great assistance, and can be so easily attached that it is inexcusable for any one to be without it.

Another very important adjunct to the bench is a good set of staking tools; by this we do not mean the ordinary hollow punches used by hand, with the common pinion stake, but a much better arrangement, that any workman may accomplish, if he is willing to devote some of his spare hours for his own improvement not only, but for the tools on his bench, and the increased facilities such tools will afford him in the prosecution of his business. Besides the mere staking on of a wheel, the same tool may be used for closing holes and expanding wheels. It often happens that a Swiss watch will be brought to the repairer that is persistent in a habit of stopping. This class of watch is often the low price variety, it is true; but this fact does not lessen the trouble the workman has, for his trade in general does not allow him to select his class of work. The watch is examined, and if the workman has been posted in his trade, he generally finds a faulty depth between the fourth wheel and scape-pinion. Nine cases out of ten he will find the wheel too small, or else that it is six-sided, and therefore the depth is wrong in every point of the wheel, except at the extremities of the arms or crossings, which have served to keep the web to its true place while it was being cut. The first step of the workman will be to ascertain whether the wheel is too large or too small; if too large, the first and only thing is to top it, and then round up the teeth with a Swiss rounding-up tool; but every watch bench does not boast of such a costly (?) article, and we have seen the Swiss workman, after the topping, round-up the teeth with a common rounding-up file. Of course his work was not so well done as he could have done it with the proper tool.

Taking the other horn of the dilemma, we find the wheel too small; in such a case it is evident that the web should be expanded, and as the amount is so infinitesimal we may apprehend no difficulty from the pitch of the wheel teeth, provided we can expand the web equally, and leave the circumference nearly a perfect circle. We have seen this process of expansion effected by a hammer on the anvil block of the vice, and then the teeth-rounded-up by means of a block of wood placed upright in the vice, and the wheel held in the fingers of the workman—he occasionally trying the wheel between centres to ascertain if it was true. This, undoubtedly, is a reprehensible mode, as no accuracy can be insured; and again, the polished surface is marred by the contact with either the hammer or the anvil block. Now in the staking tool we are about to describe, the whole object can be effected with almost a certainty of precision, and in one-half the time required under the old style. Suppose we take one of the common old style of Swiss uprighting tools, and even should it not be true it will make but little difference. There is always a square on the under section by which the tool is to be held in the vice, and as the long bearing for the lower centre is not required, the round portion may be cut off and thus render the tool more handy to be employed in the vice.

The lower hole may be bored out to a large diameter or left as it is, and we would recommend that in the selection of the tool the artisan should choose one in which the two centres accurately fit the upper hole, as then he will have two arbors to carry his punches; for he will never need to use the lower spindle for any other purpose. These conditions being assumed, the workman will first take out the centres that come in the two arbors, and ream out the hole in the end with a taper reamer; which, be it remembered, together with all the other operations, are completely within the scope of an ordinary village watch repairer, even if he is remote from any machine shop. Having reamed out the end of what we may now designate the plunger of the punching press (for it becomes this and nothing more), he may fit in the taper any number of hollow, closing, swedging, and riveting punches, fitting them with accuracy, and in the case of the hollow punches, drilling them after being fitted, from the lower hole with a drill fitted in the other mandrel, on which he may place a pulley, and revolve it either by means of the bow or a foot wheel; of course the drill will have to be ground, and formed in accordance with the mode by which it is to be driven. It will be necessary to get the drill perfectly true with the centre of the mandrel, and then it can be reversed to the upper hole to drill the dies.

The dies are made of steel wire (Stubbs'), much larger in diameter than the lower hole; the end of the wire is to be turned up to a shoulder, and then the piece is cut off to a suitable thickness, say from an eighth to a quarter of an inch above the shoulder; there should be one made of a much larger diameter, about one-half an inch thick, so large that if a wheel's pinion should be dropped in a hole near the periphery, the web of the wheel may be brought directly under the centre.

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We have received from Mr. Thos. Powell, of Milroy, Ind., a specimen of his Patent Elastic Sleeve Supporters, which are especially adapted to the use of watchmakers. Price, 30 cts. per pair. Address as above.

Electro-Metallurgy.

NUMBER TWO.

The electricity we wrote on in the last number is not the kind, however, that is used in the electro-plating processes; it lacks in quantity, though much superior in intensity. It was the only kind known up to the year 1790, when Galvani, Professor of Anatomy in Bologna, in making some experiments on electricity, was astonished to find the limbs of a dead frog take on a convulsive action while lying near the electrical machine during some experiments. This effect had been before observed, but had not attracted the attention that the fact demanded. On further tracing up the matter, Galvani found that if a metallic connection was completed between the nerve and muscle, the same convulsions were observed to take place. These facts, on being published, aroused the attention of all Europe; and, among other physicists and chemists Professor Volta, of Pavia, devoted his whole mind to the solution of phenomena that were so very much out of the common way of events. Professor Volta found that the contact merely of two bodies was sufficient to disturb the electrical equilibrium. He furthermore found that three conducting substances would induce a constant current of electricity, provided the connection was kept up between any two—the third acting as a chemical agent to effect the oxidization of either one of the two in contact. He was led by the results of his experiments to construct what is called, in his honor, the Voltaic pile, consisting of alternate layers of zinc, a piece of cloth saturated with salt water, and copper; the two opposite metals were connected by wires. The series can be carried out in imagination indefinitely.

When we consider the wonderful results that have followed this apparently simple discovery, we must be struck with the conviction that this little apparatus (a plate of zinc, a piece of cloth, and a plate of copper) is one of the most wonderful achievements of the human mind; for it was the result of pure reasoning, guided by experiment. The connection between this variety of force and that excited by friction, was not at first discovered; in fact, it was considered a new force entirely. But the real result has since been developed, and man can divest electricity of its sudden and uncontrollable violence, and thus may use whatever of power may exist, in manageable form; and it is on this fact that rest all the subsequent processes that have been introduced as means of physical research, or for the arts and manufacturing purposes. Before we leave the original Voltaic pile, we may state that any one may have a personal conception of this pile and its action, by placing beneath the tongue a small piece of zinc, and above, a piece of silver; on contact of the two pieces, the experimenter will perceive a flash and experience an alkaline taste, due to the galvanic action exerted by the three bodies—the zinc, silver, and saliva. Now, this simple experiment demonstrates as thoroughly as does the voltaic pile, that the resultant disturbance of the electric equilibrium is due to chemical action; and we may then assume the statement we made in the last article to be true, "that no chemical action can take place without a development of electricity."

As no form of chemical union is so active as that of oxidation, we should very naturally conclude that it would exhibit the most striking results. This is the fact, and the action of dilute sulphuric acid on zinc having in the solution a plate of copper, was found to give the greatest amount of disturbance, and the first form of the battery was an alternate series of zinc and copper plates, the circuit being kept up by connections with the plates, thus—from zinc to copper, and so on. Sir Humphrey Davy constructed a very large battery of this description, and by its means decomposed the oxide of potassium, thus proving for the first time that the alkali had a metallic base. From the date of Davy's discoveries the science of the Voltaic battery, or, as it is now called, the Galvanic, progressed. It having been found that the current was capable of decomposing water, other substances were experimented on, and finally it was demonstrated that the current was capable of decomposing the solution of a metallic salt, say, sulphate of copper, and depositing the metal base on an object (a conductor) attached to the other pole. The mere depositing of the metal was not the whole point to be attained; in 1805 Brugnatelli "gilt in a complete manner two large silver medals by bringing them into communication, by means of a steel wire, with the negative pole of a Voltaic battery, and keeping them, one after the other, immersed in ammonuriet of gold, newly made and well saturated." In this process was the germ of all the subsequent galvano-plastic operations; but the real art did not spring into existence until Professor Daniell discovered a form of battery from which a continuous flow of the electrical current could be kept up, with something like even power for a length of time.

The batteries that had been in use up to his time were found to lose their power after a few hours' action. This fact would alone prevent the deposition of a metal with any degree of success, if a fair cast or plating was to be obtained. Indeed, we may claim that Professor Daniell was the real inventor of electro-metallurgy; he had noticed that some scratches he made on the platinum electrode were copied with the minutest fidelity by the deposited copper film obtained on reduction. It will seem strange that the paper written by De la Rue, and published in the "Philosophical Magazine" for 1836, should have attracted so little attention. He states: "The copper plate is also covered with a coating of metallic copper which is continually being deposited; and so perfect is the sheet of copper thus formed, that, being stripped off, it has the counterpart of every scratch of the plate on which it is deposited;" and yet it was not until 1838 that Professor Jacobi made the public announcement that he could 'employ the reduction of copper, by the galvanic agency, for the purposes of the arts."

Looking into the subject with a view to the historical part, it seems that a process that is so simple as it is practised in our enormous plating establishments, in the electrotyping of wood-cuts, and copying maps, plates, and pictures, should have been so long delayed in its development, when we consider that in 1805, Brugnatelli, as we have before stated, really announced the fact of galvanic metal deposition. Mr. Spencer, in England, on the publication of Prof. Jacobi's experiments, was led to investigate the subject, and in 1839 he was able to exhibit copper casts, taken from objects by means of the battery; and to him the world is really principally indebted for the idea of an electrotype. The first form of the battery used was found too feeble in its action for any economical purposes; and precisely in this gap as it were, Daniell placed his new constant battery, composed of two cylinders, the outside one of copper and the other of zinc. So far there was no improvement, but he had found that when the solution of sulphate of copper was used there was a constant deposit of metallic copper on the negative element, thus always presenting a pure metallic surface—an item of the utmost importance, as in the old battery, although it might have more intensity on the first period of action, it was soon rendered almost powerless from the deposit of sulphate of zinc on the copper.

The Daniell battery, though so infinitely superior, has been almozt universally superseded by the Smee, which consists of simply two plates of zinc attached to a wooden bar that has depending from it a plate of platinum; the three being so arranged that, though very close together, there is no contact, either of the two zincs, or the platinum with either. Now it was found by Smee, that if the platinum was introduced into the solution of sulphuric acid and water, with clean surfaces, the decomposition of the water would furnish enough hydrogen to cover the negative plate with a complete coating of hydrogen bubbles, and this coating arrested any further action of the battery. To prevent this result, he employed the device of covering the platinum with a powder that would deliver or discharge the evolved hydrogen as fast as generated. This was effected by depositing a coat of spongy platinum, and it was found also that the plate could be made of silver, and act, if thus coated, with as much power and certainty as where it was made wholly of platinum. This form of battery is the one now almost exclusively used in the large manufacturing establishments, and as an instance of its power, we may mention that in the nickel-plating works of Mr. L. L. Smith, at 65 Crosby street, in this city, two jars only, with a plate surface in each, of four inches by eight, are sufficient to furnish a constant battery power, and also one of long continuance.

It must be understood that a constant power is not the same as durability; for local action on the zinc may give, during the course of a few hours, a great many variations in the amount of power, although the same battery may be continuous in its action.

Another great step in advance, was the application of metallic mercury to the zinc, in order to not only prevent local action, but to preserve the plates from chemical action from the acid while the battery is in action. As this form of battery is the best in use for the purposes of electro-metallurgy, we shall treat of it solely, though there are many other forms that seem peculiarly adapted to certain purposes. Grove's battery, a form of which is extensively used for the telegraph, is made up of, first a tumbler, next a zinc cylinder, inside of which is placed a porous cup made of a species of pottery, but having no glazing; this porous cup is filled with strong nitric acid, while the outside space is charged with sulphuric acid and water; attached to one conductor is a platinum plate that is introduced into the nitric acid, while connection of the other wire with the zinc completes one cell of the battery. If great power is wanted, combined with intensity, it may be obtained by using a number of such cups; the platinum of one cup being attached to the zinc of the other, and so on until it comes to the last of the series, where the platinum is attached to the wire, not to the zinc, and the same conditions are observed as in the single cell.

This battery, though apparently simple, is not well adapted for the purposes of the metallurgist, notwithstanding its decomposing power is great, owing to the intensity of the current it gives. In the laboratory, however, it is of great use; the spark that may be obtained from a series of say twelve cells, rivalling that from the old style battery of a hundred plates. For the ordinary purposes of manufacturing, however, the Grove battery is unsuited, even were its electric developments the same as the Smee, for the chemical action produces nitrous fumes from the nitric acid, that are injurious alike to the workman and any tools in the apartment where the battery is placed and worked.

Having assumed that the Smee battery is the best, and therefore most used, we will try in the next number to give a more detailed description of its make and the theory of its action, together with its direct application to gilding, plating, and casting, as it were, by the electric fluid.

Pictures without Light.

When new watches, which are engraved on the cap, have lain for any length of time, it will often be found, on opening them, that the engraving on the cap has been transferred to the polished inside of the case. Nearly every dealer and workman must have observed this effect, which is worthy of more than a passing notice, as there are apparently no causes that can produce it. We are all familiar with the Daguerreotype; but as we find certain causes alone will produce a picture, we assign the phenomenon to those causes. Thus when a plate of silver is properly polished with a perfectly clean surface, we may render it sensitive by means of iodine, and take a picture by means of sunlight. We attribute the effect to the action of light, but can go no farther; for if we decompose a ray of sunlight we shall have what is called the solar spectrum; now it has been found that this peculiar action on the sensitive plate is not equal for any two parts of the spectrum.

The various colors that are exhibited in the spectrum act with very different degrees of energy, and with very different kinds of effect. Though all bodies are affected by light, those of weak chemical affinity are attacked and changed with the greatest rapidity; and when we use the word light, it must be understood that we mean solar. Yet, while such changes are effected by solar light, it is possible to effect the same results when no *visible light* is present; that is, the plate may be impressed with an image in the dark. As the action is due to purely chemical changes, Sir John Herschell, on reasoning on the inequality of action in the different parts of the spectrum, came to the conclusion that, combined with its illuminating power, light possessed properties capable of exciting chemical action. This discovery, for such it was, has since been confirmed by thousands who have taken daguerreotypes.

The chemical ray thus found is the active cause of all the changes that occur in all the changes that are wrought throughout the various processes of photography. A certain degree of chemical action, as stated before, is distributed throughout the solar spectrum, though exhibited with different degrees of force and *kind*. This distribution does not depend on the refrangibility of the rays alone, for it seems that the length of the chemical spectrum varies with the nature of the surface on which it falls. If received on paper prepared with bromide of silver, the paper will be blackened; and this chemical change is found to extend far beyond the extreme violet, while it commences at the extreme red. With tartrate of silver, the blackened part extends beyond the extreme red, and the formobenzoate of silver gives the chemical spectrum cut off at the orange rays; with chloride of gold it ends at the blue, and the nitrate of silver places the blackened part entirely beyond the visible spectrum at the end of the highest refrangibility; but is only one-half its length. From these facts it will be seen that in the case of nitrate of silver the picture can be *taken in the dark*, for the luminous spectrum may be cut off, and the chemical only used.

The kind of action is not the same at the ends of the chemical spectrum, nor indeed anywhere within the limit of the visible spectrum—the different colors having a strong tendency to reproduce themselves; but the most wonderful thing about it all is, that while at and beyond the extreme violet the chemical ray produces the most intense black, the rays emanating from the red have a tendency to bleach the image already formed.

Now, very similar effects may be produced by electricity, and as, at the present day, light (or at least its chemical agent, electricity) and heat are considered one and the same force, differently manifested, we are led to think that heat, too, has its chemical rays, and that, like light, it may produce pictures. The fact has been established beyond doubt, that the calorific and parathermic rays act in precisely the same manner on surfaces rendered sensitive by chemical preparations, or an extremely high polish. Prof. Moser, of Konigsberg, has proved that the mere contact of two bodies, or even their juxtaposition, will produce the same effect as the action of light; and this change of surface, by contact, could be produced in the dark as well as in light. His announcement of the *discovery*, contained in the following quotation, will give our readers some idea of how, when he happens to touch the inside of a highly polished case, the marks, though not instantly, will appear, and are troublesome to be got rid of: "If a surface has been touched in any particular part by any body, it acquires the property of precipitating all vapors; and these adhere to it, or combine chemically with it, on those spots, differently to what they do on the untouched part." Every one of our readers undoubtedly has, at some time, written on a window pane on which the moisture of the atmosphere has been condensed; if he tried, by his breath, to recondense some vapor on the written part, he found that the vapor *would not condense*. The converse of this experiment is, to write or mark with any substance on a surface highly polished (a piece of blotting paper rolled to a point, or a clean brush, is the best); we may clean the plate or surface and no marks appear, but if we breathe on the plate the writing is apparent. The highly polished surface of mercury is a fine one with which to try the experiment But *absolute contact* is not necessary; for if we cut any piece of card board through with some well-defined pattern, and hold it over a polished surface at a small distance, and then breathe upon the card and surface, we shall find that after the vapor has thoroughly evaporated, we may reproduce the pattern by simply breathing on the plate.

Prof. Moser has shown that bodies exert a strong influence on each other, by the following experiments: He chose a warm metallic plate, and for a short time allowed coins and various articles to rest on its surface; on removal, the surface presented the same appearance it did before, but the images of the various articles came out distinctly when the plate was breathed on, or exposed to the vapor of mercury. This was not all; he next chose a plate of glass, and the result was the same, even when the bodies were not in contact; and it made no difference as to success whether the experiment was performed in light or darkness.

It would seem, however, that in addition to heat, galvanism plays a peculiar part, for Mr. Hunt has shown that in order to get good impressions the coin should be of a different metal from that of the plate. His experiment consisted in placing on a plate of copper, heated far below the oxidization point, several coins of different metals, such as gold, silver, composition of copper and tin, brass, and copper. These were kept on the plate until all were cold, when it was found that all had left their images impressed on the plate, but not with equal distinctness or intensity. The gold and silver were nearly equal, the bronze next, and the similar metal last. He next exposed the plate to the vapor of mercury, and the impressions were in the same order. He next wiped the plate off, and the gold and silver coins had left permanent copies of themselves on the plate. The same results were attained when the coins were raised as much as an eighth of an inch from the plate. The relative sizes of the object seemed to have an influence, for the larger the coin the better the impression.

The experimenter availed himself of this property of the metals to copy engravings and prints, by the use of an amalgamated copper plate; on this the print to be copied was laid and closely pressed by a thick plate of glass; the whole was then laid aside for a few hours; when the parts were separated the copper face was exposed to mercurial vapor, and then to that of iodine, and an accurate impression of the original was obtained. Mr. Hunt was led to this result from having found that he got stronger impressions from black substances than any other; hence an engraving was peculiarly fitted for the experiment.

We have stated that electricity would produce this change in surface, and this fact is strong presumptive evidence of the identity of forces which are commonly called by three different names. Mr. Karsten obtained the same images on the surface of a glass plate, resting on one of metal; the coin was placed on the glass and subjected to a series of electrical discharges from a Leyden jar. When the glass was subjected to vapor of either mercury or iodine, the image was brought out with perfect distinctness. More singular still, if several glass plates were piled together, and arranged as the single one had been, after the electrical discharges each plate had the image firmly impressed on its upper surface.

Any disturbance of the calorific rays will produce the same results; for, if the copper plate was reduced in temperature by means of a freezing mixture, and bad conductors of heat laid upon it, under the same conditions the results were identical. Now, all this goes to prove that the absolute amount of latent heat being disturbed, the molecular change of surface takes place; and we have reason to believe that a change in the molecular condition of the whole mass is produced, for on wiping off or cleaning a plate on which the images have been impressed, the shock of a discharge from the Leyden jar will reproduce them. M. Matteuci, whose experiments and reasoning on the whole range of galvanic and molecular changes have placed him in the highest rank as an authority, has proved that an electrical discharge does not visibly affect a polished silver plate; but that the surface was so altered as to affect the condensation of vapors.

Now, in all these experiments of Mr. Hunt, we cannot see the cause of action; but we can reason that bodies in close position do exert a reciprocal action, and he made an experiment which was attended with more singular results than those attending the former observations. He placed an engraving, with its face side on an iodized silver plate, placing over it an amalgamated copper plate; after the whole had been left in total darkness for some hours, he found on submitting the copper plate to the action of mercurial vapor, that the picture had actually appeared, and it must have been *through* the paper that the impression was obtained. Again he iodized a silver plate and placed a small coil of string on it, then suspended another plate (clean) above, at a distance of about one-eighth of an inch; after four hours' exposure both plates were submitted to the action of the mercury, and the upper plate alone had a perfect image, while the iodized plate showed no trace. We must conclude from this experiment that surfaces may be altered by some cause in the dark; and we may attribute it, with good reason, to the chemical rays of heat, for the action is precisely analogous to that exercised by the chemical (actinic) rays of light.

From all the facts stated, we are warranted in assuming that the same conditions are fulfilled in the watch case; and it must have struck the mind of any one who has observed the fact, that those domes or capes that are engraved with broad letters, matted at the bottom, are the most commonly transferred. We can, then, form the theory that the engraving has, by simple juxtaposition, as in Mr. Hunt's experiments, transferred itself to the unengraved case.

Suggestions By Practical Workmen.

Hair Springs.—I just happened to read an article in the *Scientific American* of the 11th inst., written by Mr. Septimus Piesse, and stating the fact as *just discovered*, that all hair springs, being made of steel, are more or less influenced by the earth's magnetism. Three years ago, suspecting that the compensating balance had to compensate another cause than merely the increase of length produced by heat, I made some experiments in order to ascertain whether my theory was or was not well founded. Dropping the idea that the elasticity of the spring is diminished, while its length is increased, by heat, we have effects produced by heat that can be accounted for on no method of calculation, if we take change of temperature as our base. Now, these regularities or irregularities being beyond the reach of the ordinary tests, I made careful experiments on six watches, put in perfect order in the motive power, train, and escapement. I sprung these watches with tempered steel pendulum springs, and carefully noted the rates of running during the following experiments, subject first to a temperature of 40° F., and then to one of 90° F.; the observations in each case extending over a period of twenty-four hours. The results having been taken, I replaced the steel springs with others made from a vastly different material, which, after many attempts, I succeeded in making with an elasticity very little inferior to the steel.

The watches having been resprung, were again subjected to the same test, and the difference in the results may be thus stated—which results, allow me to state, I confidently anticipated: The steel gave in the twenty-four hours, from 210s. to 296s. time lost in the test, and the new springs gave but from 60s. to 72s.—the duration of trial and the circumstances being identical in the two cases.

Now, if dilatation of the hair spring was the only reason of the loss of time of a timekeeper subjected to heat, my springs should have lost a good deal more; for, according to the table of expansion of metals, my new alloy is even more dilatable than steel. This result convinced me that the compensating balance has got to make up, not only for the increase of length in the hair springs, but it has got to destroy the effects of the magnetism, which is the inseparable companion of heat, whatever its source may be. The force of the magnetic currents being variable, and especially greatly increased by northern lights, thunder storms, and other natural phenomena, it becomes easy to account for the uneveuness of rate noticed in the best time-keepers; and to these currents, I think, we should allow a share in the disturbance produced on the instruments, compass, and chronometers of our ships at sea in a storm. These causes have been assigned as responsible for the loss of different ships a few months ago, by several scientific papers. The laws of earth magnetism being yet in the dark, it seems reasonable to attempt to avoid its effects on hair springs, and the only way to avoid the effects is to make them of some other material than steel. Gold has been tried many times, but being uneven in elasticity and composition, as well as expensive, its use is very limited. The alloy that I tried is of a high elasticity, keeping for years a beautiful color, cannot rust, and is as cheap as steel.

E. Sandoz.

Hudson City, N. J.

There are two simple arrangements that I have used in cleaning a Swiss bridge watch, lever, or cylinder, that I think are very convenient, and I will illustrate them. I have a small stand about 1¼ inches in diameter, made of gilded brass, and turned round in a lathe that is mounted on a firm base, with a stud in the centre running up to the plate; on this I have engraved the shape of a watch movement with the bridges on it, and the screw holes drilled in; when I take a watch down I place the screws in the holes as in the watch, and leave them there until I am ready to put it up again, and I find they never get mixed; they can be cleaned by drawing a brush over them, and if carefully done will not "hop out." I also have a tapering punch, something like a "pusher," as it is called, used for pushing rivets out of pins, etc.; and after cleaning the bridges in a paper, as usual, I push the punch in the screw hole with friction enough to prevent slipping, and then finish with a fine brush, and get it cleaner.

G. N. L.

Baldwinsville, N. Y.

Screw-drivers are small things, and a watchmaker's business is but an aggregate of littles; even his salary (unfortunately) is not often an exception. Probably no article on the bench is in so constant and frequent use as the screw-driver. Not less than a thousand times during a day's work is it taken up and laid down; and its proper construction and use are, therefore, of more consequence than appears at first sight. No workman who has the slightest regard for his own comfort, or any pride in the quality of his workmanship, will confine all his manifestations to one screw-driver—using one wide and strong enough for cock and plate screws, for turning jewel and hair spring stud screws. He should have at least four sizes, made from good steel, and flattened on the two sides,—not "stunt" or "stubby," but filed to a long, slender taper. The filing should be done crosswise to the long axis of the driver, and with a sharp file, leaving the file marks as deep and sharp as possible; then harden and temper to a blue, and you will have a tool that will not slip from a screw-slit, with any ordinary care in using.

Many a good watch, not otherwise injured, is rendered prematurely old and shabby by the improper use of a good screw-driver, or by the most careful use of a bad one.

The blue from the edge of the screw-slit is all scraped off by slips, or the gilding torn off around the screw hole, by using the *corner* of a driver too wide for the screw-head. Such work is abominable, and there is no excuse for it. Still, a watch so abused can, with a very little labor, be made to look quite respectable. Take all the screws that have been so abused, put them in the holes in your bluing plate, and carefully heat them till the bright spots have assumed the original tint of the screw. It takes but a moment, and you will be surprised and pleased at the fresh and new appearance it gives to the movement.

R. C.

Cleveland, O.

To Hard Solder Jewelry without Changing the Color.—One ounce borax (to be calcined before mixing), one and a half ounce yellow ochre, half an ounce aqua ammonia, water to form into a thin paste; apply with a small brush. Be careful not to have any of the paste where the solder is to go. After mending, soak in cold acid pickle.

To Soften Steel without Injury to the Polish.—Boil the article for ten or fifteen minutes in linseed or sweet oil, taking care to have it covered with oil while boiling. Large articles take longer time than the above.

To Make Holes in Glass.—Spread on thinly some borax, after warming the glass. Remove the wax where you wish the hole to be made; with a piece of iron wire put on the spot a drop or two of fluoric acid, and it will eat through the glass. Should it not be sufficient, make a second or third application of the acid. After the acid has eaten quite through, it may be enlarged or shaped with a a file dipped in oil of turpentine while using. To polish, use copper wire with rotten stone and oil.

Another Mode.—Use dilute (1—5) sulphuric acid, with the ordinary steel drill; also to enlarge the hole, use it upon the file from time to time while using. After using, wash the files well, and dry quickly.

Common Brass Clocks may be cleaned by immersing in boiling water. Rough as this treatment appears, it works well whenever they stop from dust or thickening of oil upon the pivots. Boil in rain water, and dry on a warm stove.

Flemington, N. J. L. F.

Correspondence.

EDITOR HOROLOGICAL JOURNAL :

I think it is the duty of every watchmaker to furnish his apprentices with a copy of the JOURNAL to read and file for future reference—as much a duty as to furnish proper tools to learn to work with, or instructions in any other way. If I had a dozen apprentices I would furnish each with a copy.

I notice in the communication of J. Cross, on page 152, No. 5 of the JOURNAL, in regard to rating clocks by sidereal observations, that he gives for the daily acceleration of the stars three minutes fifty-six and six-tenths seconds

Reid, in his treatise on clock and watchmaking, page 322, gives it three minutes fifty-five and nine-tenths seconds.

Who is right? I have used this method for the last twelve years, and have used Reid's table of acceleration. I would like to hear from "J. C.," as to his authority. If I have been giving the Starlings seven-tenths of a second per day for the last twelve years out of Old Sol's treasury, I would like to know it, that I might make amends.

Also for the benefit of the rising generation of watchmakers, allow me to suggest that a better way for "watchmakers' apprentices" than counting and recording the numbers of trains of all watches and clocks that come into his hands (for the purpose of enabling him to replace parts that may be subsequently lost with the proper numbers), as recommemded by "R. C.", page 149, No. 5, is to at once set himself to work and learn to calculate trains, or, where parts are lost, to calculate the numbers for the lost parts by counting the numbers of the parts remaining. Then it would not matter if he had never seen the watch, or any like it, before. He could readily produce the required numbers for the lost part.

This could be done in much less time than it would require to count and record the numbers of all the watches he might handle in a year, or even in a month, and can be done in leisure moments, instead of consuming valuable time, which should be employed in remunerative work.

For example, the third wheel, with its pinion, is lost. The watch having sixty-four teeth in the centre wheel, and eight leaves in the pinion of the fourth wheel, what are the required numbers for the lost wheel and pinion? It must be remembered that the centre wheel revolves once in an hour, and in most watches made now, the fourth wheel revolves once in a minute, or sixty times in an hour.

Now, for a pinion, let us try one of 8 leaves. This, working in a wheel of 64 teeth, would make 8 revolutions in an hour (as 8 goes into 64 8 times). The fourth wheel, as said before, must make 60 revolutions in an hour, which would be $7\frac{1}{2}$ times as often as the third wheel (as 8 goes into 60 $7\frac{1}{2}$ times). Therefore, it (the fourth wheel) must be driven by a wheel having $7\frac{1}{2}$ times as many teeth as it has leaves in its own (the fourth wheel's) pinion, which would be 60 teeth (as $7\frac{1}{2}$ times 8 are 60). Answer—a wheel of 60 teeth, having a pinion of 8 leaves, is required.

If the centre wheel has 75 teeth, let us try a pinon of 10 leaves, which would give the third wheel $7\frac{1}{2}$ revolutions per hour (as 10 goes into 75 $7\frac{1}{2}$ times). The fourth wheel, as before, having a pinion of 8 leaves, must make its 60 revolutions per hour, which would be in this case 8 times as fast as the third wheel (as $7\frac{1}{2}$ goes into 60 8 times). Therefore it must be driven by a wheel having 8 times as many teeth as there are leaves in the pinion driven, which would be 64 (as 8 times 8 are 64.) Answer—a wheel of 64 teeth, having a pinion of 10 leaves, is required.

A few lessons from the instructor, with a little study on the part of the pupil, would soon place him beyond the necessity of resorting to memorandums which are liable to be lost, but once snugly stowed away in the *wisdom box*, would always be ready reference.

J. P.

DES MOINES, IOWA, *Nov.* 15, 1869.

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Answers to Correspondents.

A. H., *Ky.*—We have answered the business matters by letter, but we prefer to answer the queries as to the horological part through our pages; for we have proposed to furnish a journal that shall be practical, and at the same time reach with whatever of information it may contain, the greatest number of our readers, with possibly some benefit accruing to each. The great difficulty existing is, to go into details sufficiently minute, without becoming tedious and prolix. You wish to re-blue or color the old screws, or any new ones. Now, for a good color, an exquisite polish and true surface are required, and the want of success you say you meet with is perhaps due to a deficient surface. Again, you cannot get a fine polish on soft steel; therefore it is advisable to harden the screws, and while in that state to bring them to a fine surface with the oil-stone powder, followed by crocus and rouge, and lastly, with

Vienna lime on boxwood. If it is desired to have the heads perfectly flat, the object may be attained by taking a small disk of brass, say three-quarters of an inch in diameter, and an eighth of an inch thick, in which countersink a centre, and from the other side lay off and drill any number of holes you may desire; only each series must be equidistant from the centre, and they should be so distributed that either circle of holes shall be capable of making odd numbers, equidistant; thus, three, five, or seven. After having hardened the screws, the threads may be let into the holes in this way, but always so that the screws have an equal bearing, the grinding plate having been covered with a coating of shellac, which also fills up all the holes.

While the plate is gently warmed, each screw is held in the flame of the lamp until it will flow the shellac; the points of the screws are just entered into the holes, and while the shellac is still warm reverse the whole on your glass-grinding plate, pressing the screws evenly into their respective seats. On letting it cool, the screws will be found to project very evenly and upright from the face of the brass holder. The polishing process has been fully described in previous numbers, and so need not be repeated here. The object of the countersink is to furnish a bearing for the piece of pegwood or steel point used in moving the whole on the grinding surface. Having an odd number of screws gains two very important objects: first, a truer bearing is effected, and next, the odd screw will make the block revolve around the centre, thus giving it a combination of motions that turns out the work better and much more expeditiously, recollecting that at each change of process from one material to another, the whole block should be well washed with soap suds and a stiff brush to remove any trace of the previous material.

After the final polish is effected, the block is warmed and the screws taken out and thrown in alcohol, in which they are boiled until the whole of the shellac is removed; the slot should be perfectly free from all dirt or oil. The bluing is now performed by dropping the screws in a brass plate, which has been prepared with holes, giving perfect freedom to the thread part of the screws, being careful to select the screws of as nearly as possible the same size. The whole is now laid on another clean plate, and the two held over the flame of the lamp until any color you may desire is obtained, when the screws are picked out with the tweezers and dropped into alcohol. You may not succeed at first, but you may rest assured that after you have got up the conveniences, the trouble of learning the true road to success will be slight.

When, however, you wish to finish round-headed screws, you will find that an ordinary lathe (shellac being used to hold the work) is by far the most expeditious tool, following precisely the same operations in polishing. The Swiss screw head tool is very handy, and where it has a polishing block a single screw may be polished up dead flat.

Your other query as to what Vienna lime is, may be answered with benefit to many others, as we have had very many inquiries in regard to it. The substance is a pure anhydrous lime, and is obtained from Vienna. It is extensively used in Switzerland and Germany for final polishing purposes. The mode of its preparation is not well understood, but from the evenness of its particles we should suppose that the carbonate of lime from which it is obtained is first pulverized to the finest powder, and then elutriated. The last precipitated from the water will be the finest. The water is now drawn off, and the dried, and finally the resultant mass, burned in the ordinary way in a kiln or oven. There is a very singular fact about the action of the lime when used as a polishing material, for it seems that the effect is not produced, as in the case of rouge, by simple abrasion, for unless the lime be used while it is slacking, the result will be very unsatisfactory. The material should, therefore, be kept in air-tight bottles, and but just enough for the occasion be taken out at a time. The way to use it is extremely simple, and may be summed up in a few words; having taken a small lump from the bottle, it is just moistened with water, and then broken down with any convenient, but *clean* tool. Having provided yourself with a slip of boxwood, you spread some of the lime paste on it and apply it to the article, using quick strokes. To polish screw-heads, you should have a section of boxwood planed on the grain as truly as possible, and apply your screw-head to the surface, on which some of the paste has been spread. Boxwood may be superseded by any other fine-grained wood, though it is superior to any other of which we have cognizance.

C. A. C., *Ohio.*—Putty, or, as it is technically called in England, tutty powder, is simply a combination of the oxides of lead and tin. The chemical combination is hardly worth discussion here, as the process is so simple that its production requires no scientific knowledge. In the article on enamelling, or rather dial making, this tutty powder was mentioned as being important for the production of opacity; but the watch repairer might use it advantageously in polishing the edges of watch glasses he has reduced, in order to fit a bezel, or the edges of the holes he has had to drill in glass. It is used extensively in glass polishing, and as the mode of making is so simple, every one with a melting pot, or even a common iron spider such as is used in cooking, may make whatever amount he chooses. Take, say one part of lead and three parts of tin, melt them together in a vessel with *a large surface exposed to the atmosphere.* This is absolutely required, for the product is to be an oxide of the two metals; and we may mention that the lead is of no use except to keep up the chemical action of the oxygen on the tin. The metals are melted and heated red hot; now, if a stream of atmospheric air be drawn or blown over the surface, a full play of colors takes place, owing to oxidization, and in a few moments this coating of oxide will increase in thickness until the intensity of chemical action, induced by the union of the oxygen with the metals, will cause a brilliant light to appear among the particles of the oxides, and when this action has commenced, all that is required is to keep the surface of the two metals clean and exposed to the oxygen; this is done by scraping off all the oxides as fast as they are formed. The process is continued until all the metal is converted to an oxide; then the result may be washed with water to separate any particles of solid metal. This is the tutty powder you ask about, and which is so extensively used in polishing plate glass.

S. D. L., *Wis.*—A great deal will depend on the quality of the goods. You ask, "how to restore the color of red gold rings, gold watch cases, and so forth, after hard soldering." The red gold ring is almost too low a carat to be affected by any solution; but if you will follow the plan given in the article on Soldering in a previous number, you will never have occasion to re-color. After the heat has been applied, and the operation of soldering performed, you may pickle in the ordinary solution (1 of acid and 5 of water) of sulphuric acid; if the color has been changed, it may, in a great measure, be restored by boiling it in a solution of cyanide of potassium (fused). This course may also be pursued in all cases where the gold is above twelve carats. Take a watch case, for example, with a broken joint; you wish to solder on a piece of hollow wire to form a new joint, yet you are afraid of discoloring the whole case, and tarnishing the polish of the inside. If you will mix with a small amount of water about half an ounce of borax, that has been previously calcined and powdered, with about an ounce and a half of common yellow ochre, you will have an agent that in hard soldering will save you an immense amount of subsequent trouble. The process of its application is simple, as it merely requires you to paint with a common camel's hair pencil every part of the surface not intended to be subject to the action of the fire, with the mixture of borax and ochre.

After soldering and pickling, the white or discolored parts may be restored by boiling in a solution of cyanide of potash. As a matter of course, the case must be rinsed in clean water, and then dipped in strong alcohol, in order to dry it thoroughly; and here we would mention, in the repair of jewelry much labor and a great deal of disappointment may be avoided if you wash, instead of attempting to clean with any polishing material. Use soap and warm water, to which you must add a few grains of the cyanide of potassium.

J. L., *Va.*—The information you wish may be obtained in almost any elementary work on chemistry. As you may be so situated that you have not access to such a work, we will try to give you some idea why, when you attempt to solder with the blow-pipe, you are disappointed because the solder does not flow; and yet you say that at other times, with the same solder, you have no trouble. Now, the flame produced by the blow-pipe has two very different qualities; one of which is called the oxidizing flame, and the other the reducing. Now, if you use the point of the long blue flame, and bring the metal up to the point of fusion, the carbonic acid from the breath carries the flame along, and the metal will be oxidized, and this coating of rust will prevent a perfect flow of solder. If, however, you hold the nose of the pipe a short distance from the flame, you will have a yellow jet, and this is the reducing flame. This tends to clean the surface of the fused solder by deoxidizing any coating of rust. You must always scrape your solder clean before using.

H. C. P., *Mich.*—The self-equating sun dial is nearly as old as Napier's logarithms, and he figured out by the analysis an equated curve that gave excellent results; but it was not accurate, from the fact that the earth's motion in her orbit is not exactly equable; both the inferior and superior planets so disturbing its course and velocity at particular times that accuracy is unattainable with the best equated curve, unless you could make the curve correspond to the changes that take place in the earth's orbit Still, a good and cheap instrument, with the nearest approximation to the true equation, would be a desideratum, and any quantity could be sold, if for nothing more than the check it affords on other observations for time. Your stricture on the statement regarding refraction would hold good had it been the intention of the writer to state that refraction is good only for angular distances on the meridian; but such was not our purpose. We referred entirely to an object in the meridian, so that there was no horizontal refraction.

D. P., *N. Y.*—There can be no means of ascertaining the fact of compensation or timing for position in a balance, except testing the *rate* for yourself; and in that case you would be compelled to have a good clock, whose *rate* you can determine by means of observation. It is an absurdity to suppose that by the eye alone the fact of compensation could be detected; for of twenty balances made with equal care, and presenting every external appearance of being equally valuable for the purposes of Horology, yet the fact is, no two are equal, and you may find one of very superior quality, but the eye or hand cannot detect the fact; trial only can be a test. If you know that a good movement is presented to you, you must judge something by its price as compared with other movements of the same quality, provided the first has been represented as having been adjusted to temperature and position. No watch manufacturer can afford to offer it without certainly an additional charge of *from twenty to twenty-five dollars.*

G. M. B., *Wis.*—There can be no such thing as perfectly arbitrary dimensions of the fork and roller; certain geometrical principles are involved in the combined action of the pallets, fork and roller, that demand, in order to get the best action of the escapement, certain relations in the sizes and angular motions of each. There is, we know, a wide range found among even the best movements; but the theory holds good, nevertheless, and any one who makes many watches for sale will regret not having paid attention to these geometrical principles, and based his escapements on the laws indicated by them.

W. M. B., *Pa.*—If your roller runs out of true, may it not originate in the fact of a bent staff—the bending having been caused by driving on a roller too hard? or the taper of the staff may be too great, and so the roller was not driven on true. At all events, you must remedy the defect, for it is impossible to make a watch run well in such a condition. Take off your roller and place the staff in the callipers to try it for truth; if bent, it should at once be thrown out and a new staff fitted; if the other cause exists, you may take down the taper and fit a new roller.

M. M. W., *O.*—Your query came too late for us to consider very carefully (as we always like to do) the whole subject involved in the question, "What is considered a good rate for a watch?" You will admit that the question is very vague. What kind of a watch? How high the class? There are some watches, as you know, that it is an absurdity to couple with the word "rate;" in Byron's words, we might exclaim—

"Ye gods, that such names mingle."

But it is not absolutely necessary that the watch should be very high priced, as we have on hand an example of a moderate priced watch that we carried nine weeks during all the changes of temperature, with a losing rate of thirty-eight seconds during the whole time. This movement, "Borel & Courvoisier," cost but $22.50, gold. Now we can answer your question in so much, that this rate of four and two-ninths seconds a week is not only a fair, *but an extremely good rate;* and if all the watches on the market would do the same, we could have a good standard rate.

A. C B., *Conn.*—We took the trouble to get the information you want in regard to the carbon-pointed diamond tool, for dressing mill stones, emery wheels, etc. At the office of Mr. John Dickinson, No. 64 Nassau street, you can find the article you wish to obtain. So much for your query; but we cannot let the opportunity slip of saying something about the carbon tools. In the articles which have appeared in this journal on the art of jewelling, as well those on the diamond, you will find that we mentioned a conglomerated form of diamond which has been very properly termed diamond carbon. This material has been introduced into the arts for the purpose of cutting the grooves in mill-stone faces, drilling rocks, etc. In our next number you will find that the watch trade has also been benefited; for the repairer may obtain now a drill (diamond) at a comparatively small price, by which he may pivot the hardest staff or pinion without drawing the temper. Mr. Dickinson is entitled to the thanks of the trade for the introduction of such a valuable aid in watch manipulations. In the next number a full description of these tools, together with the forms given to the carbon, will be given.

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*** *Address all communications for* Horological Journal *to* G. B. Miller, *P. O. Box* 6715, *New York City.*

Astronomy in its Relations to Horology.

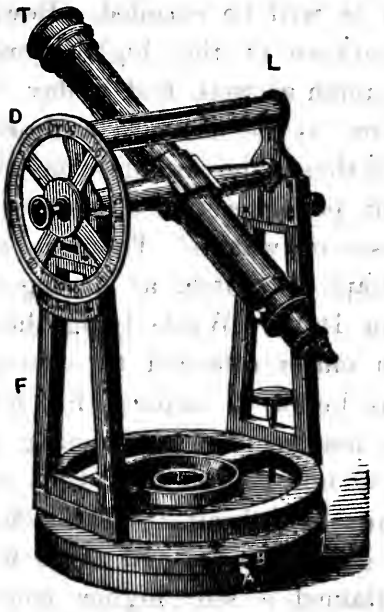
NUMBER EIGHT.

The method of obtaining time by lunar observations, as well as its accuracy, will naturally depend on a certain knowledge of the moon's place at any given moment, and at any point of observation on the earth's surface. Thus, we may suppose a star to be east or west of the moon; if her place has been tabulated, we may take from the Ephemeris her place and the relation she should bear to the observer at Greenwich, at any designated time, to any star that may be on the catalogue. It will be apparent that those stars nearly in the same circle of declination as the moon will be the best objects of observation. Obviously, one person alone could not determine the position of the moon's semidiameter and another object at one and the same moment; therefore it requires two observers to take simultaneous observations, and yet a third, to note the instant of the local time at which the observations were taken. This renders the system impracticable for the watchmaker who wishes a simple and easy method of correcting his clock rate. There is no other mode of ascertaining longitude at sea, that offers so many advantages and so great accuracy, as that of lunar distances, from the simple reason that no other resource is known in astronomy by which accurate time can be taken, where the instrument is not permanently fixed.

Before we leave the subject of lunar observations, we cannot neglect to mention that to Dr. Nathaniel Bowditch is due, in a great measure, the perfection to which this system has arrived. He was a man of the most noble qualities as well as a philosopher, and the translator of the "Mechanique Celeste," a work that, elaborated by the immortal La Place, can be equalled by nothing in the past, and it will remain for the future to judge whether it will be excelled. Bowditch was a mathematician of the highest order, and a good seaman as well, and to-day "Bowditch's Navigator" is the standard authority on every sea, with those who are desirous of determining their positions (*i. e.*, time) on the trackless waste of waters. There is an incident told of Capt. Bowditch, as having occurred in a port in Italy. While lying there with his ship, an officer attached to a foreign man-of-war was heard to express his astonishment that a master from so young a maritime country should be able to find his way through the Straits of Gilbraltar. The officer was invited to go on board, and there his astonishment attained a still higher point when he was informed that the ship had been worked almost entirely by lunar observations, and what was more, that thirteen of the crew, including the black cook, were able to take lunar observations and reduce them to time. The officer got a somewhat higher respect for a ship that possessed thirteen men, outside the officers, that could navigate the vessel into any port.

It is obvious that the motion of the ship prevents the use of any instrument for observation that is confined strictly to the meridian; and again, the change of locality, even were it possible to hold the instrument steady, would imply the obtaining a new meridian for every observation. But on land, where the location is fixed, there can be no better means of ascertaining the correct time than by the transit instrument. Its very name implies its use, for it is intended to note the passage of any celestial body over the local meridian. The fact, then, is apparent, that the line of collimation should be exactly in the meridian; and at whatever angle it may be set in the vertical arc, the true line should be maintained.

The general features of the instrument can be readily comprehended by an inspection of the cut, which represents a small transit intended expressly for the use of the watchmaker. The telescope T is hung on an axis, the two ends of which are supported in a pair of Vs. The great accuracy required in getting these ends of identically the same size, is one of the great difficulties in obtaining a good instrument.



It will be seen that there is a level, L, that rests with a pair of Ws on the axes in order to enable the observer to adjust the line of the axial motion to a perfectly horizontal position; on the end of one of the axes is a circle divided into 360 degs. for the purpose of taking vertical angles; in the tube of the telescope is placed a series of fine webs, or in the one before us a glass plate, ruled with a series of very fine lines, is substituted for the spider webs—a much better arrangement, as the adjustment is not likely to get out of order. For astronomical purposes the instrument assumes much larger proportions. The one at the Harvard Observatory, made by William Simms, of London, has a circle for measurement of vertical angles, which is four feet in diameter; the telescope is of five-feet focus, and the object glass is four inches and a quarter aperture. There are eight reading microscopes attached firmly to the two massive stone piers which support the instrument. The circle is divided into spaces indicating five minutes each; but as the micrometer head has sixty divisions, each one corresponding to a second of the arc, the readings may be relied on to within two-tenths of a second. The length of the axis between the shoulders of the pivot is two feet two inches, while the pivots themselves are made of steel two and a half inches in diameter, and the bearing plates of the Vs are eight inches broad and twelve long. The pressure of the pivots on the Vs is relieved by means of double friction rollers which rest on spiral springs. There are two micrometers attached to the eye-piece, one for a motion in right ascension, the other in declination.

We had mentioned that the telescope is provided with a series of what are called spider lines; these would be useless unless some method of illuminating them had been devised, and this is effected by making one of the axes hollow, and, by means of a lens, the light from a lamp can be condensed and thrown on the field. Here, however, is a difficulty encountered in the very nature of the pivot; the heat from the lamp is apt to expand the pivot and thus throw the whole instrument out of adjustment. To avoid this source of error, there is generally placed between the lamp and lens a very thin plate of transparent mica, which literally strains the ray retaining the heat, and allowing the light alone to pass into tho instrument. By such ingenious devices the errors are eliminated; but even then, there are some that cannot be got rid of through the imperfection of physical mechanical operation. In an instrument of the size of that in the Dudley Observatory, with a twelve feet telescope, there is a perceptible error arising from flexure of the tube. The five feet one at Harvard is constructed on a better principle, as the tube is braced in every direction.

Grand as are such instruments, they

are not absolutely required in the determination of time. We have in our memory tho image of an instrument of fifteen inches focus, that was made of tin plate by the Professor of Astronomy in the institution where we received our first introduction to the stars. The pivots were made of a composition of copper and tin, and were so hard that in turning them off the Professor was compelled to use a turning tool made of agate; and, rude as the instrument looked in comparison with those of very much higher pretensions, it gave results that were but little less accurate than those of its more formidable rivals. It will be seen by this that the watchmaker need not look to a splendid instrument only for his time.

In the ordinary instruments there are generally five perpendicular spider lines on the field, with a horizontal one in the centre. The Vs are so arranged in regard to each other that while one is firm the other is capable of a small degree of motion vertically as well as horizontally; this is for the purpose of correcting any departure from truth that may have happened since the last observation; but if the instrument has been put up on a firm base at first, there will be but little occasion for much adjustment. Such is the transit, and we will now proceed to describe its use.

As the earth revolves every twenty-four hours, any celestial object will appear to pass some certain point of observation at some instant during the twenty-four hours. Now, wherever that point may be on the earth's surface, if we know, it lies in an imaginary plane passing through the two poles. This imaginary plane is called the meridian of that place, without any reference to longitude; and yet, if this meridian is determined, the difference of time in the passage of any star or other body between that place and the meridian of any other, will give the longitude. The first effort, then, on having obtained the instrument, is to establish such a local meridian line; and in order to save trouble this line should be made permanent, by means of a mark or object placed to the south of the observer—the farther off the better; it should not be determinately fixed until the observer has verified his meridian line, and the truth of his instrument. If the circumstances are favorable, the observer should make a northern mark to verify the line, and, after this has once been established there can be no trouble subsequently in adjusting the transit. At the Harvard Observatory the southern meridian mark is placed at a distance of twelve miles. There is another method of adjustment in use; but as it is too complex for the ordinary observer, it is not worth while to describe it.

To establish this much desired meridian line, the observer having placed his transit with the telescope in as true a north and south line as he can judge by the compass or the north star, and having thus approximated the true line, the next step is by gradual corrections to obtain the absolute. Having temporarily fastened the instrument to a firm base, the observer has his choice of two methods to get his meridian line: thus, if he has his longitude well determined—and at the present date the principal points of the United States have, by means of the telegraph, been definitely located —the observer may take his local time from such a defined point. To illustrate this, we will suppose an observer at Savannah, the longitude of which is 5h. 24m. 20.6s.; in looking at the almanac he will find that the planet Jupiter passes the meridian of Greenwich (mean time) on Feb. 1, 1870, at 5h. 53m. 30s.; now if he will add to that the westing..................................5h. 24m. 20.6s.
5 53 30

the result will be.................11h. 17m. 50.6s.

Now if, at that time, he can find the planet (equating for time) on the central spider line of the telescope, he has got his instrument very nearly in the meridian. It must be recollected that in this trial the instrument should be carefully levelled by means of the striding level, L; for, if it is not, all subsequent adjustments will be worthless. The observer, having become satisfied, from repeated observations, that his instrument is nearly in line, may proceed to fix the base permanently, relying on the minor adjustment for greater accuracy. This mode of getting a true meridian line is hardly suitable for one who has not been accustomed to astronomical observation; though, in taking Jupiter as the object, we did not intend to cite him as the only one; the moon or the sun can be used, though the greater diameters of these render the observations less accurate.

As the transit is reversible, it may be pointed to the north star; and here is found a much more certain object by which to establish the line of the instrument. Though this star is not situated exactly in the line of the prolongation of the earth's polar axis, its distance from it has been very accurately determined to be at present 1° 24′; so that by the revolution of the earth it describes an apparent revolution around the true north; therefore, in twenty-four hours the whole circle would be 2° 24′.

Our space in this number being limited, we are compelled to defer any further description; we do this the more willingly, as describing the mode of working the instrument, and of recording the passages, would carry us on for three or four more pages.

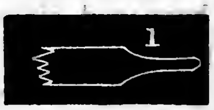
Watch and Chronometer Jewelling.

NUMBER EIGHT.

In this, the last article on the subject that has been treated on through the preceding numbers of the American Horological Journal, we shall not confine ourselves to any defined path, but in a discursive way give some hints that may be of advantage to the watch repairer. In fact, the minutiæ embrace a wide range of the ordinary manipulations practised at the bench. The subject of screws used in the work, is of great importance; it is true, that with the imported article so readily at hand, the repairer has but little call, except occasionally, to make a screw. The price of jewel screws, of the best quality, ranging from $1 to $1.75 per gross, renders the trouble of making too expensive. Now, it must be observed that even a jewel screw, for good service, requires truth; that is, a perfectly equal diameter from the point to the shoulder under the head.

This is a matter of vital importance, for if the screw is taper it will so open the hole when it is forced down, that on removal and replacement the screw will not hold. Again, the head should be turned up parallel, with a perfectly square shoulder, as the bearing on the setting is so small that a slight taper towards the shoulder might leave no hold on the setting, while it may be screwed down solid; if the head be much taper, and slightly large for the countersink, the screw will force the setting out of its place, as the bearing in the plate is so much greater than that in the setting. In the nickel plates the holes will not take so good and full a thread as the brass, and consequently, if the watch repairer is obliged to replace a screw, he will be compelled to make the hole slightly larger than if the material was brass.

Accompanying the screws, as they are imported, there are taps, left soft purposely; and the repairer will generally, if not always, find the body of the tap turned up to a square shoulder. Now, it may be a very trivial thing to write about, but many a repairer would have been saved hours and hours of vexatious trouble had he taken the precaution to turn or file off that shoulder to a curve before hardening and tempering, as shown in the cut. In fact, a square corner in any piece of steel is the very weakest part when the article is exposed to the action of fire and water. These taps may be fitted to the lathe, and if there is a tail stock a die may be easily made that may be preserved for future use.



As these dies, thus made, are altogether superior to the ordinary plate, a particular description will not be amiss. Let us suppose the back mandrel to be fitted up with a taper hole; the repairer can then proceed as follows, and he will find that after a short time he can have an assortment of dies from which he can make new taps at any time, and with very little trouble. It is to be assumed that the operator will make the blank taps of the form shown in the cut. The dies are made, or should be, of good steel wire, turned up with a taper to fit the back mandrel of the lathe; the blank need not have a very large bearing in the taper hole, but should be bored through with a hole much larger than the intended screw. After having been fitted, and the face turned true, a dovetail is made directly across the face, and two thin pieces of steel fitted in the dovetail in such a manner that the ends do not exactly meet in the centre; the broach is now used to make a round hole, excepting the space left by the separation of the ends of the two pieces of steel; the hole is now tapped, the tap being held in the lathe; after hardening and tempering it will be found that a good cutting die has been made, superior to any jam plate.

There can be no doubt of the superiority of this form of tool; and as the dies can be used for making screws, they become doubly valuable. The same process can be applied to the construction of pointing and milling tools for getting accurate uniformity of size; for if we make an attachment to the back spindle precisely like the die as described, and cut away a portion of each of the steel pieces let into the dovetail so that a sharp cutting edge will be formed, and as the steel cutters can be made slightly convex, there can be no mistake in getting a perfect size up to the shoulder. It will hardly pay the repairer to go into a full range of taps and dies, as the imported screws, whether jewel, plate, or cock, are always accompanied by taps, which, if treated as mentioned before in this article, answer all the purposes required by the repairer. Yet there are cases where a screw has to be made for a special job; in such cases the ordinary jam plate, either Swiss or English, subserves the purpose. The dies described, however, do the work much better and with less risk of breakage. There is hardly a repairer that has not a screw plate with half the holes plugged up by broken screw blanks.

In preparing the tap for use it is always best to *flute* it with a thin equalizing file, the thickness of which must necessarily be in proportion to the size of the tap. This plan, though involving more trouble, is much better than simply filing off three sides, as the last-formed tap merely squeezes out the thread, while the fluted one may be used in a smaller hole as the sharp edges of the flutings *cut* out the metal, leaving the thread in the hole solid metal, not forced into shape; this gives a much stronger thread, and a screw may be removed a greater number of times without the danger of stripping.

We have mentioned the importance of having a perfectly parallel head to the jewel screws; the remark is perfectly applicable to any other screw that is intended to go into a countersink, and it will be apparent that it is important that the heads should be concentric with the screw, if a neat fit is to be made in the countersink. For the pointing and polishing we will refer the reader to the articles on watch repairing, as the two are so intimately blended with general work that the subject is more germain to watch repairing in general than to any specialty.

There is a very meretricious practice with some members of the trade, of, in case of too close an end shake, burring the bottom of the cock with the point of a graver. The evils arising are, first, that there is no solid foundation for holding the bridge; and next, that the hole end being thrown up, the jewel is brought out of place and the wheel is brought out of upright; but the worst fault is that the successive screwing down will continually tend to flatten down the points of bearing, and thus the watch will never again go together the same. Altogether the practice is beneath any one who aspires to do good work. If the balance staff has two little end shake, the true way is to round off the pivots enough to give the requisite shake; where the shake depends on shoulders of the pinions, the shoulder should be reduced, and the repairer will find in the end that he has profited by doing his work in a correct manner.

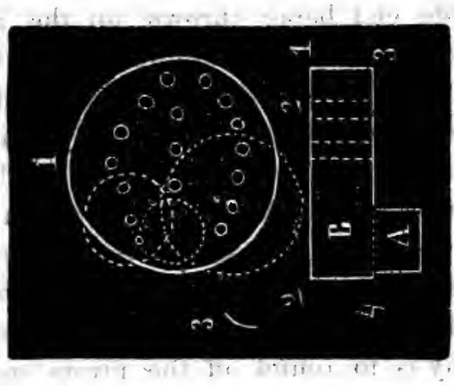
Sometimes, in the ordinary Swiss watch, one of the ends to the balance will be found broken; to replace the upper is but a slight job, as the steel disk that holds the regulator as well as the end stone, can be removed; if, however, the repairer cannot find among his stock of material an end stone of just the right size, he may be bothered. He has two modes open to him: he may reduce the stone in the lathe, provided he has a diamond tool, being careful to keep the diameter such that the face of the stone shall not rest on the jewel; if the only stone that he can find near the right size is too thick, the trouble becomes greater; as the steel cover is generally hard, it is difficult to enlarge the hole in depth by any steel tool without first drawing the temper, and this implies repolishing—a troublesome process. The remedy is to use a copper wire, rounded on the end with oil-stone powder, the steel cover being set up in the lathe, and the drill may be run either with the bow or in a lathe. Where the lower stone is broken, the task is much easier, as the brass cap may be easily enlarged.

—o—

Watch Repairing.

NUMBER THREE.

The die mentioned at the close of the last article was supposed to have the tit for the lower hole in the centre. An improvement on this would be to make the tit and block eccentric, as shown in the cut; the figures are drawn on the enlarged scale, but they show the whole principle. The holes, as indicated, should be large enough to take any pinion. The tit, A, is fitted to the lower hole, and the die, B, is turned up eccentric to A, but the surfaces 1, 2, and 3, 4, are to be made perfectly at right angles with the axis of A. The holes that are to be drilled are shown on the face of Fig. 1, and by the dotted lines in Fig. 2; they may be drilled at any distance from the centre of A, observing that if put in curved lines much nicer gradation of distance can be obtained than if put in a straight line. Though the holes are large enough to take any pinion, the truth of the centre will not be lost in the subsequent processes, even if the pinion is much smaller than the hole, for the simple reason that when the web of the wheel has been brought under the centre of the punch (or what in fact may be called a spreading tool), the pinion rests against the back of the hole in which it may be placed, and this may be turned around with great accuracy as to truth.



The dotted lines on the face of Fig. 1 represent two wheels of different sizes; the lines in each case crossing the centre of the block B; now, it is easy to see that with the limited number of sizes of watch wheels, only a few holes will be necessary. The form of the spreading tool on its face, or rather edge, is represented in Fig. 3, and the shape of this edge is very much like a common cold chisel; the curvature should someway correspond to the diameter of the wheel to be operated on. The block should be hardened and tempered, and then finely polished as truly flat as possible, and the holes should be slightly larger on the lower side than on the face.

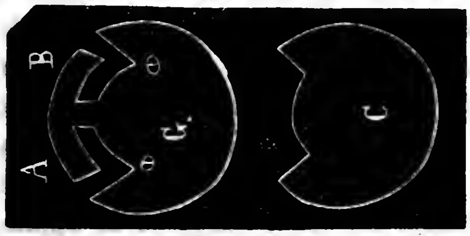
Supposing now we have the tools all prepared, the following uses may be made of them. In a great many Swiss watches, of the cheaper class, the repairer will find an ugly fault of stopping, and on investigation he finds a wheel out of true, say (and it is most common) the fourth wheel; it will run partly around, but at some portion of its periphery it will be found to be out of depth with the scape-wheel pinion, and in nine cases out of ten the depth at that point will be found to be shallow. There are only two ways to remedy this difficulty: either put in a new wheel, or so spread the *low* side of the old one as to bring the wheel true. The first step will be to ascertain exactly where the low side is, and how much of an arc it subtends; this is to be done in the lathe, or, still better, the depthing tool, as in the last the action of each tooth on the pinion can be observed. Having ascertained the part, the wheel, with its pinion, is placed on the block in the staking tool, the lower side of the wheel being up; the centre of the web should be brought directly under the tool (Fig. 3); a few blows of the hammer on the spindle in which the tool is held will make a slight crease in the web, and the displacement of the metal will be sufficient to spread out the wheel to its true circle.

This, as a matter of course, must be done with caution, and repeated trials be made for fear of getting the wheel too large; with care, the job can be done without any subsequent rounding up of the wheel teeth. It may be thought that we have dwelt on this subject at too great length; but when we consider that the common practice is to hammer the web out, and then with a rounding-up file bring the wheel to size and truth by the *eye* alone, we feel that a more perfect plan is of great value, especially as the workman can make his own tools, at times when he is not engaged. Again, the young workman may find in the discussion of the subject some important hints that may lead him to find a cause of stoppage where he least expected.

In large cities, where tools are abundant, it perhaps would be better to spread the whole web and then bring the wheel to depth by means of the rounding-up tool. The most of the repairers in the country have not the facilities that are afforded in cities like New York or Philadelphia, though they might have were they to pay more attention to their tools, and lay out more money on them than is generally done; for a gradual accretion of tools tells but little in the long run, from the fact that the repairer will have made more from the purchase and use than the prime cost. The Swiss rounding-up tool, such as we have before us now, and a description of which we are about to give, was kindly loaned us for the purpose, by the Messrs. Waaser & Lissauer, 52 Nassau street. It is one of the best, and though costing in the neighborhood of $80, the price is not excessive when the amount of elaborate work on it is considered. There are tools at a much lower price that may answer the same purpose if the cutters are as well made. In fact, the attachments to the tool are quite as expensive as the tool itself.

This tool may be described as simply a milling tool, consisting of two lathes—one with a live mandrel, the other to hold the work in dead centres. The cutters that do the work are set true on the live mandrel, which runs in a head-stock capable of a vertical adjustment, while the dead centre lathe is based on a dovetail admitting of an end motion, regulated by a fine screw feed; thus the live spindle remains always in the same vertical line, and therefore an index may be used to get the wheel held by the dead centres exactly true with the line of vertical motion of the live mandrel.

As in all tools, the cutter is above the work, and the correct diameter is obtained by stop screws resting on steel bearings, and which may be used to graduate to any size, from the smallest scape wheel up to the largest barrel or main wheel. There accompany the tool, five different arbors, with ten different centres, two of which are conical the others are hollow, with a transverse hole to enable the workman to not only clean the centre, but to oil the pivot from the end. There is one very beautiful application of the screw principle that will strike every one who sees the instrument. The saw, or cutter, which is intended to round up the teeth, is made with a segment cut out of the periphery, as shown in the cut; being placed on the live arbor, the saw is held in its place by a follower or washer, on which is a steel plate; this plate is cut away a slight distance from the edge, on two sides of a narrow neck, which is left by the undercut, as is shown in the small figure; directly back of these two horns, thus formed, there are two screws at A and B respectively, coming through the back of the brass washer on which this steel plate is screwed, the points of which take the two horns at the back. It is evident that if one of the screws is put in farther than the other, the neck will be twisted, and the edge of the plate stand at an angle to the plane of rotation. Now, if the corner represented at A is in advance just one tooth, it is evident that at every revolution the wheel will be rotated by just that much, so that the workman having the job in hand, after adjusting for size, may go on without once touching the wheel.



This process, as a matter of course, is not perfect as a matter of correct division, unless the teeth of the wheel were correctly divided in the first instance, for it will be seen that the whole element of truth has been determined in the first division of the wheel teeth. The vacant space left in the cutter's edge enables the steel place to be varied to any angle; and thus, whatever the size of the wheel, or pitch of the tooth, the instrument will operate equally well.

There are many little appliances that can be added to the bench, that may be made by the workman at a trifling expense of time and money; thus it once in a while happens that in repairing a Swiss watch, the workman often damages the hair-spring in taking out the stud, which almost invariably is put in with a pinch joint. We were shown by Mr. Henry Oehl, Jr., of his own make, the simplest instrument to effect the removal of the stud, without danger of injury to the hair-spring, that can be imagined. Take a common pair of tweezers, and cutting off one end, the other is to be heated and turned down, and then filed up in the form of a pivot; the pivot thus formed should come inside the short end, which in its turn is filed with a notch to almost straddle the stud. The use is obvious; placing the short end under the cock, the pivot is applied to the end of the stud, and a slight pressure drives the stud out, without any risk of injury to the spring.

Mr. Oehl also showed us a pair of tweezers for taking off a roller from the staff with no risk of injury; and after the roller was off, a pair of brass tweezers, with wide thick ends, having a hole drilled through both, near the end, and the holes slightly countersunk on the inside of the ends. It is obvious that in taking up the roller, or any other small round object, it would fall in the countersink, and thus be held firmly and truly. Again it sometimes will (indeed very often) be noticed that in some classes of the Swiss watch the regulator is bound down entirely too tight by the steel cap that holds both the end stone and regulator. The fault can be remedied only by taking off a slight amount of the outside bevel of the cap, or opening the regulator. The first process is much the easiest, and by very simple means. If the workman will take a pair of common pinion calipers, and file down the points small enough to enter the screw holes, he has a certain means of holding the steel cap, and can then reduce its diameter enough to free the regulator.

Such little adjuncts to the watch bench save time, and enable the workman to do better work, and that in a more workman-like manner. For instance, a pair of old cutting plyers may be transformed into a useful tool by drawing the temper and filing in the jaws a series of small angular notches of different sizes; these will be found useful in taking off a roller without any risk of bending the staff, as the jaws will meet, while the staff is perfectly free in the notch.

The repairer in a large city need not have a cutting engine, as the material shops are well supplied with every sized wheel required; but it will often occur that in case of a main wheel too much broken in regard to the teeth, no counterpart can be found by the watchmaker whose stock of material is limited, and this holds true of all other wheels. If, then, he resides remote from the general centres of trade, he cannot do the necessary repairs, and is compelled to send the work off to the city. We speak of this, as hardly a week passes that we do not receive a commission from some part of the United States to replace material. Now, no repairer should be without good tools, as the cost bears a very small proportion to the advantages to be derived. This applies more particularly to the repairer located in a village remote from the great centres of trade. He is limited in his facilities, while a workman in New York city can always find an egress from his difficulties by sending his work out to some one who makes the particular job a specialty.

As an example, we received only last week a nickel barrel with at least ten teeth out of the main wheel. The barrel was beautifully grained on top, and the party sending it despaired of getting the finish quite as much as he did of making a new one, even without the graining. We think that this repairer would have been in a much better condition had he possessed the means of turning up the barrel, cutting the teeth, then rounding them up, and afterwards graining the top by a very simple tool, which we shall describe in our next article.

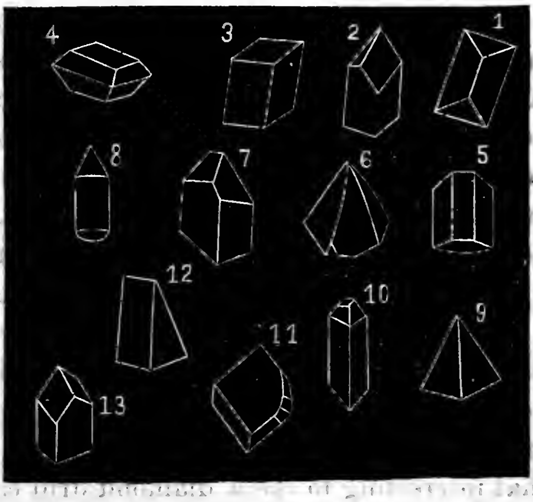
* * *

Diamonds.

There are other uses for the diamond than the mere show that glitters on the head and breast of the belle, as she floats in the mazy dance at the Academy of Music at a public ball. For it will be readily understood by the readers of the Horological Journal, that many an imitation can be substituted for the diamond, as the following anecdote will illustrate, and it has the additional element of truth:

A gentleman by the name of Bournignon, in Paris, had succeeded in the imitation of the diamond so perfectly that the spurious article could not be detected; his reputation as a jeweller was such that the élite were ready to take his word at any time as authority. One day a lady called on him and asked him if he could take the diamonds out of a necklace and coronet she presented, and furnish substitutes that could not be distinguished from the originals. M. Bournignon, with all the suavity for which his nation is distinguished, informed the Madame that it was happily possible—indeed, he could, on the word of a French gentleman, go farther, and assure Madame that he could duplicate the set. "But," says he, "Madame, where is the advantage in copying my own work?" "These diamonds are certainly not your work?" said Madame. "Pardon me, Madame; Monsieur brought me the originals some time ago, and I made an imitation set and loaned him twenty thousand francs on the real stones." This settled the whole question. Madame's husband had preceded her, and the imitation was so perfect that even a shrewd French woman was thoroughly deceived.

All this, however, brings us no nearer the real diamond; and in this article we intend to introduce the diamond to the artisan as an article of usefulness rather than ornamentation. To the watch repairer it is especially valuable, as he may by its use do work on tempered steel that he could not otherwise accomplish. For instance, he wishes to drill a hard staff without removing the balance; he has a means of centring and drilling by the use of the diamond, that could not be obtained in any other way, except he drew the temper of the staff somewhat. Not only in the transparent crystallized form, but even in the diamond carbon, do we find the diamond useful, as the illustrations we give in the cut will show. These are views of tools made by Mr. John Dickinson, the only maker, we believe, in the United States; and we are indebted to him for much useful information on the subject of that very mysterious substance, the diamond carbon. The reader may imagine a piece of coke, such as is taken from the inside of the gas retort, not formed directly from the coal, but apparently a deposit of carbon by *sublimation;* this piece of coke will give a good idea of the diamond carbon in every respect, save density and coherence. The ultimate particle of the coke, be it understood, however, is as hard as the hardest diamond, and of late years the lapidaries have in some cases used the coke dust for cutting stone, or rather polishing, in place of the real diamond powder.



The strength of aggregation, however, is wanting in the coke, while the black diamond carbon possesses it in the very highest degree, so much so as to render the working of it into form a matter of great difficulty. Like all other forms of conglomerate composition, different specimens will exhibit different degrees of hardness, and care has to be exercised to select those specimens that will not crumble, and in the best stones a degree of hardness is found not equalled by the diamond of the purest water; indeed, the hardness is so extreme that after the stone is cut, but little of the cutting can be seen; though Mr. Dickinson exhibited specimens that were brought up to a very good edge. Take Fig. 2 in the cut. It is nothing more or less than a graver point, and may be used on the hardest steel. This tool, then, would enable the watch repairer to work on the very hardest steel, either for centring or turning up a pivot; and any watchmaker will appreciate the true value of a tool that, while hard, is not at all liable to crumble off, as is the case with hard steel.

The above figures show all the forms most suitable for the repairer, as he may select. No. 1 would be but little used, as the corners are too perfect; No. 2, however, as mentioned above, could be extensively employed for turning up hard pivots, and, indeed, all that sort of work that implies steel too hard to be wrought by an ordinary steel tool; the forms exhibited are of variety enough to enable the repairer to select two or more that for hand-tooling on the ordinary lathe can be of the greatest service. These tools are cut up by the usual process of "diamond cut diamond," but the material is far harder than the ordinary crystal; and to get a shape of any definite form is much more difficult. It will be remembered that we mentioned that the glaziers' diamond seemed to depend on its form more than hardness; yet it is to the interest of the purchaser to obtain the hardest stone. These stones ("sparks") are cut and polished to shape with ease—a process totally inadmissible in the case of a piece of diamond carbon.

The tools we have mentioned are applicable to various processes at the watch bench; but within a few years the use of this very valuable agent has been extended to nearly the whole range of mechanical arts. In drilling rock for blasting purposes, it has been found, notwithstanding its first high cost, to be cheaper in the long run than any other form of drill. For dressing mill-stones, the carbon is rapidly superseding the old steel pick, not only because it does its work so well, but the rapidity with which the work is dispatched well repays for the original outlay. It is somewhat interesting to see a diamond drill capable of making a hole an inch in diameter, and this drill used in rock is worth more for effectual duty than any steel.

The watchmaker, however, wants much smaller tools; and down to the finest drills he must resort to the crystallized diamond; these, together with the turning tools (cutters), can be set as explained in the articles on jewelling, and his best plan will be to buy, say a quarter of a carat of the splints, from which he may select both drills and cutting tools. There is so great a value, in our estimation, attached to the diamond tool, that we shall not hesitate to state the fact that for turning up hardened steel, and drilling the same, it is invaluable; and whatever may have been the first outlay, there can be no loss, for if the stone should happen to break, the fragments are still of value, and thus no loss can happen.

Another form of setting the diamond from that detailed in the articles on jewelling, is practised by those who are engaged in repairing porcelain ware and drilling holes in glass. The ease with which one of these men will set a diamond, using nothing but a piece of sheet-tin and a small quantity of soft solder, is wonderful. The piece of sheet-tin is first rolled up in the form of a long cone, with the end as nearly closed as possible; the diamond having been selected, the end of the cone is filed off until the hole is just sufficient to allow the stone to be pushed through from the base of the cone. As a matter of course, the tin tube will spring open a trifle, and thus the stone will be held by the spring of the tin; when the diamond is in the position desired, a bit of soft solder is dropped into the tube, and heat being applied, it can be flowed around the stone, thus giving a firm setting, and it at the same time solders up the joint of the tin tube.

It may be interesting to our readers to give some idea of the value of the cut diamond, as used for ornamental purposes. Now, in any statement of fixed values, a false impression would be conveyed if we made the value exactly to a fixed standard. Fashion and caprice will, in many cases, influence the price; demand, as well, in relation to supply, will materially affect the market. Of late years the smaller-sized stones have risen in value, as the demand has been more widely extended for them than for the larger and higher-priced stones. We can give an approximate idea of the values, but it must be borne in mind that two gems of equal weight may not have the same value.

The size and weight may, in very many instances, become subordinate to the quality.

If, however, the diamond is of great purity and weight (a paragon), the price or value is less dependent on any law of exchange, it being fixed more by arbitrary taste than anything else; where, however, the stones are small, they are generally sold entirely by weight. The value of the diamond in the rough is calculated at half its weight, though the quality of the stone will greatly influence its value; but, assuming that the gem is suitable for cutting and of from fair to first water, the price will range from $12.50 to $25 a carat (four troy grains). In the case of a brilliant, the quality, or rather "water," cannot be decided except by comparison with other stones; for though one stone may appear to be of a pure limpid white, another may show that the gem is inferior. To cut stones, a rule has been applied, that in theory should settle the value, but in practice it does not; the vast range in quality being an unknown quantity in the estimation of the value. In 1750, Jeffries published a table of values based on the assumption that a diamond increases in value in proportion to the square of its weight. Taking a one carat stone at forty dollars, by the rule, a gem weighing two carats would be worth four times that amount.

It will be obvious that such a law is totally inefficient at the present day, for the price of moderate-sized diamonds has increased in a much larger ratio than that of the largest—the world having arrived at a too practical stage of existence to encourage the purchase of the diamonds that only kings of a former age could purchase. The diamond, like every other article of commerce, is influenced by the law of supply and demand, and within twenty years, the demand, incident to increased wealth, and the consequent ability and desire to display, of the newly made millionaires, have created a demand that has enhanced the price of gems of moderate size; but when a stone of over five or six carats is to be estimated, it will be easily seen that the number able and willing to purchase have not increased in anything like the proportion of those who have become able to purchase smaller stones. To illustrate the increase in price, Mr. Feuchtwanger, in 1861, purchased some gems at $30 a carat; the same could not be replaced to-day for three times the price: while a brilliant belonging to Messrs. Bishop, and weighing fourteen carats, would be worth, according to Jeffries' scale, about $20,000, it was offered at $14,000.

We will quote from "Feuchtwanger on Gems," as an authority not to be disputed: "A diamond with the following qualifications is in conformity with fixed prices: 1st. It must be perfectly free from the faintest tinge of color of any sort; from any flaws, specks, marks, or fissures in any part; must be bright and lively, and free from what is technically called milk, or salt, which are semi-opaque imperfections in the body of the stone. In order to ascertain this, it is sufficient to breathe on the stone, when any defect or color will be apparent. It is necessary to look at a stone on all sides, as a defect may exist which is not visible in looking at the table.

"2d. The stone must be well proportioned and properly cut, the culet must be the one-sixth of the size of the table, and from the table to the girdle must be one-third, and from the girdle to the culet two-thirds of the whole thickness of the stone. The size of the table should be four-ninths of the extreme size of the stone. Any diamond having its substance otherwise divided is badly proportioned, and therefore worth less than a proportioned stone." It is not necessary that a diamond should be perfectly white, for if the color is decided, say blue, red or green, the stone becomes an article of vertu and sometimes brings enormous prices. Thus Feutchwanger mentions a stone weighing five grains (a carat and a quarter), which, if white, would bring but $140, that brought $1,600, because it was of a brilliant emerald green. Again, the form of cut will determine the value, a well-*spread* cut gem being quite as valuable as one of greater weight. The following table may be some guide to the dealer, though the market must, of course, fluctuate. The rose is of less value, therefore we will not quote the price. For brilliants, and this is the price list of Emanuel in 1865:

One weighing ½ carat.....	$27	60
" " ¾ ".....	47	50
" " 1 ".....	90	00
" " 1¼ ".....	140	00

The proportional price, if we followed the old rule, would put one weighing five carats beyond the reach of ordinary mortals; but by the list price, the cost by Emanuel's showing is $1,600, the rate being made in gold.

Electro-Metallurgy.

NUMBER THREE.

In the last article on this subject we assumed that the Smee battery was the best for all the purposes of the electro-metallurgist. In making the assertion we were fully warranted by the practical experience of the great silver-plating establishments in England, France, and the United States. It is so simple in its construction, and at the same time so effective, that a detailed description will not be out of place. As the batteries are used of all sizes, in the description we shall assume some determinate size as a standard. We will take a common glass jar, say six inches deep and four inches in diameter; this would take a battery whose plates would measure seven inches long by three wide. Lying across the edges of the jar is a bar of wood, cut on the underside with a grain, or rebate, parallel to its sides, and in the centre. On each of the sides of the wooden bar a zinc plate, generally about a quarter of an inch thick, is clamped by a brass casting that serves as well for the conducting wire from the positive pole; the negative plate is insulated by the bar of wood, and thus a single cell consists of two plates of zinc and one of platina or silver, and, as stated in the article in the last number, the surface must be coated with platina, deposited in the black form (spongy platina), in order to get rid of the hydrogen that otherwise would accumulate were the surface smooth and clean, in a volume sufficient to destroy the efficiency of the battery.

Dr. Smee used silver as the negative; this choice was made simply from the reason that at that date platinum was too high in price; this objection no longer exists, as the pure metal, in the form of sheet, is worth but from six to eight dollars per ounce; and as the sheet may be very thin, the cost of the platina negative is but little more than the silver, and cheaper in the long run from its greater durability. The mere fact of the platina plate is of but little importance unless it is platinized, and this term is used to distinguish the deposition of spongy platina from that thrown down in the form of solid metal, the process for which is called platinating. As the process is within the means of any workman, a full description of it will not be irrelevant.

Like gold, platina is acted on by no single acid. If a solution is sought to be effected, we digest thin slips of the metal (platina) in a mixture of nitric and hydro-chloric (muriatic) acid, one part of the former to two of the latter; the resultant will be a solution of the chloride of platina, and, as a matter of course, acid; the whole being evaporated, the salt will be left; this is dissolved in a solution of cyanide of potassium. The more saturation, the more rapidly will the subsequent operations be performed.

Assuming that we have such a solution, the silver or platina plate to be "platinized" is introduced into it in contact with a plate of zinc, and if the solution is not too much neutralized by the cyanide, a coating of black platina will be almost instantly deposited. In all cases, however, the surface of the plate should be roughened by the use of sand paper, as the deposit is held much more strongly. All batteries are liable to local action on the zinc plates—the sulphuric acid entering into combination, forming sulphate of zinc. This is prevented by amalgamating the zinc plates wtih mercury, which process also prevents any action on the zinc when the battery is not in operation.

The amalgamation is effected by first washing the zinc plates with dilute nitric acid, then with water; then, taking an ordinary earthen plate, a quantity of metallic mercury is placed in it and covered with a dilute solution of nitric acid. The zinc is now placed in the mixture, and the mercury is distributed over it by means of an ordinary brush; for a small battery a tooth-brush is large enough, but the brush should be increased according to the size of the zinc plate. The whole operation is the work of but a few minutes, and the operator may rest satisfied when he has succeeded in giving the whole surface the peculiar metallic lustre of mercury. This amalgamation is of great importance; so much so, that the telegraph men dip the ends of the zincs in a small glass vessel, say a salt cellar, filled with mercury, and placed at the bottom of the battery; and thus, by a sort of capillary attraction, the zincs are continuously amalgamating themselves; for, if a bar of clean zinc be placed with its end only in mercury, the latter metal will be found, after a time, to have crept, as it were, up the bar, in the same manner that oil is fed to a lamp by means of the wick.

As a matter of course, any number of cells so constructed can be used, though for the general watch repairing and jewelry jobbing one good cell with plates, say six inches long and three wide, will be adequate to gild any plate or color any work in jewelry repairing. There can be no excuse for the workman who will turn out a discolored piece of work, when by a small outlay he can have a battery, and (as will be detailed) the subsequent processes are so simple.

The battery jar is filled or charged with a solution of sulphuric acid in water, in about the proportion of one of acid to seven of water, though the exciting fluid may be varied to suit the circumstances of the case. If a silver plate is used, a few drops of nitric acid may be added; but there must be caution that the acid (nitric) shall not be strong enough to attack the negative plate. Where the platina plate is used, the precaution is unnecessary, as that metal is not attacked by any single acid, and not by the combined action of sulphuric and nitric acids. The addition of the nitric has the effect of promoting the decomposition of the water, and the rapidity with which this is done determines the intensity of the battery. During the action the zinc is attacked by the sulphuric acid, and in the process of forming sulphate of zinc, the water is decomposed; the oxygen going to form oxide of zinc, and the hydrogen is transferred to the negative element of the battery—that is the platinized plate.

Depending on the kind of deposit we wish to get, the exciting fluid may be made of much less intensity for action, say one of acid to fourteen of water; and in some operations when a large amount of reguline metal is to be deposited, and time is of no account, the proportions may be as low as one to twenty. In all cases where the battery action is to be continued for a long period, the acid should be still more diluted, as the rapid formation of the sulphate of zinc soon saturates the acidulated water; and when this event takes place the current ceases. It is important to preserve the exciting fluid free from all foreign salts of copper or lead, for by the action of the current the vase will inevitably be reduced on the negative covering the spongy platina, and thus entirely destroying the efficiency of the battery. Should such an accident happen, the negative may be restored to its proper condition by immersing it in a dilute solution of sulphuric acid, to which has been added some of the chloride of platina dissolved in water. The copper coating will be dissolved, and at the same time a fresh coating of the spongy platina will be accomplished. Unlike the Daniell battery, the positive metal has no tendency to become deposited on the negative, as the resulting sulphate of zinc is held in solution; and so long as the point of saturation is not reached, the battery will continue in action.

The Daniell battery also depends on the decomposition of water which holds in solution sulphate of copper; the rationale of the action may be assumed as based on the oxidization of the zinc by the oxygen of the water; the sulphuric acid of the sulphate of copper uniting with the oxide of zinc to form a sulphate; while the free copper is deposited on the negative in the reguline state, thus always furnishing a bright metallic surface for the evolution of the free hydrogen. This property of depositing the metallic copper is the chief value of this battery, as the action is so perfectly uniform if the strength of the solution is kept up; and, in order to effect this, crystals of sulphate of copper are suspended on a perforated plate, but just submerged in the solution. As the decomposition of the water goes on, these crystals are gradually dissolved, and the strength of the current is rendered uniform. As time in a large manufactory is of importance, the Daniell battery is but seldom used; but in the case of the large plates used for printing the maps of the Coast Survey, some of which were three by four feet, this battery was invaluable. As the deposit is required to be of the finest reguline copper, a slow deposit is desired; and Mr. Mathiot, who has so ably directed the electrotype department of the Coast Survey, and had brought the art to perfection as early as 1856, conceived the idea of throwing down a mere film of copper about the thickness of ordinary drawing paper, and by staying the back, that is, strengthening it by placing it on a plate of zinc. In these experiments, the Daniell battery was used for its important quality of constancy. We will give in his own words the results that Mr. Mathiot has attained: "I have lately made experiments for ascertaining the practicability of printing from thin electrotypes, merely folded over the edges of a stout plate of rough metal. The result has been to demonstrate that printing plates can be thus furnished for about one-third of cost of plates made of the usual thickness, and that they are in every respect equal to them for printing." In his official report he gives the results, and we certainly must be astonished at the little time consumed in producing such large sheets of copper deposit:

"The 'Alto' was prepared and placed in the vertical vat on one afternoon and removed on the second morning following, in which time it received a thickness about equal to that of our map paper."

We shall refer to Mr. Mathiot's electrotyping again when we reach the subject of the decomposition trough. The Grove battery is no exception to the fact that the decomposition of the water is the material point, for in this case the nitric acid held in the porous cell is decomposed by the hydrogen of the water in contact with the zinc, and dentoxide of nitrogen is formed; this, on escaping into the atmosphere, takes up an atom of oxygen, and the result is nitrous acid. So it will be seen that, in every form of battery, the principle of decomposition is the same. We have seen a battery intended for permanent use, constructed with the porous cell, which was filled simply with water, and the jar had a sheet of copper with an attachment to it something like a cullender. In this cullender the crystals of sulphate of copper are placed, and by the gradual solution the strength of the battery is kept at a very equal rate. This battery is a modification of the Grove and Daniell. It is, however, of very low power, as it is intended simply to charge a number of electro-magnets; but it might be made to answer a good purpose in depositing, very slowly, metal that was intended for moulds. The subject of the salts used for plating, and the process of preparing the objects on which the metal is to be deposited, whether for a cast or for a permanent coating, will be considered in our next.

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The Borel and Courvoisier Watch.

In 1850, at Neufchatel, an establishment was started for the express purpose of furnishing to the public at large a watch that, while coming within a reasonable price, should perform with an accuracy that should rival the higher-priced movements. Borel and Courvoisier, with the assistance of M. H. Jurgensen, laid out a system of watch-making that should not only be good for themselves, but good for the public. The trade they sought at that time was on Spanish account entirely, and the satisfaction given after nine years' trial, both to the makers and public, incited the Messrs. Borel and Courvoisier to extend the market for the sale of their goods.

They were warranted in this, as the subsequent history of their offerings at fairs in various countries will prove. We may give some of the results of the investigations that various committees appointed at the fairs have made. We give the report of the director of the Cantonal Observatory, together with that of the Committee of Inspection ("Pour l'exercice for 1868").

Without going into the tabulated report we give the result of three watches:

—	Nardin, No. 3,767.	Guinand Mayer, No. 27,892.	Borel & Courvoisier, No. 33,840.
	s.	s.	s.
Mean Rate for 24 hrs.	1.14	3.34	1.14
Mean Variation one day to another....	0.20	0.26	0.23
Mean Variation Lying or Suspended	1.35	0.78	0.17
Mean Variation for 1° of Temperature...	0.01	0.09	0.03
Difference of greatest and least rate....	1.9	2 2	1.3

These results are absolutely marvellous, when we consider the wonderful delicacy of the watch—its numerous parts; and we can only stand by as spectators to an act in life in which we can take no part save to purchase the best, and be comforted with the assurance that we can rely on our time-piece.

As a matter of course, these time-pieces, whose record we give, are of the first class. M. Ad. Hirsch, who is the superintendent of the Cantonal Observatory at Neufchatel, in his report to the directors of the Observatory for the year 1868, observes that the performance of these watches is something remarkable; and in his figures (which would be out of place here), proves that the closest mean of variation in 68 watches on trial, offered by different makers, was to be, and was, awarded to the house of Borel & Courvoisier.

Skipping over a number of years, we find this firm exhibiting a calendar watch, showing all the phases of the moon, with the day of the month, and doing, like many a maiden, the leap year to the best advantage. At the Paris Exposition *it took the highest prize*, as well it might; for this watch, No. 8,245, had been running for sixteen months with a gain in its rate of only 34 seconds. When brought to this country it was allowed to run down, and was set on May 8, and by transits its rate has varied only 7 seconds to date. One need not be surprised that its price is the modest little sum of $1,000.

Neufchatel has always (*i. e.* since the watch was invented) been a great place for its manufacture; but even with people for workmen who have been educated hereditarily, it is required that the men who control the business should have not only a full knowledge of the art as it exists, but be willing to take any advantage of an improved idea in regard to its construction. The firm of Messrs. Borel & Courvoisier has progressed, and, instead of confining themselves to the manufacture of any extreme class of watch, are desirous to furnish an article that, at a moderate price, shall equal in performance, durability, and beautiful workmanship, any thing offered to the public. They have *succeeded;* for at the English Exhibition a watch, taken at random from a lot sent for competition, gained the prize; this is the more remarkable, as it was the first prize ever given by the English judges to a foreign competitor; and at every annual test of watches produced in Switzerland since 1859, these watches have carried off the honors.

In 1859 they were first introduced into the United States, and have given all the satisfaction that could be calculated on from such antecedents, which are based entirely on foreign sources. We can give a personal fact relating to a movement, taken at chance, that for nine weeks gave as a result only 38 seconds loss—but little more than one-half second a day; and this, too, during the variations of temperature incident to a New York autumnal season. Now, how well the manufacturers have succeeded in producing a good watch, at a moderate price, can be judged of when we state that the cost of the movement was only $22.50, gold. Of all the Swiss movements we are acquainted with, none come so close to the standard want of the community—low price, and a first class article.

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Examining the Lever Escapement.

We have had so many inquiries as to the qualities of the lever-escapement and its performance, that we think we can do our readers no better service than to quote the chapter from Grossmann's masterly work on the lever escapement, on the rules that should guide the examiner when he looks over his work; and the deductions to be made from the different observations will be of value to the watch repairer:

"It is an inseparable consequence of the compound action of the lever-escapement, that, for a good performance, it is not sufficient only to have the separate actions of it correct, each in itself, but a perfect harmony between these separate actions is also necessary.

"Therefore the careful examining of a detached lever-escapement is by no means an easy task, for there are many points to be tested, on which the good performance and time-keeping depends entirely or partly.

"To begin with the wheel and pallet-action, the examiner has to verify whether the wheel is perfectly concentric and true in its division;

for any want of accuracy in these points diminishes the soundness of action, and shortens the mechanical effect, because the amount of drop and locking sufficient for a true and correct wheel, would not offer the necessary safety of action.

"The cut of the wheel-teeth is a matter of some consequence, because the accuracy of division would be prejudiced, if the surfaces of the teeth, and especially the acting sides of them, were not cut even and smoothly, presenting furrows which might, when coinciding with the point of one tooth and not with that of the other, affect the accuracy of division.

"The form of the teeth must be fit for the work to be done; the foreface being sufficiently inclined (undercut) to produce the draw without great friction or adhesion, and the back not more divergent than required for the solidity of the teeth.

"The examiner has to ascertain whether the wheel and pallet are at the proper height to suit each other, and that the end-shake of the escape-pinion and pallet-arbor are equal or nearly so, to avoid the risk of alteration in the soundness of action, arising from the acting of the escape-wheel at another part of the driving-planes, than the highest point of their convexity. For securing this point, it is also essential to see the wheel perfectly true on the flat.

"The locking and driving-planes of the pallet must be examined, to see whether the surfaces are well polished and the edges carefully rounded, the drawing-inclination in the right proportion, so as just to draw the pallet in, without augmenting the unlocking resistance by any excess.

"The pallet and its shape must then have some attention, as it is desirable that it be not heavier than is required for solidity. Besides, it is necessary that the part between the arms should allow free passage to the wheel-teeth, without being filed out so much as to cause fear of breaking near the hole in the centre.

"The examiner then ought to try the action of wheel and pallet, to ascertain whether the pallet has been properly pitched. This is very often not the case, and if the pallet be pitched too deep, the effect produced will be an increase of the locking-arc and consequently an addition to the unlocking-resistance and to the arc of vibration required for the unlocking. Besides, the drop will not be equally divided, and too little of it outside, and too much inside the pallet, thereby making the action unsafe. This is the reason why a defect of this kind cannot be removed by exchanging the escape-wheel for a smaller one, which would only amend the first deficiency without correcting the inequality of the drop. If, on the contrary, the pallet be pitched too shallow, the locking will not be safe, and there will be more drop outside, and less inside the pallet. It would also not answer to exchange the wheel for a larger one, for the reasons just mentioned. Any alteration of the diameter of the wheel, together with taking away something of that part of the pallet where the drop is not sufficient, would restore the necessary extent of the locking-arc and make the drop on both sides the same; but as the drop on one side was too much, of course there will be afterwards on both sides an excess of useless drop, and consequently a loss of power. Therefore, in all cases where the pallet is improperly pitched, the best way will be to alter the pitch in the direction required. In all cases where the locking is as it ought to be, and the drop on both sides is not equal, the pallet must be considered defective and ought to be replaced, as also a pallet with too much drop.

"The examiner ought also to measure the pallet-arms, to verify that they are of equal breadth, because, if they are not there is an inequality in the distribution of action between the two driving-planes, the one lifting more and the other one less than it ought to do.

"With regard to the fork and roller-action there are also many essential points to be tested. In the first place the examiner ought to see whether the lever is solidly joined to the pallet (in those escapements in which lever and pallet are two separate pieces). Any shake between these two parts, arising from the pallet-arbor or the steady-pin not fitting tightly into the holes of either of the two parts, would occasion a great insecurity of action and loss of power. A defect of this kind in a completed watch is not easy to discover, though very easy to remove. One of the most essential points is, to examine whether the angles of movement produced by both the wheel and pallet-action, and the fork and roller-action, are exactly corresponding to each other.

"The lifting at the roller is merely dependent on the respective lengths of the two levers or radii, if the angle of pallet-motion is given. But when the lever and roller are ready made, the angle of their lifting is in a certain proportion to the angle of pallet-movement, and the balance must be pitched exactly, so as to produce the angle of lifting, for which the proportions of the lever and roller are calculated. If, for instance, the balance be pitched to a greater distance from the pallet than it ought to be, a part of the impulse given by the lever is lost in useless drop.

"Another inconvenience arising from such incorrect pitching is, that the ruby-pin in both the unlocking and impelling function, does not meet the acting-faces of the notch in the fork properly. In such cases, the unlocking and impulse would take place at the edge of notch and horn, or at the beginning of the horn, and with decided mechanical disadvantage."

[In using a triangular ruby-pin the notch in the fork may be made slightly larger at the bottom, for it can easily be seen, that when the first corner enters, the other corner is entirely free, and if the notch is a trifle smaller than the pin the angular position assumed by the pin in its rotation will enable it to free itself with the greatest ease.—Ed.]

"If, on the contrary, the balance be pitched too close, the result will be the necessity of setting the banking-pins farther apart, to allow the ruby-pin to perform freely the increased angle of lifting. By this wider banking the pallet will be drawn farther into the wheel than it ought to be, thus increasing the unlocking resistance. At the same time the unlocking function of the ruby-pin will be rendered more difficult by its taking place at a greater distance from the line of centres, not to speak of the liability of the ruby-pin to touch the bottom of the fork, which is not intended for this deeper intersection.

"The effects of incorrect pitching of the balance, though very grave for the performance of the escapement, may very easily be removed by an alteration in the length of the two parts. But as the lever is generally finished when the escapement passes the examination, we will suppose that it must not be touched, and that the above-mentioned defects must be removed by altering the place of the impulse-pin.

"In the first-mentioned case, the impulse-pin must be brought a little nearer to the roller-edge, to establish a sound intersection, and to turn to profit the whole angle of pallet motion.

"But it must be understood that this alteration, at the same time as it restores the correspondence of the lifting-angles in the two actions, for the given centre-distance, produces a diminution of the angle of lifting intended for the balance. If, for instance, the 10° of pallet-movement were intended to produce a lifting of 40° at the roller, and the lever and roller were made accordingly, but the balance had been pitched at too great distance, the angle of lifting would, by the subsequent alteration of the impulse-pin, be reduced to 36° or 33°; but the angles of the two actions would correspond to each other, and the escapement, though not having the lifting-angle formerly intended, would still be correct in itself.

"In the case of the balance being pitched too close, the opposite proceeding will be advisable. The pin must be approached to the centre of the roller; by doing which, the angle of lifting at the latter is increased. If the circumstances admit it, the fork may also be shortened a little, by taking away slightly all along the inner faces of the horns, thereby reducing the acting lever-length a little, in order not to alter too much the intended lifting-angle. The acting parts of fork and roller must be finished as smoothly as can be, as well as the outer edge of the table-roller and the inner side of the horns. The ruby-pin must be fixed upright in the roller; any deviation in whatever direction is defective. Care must be taken that the pin is tightly fixed in its hole, and that the notch of the fork be of the right size, just to afford the necessary freedom of action.

"The horns ought to be examined, to see that their length is sufficient to complete the safety action during the period of the guard-pin passing the hollow of the roller. This is tested by bringing the balance into the position in which the guard-pin begins to enter the passing hollow. In this position the end of the horn ought to reach at least to the middle of the breadth of the impulse-pin. The horns of the forks in escapements with the double roller must be longer than those of the table-roller escapement, because the safety-action has to perform a much larger arc of intersection. The eccentricity of the horns may be supposed sufficient, if the balance stands with the guard-pin just out of the hollow, and the end of the horn keeps at a very little distance from the impulse-pin when the guard-pin is pressed lightly against the roller-edge.

"A defect of very pernicious result to the rate of a lever watch with the double roller in different positions, is an excess of length of the impulse-pin, when the end of it comes too near the index, and touches it in any position of the watch. This is very often brought about by a difference of the end-shake between the balance and pallet-staff. These two parts and the escape-wheel pinion, therefore, ought to have nearly the same quantity of end-shake.

"The examiner must also look carefully at the necessary freedom of the guard-pin at the edge of the detaining roller and in the passing-hollow. Defects in this direction are very often caused by too much side-shake of the balance-pivots in their holes, and, therefore, the holes must be also carefully examined, whether they are not too wide. The guard-pin or index must be shortened a little, if necessary, for the purpose of obtaining the required freedom of action. If, on the contrary, there is too much space between the guard-pin-end and the roller-edge, so that the wheel-tooth is not on the locking when the guard-pin is lightly pressed towards the roller-edge, and the impulse-pin butts against the end of the horn, the safety action is defective, and must be corrected by insertion of a larger roller, or a longer guard-pin. It must be observed if the notch in the fork be deep enough to let the impulse-pin pass free without getting too near the bottom of the notch. Care must be taken to ascertain whether the horns of the fork are not too long, so as to rest with their ends against the balance-axis.

"The pallet and lever must be examined as to their equipoise, and if required, they must be carefully poised. A defect in the equipoise of pallet and lever occasions serious differences of rate in positions, especially in those watches in which the lever is in oblique or right angle to the vertical line from the pendant through the middle of the watch.

"Finally, the width of banking must be looked into, which ought not to be wider than just to allow the indispensable freedom for the movement of the acting-parts.

"It is also very essential that the banking-pins are straight and vertical to the plate, for if they are not, and the pallet-staff has a little too much end-shake, the width of the banking will be considerably altered, whether the watch is lying on the back or on the glass, especially when the banking-pins are not standing near the fork-end of the lever.

"Lever watches in which no faults can be found in the escapement in the above-mentioned points, offer very good promise for a satisfactory performance."

Tower Clocks.

Agreed that most men carry a watch and regulate their motions by its indications, still they rarely pass a public clock without comparing their time, in order to determine how well their watches are running. Thus there can be no more useful time-keeper than a good tower clock, as it is patent to all, and is even more useful to those who do not possess portable time-pieces. The Yankee clock on the shelf of the humble room of the laborer is looked at and compared with the time when the bell of the clock strikes the hour; and in the sick-room of the rich the silent monotony of the long night hours is relieved by the cheerful tone of the bell of the tower clock.

The village church or court-house should be furnished with a good clock to toll off the hours that, passing so rapidly—alas too rapidly—sum up man's total existence. In England there is hardly a town that has not a decently running tower clock—the public convenience demanding the accommodation; while in this country, the subject is almost entirely neglected, except in large cities. It is useless to object to the tower clock on the ground of inaccuracy, for they can be made to run equally as well as any chronometer, if not with a better rate. But it must be remembered that to insure good rates high prices must be paid for the machinery that divides the hours. We may more properly appreciate this fact, if we take into consideration the many disturbing causes that combine to make the clock in error. Thus, a violent storm, acting on the hands that must necessarily be exposed, will sometimes stop the clock altogether, the motive power not being sufficient when transmitted through the escapement to overcome the friction and resistance of the storm, when the hands may perhaps be loaded with snow and sleet. But as a proof that in spite of all obstacles tower clocks can be made to keep time, we may cite the old clock on St. George's Church, in this city, manufactured by Mr. A. S. Hotchkiss, years ago, and which, with but little chance of compensating, made the exceedingly close rate of five minutes in the year; this certainly cannot be excelled by any time-piece, all the circumstances being taken into consideration.

But a cheap clock is worse than none, and many a village has repented the day it put the purchase of the town clock in the hands of a committee, no member of which knew the first proximate principle that should be observed in buying a public clock. The first point generally made by such committees is price; the builder whose price is the lowest generally getting the contract, regardless of quality. True, the constructor may have guaranteed a certain quality, but the fatal fact steps in between the promise and performance—*he cannot do the work for the price* the committee is willing to pay. A mistaken idea of economy, resulting in a tower clock that is hardly as truthful as an epitaph. The gentlemen of the committee might just as well have thrown the money away.

Even should a good clock have been procured, there are other contingencies to be looked after. The tower should be firmly built and the clock-room thoroughly protected from all dust or moisture. Again, the care of the clock should be intrusted to no one but a good mechanic, who, for his own reputation, will take pride in keeping it in order. As a matter of course, a good maker will spare no pains in putting up his own work, and it then devolves on the owners to keep this work in order. If every tower clock could be as well set up and as well made as was the clock in St. George's before the fire, we would have standards of time throughout the country that would bear comparison.

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Correspondence.

FERRYSBURG, MICH., *Dec.* 7, 1869.

EDITOR HOROLOGICAL JOURNAL:

Perhaps the experience of one who has been under the necessity of "laboring under difficulties" to find the meridian, may be of use to your California correspondent, and to others in like circumstances.

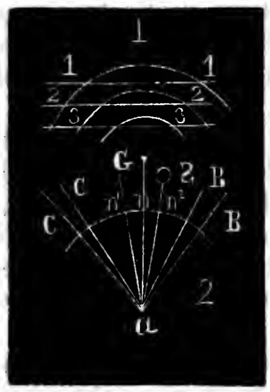
There is a class of men, as surveyors, navigators, geographers, and astronomers, who, having astronomical data and instruments for measuring angles always at hand, are never at a loss for the meridian; but the great mass of the industrial community are not thus supplied, and to them the problem of finding the meridian is one of forbidding aspect, and the question comes up among them, "How may we find the meridian to a good degree of accuracy, *with such appliances as may be extemporized for the occasion?*"

Among the various modes given in all modern works on Surveying, the method of "Equal Shadows" is probably the best for this occasion, as it may be employed without the use of instruments for measuring angles, and without the use of astronomical data. It has been objected to on the plea that it is not rigorously accurate, except when the sun is near one of the solstitial points; but if the insignificance of the discrepancy resulting from this method at other times were more generally known, more confidence would be had in it. It depends on the same principle as the method of "Equal Altitudes," as practised in Astronomy and Navigation.

As the instructions given in books, for finding the meridian in this manner, are generally nonprecise, and give only a rough approximation, I shall give my own experience, first premising that the observer is in north latitude.

Instead of selecting a piece of "level ground," as some books tell us, prepare a smooth surface, fifteen or eighteen inches square, by laying fine paper over a board, or otherwise smoothing its surface so as to take the marks of a fine drawing-pen, or pencil, or sharp compasses; and near one side of the board, fix a "centre" for one foot of the compasses by driving a small nail down smooth with the surface, and pricking it on the top with a sharp awl or graver; and from this "centre" describe a number of concentric circles. Near this "centre," but a little *out* of the meridian, erect a style of stiff wire, four or five inches high,* with its upper end round to the form of a semisphere, as nearly as may be; then, by means of a square set with its stock on the face of the bed, and its tongue perpendicular thereto, and in cross positions, adjust the rounded extremity of the wire, bending it to a position exactly perpendicular over the "centre."

Having fixed the face of the board in a truly horizontal position, with the "centre" on the southerly side, commence to observe, about two hours before noon, the points at which the extremity of the shadow of the style crosses any of the concentric circles, pricking the intersections. In the afternoon, observe in the same manner where the shadow crosses these circles, pricking in, as before the intersections.



A right line joining the two points on the *same circle* will be an *approximate* east and west line; therefore, if the second line, joining the two points on each of the several circles observed, be bisected, the perpendicular, common to them all, and passing through the "centre," as per figure (1), will be the *approximate meridian.* If the sun had not changed his declination during the time of observation, and supposing the work carefully done, this would be the *true* meridian; but the declination is constantly varying. Then, how much is this line out of the true meridian, and which way must it be swung to be in the true meridian? The following considerations will show:

The sun's greatest daily change of declination is at and near the equinoxes, where it is about 24′ of arc per day, or 1′ of arc per hour, for some 15 days or more on each side of each of the equinoxes; then allowing four hours as the average time of making the observations as above specified, the change of declination during the time would be 4′ of arc, and the approximate meridian, A N_1, or A N_2 (see Fig. 2), would be away from the true meridian by the half of this amount of arc, or 2′, which corresponds to 8″ of time.

The following consideration will show *which way* to make this correction.

When the day (*i. e.*, the illuminated portion of the 24 hours) is *increasing*, the afternoon is *longer* than the forenoon; and conversely, when the day is *shortening*, the afternoon is *shorter* than the forenoon. Hence, the following rule, viz.: From the December to the June solstice, this proximate meridian will bear to the *east* of the true, and from the June to December solstice, this line will bear to the *west* of the true meridian.

Thus (Fig. 2), let A N be the true meridian which we wish to find, N being to the north of the observer; and let A B be the direction of the shadow for a given altitude in the morning, and A C the direction of the shadow for the same altitude in the afternoon, at any time between the December and the June solstices; then the angle N A C is greater than N A B, because the day is increasing; and the line N A, which bisects the sum of these two angles, bears to the *east* of the true meridian. And in the same manner, at any time between the June and the December solstices, this observed meridian will bear to the *west* of the line, as at A N_2.

This angle, N_2 A N or N_1 A N, is, of course, an azimuth angle, slightly variable with the sun's declination, and the latitude of the observer; but disregarding these effects, and supposing the maximum value of this angle to be 3′ of arc, end the line A N to be ten feet long, the offset N_2 N or N_1 N would be but $\frac{1}{10}$ *of an inch.*

Therefore, knowing the maximum *value* of this offset for the correction, and knowing from the time of the year *which way* to make it, and that it diminishes each way from the equinoxes to the solstices, as the co-sine of the sun's longitude, the meridian may be determined in this manner to great accuracy. Indeed, by careful repetition, the observer will be surprised to see the degree of precision attainable *without the use of goniometer and transit instruments.*

H. C. P.

EDITOR HOROLOGICAL JOURNAL:

In the last No. of the JOURNAL, page 216, J. P., of Des Moines, very properly calls attention to the difference of the daily quantity of ac-

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* The object in using a short style, is to avoid *Penumbra*, which increases with the length of the style, rendering the margin of the shadow more and more indefinite as the length of the style is increased.

The meridian, being thus satisfactorily determined on the board, may be "ranged out" by applying to it a carefully prepared straight-edge, and suspending from each end of it a plumb line of fine thread or horse hair, and ranging by these plumb lines to some permanent object in the ground, as a rock, wall, or building, where it may be permanently marked for all time to come.

celeration of Sidereal on mean time, as given by Mr. Reid in his treatise on clock and watch-making, and by myself in a former article in the Journal, page 152. It is due to all concerned to state that by mistake I gave the quantity (3m. 56.6s.), which is the Sidereal time, instead of the quantity (3m. 55.9s.), mean time, which I ought to have given. He asks my authority. I will say that the American Ephemeris makes the quantity (3m. 55.19s.). Bowditch's Tables make it (3m. 55.9s.); but Mr. Edmund Becket Denison, in his treatise on clocks, watches, and bells, page 14, makes it (3m. 55.7s.). Thanks to J. P. for calling attention to the mistake, and to yourself for publishing this correction.

Yours truly,
J. Cross.

Vineland, *Jan* 10*th*, 1870.

Editor Horological Journal:

As you will remember, the Greek, Latin, German, and French words, from which the name of your Journal is derived, mean also the Bell which marks the hours, as well as the definition generally given; so I thought what the Bells said (which mark the hours at Trinity) might not be inappropriate for your Journal, if such a poor translation merits so high an honor. I was sufficiently near to catch every word, as it fell from the tongues of the Bells, and transcribe it,—which transcription I enclose to you.

Yours Horologically,
Elisie.

N. Y. City, *Jan.* 6th, 1870.

TRINITY CHIMES.

Chime—chime—chime, O bells!
Keeping guard in your tower so high,
What word from the dying year
As its final hour drew nigh?
You were watching its shortening breath,
And you sounded its knell on the air:
O say! were there tears for its death,
And sobs and a parting prayer?

Chime—chime—chime, O bells!
Keeping watch o'er the slumbering earth,
What signs were abroad to tell
Of another new year's birth?
You proclaimed with silvery voice,
The hour when it came to man—
Did the sleepers in their dreams rejoice?
Say, tell us it all, for you can.

Chime—chime—chime, and the bells,
Keeping watch in the tower so high,
That mark with their deep-toned swells
The hurrying hours go by;
They told this tale of humanity's sin,
Repeated each New Year's night,
Of sorrow and wrong that e'er hath been
To the heart a pang and a blight:

"We saw from our aerie that folly and shame
Went snuffing their victims, like hounds their game.
A young man reeled from his revelling den
And crept away from the eyes of men.
A courtesan flaunted her gaudy attire,
And strove to laugh in her filth and mire.
A mother wept o'er her dying child,
Till it seemed her grief would drive her wild.
A laborer strode with paternal zeal,
From his late wrought task to his scanty meal.
We saw the miser hoarding his gain,
While the beggar crouched in the sleet and rain.
The rich man bolted his oaken door,
That he might not hear the cries of the poor.
A matron caught up her rustling dress,
And turned her head when she met distress.
A maiden rocked in her easy chair,
Unheeding the lowly, plaintive prayer
Of a wayward sister, who, fainting for rest,
Strove to warm her babe in her shivering breast.
A bride, rich dressed and heartless, sold
Her charms to a brainless fool for gold.
A wife sat waiting, in harrowing dread,
The sickening gulp and staggering tread
Of a drunken lout, whom the law, by a breath,
Hath chained to her life like a body of death.
Religion dwelt in the carpeted aisles,
And cushioned pews of grand church piles.
The fashionable pastor whispered the prayer,
'We thank Thee we are not as our neighbors are;
The magistrate winked at genteel fraud,
And justice was mocked in the eyes of God.
Crime strode by, with brazen face,
Trampling on innocence—shunning the race.
Slander went hawking its poisons vile,
Chilling and killing sweet Charity's smile.
Honor chafed—for manhood slept;
Modesty pined, and virtue wept."

Chime—chime—chime, false bells!
Have you watched in the tower so long
To tell us naught, with your silvery swells,
But a story of woe and wrong?
There is joy on earth that you know not of,
And your iron tongues have lied;
There are truth and innocence, born of love,
And nursed by charity's side.

Many and many a sun shall flush
The sky of a New Year's morn,
Ere man, in his self-souled pride, shall blush
To make his fellow mourn;
Yet hearts there are, alive to distress,
And hands that are ready to aid
Wherever a brother's wants oppress,
Or a sister's plea is made.

Each tone of your joyous chimes, O bells!
Sets right some human error,
And tolls the gladsome funeral knells
Of some great social terror.
Each New Year's sun sheds warmer rays,
Our laden hearts to lighten.
And hope with happy fancy plays,
As human prospects brighten.

Chime—chime—chime, O bells,
Keeping guard in your tower so high;
This word from the dying year
They brought as the hour went by.

Ed. Horological Journal:

Sir,—The importance of a perfect, cheap, and easily applied method of pendulum compensation is so great that I presume a few, even small, ideas on the subject will not be out of place.

The pendulum described in No. 3, page 83, invented by C. T. Mason, is an ingenious modification of those previously designed by Ellicot, Zademack, and others; but it is far more simple in construction, can be more easily got up, and is every way worthy of trial. It will need, however, some further improvements before it will fulfil all the conditions of a perfect compensation.

In the article referred to, no description is given of the way in which the points 4 and 5 are to be adjusted for the difference of expansion, though it is clear their relative place on the lever must be changed; but, as the pendulum is represented in the engraving, any alteration of these points would involve a *change of rate in the clock*, amd thereby defeat the object sought.

If, however, the levers, 1 and 2, are made to form the arc of a circle, having G C for radius, they will curve in the opposite direction, and any movement of points 4 and 5 will no longer affect the pendulum ball, and consequently not disturb the rate.

It would also be advisable to set the upper ends of the rods D D as near the centre rod as possible, and strike the arcs for the levers from that point.

For the purpose of adjustment, I would suggest a right and left hand screw of equal pitch, with the head slotted into the central rod (as near the lower end as possible), made free to turn either way, but *entirely without side shake.* The screws may take directly into the side rods; there must also be some little play vertically in the centre slot to allow the screws to accomodate the curve.

If pin points are used as represented, they will have to slide. Would it not be better to pass the rods D D through the levers, and let the latter rest on knife edges? The adjusting screws would hold them rigidly in place.

I think with you, Mr. Editor, that this pendulum would perform better than the old gridiron; indeed you might as well use the last-named instrument, in fact, and expect a steady rate, as use many of the Harrison pendulums constructed in the present day.

There will still be eight joints movable in the Mason pendulum, though the lower ones, C C, might be dispensed with, reducing the number to six; but as the pressure is constantly in the same direction, there is room for very little lost motion except in the centre joint, 3, though I think there would be some tendency to flexure in the centre rod when carrying a heavy bob. Another advantage, I think, obtains in this construction, viz., an easy and quick adjustment independent of the clock.

Thos. J. Bailey.

Nashville, Tenn., *Jan.* 10, 1870.

Answers to Correspondents.

C. H. B., *Wash., D. C.*—The rouge referred to in the article on pinions, in No. 1, is not the rouge used by the gold and silver polishers. To give the difference, it will be necessary to describe the process of the manufacture of both the "sharp" (crocus) and rouge intended for steel work. The two are the result of the decomposition of sulphate of iron (common copperas or green vitriol). This decomposition is effected by placing a quantity of the sulphate in a crucible and subjecting the whole to a high heat; the sulphuric acid is driven off, or rather the suphur, with two atoms of oxygen, leaving in the crucible a semi-vitreous mass of the oxide of iron. By reason of the intense heat, all the water of crystallization is driven off, and the solid mass in the crucible after being cooled, is broken up into fragments. This product is called sharp, or crocus. To refine this, it is ground fine and exposed in an open fire to a high degree of temperature; the action of the oxygen raises the degree of oxidization, and the resultant product is the red peroxide of iron (rouge); this product is still further pulverized, and then washed and elutriated. The very finest is that used by the soft metal workers, while the coarser is suited for steel. It can be purchased of any of the material dealers here in New York.

As to polishing glass with the "tully powder," the process is as simple as any other mode of polishing. If the object is small, a wheel may be used on the lathe, made, for the preliminary surface, of common willow wood; this has been found by the glass-cutters to be the best, as it retains its form and holds the powder better than any other wood. For the final polish, the wheel is covered with a piece of hard, thin felt, on which the powder is used. When grinding with the wooden wheel, it is necessary to keep it constantly wet to avoid too much heat, as this endangers the work. The powder can be bought of the wholesale druggists and paint dealers, here in this city, and we should suppose that you could obtain it in your city, or in Baltimore. When obtained, you should wash it thoroughly, in order to get rid of any metallic lead or tin. The general principles of polishing will determine your method of using it on large surfaces.

The stones for polishing will be forwarded. We will caution you, however, to make the two surfaces of different degrees of fineness, which may be effected by the use of an extra (small) stone, and the use of the different degrees of fineness of the diamond powder; the small stone you must undoubtedly have in your waste stock, and you can easily reduce it flat by means of a cast-iron plate and a small quantity of emery. The diamond powder may be purchased for six dollars a carat —a quantity that would last for two or three years, and is the *cheapest* article for bringing up a surface and polishing steel work that you can get. You can purchase any quality of emery at the hardware stores in your city.

C. J. L., *Me.*—The beautiful surface and finish given to new work, is the result of having prepared the plates or bridges thoroughly *before* gilding; and in the preceding answers to correspondents you may find the process by which the beautifully malted surface is obtained. With the scratch brush, used by hand, no such surface could be got. The gilding is done subsequently, and the plate, after coming out of the vat, is simply washed in cold water, and dipped in strong (95 per cent.) alcohol, which takes up all the water and thus thoroughly dries the work. The Swiss obtain the fine surface by first throwing down silver in a crystalline form, and then gilding on the silver; and if C. J. L. will look over the back Nos. he will find the same statements. When we get to that part of electro-metallurgy that is connected with the deposit of metals for adhesion, we shall give the full process in detail, as it is done by the various watch manufactories in the United States.

In regard to your second inquiry, we are happy to state that there is in course of preparation a series of articles on escapements and their relative proportions, which will be published in the AMERICAN HOROLOGICAL JOURNAL. They are being got up with a view to meet the wants of the workman, and divested of technicalities, to render the subject of escapements familiar to the most ignorant workman.

G. B. A., *Iowa.*—When by constant use that part of the case edge held by the hold-down spring is so far worn away that the catch is lost, you may remedy the difficulty, and that too in a manner that leaves the case with all the appearance of having never been repaired. File out a notch on the edge where the worn part is, and so prepare it that it will take in a dovetail piece of silver or gold, as the case may require. The bottom of the notch should be filed flat, and the undercut made so that the new piece to be soldered in can be held firmly without having to use binding wire. If you have been accustomed to soldering you will readily understand the rest. Use as little solder as possible, and in fitting in the piece, finish the inside edge to correspond to the general circle before soldering. The outside and the edge of the bezel can easily be brought to form and finished, though there should be an excess of metal in the piece put in. To avoid repolishing the inside of the case, the workman should paint the whole surface with a mixture of borax and yellow ochre, as described in a former number of this journal; this mixture preserves the surface, and when the work is pickled, after the soldering, the inside of the case will be found to be easily restored to its first finish. As will be readily seen, the heat must be applied very generally over the work in order to avoid warping, and just at the melting point the solder may be flowed by a blast directed especially to it. Should any fire marks remain after pickling, they may be taken off by the use of the fused cyanide of potassium, in a solution of which the work is to be boiled, the same as was done with the sulphuric acid and water.

J. J., *Miss.*—As you have received all the information and services you wished in regard to enamelling the case, we can answer the other inquiry. The ray-like light that is seen to come from the enamel is due to two causes. In the first place, the surface on which it is placed is engine-turned, and next, the semi-transparency of the enamel itself. The repairing, or rather re-enamelling, can be done in New York, as we have already informed you by letter; for a case came under our notice a short time ago, which had been decided by a leading jeweller on Broadway could not be done without sending it to Paris. It was done, however, here in the city, and that too as finely as it could have been in Europe.

P. M. G., *Pa.*—Mosaics are peculiarly an Italian product. The best come almost exclusively from Rome, and some are of great value. They are made up by the use, in the common ones, of small glass bits that are cemented in a cavity cut in the stone base, usually an agate. Those of the finer variety and higher cost are set with stones, sometimes on an amethyst base, the color of which yields a very brilliant effect. The glass bits, or pieces, are taken from glass rods of every conceivable color, and shape, and size; the rods are made at Venice, expressly for the purpose. The work is exceedingly tedious, as will be seen when we state that a table belonging to the Duke of Tuscany cost 700,000 francs and fourteen years of labor.

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⁂ *Address all communications for* Horological Journal *to* G. B. Miller, *P. O. Box* 6715, *New York City.*

Astronomy in its relations to Horology.

NUMBER NINE.

To be certain of the meridian, it will, in every case, be necessary to not only take the star "Polaris" as the greatest elongation, but to reverse the instrument on its axis, for any error in the diameters may be thus detected; and as the meridian line may be taken by the method, we shall quote Mr. J. E. Hilgard, at that time Assistant, United States Coast Survey.

At this point we must advert to an error in the last No that gives the diameter of the apparent revolution of Polaris as 2° 24′; it should have read 2° 48′. Now, as this star is so nearly in the meridian of any spot on the earth's surface, it becomes the guide to any one seeking to establish a line. As the apparent revolution of the star must at two periods in the twenty-four hours be either above or below the point where the polar axis, if prolonged, would be supposed to (and it really would) fall on the celestial surface as seen by the eye, or even imagination, it is evident, then, that, if a plumb bob, with its attached line, is hung in the line of collimation of the transit, having levelled the axis, that at those two points of the greatest elongation in the vertical line a very slight motion of the star will be detected. Now Mr. J. E. Hilgard states that "a mark was placed nearly in the vertical of Polaris at elongation—the aim being so to place it that the star should be equally on both sides of it during the time of observation * * * * The difference between star and mark was observed micrometrically; but instead of using a telescope micrometer with movable wire, the azimuth micrometer of a twenty-six inch transit was used, the fixed wire being pointed alternately to the mark and star. The collimation error is eliminated by reversal."

These were azimuth observations, totally inadmissible in the ordinary transit, but the plan of getting the true meridian is fully developed in the principle; for if the observer gets a true distance by means of the spider lines of the star at its superior or inferior elongation, he can add the times, and taking the mean he will arrive at a very close approximation as to the position of his instrument. A few trials will, if he is careful, enable him to get the true line. If the observer has got the instrument level he may now reverse and set up an object to the south; but, in attaining the requisite degree of accuracy, he must reverse the transit on its bearings. It is apparent that if he has not taken his polar observation right, the instrument will be out of the line of the meridian; yet he must not despair, for on the succeeding night he may be able to get another observation on Polaris by which he may correct the first.

The new beginner must not expect to get the line of his transit at first true with the meridian; so many slight errors exist that even in the very best appointed Observatories no little trouble is found in effecting this object. The sources of the errors are found in the difference of diameter of the pivots, in the want of firmness of the base, and inattention to careful adjustment of level even after a true mark has been obtained; and never should an observation be taken without first adjusting to level; for, however firm the base maybe, changes will occur from expansion or contraction, produced by changes of temperature.

Let it be assumed that the observer has succeeded in setting his instrument, and getting the true meridian. We will next consider the objects to be observed, and herein is a difficulty; for if the instrument is not of high power, the only two bodies capable of being observed at night or in the day time are the sun and moon,—the diameters of either rendering the observation liable to inaccuracy. Again, it is almost impossible to detect the instant that the limb touches a wire, and so the true centre is not found. In the case of the sun having been selected for a transit, the dark glass reduces the size of the image, and if the telescope is of low power the disk will be well defined, and for ordinary purposes the observation will be accurate enough; for the sharp outline can be detected at once as it touches the first wire, and as the transit has five wires, the mean of the whole number of contacts and departures will give the centre and the instant of its passage. It is not so easy to take a transit of the moon, for it is subject to two errors—the probable error, which must always be greater than the passage of a star, and a constant error, arising from the variations of the apparent semi-diameter. The outline of the moon's disk presents several irregularities, and her revolution is attended with alternately greater or less distances from the primary; it will be obvious, then, that the apparent diameter of the disk will not be of the true apparent mensuration. There is a mode of lunar observations, using the method of star culminations with the moon. While this astronomical method is recommended by its simplicity and the readiness with which the observation can be taken, it is somewhat doubtful, owing to the fact that the light is too intense in its effects on the retina; and again the agitation of the atmosphere—the two causes producing a swelling undulation in the apparent limb. To the inexperienced observer, this method would be too intricate to be of any service. We have mentioned it only as one of the modes of ascertaining longitude (time).

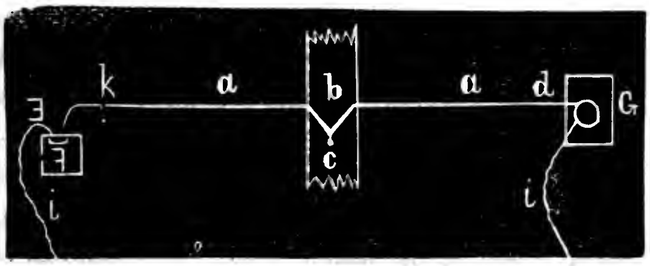
In the more refined astronomical operations of the present day, some one spot on the moon's surface is taken for the object, and if its latitude and longitude are known, it is a simple matter to take the observation, and reduce the centre by an easy calculation. It will be evident, however, that the instrument must be one of high power, and the adjustments as perfect as possible. The watchmaker will do better to rely entirely on the sun's passage, unless his transit is well illuminated, and at the same time of sufficient power to reveal a star, say at nine or ten o'clock in the morning; if he does possess such an instrument he is perfectly independent of the sun's meridian, for he can take from the Ephemeris any star of sufficient magnitude, and by adding his westings or subtracting his easting know the instant it will pass the centre spider line of his transit; now he can get, by comparison with his clock or chronometer, his true local time, and thus determine the rate of his timepiece.

If the transit is not equal to such performance, perhaps the best thing will be to rely entirely on the sun, being careful every once in a while to verify his meridian by observations on the pole star; and these would also enable the observer to ascertain the error of his instrument and his own pesonal equation, for there are few who can observe equally; that is, the observer will be able at times to discern and note a star, or the edge of the sun, in the passage over the wires, much more readily than at other times.

This last fact, taken in connection with the time lost by the observer in taking his eye from the instrument to note his time, even when he has, as he should, an assistant, led to the more perfect mode adopted by the late Prof. Sears C. Walker, of the United States Coast Survey, assisted very ably by the talented Director of the Harvard Observatory. The object aimed at was to record the results of an observation instantaneously, and the telegraph offered the required means; but now came in an element of error that must be eliminated to insure accuracy. It became necessary to know the speed with which the current travelled on the wires. By a series of experiments and observations, the velocity was found to be so great that it could be but a trifling source of error. Granting this, we will imagine a perfect system of the telegraph instituted in the Observatory, though it may be, as it is at London from Greenwich, and Boston from Harvard, extended to distant places.

When we consider the full value, we are led to class the operation with something of the marvellous. Here sits an observer, at Harvard, with his eye applied to the transit, and by the simple stroke of his finger he announces to another observer, at Ann Arbor, the instant some particular agreed-upon star for observation has passed the meridian. The click of the instrument gives the Ann Arbor observer full time for his adjustments; at the time the star passed the wire, say at Harvard, its instant of transit was recorded in the Observatory destined to receive the time. The velocity of the current has been ascertained, and the distance is of no very great importance, for it has been found that a signal, under favorable circumstances, is transmitted at a rate of 16,000 miles per second. The clock at each station, having been rated, say for the few days of the observations, *records* its time at both stations nearly simultaneously. To do this, the pendulum is made to break the circuit automatically. These astronomical clocks are, of course, constructed with the greatest care. We can do no better than to give Mr. Bond's description of the modes by which the electric current is broken by the clock. The mechanism is so very simple that it is a wonder the plan had not been adopted before. The object being to charge an electro-magnet, the lowest power may be used to effect the result; a common water battery is all-sufficient. Mr. Bond, in his description of the electro-recording apparatus, says:

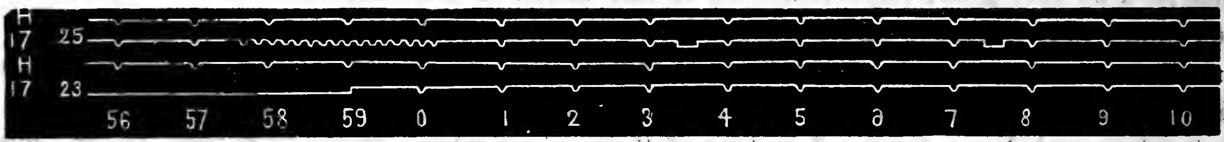
"From one pole of a galvanic battery an insulated copper wire is extended to the two transit instruments, to both of the equatorials, to the prime-vertical transit, the sidereal clock, and the recording machine, where it is connected with the wire of an electro-armature magnet. It is thence carried forward and attached to the other pole of the battery, forming a complete circuit without ground connection. A break-circuit key is placed on the wire at each instrument, within convenient reach of the observer. The galvanic current is momentarily interrupted by the action of the clock at every second of time. This interruption of the galvanic current was originally effected by insulating certain portions of the escapement of the clock; but during the last two years we have adopted the following method:



"At *a a*, is shown a steel spring, six inches in length, terminating at *e* in a platinum point. This spring is bent at *b*, so as to form a double inclined plane, the angle at *c* being 80° nearly. One end of this spring is secured to a plate which is screwed fast to the backboard of the sidereal clock. At *b* is shown a portion of the pendulum-rod, in which a gold pin, *c*, is secured in such a position as to act delicately upon the inclined planes of the spring when the pendulum is in motion, thereby raising the point, *e*, and detaching it from the mercury contained in the cup, *f*, at each vibration. It will be noticed that, when the pendulum is removed a little distance from the vertical position, the platinum point will dip into the quicksilver, and the spring then rest upon the support, *k*, placed below it. The repetitions of the armature beats of the magnet are brought to coincidence with those of the clock, by means of the screw, *g*, and by raising or depressing the support, *k*. The galvanic connection is formed, first, by immersing one end of the main conducting-wire, *i i*, in the quicksilver at *f*; the current then flows through the quicksilver and spring to the block, *h*, thence through the other portion of the main conducting-wire, *i' i'*, which is also fastened to *h*, and thence to the other pole of the battery, in its passage charging an electro-magnet."

* * * * *

"When preparing for an observation with the machine already in motion, the circuit is at first opened by means of the last mentioned key, during perhaps half a minute, and then *immediately after* the clock has beat the fifty-ninth second, the circuit is closed by this same key. The first recorded second will then be 0 seconds, or the even minute by the clock; a memorandum is then made of the minute and hour, and when the observations are completed, these are transferred to the left-hand margin of the paper. Should any doubt be entertained in regard to the correctness of the first closing of the circuit, the operation is easily repeated for any of the subsequent minutes, without any danger of losing the sequence of the seconds; indeed, it is our constant practice to do so at the termination of each group of observations. In regard to reading off the observations from the sheet, when it is taken from the cylinder, it is done in the following manner. As the cylinder makes one revolution in a minute, each horizontal line represents a minute. The vertical columns represent seconds, counting the seconds from left to right. All that has to be done is to mark the zero column of seconds, and write the hour and minute opposite the appropriate line on the left-hand margin, recollecting that the order of the minutes is from the bottom of the page towards the top. A scale with corresponding division-marks of the seconds is laid on the paper parallel with the minute lines, and the zero on the scale is brought to coincide with that of the record. The hour, minute, second, and decimal part of the second, may then be very readily distinguished by the eye to the tenth of a second, and, when necessary, the hundredth parts may be read off by using a lens and a finely divided scale. As the reading scale is made double the length of the minute line, it is of small importance where the minute commences, provided that the minute which may be in progress at the beginning of the line is correctly marked.



"The annexed diagram has been engraved from an original record, and exhibits the manner in which two wires of an equatorial star were recorded, and the sheet prepared for reading off. It will be seen that in this specimen the twenty-fourth minute of the clock-time commences at the fifth second from the beginning of the line; but 23^{m} is marked on the left-hand margin, and this was done for the reason that the twenty-third minute was then in progress. The close succession of offsets shown on the third line of the diagram was occasioned by the observer's having made a number of taps on his break-circuit key in rapid succession; this was intended to indicate that the star was approaching the system of wires of the instrument. At the instant when the star appeared to be bisected by the first wire, he made a single tap; this is shown by the prolonged offset; and this operation is repeated at each wire.

"In observing by the electric method, an equatorial interval of four seconds between the wires has been found convenient. When an observation has been completed, the observer affixes his signature to it by means of the same apparatus which enabled him to record the transit of the star. The evidence of the degree of accuracy which may be obtained by the use of this method will be included in the discussion of the observations."

In a former number of the American Horological Journal, mention was made of recording the taps that are given by the observer, as the object passes the system of spider lines in the diaphragm. The record as stated in No. 5, is better shown by W. C. Bond's report, which we give, premising that the star readings were got on the paper of the cylinder by the break in the circuit, effected by the motion of the pendulum. Now, suppose that while the cylinder is revolving and the clock making its marks at the regular seconds intervals, the observer should, as the star touches the wire, press his finger on the make circuit; he holds the key until the star has passed, and then allows the clock to assume its normal function of merely recording the seconds.

This system was used over a circuit of wires of two hundred miles, and the only possible error was in the appreciable retardation of the current on the wires.

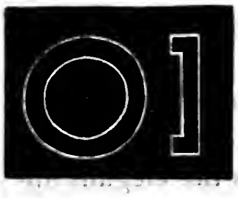
Watch Repairing.

NUMBER FOUR.

It behooves the workman at the bench to do his repairs in such a manner that the watch will not only run well, but that all the new work put in may be equal to the original. We mentioned in the last article the case of a nickle barrel grained on the top. Suppose that the repairer meets with a case where only one tooth of the main wheel is broken, and he is to replace the lost tooth. If he chooses he may drill for a bearing, and as the bottom of the tooth is on a level with the barrel, he has but little trouble in planting his centre for drilling; and what is better, the hole may be planted below the centre of the teeth, and thus a larger neck be given to the blank. As a matter of course, if the operator succeeds in getting the neck of the blank just right to make it level with the top of the barrel, but little trouble occurs afterwards; if, however, the blank comes above the top, it has to be reduced to the general level, and here comes a difficulty that, to most workmen, is rather formidable; for if he files off the surplus stock he is very liable to mark the top of the barrel, and thus destroy the whole beauty of the work, however well it may have been done in other respects. If he stones off the surface, he is in trouble, as the work would not correspond to the rest of the movement, and if, as in the case cited, the top of the barrel is grained, the difficulty is still greater; for though the repairer may have a battery, and a full knowledge of gilding, in this case very few are posted as to the tools and process used and followed, in order to obtain the beautiful grained surface that obtains so universally in the nickel movements.

This graining is not confined to the nickel movements, but is extensively used in brass work of fine marine chronometers, as well as clocks; and as it replaces, or rather answers the purpose of gilding, it is worthy the minuteness of description we propose to give. Every workman that has used the ordinary Scotch and blue stone well knows that he can produce a surface with either nearly straight or circular lines; but it has a cloudy look, arising from the irregularity of the strokes, and the uneven distribution of the lines. Now, if the lines could be made perfectly straight, and what is more, evenly divided, as in any straight line ruling, the effect would be a clear, even surface, perfectly uniform in appearance. But except in particular cases the straight line work is not desired, and we will now come to the circular. If the lines, as made by the stone or other abrasive material, cross each other at uncertain intervals, the same cloudy surface, before spoken of, is produced. It is obvious, then, that to get the full beautiful effect of the stoning, it is necessary that some regular system of motion shall be observed in order to get the pleasing effect that is observed on the stop plate of an English fusee. The regularity of the lines gives a faint idea of engine-turned work, as the principle involved in doing the work on steel, brass, or nickel. We shall select for the illustration the snail-formed piece on the top of the fusee, and which serves to make the stop.

If the reader of the JOURNAL will refer to the articles on the "Lathe," he will find a description of a tool to be applied to the lathe that will answer our purpose of illustration. Suppose, then, that we take the grinder from the spindle of the swing rest and replace it by another, the face of which is so cut away as to leave but a narrow surface to come in contact for grinding purposes. The cuts we give will enable any one to make his own tools for the purpose, and to do the work. If we take the ordinary lathe, and on the swing place a cylinder whose section is represented thus, it will be apparent that the plate to be grained will come in contact in the same places with the grinder, exactly in proportion to the relative speed of the two; and if the belts are tight, there will be but two little variations in the markings. It is plainly to be seen that the grained marks will be narrow at the centre and wide at the periphery, from the fact that the motion at the periphery is much greater than at the centres, and thus any point there will have moved under the grinder a greater distance during any one revolution; it thus happens that the graining presents curved radial lines gradually increasing in width until



they reach the edge of the plate or article under operation.

If our readers will refer back to pages 79 and 117 of the JOURNAL they will find a description of a mode of polishing pinions, together with a wood-cut illustrating the tool. If, instead of using the edge, the workman will use the flat side, as shown in the design, he will see at once that whatever marks are made on the article in the chuck, they must all be cycloidal, and radiate from the centre, with increasing areas, as they approach the circumference. The grinder, as represented in the cut, is put on the end of the mandrel of the swing on the rest, and used the same as though it was intended to face up a pinion. If the face of the raised edge of the grinder is slightly bevelled, it may be set at an angle to the work, which must revolve much slower than the grinder.

For steel work, oil-stone powder is used with oil, and tripoli with water for both brass and nickel. The beautiful mottled surface often seen in some work on the surface of the plate is produced by using a grinder in a lathe of the diameter of the intended mark. Now, if the grinder, having been made to make one circle, is so placed on the plate that the next circle shall overlap the first, there will be an intermingling of the lines at the points of intersection. When the next circle intersects with both of those previously made, the effect is to leave a small space not marked by the grinder, while the commingling of the lines will give the clouded surface, by the contrast. All this work on the plates may be performed with a drill bow and stock, though the work cannot be so uniform, or good when done. In some clocks, the stoning is done entirely by hand, and subject to the caprice of the workman; as a matter of course, the work never presents the elegant appearance of that performed by the aid of a lathe, with a rest capable of holding the plate, and of being moved in relation to the grinder a definite distance at will. This makes the surface appear very nearly as though it had been made by the aid of the rose engine lathe. The abrasive material used must be determined by the nature of the metals, both of the object and grinder.

We have extended this subject so far in order to show the beginner that he may just as well do the work thoroughly as to do it in a shabby manner, leaving the general appearance inferior to the rest of the watch. In case the barrel should be gilded, it is an easy matter for the repairer to restore its surface, when injured from careless filing, or, more reprehensibly, has become so through energetic scrubbing with the brush and chalk. This sort of work, however, requires the use of a battery; and the reader will find a detailed account of that in the articles on electro-metallurgy.

As we have taken the case of a broken tooth in the main wheel, we will carry out the subject by taking up a case of a broken tooth in the centre wheel. Here the thinnesss of the stock in a great measure precludes the drill. In the English and American watches, where they are full plate, the centre wheel is always out of sight, and should a broken tooth occur it may be replaced very readily by filing out a small dovetail and fitting in it a piece of brass, just a trifle thicker than the thickness of the web of the wheel. If, now, the edges of the dovetailed recess are slightly chamfered, it will be obvious that a very slight blow of the hammer, the wheel being on a smooth stake, will rivet the false tooth in so that no solder will be required, though the web will be much stronger if the piece is soft soldered in, using the very smallest quantity of the solder that will answer to just flow the joints, and nothing more. If the workman desires to do good work he will put the wheel on its centres and file down the piece of blank metal until it corresponds with the general circumference of the wheel; then with his equalizing and rounding up files he can make a perfect substitute for the lost dental. But, now comes up the question of finishing the faces of the wheel, or rather getting the newly placed tooth exactly equal in thickness to the wheel.

The repairer must not suppose that he can carelessly rivet the blank in; for if he uses too much force he may stretch the web of the wheel, and render the depth at that part of the periphery defective, not only as to the new tooth, but for a number of teeth each side of the inserted one. If he has filed the dovetail with the large side up, so as to make the piece slip in almost level with the surface, he will find very little trouble in reducing it to a common level. Here, however, comes in another trouble; for if he files the tooth level, he must mar the surface of the rest of the web. This would be of but little consequence in a full plate; but if, as is the case in a three-quarter plate, the wheel is exposed, the job would be a botch. Now, it so happens that, the web being thin, the dovetail must be made much more shallow, and solder is inadmissible.

In the Swiss watch, where the wheel is exposed, the tooth that replaces the broken one must be brought down to the general level, and it will be plain that the upper face must be finished off after the piece is riveted in. If the file alone is resorted to, the marks of the file teeth will show in strong contrast to the general finish of the watch. The majority of the three-quarter plate watches have hollow centre pinions, so that the length of the pivot of the pinion is but the thickness of the plate or bridge to which it belongs. Now, if, after having set in the tooth, the repairer will take the pains to make a small lap for his lathe, or, in case he has no lathe, will make a polishing block (which we are about to describe), he can, after putting in the piece that serves for the tooth, finish up the job so that no one can detect the replacement except with a strong glass.

The first supposition is that he has a lathe; then the workman can make a type metal chuck, fitted to the mandrel perfectly true, but recessed in the centre enough to give play for the pivot in order to allow the wheel face to lie flat, and at the same time a slight lateral motion can be given. Having first made sure that the new tooth is securely fastened, the sides are filed down enough to permit of stoning off until no appearance of repair exists, and this too without driving the wheel off the pinion. The pinion may then be pressed into a piece of cork, and this will leave the face side out; the type metal chuck, having been faced true, is to be scratched on its grinding or polishing face with a somewhat coarse file, taking care not to file enough to alter the general truth of its plane; the wheel is applied by means of the cork, and by the use of at first rotten stone succeeded by rouge, the whole face may be brought up to its original condition. It must be observed that the end of the cork should be cut as truly flat as possible, and the recess, cut out to receive the pinion, may and should be large enough to insure perfect contact with the wheel surface and cork.

If no lathe is at hand the same effect may be produced by using a block of type metal, and after drilling a hole about two diameters larger than the pivot, facing it with the file, using the cork in the same way as if the work was in the lathe. The scratches, or rather file marks, should not be in one direction, but should be made by circular as well as straight motions of the file; this will give a patched surface to the grinding block. The cork should not, for the hand work, be long, as the end of the finger is to be applied to produce the required motion for polishing.

If the wheel is not on the pinion, the case becomes more simple, as the glass plates can be used to advantage. This method applies to all the wheels whose surface it is desirable to polish, and by the use of the glass and rouge a finish can be obtained equal to the original work. A very reprehensible manner of finishing the train is the practice of dipping the wheel in acid and then gilding; the matted surface is all that is gained, but the surface of the teeth is injured by the action of the acid.

The beautiful gloss attained on Swiss wheel work is certainly preferable to the ordinary matted and gilded wheel. Aside from the superiority of finish, the corners are all left perfectly sharp, and the teeth are in the same condition as when the wheel was taken from the cutting-engine or rounding-up tool. The finish is so easily got that no repairer can be excused for neglecting, in replacing broken work, to make the quality of the surface quite as good as the original; and in ending this article, we would like to impress on the apprentice or the young workman, that next to getting time, his object should be to so do the repairs that they cannot be discovered. He will not only please his customer, but render his trade a source of pleasure and pride.

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Do not turn your watch when winding, as, in the case of the chronometer or duplex, the watch is very liable to set, from the fact that the turn may just meet the vibration of the balance.

Electro-Metallurgy.

NUMBER FOUR.

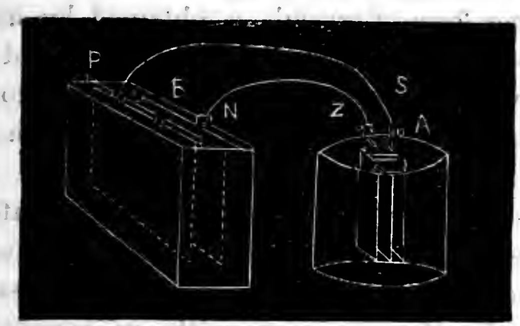
The battery having been treated of, we proceed to discuss the subject of the decomposition of a metallic salt in order to deposit the metal. For the very latest improvements we are indebted to Mr. Wm. Orr, the foreman of the depositing rooms of the extensive establishment of Messrs. Adams, Chandler & Co., in Brooklyn, and 20 John street, New York. Mr. Orr has grown up in the business, and after a long experience is certainly good authority. We mention this out of gratitude for the freedom with which he inducted us into the mysteries, and it was no small favor when he showed us the numerous Smee's batteries, the interminable system of wires, and the scrupulous fidelity with which each article was weighed in order to guarantee the quality of the goods. We hope he pleases his employers, for certainly no one can be more careful or expert; and, whatever Messrs. Adams, Chandler & Co. may wish to have done, one thing is certain, that Mr. Orr will, in every case, give the certain weight.

The deposition of one metal on another, apparently without the use of the electric current, was known long before the introduction of the battery. If a clean piece of iron or steel is introduced into a solution of the sulphate of copper, a chemical action is at once excited; the iron will almost instantaneously be covered with a coating of pure reguline copper. Investigating the mode of action, we may take into consideration the fact that the coating does not adhere to the metallic surface of the iron, but may be easily rubbed off with a slight amount of friction. On inspecting the iron surface from which the copper has been removed, we find it perfectly oxidized—no longer bright. The rationale of the chemical action may be summed up as follows: The sulphuric acid of the sulphate of copper decomposes the water in which it is dissolved, immediately on the immersion of the iron; but in decomposing the water an atom of copper is set free which goes to the iron—the oxygen of the water attacking the iron at the same instant. This simple arrangement and experiment is only the forerunner of the battery, for precisely the same action takes place in this that obtains in the largest battery.

This mode of deposit is not confined to copper; if gold, in thin strips, is immersed in nitro-muriatic acid it will be dissolved, or, more strictly speaking, be acted on, and a chloride of gold be formed; the product will be in the liquid form, and the gold is added until it is not acted on by the combined acids. Now, if to this saturated solution of chloride of gold there be added three times its weight of sulphuric ether, a mixture is formed that is perfectly neutral; yet the gold is held in such feeble combination that a piece of steel dipped in the solution will instantly be coated with gold. Surgical instruments are often treated in this manner to preserve them from rust. In order to insure success by this method it is requisite that the surface of the article shall be chemically clean, and that the solution shall have no acid reaction. The deposit thus made is firmly attached to the surface, and does not, like the copper acid solution, oxidize the steel; on removal from the bath the article is to be washed instantly by agitation in cold water.

The above described process, though so very simple, is of very little use in the arts, and is therefore at the present time not followed, except for some special purpose. The first use made of the new process by means of the battery was to obtain casts of articles in copper, and it was not until Elkington discovered and patented the cyanide solutions that it came into use for the practical purposes of life. Of late years, other solutions of metals, such as is used for iron, made by dissolving the common green vitriol (sulphate of iron) in water in which there has previously been dissolved a quantity of sal ammonia (chloride of ammonia), are used. Nickel is treated in the same manner with a solution, only a salt of the metal is substituted for the iron.

It will hardly be necessary for us to go into the details of any other metals than the three so extensively employed in the giant plating establishment—copper, silver, and gold—and we shall take them up in that order. If in a solution of the sulphate of copper there be suspended any object with a surface rendered by any means a good conductor and connect that surface with the positive pole of the battery, at the same time attaching a plate of copper to the negative and immersing it in the same solution, the battery will instantly commence action, and in the solution the copper will be dissolved, and then transferred to the article at the positive pole.



The general arrangement of the battery and decomposing cell may be illustrated by the cut which we give, in order to show the subject more fully. The solution of the sulphate of copper is contained in the vessel B, which of course may be of any size or form, according to the wants of the operator A represents the ordinary Smee battery. Now, the object in which the metal is to be deposited is connected with the two zinc plates, as shown at N and L; the negative plate, whether of silver or platina, is connected with the copper plate, P, which is suspended in the same vessel. The moment the connection is made, action commences in the battery, and then the water is decomposed—oxygen passing at once to the copper plate, and oxidizing the particles. During this operation the hydrogen passes to the negative plate, and this plate is the object on which the metal is to be deposited; the oxide of copper is carried in a state of solution to the negative pole of the decomposing trough, where it is deoxidized by the hydrogen, and the metal deposited in a metallic condition. This action will continue as long as any copper is attached to the negative of the battery. It may be well to state here, that the combination of the decomposing cell with the battery changes the relations as to the current, for in the solution the end of the positive wire becomes negative, and the negative becomes positive.

The larger the object to be coated, the larger must be the plate from which the metal is dissolved, for some very curious effects are produced by variations, not only in size but in the distance at which the two are held in the solution; for instance, with a large negative in the solution, and a small positive, the metal will be deposited in various thicknesses, commencing at the point of least distance, and gradually diminishing as the distances increase; the graduations in thickness are so minute that colors can be produced by the different layers, very much as the colors of the pearl are produced by a succession of fine layers.

M. Gassiot formed, by this process, what he termed metallo-chromos, and succeeded, making use of the fact that though lead has a strong tendency to crystallize, the positive pole will become incrusted with the peroxide of lead. The colors are produced by throwing down a deposit of the oxide of lead; the various thicknesses being obtained by placing the object at various distances—unequal, as a matter of course, from the negative pole. These specimens were done on a burnished steel plate. Suppose, then, that we made the copper plate of a concave form, like a reflector, we should accomplish the whole thing with ease, for the distances would be unequal as in the exact proportion of the curvature. The colors produced are in the true prismatic order, and are due to the decomposition of light by layers of different thicknesses.

All this seems simple enough; but there are difficulties that invariably attend the deposit of metals, that, even at the present day, are not fully understood. A great deal will depend on the strength of the solution. In relation to the intensity of the current, much, too, is dependent on the temperature of the solution; for if the intensity of the current is too strong, the metal will be deposited in the crystalline form, but the crystals so small that the surface will appear black. Again, if the temperature of the solution is high, the resistance to the current is less, and the same result follows; and the beginner may be disappointed in his efforts on first trials by making his battery too active. The crystallized form of copper is is thrown down with an intermediate intensity, while a still lower degree will deposit the reguline metal.

Copper is about the only metal used for massive deposits, and we will give some of the cases where it has been so used. As a matter of course, the mere coating of an object for ornamentation, or protection, requires but a thin film of metal; but for a deposit that is intended as a mould, or a counterpart of another piece, as in the case of copying the original engraved plates for maps, it becomes necessary to provide some means by which adhesion can be prevented. In the Coast Survey Office, Mr. Mathiot succeeded in this by washing the plates (the originals) with a solution of iodine, which prevented absolute contact, while it did not prevent the conduction, and consequently the deposit could very easily be detached from the matrix. The slight film of air that adheres to the surfaces of all bodies is taken advantage of to prevent adhesion, though it is not safe to rely on it, as the deposit may be partial or local, on the surface; that is, while some of the deposited metal is free, another portion may make absolute contact, and thus the cast is completely spoiled. The only remedy in such a case is to reverse the plate and object on the electrodes, and by this dissolve off the formerly deposited metal.

When it is desired to deposit copper on iron, the solution of the sulphate is inadmissible, as would be inferred from the first example of deposit given in this article; some neutral solution, such as the ammonia-sulphate, or, what is still better, a solution of the cyanide, is required in order to avoid the oxidization of the iron. In depositing copper (indeed the remarks will apply to all the metals) the distance between the positive and negative will determine, in a great measure, not only the quantity thrown down in a given time, but also the quality of the metal, as the whole of the result is produced by the passage of the current through the solution in the decomposing trough; and the quantity will depend on the distance, on the extent of surface presented by the electrodes, and their relative size to each other. This is not all; the strength of the solution is of importance, for any change in its strength implies a variation in the resistance to the current between the electrodes. The more near saturation the solution becomes, the higher will be the power of battery force required.

In depositing copper the operator may obtain two varieties, or rather states of metal. If a very strong solution is used with a feeble or deficient quantity of battery power, the metal will be deposited in minute crystals; and in this state the new plate of metal is but an aggregation of these small particles, with but little cohesive power among themselves, and therefore the metal is exceedingly brittle. Another form of crystals is obtained by using a strong solution with a strong current, and the positive electrode very large in proportion to the negative. The crystals thus thrown down are large and very hard.

The great trouble found in getting uniform success depends on various causes: the solution alone is liable to many disturbances; a want of uniformity in strength, unevenness of temperature, and the distance of the electrodes in proportion to the strength of the solution and its resisting power. These obstacles are found at every stage of the operation; but care and practice will enable almost any one to operate with copper with almost a certainty of success.

As the copper deposit has been described as to its method of deposition, we will turn our attention to silver—the more willingly that its deposit is of use to the watch repairer, as a branch of repairing; for occasionally the workman finds some parts of the watch so badly scrubbed that the gilding is thoroughly destroyed, and what is more, the crystalline character of the sub-surface destroyed. In cases of this kind the workman may gain a reputation for good work with but little trouble; for if he should re-gild the white parts, he restores the movement to its original beauty, and appearances are of some consequence. In investigating this subject, we consulted Mr. Orr, who deposits the metal in a large way and in every form of crystallization, as well as in the reguline condition. Though the watch repairer, for his purpose, does not require the apparatus used in a large factory, we will describe the plan on the factory scale, and state at the same time that the sizes may be reduced to the dimensions of a thimble; for the principle remains the same, whatever the size.

The batteries used by the Messrs. Adams, Chandler & Co., are Smee's, set in stone pots (common earthenware), the platinized negative plate being kept free from the zincs by two small pieces of cork at the lower end. Whether glass would not in the long run be cheaper is to us a question; but there may be some advantage in the semi-porous earthenware, as it allows the sulphate of zinc that is formed during the operation of the battery to effloresce on the outside of the jar, and thus render the battery more constant in action. These batteries are arranged at convenient points; for it must be understood that distance is of very little account except in the resistance the current finds in its passage on the conductors; the longer they are, the greater force of battery required. The solution for decomposition is held in several large wooden tanks, oval-shaped, and about three feet deep by four feet long, and two wide. These are filled with the solution nearly to the top; so the reader will readily conceive that one of the troughs would contain hundreds of dollars' worth of pure silver when the solution is completely saturated.

Now comes up the question of the formation of the solution, as everything is dependent on its proper condition, to insure success. The only one we shall treat of is the argento-cyanide of potassium; that is, cyanide of potassium holding in chemical solution the metallic silver. This important solution may be formed in various ways. Suppose we take a given quantity of nitrate of silver, dissolve it in water, the result will be, if we introduce a solution of common salt, the cloride of silver in the form of a copious precipitate. This chloride is insoluble under ordinary circumstances, but if allowed to stand in the sunlight, chlorine will be evolved and the oxide of silver formed, which being boiled in the cyanide will partially dissolve. This process, however, is not applicable to the formation of the large quantities required for manufacturing purposes. The precipitated chloride of silver may be used by boiling in a solution of the cyanide; but in this process another element enters into the question, for the chlorine liberated, as the silver is taken up, will take up its combining equivalent of potassium, and thus we shall have in the same solution the argento-cyanide and chloride of potassium.

There is a method which, while it implies no labor except the preliminary preparations, furnishes the best solution, as it is free from any foreign salt and requires no care in the operation. If we place on the wire attached to the platinized plate of the battery, a very large plate of silver to be as the positive, and a very small one of platina to form the negative, we may, by the aid of a strong current, dissolve a large amount of the silver; as the small negative will not take up all the silver dissolved, a portion must remain in solution; and it is only when reguline metal is deposited on the negative that the solution becomes saturated sufficiently for practical working. There will be some free cyanide of potassium; but this fact is of advantage, as its higher conducting power facilitates the reduction of the metal. The salt used for making the solution needs no description; it is only the fused cyanide of potassium, and can be purchased at any of the drug stores, and is not expensive.

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Horological Institutes.

At the first appearance of the AMERICAN HOROLOGICAL JOURNAL, a correspondent suggested the formation of a Union of the watch repairers of the United States. How the plans were to be carried out was not stated, though we have had numerous suggestions from the trade as to the formation and objects. In England, where the *watch-making* is concentrated in a few localities, it would seem that a community of interest would induce the manufacturers (that is, the employers) to educate their mechanics up to the very highest point. It is, undoubtedly, of greater interest for the employer to get the educated workman than the ignorant, however well the last may be able to perform the details of watch-making. In London there was established, in 1858, a society, entitled the British Horological Institute; but it has not, up to the present date, received a very cordial support from the members of the craft, notwithstanding that classes for instruction were formed with able instructors and a library (free), which contains every work on Horology ever published.

Mr. J. Hermann, on the first of December, delivered a lecture before the Institute; he has a class under instruction, and we will quote from his remarks: "I, a foreigner, appearing before a British audience to advocate the cause of a British institution, have some presentiment that by so doing some will consider me both assuming and impolitic, and thus the interests of the institute may be thwarted. Had the science of horology, the welfare of the institute, and the prosperity of the trade in general, not lain close to my heart, I should never have placed myself in this position. I crave, therefore, your forbearance in the somewhat disconnected remarks that follow, and proceed at once with the subject of my discourse, namely, first, The British Horological Institute and its work; secondly, Why does it not receive the general support of the trade? and, thirdly, A suggestion for the improvement and extension of its influence. Not unfrequently the questions are asked: What do we want a Horological Institute for? of what use can it be? Hence, let us consider for a moment how much, or if at all, such an institute is needful, or even desirable. Horology, in its origin, in its various accumulated improvements, and in the construction of the proportions of each simple and complex mechanism, is eminently scientific as well as artistic; it is the cause and the effect, the root and the power of science. It was by the aid of science that the pioneers in horology have made those valuable inventions and improvements by which many have earned their bread, and not a few gained wealth and position; and science must more than ever be the handmaid of horology and the standard in the march of progress. Horology occupies a position in a scientific point of view to which no other mechanical craft can aspire. It is horology that furnishes the index of the motion of our planets. It is horology that enables the astronomer to observe and to determine the motions of the celestial bodies as law. Therefore, my answer is, that the honor, the interest, and the welfare of the trade, its present and future prospects, demand a special scientific depot—a horological institute. The Horological Institute, established in the year 1858, for the science and practice of horology, has ever endeavored to carry out its programme by the diffusion of horological knowledge through its journal, its lectures, its library, its museum, and its classes. Yet by all these advantages and opportunities, that the voluntary services of its working members enable it to offer, by all their labors in its behalf, it has not been able to enlist more than some 315 members in its service. When we further consider that out of this number, some 40 are amateurs, or non-professional gentlemen and resident abroad, leaving some 275 subscribers out of 30,000 who are in some way connected with our own trade, and deriving benefit through its agency, we find that not more than one in 100, at a maximum, is giving any aid whatever to an institution which is laboring hard to benefit and improve the horological profession. Further, out of this number of subscribers some pay their subscription with a sense of great sacrifice, and others appear not to be able to make the sacrifice at all—the result being that the current receipts are not sufficient to pay for the negative work of the institute, and hence, if a few gentlemen did not give occasionally large donations, it could not exist at all. The positive work is supplied voluntarily by a few enthusiastic gentlemen of the Council, and, therefore, there is not only no cause to justify any one outside or in, to complain of the inefficient work it is doing, or to make such an excuse for keeping aloof from it; but it is a stigma and a disgrace to the members of the trade to neglect such an institution, while, at the same time, they are ready to appropriate whatever benefit they can from its works and labors."

It will appear from the above that the institute is hardly in a healthy condition as regards the sympathies of the watch-making community, and the lecturer assigns as the reason, that: "The cause cannot be charged to the institute. The cause of the existing effect is rooted in the applied system of horology, and horological commerce, as prevalent throughout the country, and which I trace to two main sources. First, the suppression of horology as both a science and an art, through the present system of horological trading; and, secondly, the inability to appreciate the pleasure and advantage which horological science supplies, in consequence of the want of a proper education by the operative. Although, in dealing with the first cause, I shall apply myself chiefly to retail watchmakers, or that part of the horological community which is mostly engaged in buying, selling, and repairing, because it is this section that requires the most extensive horological knowledge, and likewise embraces the greatest number of watchmakers; and hence it is here that we can anticipate the chief support. Yet my subdivisions will also apply to the manufacturing branches, time not allowing me to take them separately. In order to make myself understood, I divide these into three classes: First, dealers or those who use the trade as an investment of capital or otherwise for trading, having no technical or practical knowledge; secondly, watchmakers, or those who are more less practical or skilled workmen, engaged in horological commerce; thirdly, assistants, or those whose source of maintenance is chiefly derived from hand labor rendered to an employer. It is to the first class, or dealers, that I ascribe the principal cause of this horological dearth. It is here where a great obstacle to horological progress and development, and a great stumbling-block and barrier to many promising members of our trade, lies. When it is possible for a reckless speculator, by dashing, puffing, and flash advertisements in newspapers, on boardings, and in shop fronts, to gain the highest patronage and public honors and distinctions, while the man who is an honor and an ornament to horology is standing by unnoticed and unknown, blushing for his profession that allows such barefaced deception; when it is possible for pawnbrokers, Dutch clockmen, or 'old clo' men, to pass themselves off as skilled horologists, and profit by the pretence—while the workman, a man of obscurity and care, receives his small remuneration with a grudge—where is the incentive to horology?"

It seems, then, that the United States are not much worse off than the United Kingdom, and it certainly is humiliating for the trade that a German shall tell such a story; but let us see what more he has to say, and unfortunately it is the truth both here and abroad: "While the garden of horology lies open to the beasts of the field and birds of prey, can you expect the gardener will till the ground and sow seed with diligence? With such obstacles, with such examples before the young and aspiring, can you wonder if the grass is growing on that honorable but tedious path of horology? It is not against capital that I am declaiming. On the contrary, I should like to see much more of it employed in our business, but I want to see it done honestly. Let the capitalist be known by his proper character, and not represent himself to be what he is not, in order to make a short cut to honors and benefits due only to the true horologist. Such men are occupying posts solely for making money, and hence, as the horological commerce must be limited to a certain extent, the share of business falling into their hands must be reckoned as going out of the trade, and so the means of intellectual and pecuniary assistance to horology, and the influence of our institute, is necessarily diminished in proportion to their number. Further, they prove a stumbling-block to the second class, namely, the watchmaker. It is in this section we find the brightest horological stars, the mainstays of the institute; but of course their numbers are continually thinned, and so require recruiting. But when at a period like the present, when men are chiefly guided in learning any trade or profession, or supporting any scheme or concern, from a consideration of the pecuniary benefit accruing therefrom, the horological student sees better results in regard to money-making by a bold face than by years of close application to the study of horology; this example must prove a stumbling-block to many, and thus you cannot wonder if horology has become unpopular as a money-winner. Puff is ever found in the inverse ratio to the ability of the workman, and while the public is led away and men succeed by it, while ignorance and falsehood ride triumphantly, the friends of the institute will ever be in the minority. I have now to consider the third and last class, namely, the assistants. It is this class of men that are the greatest sufferers by this fraudulent system, and shame be it to horology that her most faithful sons receive often the smallest reward. There is a general spirit of 'getting' among dealers and inferior watchmakers in their business transactions with the public, regardless of a just and proper charge for proper work; and as they always take care to be on the safe side, work must be done cheaply. As a good workman finds it difficult to 'scamp' or work to low prices, we find often that the man who spoils everything thrives, and that he who renews almost starves. Can you expect a man to care for the honor, interest, and prosperity of a profession that consigns him to many weary hours of labor, the sweat of whose brow is but swelling the fame of the usurper, while he himself remains scarcely recognized in society?"

Certainly Mr. J. Hermann has been to this country, or he could not tell the real facts of the case as they exist here so well as he has done. With one or two more quotations we will close. In illustrating the impenetrable stupidity of some members of the craft, he says: "By reason of a deficient education, working watchmakers are unable to conceive the principles which are comprehended in a single 'escapement' or 'depth,' and I am sorry to say, they are too often above being taught, looking upon such matters as not worthy of the notice of a sensible man. Yet these men are sometimes reminded that there are little things in watch work which they do not quite comprehend; but, instead of acknowledging it, they stigmatize the trade as the most contemptible in existence; and the very idea of asking such a man after he has perplexed his brain all day about watch work, to come and receive some enlightenment at the institute, is the height of absurdity to him. The result is, he seeks some violent recreation instead, intellectually degrading, and physically ruinous." Could a photograph be truer to nature than the above life sketch? We see many a workman here in this city, whose only knowledge of the trade is purely mechanical; and for the want of theoretical, technical knowledge he can "puzzle his brains," and very probably spoil his job. The contempt he exhibits for anything beyond what he learned when an apprentice is equalled only by that the ignorant farmer exhibits when with a look of cunning wisdom he denounces book farming; and this mental condition is attended with the greater fault that an apathy grows on the workman. We would like to put this lecture of Mr. Hermann's before every watch repairer in the land, and we are of opinion that there would be a large demand for works on geometry and the AMERICAN HOROLOGICAL JOURNAL.

Engraving.

No art is of higher antiquity, with the exception of the making of pottery, and even then it must have been used in embellishing those humble yet useful articles of fabrication. In fact, we can scarcely conceive of a time when engraving in some form or other was not done. The Indian who ornamented his pipe had a rudimentary idea of the art, and long anterior to the Pharaohs engraved tablets of hieroglyphics were made, and found thousands of years after, still legible, and, under the scrutiny of men like Rawlinson, have been compelled to yield up their meaning.

After the engraving on stone, we would naturally expect that carved work would follow, and the expectation is fully realized. There are many species of engraving—the general acceptation of the term being, however, a cut in character on a surface from which a print can be taken. Undoubtedly wood was the first substance used on which to engrave for the purpose of printing, as we are assured that the block printing of the Chinese has been in existence some thousands of years before the present epoch; but in wood engraving the subject is made in relief, or in some cases only the design is cut out and the subject will then be represented by white lines, the face of the wood taking and impressing the ink from its whole surface. The illustrations in this journal are thus engraved and printed; the other mode would necessitate the cutting away of all the black parts and leave the wood elevated above the general surface wherever the design is traced on the block.

As the watch repairer has but little in common with the wood-cutting, we will confine ourselves entirely to the metals. We do not hope to teach any one the tact of hand and the artistic taste that are requisite to the production of a good engraving; but there are many things of a general nature that are of interest in the manipulations of the engraver on a piece of work, whether it be for printing or ornamentation. Thus, the repairer who sells goods is frequently called on to engrave the goods sold, and if he is desirous of doing the work well, he must make the engraving on each article the exact counterpart of any of the others. To do this correctly and surely, he must use the process of transfer, and as this is one of the important elements in engraving, we shall not hesitate to describe it minutely, whether the work is intended for printing, ornamentation, or lettering.

In the first place we will take up steel-plate engraving. In this process the base of all the subsequent operations is a steel plate about one-quarter of an inch thick, the face of which, after being brought to as perfect a level and as uniform as possible, is decarbonized, leaving it, in fact, nothing but pure soft iron. It will be seen from what follows that this surface should be not only uniform on the face, but in the evenness of the texture of the metal. After decarbonizing, the surface is finished up with a high polish in such a way that it is left in the softest condition possible. This plate, so prepared, passes to the hands of the engraver, whose first work is to copy the design or subject on a piece of gelatine sheet, which is then laid on the design and fastened by wetting the corners of the gelatine sheet.

The artist is now prepared to copy the design, which he does by means of a sharp-pointed stylus; this produces an outline of all the important parts of the design, and this outline is cut in the surface of the gelatine. On being removed, the whole surface is rubbed over with finely-powdered chalk or vermilion; the color is immaterial so long as it will make a contrast with the ground on which the transfer is to be taken. The surface is now carefully wiped off, leaving the color in the cut lines only. The next step is to cover the steel plate with a solution of asphaltum in turpentine, and this is done by means of a ball made by covering a quantity of wool or cotton with glove leather, and the edges of the leather are brought together at the top of the ball; the superfluous material forms a handle, as it were, by which to manage the ball when in use.

The plate is now thoroughly cleaned with alcohol in order to remove every trace of extraneous matter, such as grease, etc. The ball is now lightly dipped in the asphaltum mixture and then dabbed on the surface of the plate; of course the asphaltum will adhere to the surface, and if care is taken, a perfectly uniform surface will be the result.

As the turpentine evaporates, a thin film of the asphaltum is left on the plate, and one great advantage in using this article for the ground is, that while it is firm and unyielding when cut, it possesses sufficient tenacity to prevent any raggedness to the edges of a line that may be cut through it to the plate. This uniform coating or ground has a tacky feel, and when the gelatine is reversed and applied to the ground and gently rubbed on the back with a burnish, the adhesive ground takes out the coloring matters from the tracing, and when the tracing is removed from the plate a complete outline of the original design is seen on the ground.

The engraver now, with a point, cuts through the ground, following the lines, being sure to reach the steel at every point. As yet he has not made any impression on the plate; to do this he builds up a small wall around the edges of the plate with beeswax; when this is effected he pours on the traced surface some nitric acid, observing closely the effect. A series of bubbles will be observed to arise from every point of the lines, and when the action has been continued long enough to produce the effect desired by the artist, the acid is poured off and the whole well washed with water to remove every trace of acid. The ground is now washed off with turpentine, the plate cleaned, and the engraver has before him a perfect outline of the original, only reversed. These lines are bitten in the steel, and this whole operation is called etching. In all the subsequent stages this process is the most important, and the skilful engraver manages to produce both light and heavy lines to represent the various lights and shades in the original. We will give only one example of the way the line may be rebitten. A new ground is carefully put on the surface over the whole picture; the very gentle pressure used enables the ground to take on only the plain surfaces of the plate, while the lines are left exposed. The artist, having determined the part he wishes to rebite, stops out all the rest with the asphaltum varnish; the same etching process is now gone through with the lines that are exposed, and according to his judgment the action is stopped when the best effect has been produced. The operations are necessarily tedious, for they involve constant washings, and then on inspection the artist picks up any little faults with his graver. In putting in all the various parts of the design, recourse is had to etching, interlarded with patient touchings up by the graver. In the course of engraving a large picture this process is repeated many times. The final effect, of course, depends on the skill of the artist, his taste, genius, and comprehension of the subject.

One great difficulty encountered arises from the tendency of the acid to bite the sides as well as the bottom; in fact the action might be continued so long that the etched line would be too wide, and thus spoil the effect intended to be attained. Consequently the artist watches with jealous care and anxiety the action.

There is another mode of engraving on steel that applies more particularly to bank-note work, which work has been carried to a very high degree of perfection, far beyond any thing in foreign countries. In this class of work the etching process has no place. The beautiful ovals that are found on the note are called die work, and the die work need not be confined to the oval, but may take any form that is geometrical. On inspecting this die work with a glass of considerable magnifying power, it will be found to consist entirely of lines always concentric, and sometimes parallel to each other in every part; but the general direction of the different lines may be such as to produce a beautiful reticulated appearance. Indeed, every variety of effect can be produced. This species of engraving is done by machinery, the geometric lathe being the first agent used.* Now, as this tool is one of the highest products of human genius, and at the same time involves some of the principles of the rose engine, a general description of its construction and its action will not be amiss.

A lathe-head, with its mandrel admirably fitted, is put on the bed of the lathe, and is so adjusted as to be capable of a slight side motion; the tool, which is of the hardest steel, or more preferably of diamond, faces the chuck as in all lathes. Now, it is evident that if the lathe-head, with its mandrel, should be moved sideways during a revolution, and the tool remain a fixed point, the line traced by the tool would not be the true circle, but it would had the mandrel remained *in situ* during the revolution. Any arbitrary movement would produce an irregular figure, having no symmetry, and therefore not desired. Now, the question to be considered is rendered free from all complexity if we assume the revolution and side motion to be in some proportion definite and absolute. If the tool remains a fixed point, and the mandrel was moved backward and forward, the line described by the fixed point would not be a true circle; and to illustrate, we will assume that previous to any lateral motion a single revolution had been given with the point of the tool pressed against the face of the object on the chuck, we should have a true circle. If, now, by any positive mechanical motion we should give the mandrel a gradual advance to the front of the lathe-bed, we should find that the line fell very gradually within the circle, and on the return of the mandrel to its original position the line would have as gradually approximated until it met the circle; this would be done in the half revolution. The other half of the revolution is affected in the same manner, and the new line described would be an ellipse, whose major axis is exactly equal to the diameter of the primitive circle, and the minor axis is less by double the amount of motion given to the mandrel.

We have thus the oval, and its amount of ellipticity is determined entirely by the amount of motion. Suppose, however, that during the revolution the mandrel is moved eight times, we should have a figure that would show four departures from the original circle; and the principle may be carried out to any extent, say even one hundred times, and then the original would represent only a waved line. If, during the time of drawing the oval, the rest should be allowed any number of side motions, backward and forward, it is evident that, in proportion to the number of such motions, the line would appear as a series of waves, small or great, as the case might be. If now the cross feed-screw of the rest should be made to take one turn, or a fractional part of a turn, the next revolution would furnish a smaller or larger waved line exactly corresponding to the first; but in this case the starting point for the second line must be in the radial line of the first. It will appear plain that the height of the small curves, constituting what we have designated waves, will depend on the extent of motion given to the rest that carries the tool; for if the point were moved, say four times, at stated intervals, from the centre of the mandrel out to the original curve and returned back to the centre, that an ellipsoid would be traced, having its greatest curvature at the circle, and least when approaching the centre; there would be four of these, and their dimensions, in all, except the longest diameter, will be exactly in proportion to the relative speeds of the rotation and the lateral motion of the rest.

The combinations are endless, and the positive motion is secured by gearing of different numbers, so that a great variety of geometrical figures can be obtained; not so many as in the Kaleidoscope, the figures of which must consist of angular forms. The work to be done is put up in the chuck, and therefore the lathe would assume enormous proportions were each plate to be engraved to be chucked; and, again, no two figures would be exactly alike. Resort is had therefore to the principle of transfer; a small plate is chucked and the lines cut in for a design, and after the engraving is done, the plate is hardened. It will be observed that these lines are cut in; and if we transfer, we shall have them in relief, but reversed.

A steel roller is now prepared of a circumference so large that the design will measure but a small part of it; its thickness, of course, a little more than the width of the engraving to be transferred; this roller is made of the best steel, and turned up true; the surface is decarbonized, and in this condition it is set upon its edge, on the hardened engraved plate, which has been placed on the bed of the transfer press, a machine capable of giving an enormous pressure, and fitted with adjustments on its bed for correct positions; the point of contact with the roller which it presses on has the facility to move while the pressure is on. Now, the roller being placed on the die, the pressure is applied at the same time the roller is made to rotate over the die. In this manner a relievo impression of the die is obtained, and then the roller in its turn is hardened and is ready for use, to transfer a *fac simile* of the original on to any steel plate. The pressure required for the second transfer is not nearly so great as it was for the first. We have given no drawings, for our readers may examine any national bank note, and he will find a much better illustration than we would dare attempt.

The combinations of lines can be multiplied to any extent, and the devices will vary with the gearing that gives the positive movement to the mandrel and rest; one tooth, more or less, would give an entirely different device. The geometric lathe can give them any outline, from a triangle up to the full circle. Now, in watch-cases a somewhat analogous lathe is used; the principle of motion (positive) is employed though the rest is not movable, except by the screw that is used for feed.

If the reader will attentively examine a gold dial, he will find that the whole effect is produced by lines cut in the surface. He will see that, to produce the effect of rays, the lines are divergent, or radial from the centre. This, however, is done by the ruling, or, as it is technically termed, the straight line machine. The backs and fronts of the cases are generally barleycorned—at least, on some portion of their surface. On looking attentively at a finely barleycorned case, the first thought is, that it is done by curved radial lines. Such is not the case, however; the lines are circular, but waved, the wave of each succeeding line halving on the wave of the preceding. This is done by means of the rose engine; and as it may be of interest to a great number of our readers to learn something about it, we will endeavor to give a description of the machine by which such beautiful work is done. If the reader will refer to page 107 of this journal, he will find in outline, the delineation of the swing rest. Now, we will suppose the mandrel of the lathe to be placed in a frame, being analogous to the swing rest. The head stock of the rose engine is hung on centres, and the mandrel is capable of an end long motion. This arrangement enables the centre to be moved as in the case of the geometric lathe; the only difference being that while the centre of the first describes a straight line in its motion, the centre of the rose engine must describe a curve. On the mandrel of the lathe are placed loose, but attached to each other, a series of brass or rather composition disks, cut on the edges with varying degrees of fineness, with the different amount of wave sought to be produced in the line the tool cuts in the surface of the gold or silver. These disks are also fluted on the face to produce an end long motion of the mandrel.

Firmly attached by a key to the arbor, there is a large plate that carries a tangent screw, which works in a worm gear that is screwed to the composition forms; so that it is plain, if the pitch of the screw is just one half the pitch of a wave, one turn will set the pattern one half the wave at a turn. We have given this only as the theoretical idea; in practice there are from five to six different composition patterns on the arbor, with as many different sized waves; and it follows that some calculation is necessary to get the proper amount of turn to the screw. On the lathe bed there is a base firmly attached, that takes in, like the ordinary slide rest does, a pair of dogs, polished on the end and rounded enough to take off any sharp edge, and which are pressed firmly against the corrugated patterns. The mandrel is pressed forward by a strong spring, and the same may be said of the end long motion. Now, if the mandrel is revolved with the pattern in contact with the dog, the mandrel will have a vibratory motion, the spring always keeping the contact complete. The tool is a stationary point, compared to the mandrel, for it is moved only by the feed screw in order to give the difference in the distance of the lines.

The rest is capable of three motions: a circular, a straight feed, and an end motion to bring the tool up to the work; and this effect is produced entirely by the hand, as the whole is regulated by a stop just one side of the cutting tool, which regulates the depth of the cut. As the point of the tool is ground up and finished with two angles, it is plain that at the curved portions of the work the cut would not be correct if the tool was kept parallel to the axis of the mandrel, for one side of the cut would be broader than the other, and thus spoil the effect. Now, in the operations the workman is careful to keep the tool by means of the circular rest always at right angles to the part of the surface he is turning; but as a watch case is not a true sphere, much judgment has to be used in attaining this point; again, if the lines are not equally divided in proportion to the curvature, a cloudy appearance will be the result.

We intend to refer to this subject in a subsequent number, as we have already overstepped the limits assigned for space.

Trade Morality.

In all the intercourse between the seller and buyer, there is a line of conduct that cannot be passed without subjecting the party in fault to the charge that he is deficient in correct views of the morality that should be observed and practised. For instance, a wholesale dealer sells his goods to parties to sell again, and it is supposed that, after allowing for margin for profits, the wholesale dealer sells the goods at such a rate that the retailer finds his profit in selling again in small quantities. In both transactions the price will be regulated by the state of the market and the demand for the goods. So far the strictly moral line of conduct has been observed. Suppose, however, that after the retailer has exposed his wares at his place of business, he should find that the wholesale house was selling goods of the same description to the retailer's own customers at nearly the same price that he held them at when the retailer purchased; here would be a course of mercantile conduct that every one with any idea of trade morality would condemn. The retailer, having purchased his goods at the best possible rate, has a perfect right, in the absence of any agreement with the manufacturer, to sell at a fixed price, to place his wares on the market at such prices and in such manner as he may think is best for his own interest.

As we are writing for the Horological public we will illustrate, by taking the article of watches for instance. A dealer may seek to extend his trade by advertising to forward watches to parties residing at a distance, by express, the price to be collected on delivery. No one can dispute his right so to do, neither can he question the strict morality of the transaction. If he undertakes to undersell the local dealer, and puts his goods at less than a living profit, failure follows as a matter of course, and his experience serves as a warning, or should do so, to all who attempt to sell goods at less than a living profit. We can conceive of no stigma attaching to a C. O. D. business, and in a moral point of view we can conceive of no possible objection to this method of conducting mercantile transactions. There is scarcely any branch of business in New York that does not send goods all over the country to be paid for on receipt of the goods. The man who is sending out large quantities of watches can, perhaps, sell them for a less profit than the country dealer, whose trade is limited to his own immediate vicinity; but by the time the customer has paid the express charges on his watch, and on the return of the money to pay for the same, and then paid the watch dealer in his neighborhood for putting his watch in order, he has actually paid more for it than he would to have purchased it of his neigbor. That, however, has nothing to do with the right of the other party to sell his watch in any manner he may choose. C. A. Stevens & Co., of Fourteenth street. Lord & Taylor, D. Appleton & Co., Harper Bros., and numerous other firms of equal standing in this and other cities, sent out goods on the C. O. D. plan, and we presume no one would question the morality of this dealing.

As a general rule, any dealer will find it more to his advantage in the long run to conduct his business in a strictly honorable manner, never resorting to petty tricks of trade, or endeavors to depreciate the goods of a rival in business. And we hold it to be especially incumbent upon all American watch manufacturers to sustain the reputation of the products of each other, and to make common cause with each other against the pirates who counterfeit their trade marks, thereby imposing upon the public an inferior article as an American production. And perhaps we might be allowed to suggest that the watch repairer is not entirely free from the suspicion that he sometimes allows himself to speak slightingly of a rival in business, both as regards workmanship and business integrity.

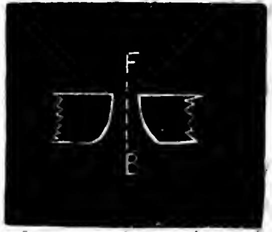
Wire.

Imagine, if you can, reader, the world without wire; the instant you wish to accomplish some work you will be called on for wire. The fact is that, like steel, it is a *sine qua non.* We could no more get along without wire than steel itself; so we propose to state something about how it is made. Two properties of metals have to be taken advantage of, and no small amount of skill is required to successfully reduce a large bar of metal, say a quarter of an inch in diameter, down to the size of fine binding wire, to say nothing of the size of the wire used for the lightest hair springs; yet wire has been drawn still finer, as we will show in the course of this article, for a wire has been drawn that, though it might be rolled up in the cubic space of a common die, would reach from Paris to Rome—a wonderful attenuation of metal.

The first step in drawing wire is to have the plate or plates so well graduated that the metal is successively reduced by drawing the stock through the holes. Now, we will suppose a piece of metal rod, round or square, to be tapered slightly at the end, to be forced through a hole that has been made in a plate of steel the thickness of which will be proportioned to the size of the wire to be drawn; if now with a pair of plyers we clutch the end that projects through the plate, we may draw the whole rod through, and it will assume the form of the hole in the steel through which it has been drawn.

The whole process then depends on the softness of the metal, and what is of still greater importance, the gradation of the holes in the steel plate through which it has to be drawn in order to get the original stock down to the required size. That the thing can be done is testified to by the thousands of miles of telegraph wire now in use, and lately a steel galvanized wire is in use in the city of New York whose stretch from point to point is marvellous. The process, though apparently simple, is attended by various difficulties, which will appear as we describe the process. First, a steel plate is prepared, and a series of holes drilled in it, which are afterwards broached out to the different sizes of the wire gauge; not that each hole is of a definite number on the gauge, but as the drawing must be done very gradually, the holes are made in successive steps or sizes, so that a slight amount of reduction takes place on drawing the wire through each successive hole. In the large way, the holes are brought to size by means of a punch, driving it through from the back side, or the side on which the hole is largest.

The section of the hole should be (considered theoretically) two curves, the nearest point of approximation being just back of the face side of the plate. The cut will show what we mean, and as we will be compelled to refer to jewelled holes, which are, as a matter of course, of the same general form in the hole, the cut will represent a jewelled hole for gold and fine steel wire, though the same principle is applicable to metal holes.



The drawing is purposely made of a disproportionate size, in order to show the section of the hole. It must be borne in mind that in reducing the metal a certain change of particles must take place. For instance, if a bar of any metal is reduced from a quarter to an eighth of an inch, there must have occurred a change of structure; that is, the atoms must have been so changed in relation to each other that one atom has been crowded back on another. If, then, we take a piece of rod for the purpose of wire-drawing, we will find that the continuous interchange of the atoms has made the metal too hard to be used for further operations, and annealing must be resorted to, and this is done by heating the coil and allowing it to cool slowly, as an oxide of iron will inevitably be formed by the annealing. The coil of wire, whether great or small, is dipped in a dilute solution of sulphate of copper, and then in a soda ash bath. Now, the iron has a strong affinity for copper, and it is immersed in a bath of sulphate of copper, and in the subsequent drawings the copper protects the surface of the iron, while it preserves the draw-plate at the same time from wear; there can be no steel plate that can preserve the size of the hole with a large amount of drawing, and the workman is continually gauging the wire as it comes from the plate, in order to determine the size of the next hole, for the gradation must be perfect, or else the wire will not have sufficient strength to draw; or, in other words, reduce the metal to the size of the wire already held by the tongs. On the other side of the draw-plate it is evident that the particles of metal must move on each other, and thus a total change of particles will take place as to their relative positions.

In the ordinary way of drawing wire the rod is broken down by rolls until the size will meet with the largest hole in the draw-plate. These rolls are made with grooves that take in just one-half the circumference of the metal, and the grooves are so graduated in their respective sizes, that the bar is rolled down to the proper size without forcing the metal out of place. The end of the rod is now tapered, and the drawing commences by means, first, of a lever with a pair of tongs attached. This lever is moved by means of a cam attached to the shaft which carries the drum or reel; as soon as enough has been drawn through the plate the end is attached to the drum, and then the drawing is continuous. The metal becomes so hard, however that the coil has to be placed in an oven, and brought up to a low red heat, and then allowed to cool gradually with iron wire. The usual custom is to dip the annealed coil in a solution of the sulphate of copper in order to give it a coat of that metal, as the draw-plate is worn less than if the oxidized surface of the iron was allowed to pass through the hole. By these successive drawings the wire is reduced in size, and in the case of gold and platinum the degree of fineness seems to be limited only by the practical difficulty in making a hole small enough. The wire that at one time was used for the spider lines in transit instruments and other astronomical apparatus, was made by a very ingenious process. The bar of platinum was placed in the centre of a mould, and silver was cast around it; as the bar was perfectly clean a fusion took place between the two metals; the compound thus formed was drawn down until the silver wire was too fine to be reduced any farther, and then it was placed in nitric acid, which, dissolving the silver, left the fine thread of platinum; the drawing having reduced the platinum in the same proportion as the silver, so that if the latter was twenty times the diameter of the former the result would be a wire twenty times less than the silver. This method of reduction is advantageous in other branches of art; for instance, tin is a high-priced metal, while lead is cheap; but tin foil is in great demand for various purposes, and the question is, how to make it cheap enough for the market.

The plan adopted is very simple, and is applicable to many other metals. An ingot mould is first procured, and then an ingot of lead is placed in it; the ingot, however, is less in dimensions in every direction. The lead is supported on blocks of pure tin, and the whole mass is then surrounded by fused tin; the distance between the lead surface and the mould will determine the relative thicknesses of the tin and lead. The compound ingot is now taken from the mould and rolled down to the required gauge; by this process a foil is obtained that is cheap, for the tin bears a very small relation to the lead.

The fine binding wire, so much used in every trade, is simply good iron, and the color is got by the last annealing. We sometime since saw a specimen in the late Mr. Ichabod Washburne's wire mill at Worcester, Mass., that was finer than any human hair. We may mention here that to him belongs the credit of first drawing piano-forte wire in this country, and previous to his death he brought the work up to such perfection, that instead of importing, the wire was exported, and its quality was acknowledged to be superior to the best English or German manufacture. The condition of temper, or rather hardness, is governed by the number of times the drawing takes place without annealing; the wire used for clock springs in the ordinary Yankee clock is thus hardened, and its elasticity given to it. Continuous rolling affects metal in the same way, though not so rapidly as the wire process. The temper that is found in the ordinary hair spring wire is got by drawing and the flattening between rollers, so that the particles of the metal must be in a very different state of aggregation from what they are when the wire is simply drawn; and, though it may seem a slight matter, the condition is of great importance. We remember years ago, in trying to draw hair spring wire, we failed time after time in getting a continuous draw; the wire would break. The apparatus we used consisted of two drums, between which was placed the draw-plate, the holes of which were made in sapphire. Anneal as often as we would, and polish by means of a cork with rouge, to prevent excessive friction, we failed. It was merely from a want of consideration of the state of the atoms that we failed; the machine was so constructed that the drums could be changed on each other's spindle, so that after one drawing they could be reversed, and the wire run through the next sized hole. And this apparently simple arrangement was just the thing that foiled us, for in using it as it was intended to be used, the wire was drawn from each end, which should not be done; the wire should be reeled off after each draw, and the original end used.

This little fact having been discovered, there was no longer any difficulty in drawing wire without breaking, and of any length required. This wire was drawn from Stubb's steel, and the size was two and a half degrees on the standard gauge with the $\frac{1}{2500}$ of an inch to the degree; it was afterwards flattened between two rolls, the faces of which were only three sixteenths of an inch, while the diameter was four inches. The faces of the rolls were polished as finely as any steel work in a watch or chronometer, and the wire when rolled presented the same surface.

The repairer who is located at a distance from any material market, will thank us, perhaps, for the few suggestions we are about to make on the use of the draw-plate. It often happens that the workman wants a piece of hollow wire. Without the plate, he is compelled to roll up a piece of plate or sheet-metal, and then solder the joint; the size may be just what he wants, but in nine cases out of ten the hole will be too small, and will need broaching out to get the size.

The desired work can be done much better with the draw-plate. A piece of wire is selected, of just the required size; the sheet metal is then cut in strips, the width of which is such that on being bent around the standard the two edges shall just meet. The strip is cut with a slight taper at one end, and the edge bent up enough to enable the end to pass through; if now, with the plyers it is drawn through the hole, the edge will be turned up; taking a smaller size in regular gradation, there will be formed a tube, the outside diameter of which may be too great from the thickness of the metal. If, now, the same piece of wire used originally as a gauge is put into the tube the process can be repeated until the requisite thickness of hollow wire is achieved. Although the description is long, the process is so short that one is astonished at the facility with which metal can be flowed. If the joint has been soldered when the edges first meet, it will be necessary to oil the wire used as a mandrel, in order to enable it to be withdrawn when the hollow wire has been brought to the required diameter—outside, of course; the inside diameter will be the size of the wire used for the mandrel.

When, by this process, the edges of the plate have been turned over the wire so as to come in perfect contact, the soldering of the joint is an easy matter. We have taken about four inches of the sheet metal, drawn it up until the edges met, when it would, perhaps, be four and a half long; the force applied had so closely joined the edges that a very small amount of solder was required. All the care we took in flowing the solder (silver) was to have the heat uniform over the whole of the tube, and we were enabled, by careful annealing, to draw a very thin tube to the full length of a Stubb's wire, one foot; but for jewelry repairing, the joint can be closed at the time the repair work is done. For instance, a joint of a watch case is required; a piece of the hollow wire is cut off, and the proper length having been made, the joint side being laid in contact with the case, the solder not only flows to the case, but it takes the joint off the wire as well. For the repair of jewelry the draw-plate is invaluable, as the smaller or larger sizes of pin joints are sometimes longer than the joints furnished by the material dealer. In such a case a bit of hollow wire that can be cut off to any length comes in very acceptably; and not only that, but the size can be reduced at any time by using a smaller mandrel and repeated drawings.

Answers to Correspondents.

M. L., *N. Y. City*.—There can be no doubt that the fork may become strongly magnetic, and in a very fine watch this force would influence the rate in position when the watch is lying on its back or face; for if the fork end takes northern polarity, the staff end will necessarily assume southern; and if the position of the watch should be such that the fork is due east and west, the tendency of the extraneous force due to the magnetic attraction will be to add an increased power to *one side* of the escapement, and diminish the impulse on the other. The effect will be greater when the fork happens to come in such a position that the two poles are reversed in relation to the earth's magnetism. In this case, the tendency of the fork will be to reverse itself in order to bring the poles in accordance with the magnetic meridian. Why the trade persists in the use of a material so liable to a grave error, and at the same time is the most difficult to work, is one of those mysteries of prejudice that can be accounted for only on the basis that bad habits are not easily got rid of. The aluminum bronze (copper 90 and aluminum 10) offers every advantage and quality possessed by the steel, with none of the disqualifications pertaining to that metal. Its strength is equal to the steel, while its specific gravity is 0.2 less. It takes a high polish and is not more readily tarnished than polished steel. These qualities point out the alloy to be the metal used for forks, especially when we consider its entire freedom from magnetism.

J. E. R., *Vt.*—How the Swiss color their watch hands so exquisitely may be inferred from the following considerations. The hands are rarely over eight carat gold, and the large amount of alloy allows the chemical action of sulphurous acid, and a richly colored sulphuret of copper will be the result. Some thirteen years ago a fire occurred in a store in Maiden Lane on the morning of the fourth of July. As is usual, the store had been made the depot for some manufacturer of pyrotechnics, and by some means or other the store went up like a sky rocket. Unfortunately, Mr. Saltzman, an importer of watches, ran to the back of the store to shut up his safe, but lost his life, though he succeeded in closing the safe. After the debris, resulting, had been removed, and the safe opened, it was found that a very singular effect had been produced on the gold balances of all the Swiss watches, the color being changed to the most beautiful purple; and this was permanent. From this incident we have always sincerely believed that the same color was produced on hands by some sulphurizing process, and we were afterward confirmed in our opinion by trying the experiment on hands we had polished and then colored by exposing them to the fumes of sulphur and saltpetre.

W. T. W., *Enterprise, Miss.*—If you are not in too much of a hurry for a Lathe, we should like you to wait for a few days for our opinion. Mr. Waaser, of the firm of Waaser & Lissauer, is now in Europe, where he has gone for the express purpose of getting everything of the most improved construction in the way of watch tools. He will also make arrangements for the manufacture of some small tools of his own invention.

E. L. M., *O.*—There is a chuck made in this city for ornamental turning; any design may be obtained, and the work is purely geometrical, but produced by the motion of the auxiliary face plate, while the rest and mandrel retain their respective positions. If you will refer to the article on Engraving, in the present number, you will find that a rose engine is of some value. We doubt whether it would be worth while to get one for the single purpose you propose. If you will write again, stating just what you want, we will make the necessary inquiries, and inform you by letter. Be definite, however, in your directions; for we would not like to make a fiasco in the execution of an order for a subscriber.

H. C. P., *Mich.*—The fault you complain of was not caused by the artist, but by the engraver, who *traced* the lines instead of making a transfer; the consequence was a reversal. The fact was not discovered in reading the proof, for the cut was not before us. We would have had a new engraving made, if, unfortunately, the whole impression had not been run off before the fiasco was noticed. The wood-cut went from the engraver to the printer, and there put in the form *after* the proof of the letter-press had been made. The reader will notice that in the communication of H. C. P., in the February number, the lines of the engraving are reversed—the right hand lines being on the left and *vice versa.* So far as the correction is made of the sidereal day, reckoned by mean solar time, we merely gave in round numbers a day of twenty-four hours; and for the purpose of transits the time or longitude of the vertical elongation of Polaris would make but little difference whether the day was 23h. 56m. 4s. or 24h.; for if you can get the moment of elongation you have a guide for the establishment of a meridian line; for whether the star be 1° 24′ or less to the true polar axis, there must be some point where the elongation is in line with the meridian irrespective of time or distance. Were we writing a work on Astronomy we should endeavor to be more exact, but for our present purpose the round numbers we give are sufficient.

W. C. D., *Ala.*—Your inquiries are such as to cover a large extent of subject. For *British Horological Journal*, address J. Herrman, 21 Northampton Square, E. C., London. So far as the matter of the color for Etruscan work, we will give the modern practice; of course the work is made in the same way as any other jewelry, the gold being generally about sixteen carats. Now, the coloring by the old process was based on the fact of extracting the alloy from the surface, and thus leaving the pure gold of, say, twenty-three carats, for the surface; this would give the deep color required. The operation was troublesome, and has been entirely superseded by the use of the battery, which, with skilful management, deposits the gold at twenty-four carats with a much higher color and much more easily obtained. The next number will have an article clearly showing the whole process, and therefore we will not go into the matter in detail, as the next article on electro-metallurgy will be all that our correspondent requires.

H. O., Jr., *Conn* —Your query as to wood engraving, or rather as to a work on the subject, was the suggestion that started the article on Engraving in the present number. We thank you for the subject, and in return will state that there is a little work by Miss S. E.

Fuller, published in Boston in 1867, that, so far as practical information is concerned, is just the thing you are desirous of obtaining. The lady is a practical workwoman, and has a love for her art that places her above the mere humdrum of a mechanical occupation. In the little work (only forty-eight pages) she has, in the most lucid, but condensed manner given a "manual of instruction" that puts to the blush very many more elaborate works, and, what was is more, the author illustrated the work, and the cuts are a good evidence that a full knowledge of the art was absolutely necessary to produce the work.

The work can be obtained by addressing S. E Fuller, 35 & 37 Park Place, New York. Price 50 cents.

E. A., *N. Y.*—Malachite is the green carbonate of copper in the conglomerate state. Its history is very simple. It is found in the Ural mountains in Russia, but we have seen in a lapidary's establishment some from Africa that vied with the very best specimens of the Russian yield. It occasionally occurs, in very large masses, and these are sawed up to make veneers; and at the Exhibition in London, in 1851, a Russian nobleman exhibited a pair of doors veneered with the malachite that cost about twelve thousand dollars. The working of the material is about the same as the processes used for carnelian. There will occur, however, once in a while, a piece of quartz that somewhat interferes with the operation, and may totally defeat the best efforts of the lapidary.

AMERICAN

Horological Journal.

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⁎ *Address all communications for* Horological Journal *to* G. B. Miller, *P. O. Box* 6715, *New York City.*

Astronomy in its Relations to Horology.

NUMBER TEN.

We feel that we have hardly been definite enough in our description of the transit; it is certain that, if well understood, many would avail themselves of its use for the verification of their clocks, and we therefore offer no apologies for giving a more minute description of the instrument, together with the manner of using it. It must be recollected that if the instrument does not revolve in a true vertical plane, no good result can be obtained with any instrument, however finely it may be constructed.

It must be understood that a perfect adjustment is required both as to the azimuth error as well as the level; that is, its perfectly horizontal position. These points are absolutely required, and without the proper adjustment no one need expect an approximative result to truth. We will, then, go into the subject of adjustment more thoroughly than we have done, and also recall the attention of our readers to the line of the meridian and the means of getting it. In selecting the instrument, it is necessary to first ascertain that it affords distinctness of vision. The system of wires or spider lines must be in the common focus of the object and eye-glass; and we will first state that the horizontal wire must be perfectly level, for the distance of the fixed stars is so great that their motion appears as if it was in a straight line. As will be seen subsequently, this observation does not apply to the pole star, for here the distance has but little effect, while the angular motion is equal to $\frac{60^{\circ}}{24h.}$, that is just 15° to the hour; consequently the upper and lower culminations of Polaris will take place in intervals of exactly twelve hours.

When the instrument is (we refer, of course, to the transit) set up, its telescope should point as nearly north and south as possibly can be attained by approximation; when the instrument is directed to the horizon, more than this cannot be done until the other adjustments are perfected, and we must remind our readers that in any astronomical observation, the closest approximation is required, though no one expects to attain perfection. For instance, no two observers can see or take the time of the passage of a star at equal times; and that this fault is not due to carelessness, we will give the table of personal equation of several of the most eminent observers in Europe and the United States.

In 1843, Dr. Peterson, at Altona, and M. O. Struve, of the Pulkova Observatory, found that from a series of observations, while the former observed a star say at $7^s.195$ the latter would record the same transit at $7^s.581$, showing a difference in the personal equation of $0^s.203$.

Peterson & Sablen	$0^s.324$
Henderson & Wallace	0.42
Morton & Rogerson, Greenwich Obs	0.68
Messrs Bond, Cambridge	0.31
Prof. Keith & Lieut. Almy, Washington	0.36

We must in all these cases presuppose that the best effort of each observer had been obtained, and yet we cannot rely on the same observer; for M. Bessel, from the comparison of numerous observations, concludes that there was no difference in the personal equation between himself and Struve in 1814, and yet in seven years later, 1821, Struve observed transits $0^s.8$ later than he did, and two years after, the difference amounted to an entire second. Bessel found that he was $0^s.49$ later in taking transits with a chronometer beating half seconds than when he employed a clock beating seconds. Query—would he have done better to have taken a two seconds pendulum?

This is, however, immaterial to the general observer, for he can correct his own personal equation, and will fall in no error, for his observations will be equal on the average. We must, however, consider the fact that the two axes must be equal; for if they are not, the plane of the vertical revolution will not be true. This is totally independent of the true level; for if the axes are equal, the vertical plane of revolution would not be true if the Vs are not perfectly in the horizontal plane, and it becomes necessary then to make the striding level perfect.

We should call attention to the fact that the system of wires or spider lines should be in the common focus of the object-glass and eye-glass. Any error can then be detected by directing the line of the optical axis to some distant object and moving the eye a little to the right or left. If on so doing the object appears to move over the lines, the diaphragm should be adjusted to the optical axis, and this is the adjustment for parallax. Still, it is necessary to test the instrument for the horizontal wire, and this may be done by observing a star pass along the horizontal wire. If the eye is now moved up or down, it will be found, if the instrument is out of adjustment, that the star will cease to be bisected by the wire through its whole length.

In this case it may be assumed that the adjustment for parallax is incomplete. We mention all this, for if the preliminary adjustments are not correct, no true meridian can be got. Thus, suppose the horizontal axis to be out of truth, the revolution of the telescope would define a plane not at all corresponding to the plane of the meridian; hence each star observed will be to the east or west, as the case may be. Suppose, for instance, that the west end of the axis is not in the same horizontal plane with the east; if we reverse the instrument on its bearings, the error will be twice the amount, for the vertical plane of rotation would be just the reverse of the first, and therefore the error would be double. To correct this error has been the great object of all time takers—that is, observers of the passage of a celestial body over the meridian. With every instrument there is a striding level provided, and this being ascertained to be true, the real horizontal error of the axis may be found, provided the instrument is reversed and the error detected. Again, the striding level should have its axes exactly parallel to the horizontal axis of the instrument, and we will show how any error in that way may be detected. If, with the telescope turned as low as possible to the horizon, we set the level on the pivots or axes, we note the position of the bubble in the level with the end on the western pivot, and the reverse. Now it is evident that the error of level alone must be one-half the difference of the variation in the bubble in the level. The reversal of both the axes and the level must be continued until the bubble is stationary at any point. It may occur, as it frequently does, that the axes are not truly cylindrical; to test this, the instrument should be pointed as low down to the horizon as possible, and on revolving the telescope on its axis, there may be found a difference in the level, as may well be conceived. Such an error, if it exists, is hardly remedial, though patience and constant observation may enable one to make a table for corrections.

This degree of accuracy is absolutely required if a very close approximation to time is desired. Another point is the perpendicularity of the central wire, and consequently of all. Now it makes no difference if the instrument be perfectly horizontal, if the centre wire is not at right angles to the axis of rotation in the vertical plane. A star, though bisected at the centre of the wire, would be either east or west if the eye is up and down on the line of sight. Having the instrument as nearly horizontal as possible, if the star cannot be kept on the wire in the perpendicular, the diaphragm must be rotated on its axis, so that when the instrument is reversed the star shall be bisected at the extremes of the field of view. As the horizontal line is at right angles to the transit, the whole system will be true when the perpendicular is true. We have to take into consideration the line of collimation and its adjustment, for here is a very important source of error.

In every lens there is what is well called an optical axis, and this is the straight line that passes through the centres of the spherical surfaces of the lens. Now, it is all-important that the instrument should be so constructed that the same straight line that forms the optical axis of the object-glass shall, on prolongation, form the optical axis of the eye-glass; and it is in this line that the centre spider line should fall, and this is called the line of collimation. Not only must it take in the centre wire, but must be on the horizontal as well; and if the instrument is reversed the amount of error will be double, and the adjustment must be made in the same proportion. Now, all this takes time, and no one can expect to achieve a good result, without a vast deal of patience. As in all instruments, there will be an azimuthal error, however firm the base may be placed; there is a screw provided for the correction of this error, and is called the azimuth screw.

Supposing we have adjusted the instrument to the horizontal and perpendicular, we now must get the line of collimation as nearly as possible in the line of the meridian. Here comes up a difficulty; for very few will take the trouble to understand thoroughly the position of the object of observation, and, unless this position is well determined, there can be no certainty of a good result. The principal line of sight, or, in other words, the line of collimation, is the ray of light that passes through the centre of the object-glass, and touches the centre perpendicular wire at its intersection with the horizontal wire; if now the instrument should be revolved on its axis, the object selected should remain steadily bisected; if the axes are reversed, the adjustment for collimation will be perfect if the same object is truly bisected. This will be well understood if we take a circle and draw a line across it; if the line does not fall exactly in the centre on reversing the circle, it will follow that just double the error will be found.

To determine whether the line of collimation is right, we take some small but well defined and distant object, and bisect it with the middle wire. Now the telescope is to be raised from its supports and reversed, pointing the tube to the same object; if the line of collimation is correct the object will be bisected the same as in the first position; if not, the diaphragm is to be carefully moved half the distance, and the tube is again to be reversed. By continued observations the adjustment may be made complete. The next step is to adjust for position in meridian; and here we will state that one of the Vs is movable by means of what is called the azimuth screw, and we can do no better than to give Prof. Loomis' directions to effect the attainment of the meridian:

"POSITION IN THE MERIDIAN.

"This adjustment is effected with the assistance of a clock, which, for convenience, should be regulated to sidereal time, so that the time of each star's passing the meridian will be indicated by its right ascension.

"*By the pole star.*

"Direct the telescope to the pole star at the instant of its crossing the meridian, as near as the time can be ascertained. The transit will then be nearly in the plane of the meridian. Having levelled the axis, turn the telescope to a star about to cross the meridian, near the zenith. Since every vertical circle intersects the meridian at the zenith, a zenith star will cross the field of the telescope at the same time, whether the plane of the transit coincide with the meridian or not. At the moment the star crosses the central wire, set the clock to its right ascension, as given by the catalogue, and the clock will henceforth indicate nearly sidereal time. The approximate times of the upper and lower culmination of the pole star are then known. Observe the pole star at one of its culminations, following its motion until the clock indicates its right ascension, or its right ascension plus 12 hours. Move the whole frame of the transit, so that the central wire shall coincide nearly with the star, and complete the adjustment by means of the azimuth screw. The central wire will now coincide almost precisely with the meridian of the place.

"The axis being supposed perfectly horizontal, if the middle wire of the telescope is exactly in the meridian, it will bisect the circle which the pole star describes, in 24 sidereal hours, round the polar point. If, then, the interval between the upper and lower culminations is exactly equal to the interval between the lower and upper, the adjustment is complete. But if the time elapsed while the star is traversing the eastern semicircle is greater than that of traversing the western, the plane in which the telescope moves is westward of the true meridian on the north horizon; and *vice versa*, if the western interval is greatest. This error must be corrected by turning the azimuth screw."

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Manufacture of the American Watch at Waltham.

NUMBER ONE.

We purpose to describe the mode of manfacture, together with a general description of the tools and appliances used in the making of the American watch, an article which has achieved a universal reputation for quality. The watch manufacture in the United States has, within twenty years, become a very important source of wealth; but it has done the country an immense benefit, inasmuch as the peculiar circumstances surrounding the new interest have brought out a degree of mechanical skill and inventive power that is not equalled in the world beside. It must be remembered that the whole of the workmen had to be educated up to a certain point, while the teachers were compelled to educate themselves. The obstacles to success were formidable, and it will be seen as we progress, that ingenuity, patience, and faith in the ultimate result were absolutely necessary to insure success.

The first step, it is obvious, was the determination of the form, size, and style of the watch which it was the intention to make. If the watch was to be made economically, it will strike the reader at once that equality of size was of the highest importance; for if the tools were made to take in different sizes, the number would be enormous. The first thing, then, was to prepare or make a watch by hand that was to be the pattern for future reference both for form and size. A series of punches were next in order, as the blanks can be made more nearly equal by the punching process than by any other means. Coin is a good illustration, though the blank goes through the two subsequent operations of swedging and milling the edge. The piece of coin thus stamped is not only equal in size to all the others, but is equal in weight, within a small fraction of a grain. In the Mint this is achieved by the following processes; and as accuracy is the fundamental principle of the American watch, we do not hesitate to describe them.

A certain amount of the metal to be coined is melted down with the required amount of alloy; if, on assay of the ingot, the metal comes up to the standard fineness, the ingot is rolled into strips wide enough for the blank, allowing only a slight margin for scrap. Although rolled in the most accurate rolls that can be made, the strip is not of equal thickness through its whole extent, for the rolls are not perfectly round, and the bearings are subject to the same fault. If the strip, as it comes from the rolls, was subjected to the punching process, the blanks, although of the same size, would not be equal in weight. It is plain, then, that to insure the highest perfection in equality of thickness, some plan should be adopted by which the surfaces of reduction should be absolute in distance, whatever the strain. The plan adopted by the English Mint was successful; it was simply that after the strip had been rolled it should be *drawn* through the space left by the distance between two fixed surfaces that, so far as practicable, should be constant. The director of the Mint devised the plan of using two pieces of agate, or other hard stone, set in steel, which were made so that the rounded surfaces did not describe the segment of a true circle. The theory there was, that if the two agates or other stones had been set to the *true* thickness, the strip, when drawn, would not only be of equal thickness, but density. The plan was followed, and the result was, that the thickness could be equalized to an extent that is marvellous.

This extreme accuracy is not required in the watch manufactory, for in the subsequent operations the thickness has to be reduced to gauge in the lathe. But the punches used in the watch factories are more delicate, and, with the exception of the sunk die, more expensive. These punches vary with the work they are intended to perform; as used for watch work we may class them first as the through die cutting out a blank, which is the object we seek in the punching, and which may be the subject of repeated punchings, as will be seen subsequently. The second class may be denominated a draw punch, for the blanks made by the punch are but scrap, while the punch takes up the very article that is required. Again another punch is made that draws the metal, as will be seen in the case of dial coppers.

Commencing at the first stage of the watch, we find the punch simply and a through die. The stock having been selected with reference to the quality of the metal and gauge of thickness, the sheet is cut up into strips that, while allowing the full blank, leave the very least amount of scrap. The punch for the pillar plate is simply a cylinder of steel with the end at a perfect right angle to the line of the sides; the die is a piece of steel sufficiently thick to stand the strain, with a round hole slightly larger at the back than at the face, so that the blanks or punchings will clear easily.

The die is placed loose on the bed of the punching press and the punch itself fitted firmly in the plunger of the press; the punch is now brought carefully down and entered slightly into the die, and while in this condition the die is firmly fastened to the press; all this must be done with the greatest care, for if the cutting edges are not exactly opposite, the operator runs the risk of breaking down the die. Suppose everything to be right, the punch must be adjusted for height, which is effected by raising the plunger so far that at its lowest point of downward motion the punch is just level with the face of the die. It is customary for the operator to ascertain the relative positions by placing a piece of tissue paper between the tools and then allowing the plunger to take its greatest motion.

This class of punch and die is used not only for the plates, but for the bridges, cocks, potance, the copper blanks for the dials, and the blanks for the whole train, including the barrel. There is but little risk in breaking the punch or die if properly set, and the thickness of the stock proportioned to the strength.

The dial copper has to go through three different processes; the blank is simply a round disk, but it is necessary to punch the centre and seconds hole. The disk in this condition would not hold the enamel, and therefore the edges must be turned up to such a height that will take in the required thickness of enamel; and it is done on the press, but with a punch and die of another kind. The die is turned out with a level face just deep enough, and the punch is turned down two thicknesses of the copper smaller in diameter than the die, which is smaller than the blank. If, now, the tools are placed in proper position and a blank laid on the face of the die, the punch on descending will force only a portion of the copper into the die, and the edges of the copper will be turned up in the space between the punch and die. But as simple as the matter seems, there comes up the the trouble of so placing the blanks that the turned up edge shall be exactly equal at every point of the circumference.

This renders a guide necessary, and this guide is made from a piece of sheet metal that has been punched through by the same tools that are used for the copper. This guide is now screwed on to the face of the die with the edges of the hole exactly concentric with the die.

The process of punching that has been described merely comprises the two forms of a through die and a swedge. The form of the articles requires, however, something that a subsequent process has to be gone through. Suppose we should first punch out a blank, as in the case of the dial copper, we may have subsequent operations to perform on the blank. But before we treat of this we should mention that the punch has wonderfully extended the mechanical appliances that to cite would be too numerous, but we will take the manufacture of guns and pistols, or rather the different parts which are first swedged, and the "fadge" that is so formed is taken off by means of a through die and punch, and implies two punchings. Another form of the punch will be seen in the dial copper for the dial, but perhaps the very highest point reached in the trade is where the crossings are made in the wheels of the train of the American watch.

If we assume that we wish six crossings or arms, the first punching will be perfect; the blank, having been first punched, is laid in the guide under the crossing punch; if the punch was to make but one crossing the next crossing would draw off the arm in such a manner that the arm would not be straight; it follows, then, that the whole number of crossings should be made at once, in order to preserve the equality of the spaces, the arms as well as the inside of the web, and it will subsequently seem that in the American system of cutting wheels this equality should be absolutely preserved. The die in itself is an elaborate piece of workmanship; in the first place the face of the die is divided equally into the required number of spaces, while the inside of the web is marked in the lathe when the outside of the die is turned off, so that the web will be concentric with the outside circumference of the die.

The die maker then pierces the die by means of drills, and this has to be carefully done, as on the accuracy of the die depends all the subsequent truth of the operations. The die is carefully fitted to the model or the design drawn on its face. There are many difficulties now to be encountered; in the very outset the die maker may choose to use a large drill in order to get rid of as much of the stock as possible without injuring the edges that are to be left for cutting.

A better plan, however, is to drill a small hole so near the edge that while it leaves just enough stock to file away the cut part, it does not enter the lines drawn for the die. Now comes up the question, how shall we cut away the metal so that we shall not have to use a very small file for the extraction of the mass we wish to get rid of? The process is simple, though attended with some trouble; for instance, we select a twist drill of determinate dimensions, as compared with any specimen of Stubb's wire we choose to use, or the nature of the work demands. After drilling the first hole we select a stick of the soft wire, and taking it somewhat larger in diameter than the hole, we drive it in the drilled hole; the wire is now cut off, and the end remaining in the die is filed down to the general level of the face of the die. A new centre is now made for the drill-point, and that centre is so placed that the new hole shall take out a portion of the wire plug and a portion of the stock. Now it will be the object of the operator to put in the plugs, one after another, so hard, or rather so tight, that the greater part of any two plugs may be drilled out, and the stock may all be removed with but little filing after the drilling. It may, perhaps, seem that the method is tedious; but we can assure our readers that it is in the long run the most expeditious.

The slight corners left after the drilling are easily filed away. The vacant space through the die must not have parallel sides, as the waste punchings would be firmly held in the die, and consequently the back side of the die is a trifle larger than on the face. A great deal depends on the nature of the force applied to the punch. Thus, if a sharp sudden blow is given, the punch may be quite soft, as in the case of the drop, where the punch may be of brass, while the through die is required to be of steel, hardened and then tempered. In the case of the crossing die and punch, however, it will be seen that the blanks are not the objects sought; the round disk of metal that is to form the wheel is to be punched, we will say, with six spaces, or, as in the English watch, the scape-wheel may have but three.

The punch next comes into notice; and here is one of the finest pieces of mechanical work that can be conceived of, for not only must the outside of the punch be exactly a fit for the die, but the spaces that leave the arms must just as accurately fit the die. Again, the object we seek will be left on the punch, and some provision must be made for drawing it off. It is plain that if the draw-off presses only on the web the wheel would come off concave, as the arms and centre would hold in the punch while the web was forced down from the outside.

We will endeavor to give as intelligible a description as possible of this very fine product of human ingenuity, premising, however, that no wood painting can give a perfect idea the principle will be readily seen through, and we must leave it to our readers to work out the details. Taking a cylinder of steel, the workman turns it up to the exact size of the inside of the web that is to be on the wheel; a hole is now bored through the cylinder longitudinally, which is exactly the size of the hub or centre of the wheel. This tube, as it were, is counterbored from the back, and a centre is turned up to closely fit at the face end of the punch, as well as through the whole tube; the body of the punch is now slotted to allow of the motion of a pin in a longitudinal direction. On the outside of the punch a sleeve is fitted as closely as possible, and yet leave perfect freedom of action. When the parts are ready to go to action a hole is drilled through the sleeve at the central point of the slot; this hole is also passed through the inside spindle, and a pin is driven through both. It is evident that the two are firmly fastened together, and yet are capable of an end-long motion, irrespective of the punch itself; the faces of the sleeve and the inside spindle are made perfectly even with the face of the punch, and a spiral spring is so arranged that the three surfaces shall always be equal, except when the punch is in action.

The end of the punch is now to be so cut away that the arms may be left on the die; this is effected by sawing a short distance into the punch with a milling tool, and then finishing up by the file until the approximation is close enough to enable the operator to shave the punch in the die. This has to be very close work, for if the punch is too large, a great risk is run that the die breaks down in the shaving; for the die has been hardened and tempered previously. The punch is but slightly entered into the die, the object being to merely mark the punch, and then finish the back with the file or drifting tool, as the circumstance of the case may require. As the wheel is to be drawn off the punch, the depth of the cut for the arms may be only a trifle greater than the thickness of the stock to be punched.

After all the parts have been fitted and tempered the punch is placed in a permanent frame. We now will explain the action, supposing the three surfaces to be level; the die having a guide, a blank disk of metal, of the size of the wheel it is intended for, is placed in the guide; the three surfaces will come on the blank at the same instant, but the centre-pin and the outside sleeve are free to move, while the punch itself has a positive motion that leaves the two attachments resting on the surface of the stock the punch takes out the crossings. Now the punch has evidently gone through the stock, but the spiral spring has yielded to just that thickness. When the punch is drawn back, the sleeve and centre-piece being firmly united, the spring throws off the wheel both by the centre and outside. The arms are rarely bent, and the blank wheel comes out of the press (punched) ready to be stoned down on the sides, and sent to the cutting engine. These punches and dies are the most conplicated that are used in the watch manufacture; but in the ordinary toy business, or the kerosene lamp, there are punches used much more elaborate in construction, though in accuracy not at all equal to the crossing punch of the watch factory.

There is another form of punching where the blanks are first punched through, and then are used to make up forms. We allude particularly to the formation of the Adelaide chain, which is made entirely without solder, and the link is formed by the punch; in this case the blank is cut out with four projections from the centre, each projection having at its end a counterpart of the quarter of the centre cut. Now it is evident that if the thin piece of gold or plated metal were placed on a die that is made to receive the centre, and yet allow for double the thickness of the metal, and then a centre should be pressed downward into the hole, the arms, or rather projections will be bent up at right angles to the centre; the punch is so adjusted that when at the lowest point the metal is forced into the die only its own thickness. The projections now serve as a guide for the next link, which is placed at the quarters, and then an outside spindle, with a concave face, takes in the ends and forces them to the centre the next action of the centre will take the ends, force them down to the centre, and at the same time double up the new link ready to take another. As a specimen of ingenious interlocking, the Adelaide chain is hardly surpassed.

Watch Repairing.

NUMBER FIVE.

We, in speaking to the apprentice, will endeavor to be as explicit as possible, and can only urge upon him the necessity there is for his using his own reasoning powers; true it is that a mechanical fact cannot be altered by any amount of logic, but we wish to urge the beginner to reason on the application of any well developed and ascertained mechanical fact. And as we are writing for those just starting to learn the watch-repairing trade, we shall not make any apologies for going into detail.

Suppose, for instance, we have so far progressed that we are enabled to get a fine polish on brass; our very next effort should be to try our skill on the steel works. The method of this may be varied according to the circumstances; the surface having something to do with the way by which the finish is effected. In the first place, a few strips of bell metal (copper and tin) are really useful, though not indispensable. If a perfect dead flat is to be attained, such as the click, or the strap over the ratchet in a Swiss watch, the strip of bell metal should be wide enough to allow of motion in every direction, and the surface must be roughened by a file—the file marks to be at right angles to the length; or the surface may be made by circular strokes of the file; while this last will not grind down very rapidly, it enables the operator to get a much truer result and finer finish, and we may state that very rapid grinding is always more liable to destroy the truth of the surface than a medium rate; though this must be taken with some grains of allowance, for long continued abrasion will be worse than a quicker process.

The surface of the polisher should be made as truly flat as possible (these metal polishers are sold by all the material dealers, and can be got of almost any size or shape). The case becomes different when a hollow conical or spherical concave surface is to be operated on. Here the lathe is an all-important tool, for the work may be set up on the chuck and leave the surface perfectly free to be acted on. Thus, suppose we need to repolish the concave surface of the steel disk that usually is on the fuzee arbor, we may chuck the work, either by the centre or outside; if we now take a piece of the bell-metal, and round up the end to about the convex required to fit the concave, we may in a very few moments get a polish equal to the original. It does not require that the bell-metal should be absolutely necessary, for a small cylinder of type metal may be used; and we would here state that the cylinder should be short, so that the vibratory motion may be more easily obtained. If now we have chucked the piece, we first use the rounded end, with a little oil-stone powder and oil, the process being precisely that of polishing the concave of a jewel; the same motions of the polisher must be made, and from the getting of the first surface the abrasive powders used must be increased in fineness until the final polish is achieved.

The lathe here gives the workman the additional advantage that he can polish up the outside as well without removing the work from the chuck. The same means cannot be used when a bevelled surface is to be polished, for the reason that if a cone were used the result would be to create rings on the surface; so it is necessary to use a polisher on the same principle of the opener in jewelling. The polisher may be of composition, or even, if the steel is well-tempered, a piece of soft iron may be used for the grinder, and type metal or lead for the polishers. In all cases the primary surface is got by the use of either oil-stone powder or diamantine; and in using the latter, if the operator would float it off the same as diamond powder, he could succeed in getting a very good final polish. The outside edges are finished in the same manner, the grinders and polishers being formed into the shapes best suited for the work.

All this relates entirely to finishing of surfaces; and where the steel work of a movement has become dull and rusted, the repairer can not gain a better reputation for thorough and careful work, than by restoring the surfaces and skilfully bluing whatever requires color. Although this course would consume time, it will amply repay in the end. We mentioned on Watch Repairing in article Number Three, a mode of spreading the web of a wheel; since then we have seen a tool that is designed expressly for this purpose, and a description of it will not be out of place, as the tool is a perfect success. Imagine a common depthing tool with one of the heads made large enough to take in a small stake, the other head on the same side being fitted for any punch or spreading tool; the other side of the tool is fitted with the ordinary two centres that take in the wheel on its pinion. The use is simple; the wheel is swung between the centres and brought down so that the web may rest firmly on the stake; by the use of the opening screw the centre of the web may be brought directly under the punch. Now, by turning the wheel around with the punch for the index, or another centre in its place, the exact spot where the spread should be made can be perfectly defined. There is a flange at the bottom of the head that holds the die or stake that can be held in the vice, and the stake thus becomes solid. Altogether the tool is one that we should strive to get were we at the bench.

We do not suppose that any difficulty would be met with in converting it into a staking tool, the only change to be made being to remove the stake and furnish dies with hollow punches; and the assortment might run through a large range, for the hollow punches might be made from Stubb's wire of just or very nearly the size of the hole in the head opposite to the die. There would be but little trouble, as the holes in the heads are in the same straight line. The value of the instrument is great, for the workman can ascertain the faults of the wheel while he can bring the part to be spread absolutely true under the punch. We have taken some little space to give an idea of the tool, for we think it the most complete one we ever saw.

Another important point in watch-repairing is to ascertain that the pivots are sufficiently well polished, and, what is of equal importance, that they are round. There is a style of polishing the pivots by means of a burnish file; this cannot be too severely condemned, for the burnisher will not leave the pivot round, as the pressure will not be equal at all points of the revolution when the pivot is turned with a bow; again this burnish file does not leave the shoulder of the staff or pinion in a fit condition to meet the amount of friction, however slight, that will occur when the shoulder rests against the jewel or plate. It can easily be seen that the edge of the file must have a shaving effect on the shoulder unless the corner of the file were rounded off; and this would leave the shoulder of a curved form that in the ordinary pivot is still worse, for if the side shake for the pivot is correct when the end shake is equally divided, it will not be correct should the shoulder be forced by any means up to the hole.

Now it may perhaps be well to make the remark that the jewel holes are not in all cases round; indeed, if one is found that is round it is the exception, except in very small holes. If, then, the pivot is not round and the side shake very close, the merest tyro will at once perceive that there must be times when the pivot will find the low spots in the hole. For instance, if a triangular taper file were introduced into a hole that was truly round, the file would turn with the same ease as a perfect cylinder; but if the hole is not true, the corners of the file, as it is pressed into the hole, will take the hollow spots and thus prevent rotation. This want of truth in both the hole and pivot is of more detriment to the good going of the watch than friction; for as the pivot is in almost every case taper, the end being the smallest, any alteration then in the end shake will cause the pivot to enter deeper into the hole, and the same results follow as in the illustration we gave of the taper file.

It is for these reasons that a conical pivot, jewelled on ends, is so very much superior, for it is evident that all the friction that exists is due only to the end of the pivot and the small arc it touches on the side of the hole. It was a great improvement in the American manufacture of watches, and we are pleased to find that the United States Watch Company has introduced, as a *sine qua non,* that the whole escapement shall be jewelled on ends with conical pivots, as there can be no doubt of its advantage; and we will try to show why the conical pivot is so much better, and then will proceed with our remarks on polishing pivots, together with the faces of the pinions.

The pivot is first turned down to a size that will allow the subsequent operations to reduce it to a proper degree of side shake in the hole. If the "turns," as the English watchmaker calls them, are used, the dead centres give a degree of truth, not so exactly attainable where a live spindle is used; though even here a very true pivot may be turned up if sufficient care is taken to make the back centre perfectly true; and the only imperfection that can arise will be due to the slight inaccuracies of the live spindle. A very neat and true arrangement for the purpose is shown in Saunier's great work on Horology. The live spindle is driven with a bow; on the lathe bed a right angular piece is so attached that by loosening the hold-down screw, it can be placed at any distance from the chuck. This right angle may be bored out so large in the line of the centres that bushings may be put in and fastened by means of screws, and may be drilled to any size; and as they must be very thin in order to let the pivot project, they are counter-sunk on the back side. This counter-sink only takes the bevel, or rather chamfer of the pivot shoulder, and it follows then that the rest may be brought up to the work and the pivot turned to the desired size and polished both on the sides and end without removing the work.

It is plain that the pivot turned up and polished must be true; but we must account for the other centre that has got to be or ought to be true when finished in the same straight line with the axis of the first pivot. We will assume that the back or centre rest has been removed from the lathe bed and the rest brought up to a chuck, in the face of which a female centre is sunk as truly as possible; a dog is screwed on the chuck, the end of which may take in the leaf of the pinion or tooth of the wheel. The centre rest is then brought up, and it is evident that a pinion or staff having been placed in the centre made in the chuck and the hole in the centre rest, the common hand rest may be used for the turning down the size, and then the polishing may be perfected. We would refer to the articles on the Lathe to explain the process by which the pump centre is used, and need not dwell on it, as the tool is intended for a specialty, and therefore not adapted to the requirements of the general repairer.

Isochronism.

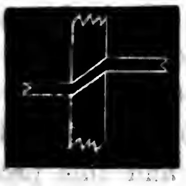
The true meaning of the term that is so glibly used by those who do not understand its first principles, we will endeavor to explain. Now, isochronism is not at all a question of adjustment for temperature or time in position, as its only application is to produce just what the name implies, "equal times," and refers simply to the fact that a spring can be made that shall control a balance, although the arcs of vibration of the balance may vary within certain limits, without making any change in the time of vibration, though short or long. Thus, to explain the matter in a familiar way, suppose we should take a plain balance, with the ordinary flat spring; it is evident that if the turn of the balance was always exactly equal, the spring would always be equal in the extent of its openings; in this case we have the spring coiled and the centre curve attached to the collet on the arbor, while the other end of the spring is made fast in the hair-spring stud.

Supposing the balance to have a certainty of extent in vibration, this spring will answer all the purposes of isochronism, provided the conditions were fully carried out; but if we take a chronometer balance with a plain spring, the conditions are altogether different. The balance is not at all times of the same dimensions, for by the centrifugal force causing the cut rim to open, the next vibration will not be in proportion to the spring, that is, so far as isochronism is concerned; for if the rim, under the increased vibration, enlarges its diameter, the control of the spring over the vibration is lessened. Again, the curvature of the spring and the full number of coils will have a very material effect on the isochronism of the spring. It would be very simple to isochronize the spring to an uncut balance, though the compensation for temperature could not be effected; and perhaps this gives a better idea that isochronism is independent of all other adjustments, either for position or temperature.

If we could make a spring in the form of a perfect sphere, and the ends could be attached exactly in the centre of motion, nothing more would be required, and the spring would be isochronal for a wide range of variation in the angular motion of the balance. But even under such circumstances, the power must be constant, and the side shakes of the pivots of the escapement must be finely adjusted, and any change in the relative proportions would destroy the isochronism. Again there comes in another series of difficulties that go far to disappoint the workman. First the metal of the spring may not be of homogeneous character, and although the wire is drawn from the same steel, it will be found that in some of the curves the vibration, or rather openings of the spring, a rigid spot will cause a distortion, and, consequently, there can be no isochronism. Secondly, even if the spring be homogeneous, it changes its molecular condition after a continuous series of vibrations. The same thing takes place in the axles of railroad cars. In the first place, the article is made of the best fibrous iron, yet after running a few years, and perhaps only a few months, the general condition of the iron will be found completely changed; a high degree of crystallization having taken the place of fibrous condition. This liability to change is not confined to steel or iron, for every reader knows that by repeated bendings any metal, however tough or soft, may be broken, from this change of molecular condition.

Theoretically, perfect isochronism ought to be obtained for the true times of a small or large arc up to a certain degree of accuracy, and therefore we may well argue that the deficiencies are attributable to the mechanical imperfections; and in support of this, it is found that if the isochronism is attained, it will gradually be modified by the thickening of the oil on the pivots, and then the difference in the arcs of the vibration will become noted, however good the adjustment originally was. Another source of error is in the uniformity of the coils of the spring; by this we mean that the spiral should increase in a uniform rate from the centre to the outside coil, and if a return spring should be used the return coils must be just as uniform in the decrease.

We can suppose the nearest approximation can be attained by making the coils of the springs to assume as nearly the form of a sphere as possible, and in the ordinary way the spring, if a flat coil, will get a better isochronism by returning the stud end of the spring to a point as near as possible to the centre of motion of the balance; and here we may make the observation for the benefit of beginners, that, even in a movement where the point of isochronism is not in consideration, in every watch the workman should, in all cases, place the spring so that the sum of the coils shall be concentric with the axis of rotation. The spring, in this case, must be so bent edgewise that the decreasing coils shall be perfectly free to move over the lower coils. This is effected in the Breguet spring, where a portion is turned up; even in a tempered spring this may be done by putting a hole through a brass plate of just the thickness you wish the bend to be long—the sides of the hole being flat. After the spring is strung through, a flat pin may be wedged in to hold the wire. Now, on warming the plate the wire may be bent on each side of the plate, and the consequence will be that the diagonal direction of the bend of the spring throws the upper coils free. The cut will fully illustrate our meaning, although entirely out of proportion.



There is, however, a difficulty in this, for the angle made by the bending renders the spring much more dense at that point than at any other; or, in other words, that portion of the spring does not possess the same elasticity as other portions. Other springs are returned by a very gradual spiral bending that equalizes the action. The best form of spring for isochronism is undoubtedly the spiral *helix*, and this form has been adopted for all marine chronometers, and is occasionally used in the pocket watch, whether of the lever or chronometer escapement; here there is a closer approximation to perfect isochronism than can be attained by any other form of spring except the true sphere, and it will strike any one that the centres of motion, even in that case, can not be attained; that is, the final curves cannot terminate in the same straight line with the centre of the balance arbor.

An ordinary spring is coiled very simply in a box that has an arbor that takes the ends of a number of wires, for there must be enough to give the necessary space between the coils. If only a single wire was wound up in the box, and then "set" by the bluing process, the spring would not be open at all; thus it is customary to enter four ends, and wind the four pieces in the box, which gives four springs with spaces just four times the thickness of the wire when closely coiled in the box. On removing the box with the springs from the cut arbor that takes the ends of the wire, the whole (box and springs) are laid on a plate of metal which is heated until the color of the springs indicates that the "set" has been effected. This process is designed only for soft springs, but at the present day no spring is considered good that is not tempered; and no positive, or indeed probable chance of isochronism exists where the spring is not tempered.

The flat spring, even if tempered, has the disadvantage of having one point of attachment at a distance from the centre of motion; and we can well conceive that with an increased vibration the whole lateral tension of the spring would force the pivots against the sides of the jewel holes, and the whole amount of the resistance would tell on the extent of the next vibration: and this process must go on indefinitely were it not that the motive power is pretty nearly constant, and thus a series of compensations take place; for when the balance has made too large a vibration the spring brings it down perhaps to a too small vibration, but the next impulse will make up for the variation, and this process will go on continuously. Another form is where the spring is turned back without any distinct bend, or where the hair-spring stud is placed so close to the centre of motion as to equalize the lateral tension of the spring.

We shall continue this subject in our next number, as it is one of great importance.

Spectacles.

To the majority of men there is a romance about the grandeur of the discoveries made by the instrumentality of the telescope. Distances that must be read by millions, and revelations of objects afar off in the blue ether, and that had not been apparent to mortal ken, are the general points only on which popular opinion rests. Grandeur is a natural concomitant to every observation, and from this alone arises the indifference of the public mind as to the practical results that have flowed directly from the use of such instruments. The description of Lord Rosse's seven feet speculum is eagerly devoured by those even who have not the slightest idea of how the instrument is used, or the specific purposes to which it is applied. The same minds would be wearied by any account of detail, and if told that its highest use to mankind is to be found in the applicability of its powers to every-day life—to the wanderer on the sea or land—the statesman and mechanic—in short, whoever uses time and its divisions, or who has boundaries to establish or defend, would fail to comprehend the significance, and, for want of patience or comprehension, would hardly listen to the facts in the case. The scientific curiosity that induces the passer-by to invest a few quarters in looking at Jupiter through one of the street instruments is completely gratified if a full view of the primary and satellite is obtained—nothing further. That the motions of this group indirectly have had a bearing on the price of tea, is, to the casual observer, absurd; and yet it is of truth; the determination of longitude, by increasing the safety and decreasing the duration of the voyage, has influenced the value of every imported article.

The microscope, too, is one of those popular wonders that has its hold on the public mind solely by the marvellous. The popular eye is applied to the instrument, and lo! the marvels of the microscopic world are unfolded; here the interest ends, for beyond this point no thought is had of its adaptation to the real every-day purposes of life. Yet it can be shown in thousands of cases that the microscope has stretched its benefits to the most common of the wants and necessities of mankind.

These, the telescope and microscope, are optical instruments on which human ingenuity has lavished all its wonderful resources. They are constructed with skill, patience, and with noble disdain for expense, if an improvement of the most minute dimensions may be thereby effected. They deserve and have reaped their full meed of praise and admiration, while a smaller optical adjunct to vision is scarcely ever thought of unless there should exist some defective formation of the eye, or disease or old age should shut out in a measure those objects that have before been familiar to our vision.

The spectacle is too familiar to be a matter of wonder; and yet its capacity to increase the average happiness and comfort of man is not one whit less than that of the telescope, which reveals the star millions of miles away, or the microscope that defines the smallest atom in the series bounded by finity.

A pair of spectacles, just suited to the highest development of well-defined images on the receptive membrane of the eye, is difficult to obtain, and it will be shown that this very trouble is owing to causes that can never be entirely eliminated, and the searcher after the best will always be compelled to exercise patience in his selection. The human eye is an optical instrument, and the nearest approximation to perfection that is known; its adaptability to the varied circumstances of vision—its self-adjusting powers—the reception of colors and a ray of pure light, are the envy of the instrument makers, whose glasses are limited in every direction, owing to the refraction of light, for each ray will be deflected from its course. Now, if the ray should fall on the denser medium in a perpendicular line, it would not be refracted in its passage through; but should it fall at any angle to the perpendicular, the ray will be bent in passing. Now we will suppose a piece of glass to be shaped on the sides, as in Fig. 1, and trace the action of three rays of light, A, B and C, falling on one surface at different points from the centre. The whole of the ray, B, would pass through L in a straight line to an indeterminate length through the point F; the lines A and C, however, do not meet the surface of L at right angles; they each fall on curves that we may, for the purpose of illustration, consider as made up of an infinite number of planes; therefore the rays A and C are bent in their passage; but as the surface of L is supposed to be a part of a true sphere, the lines would fall upon the centre ray at some common point, say F; this point is called the focus of the glass, or lens, and is nearer, or more distant, as the curvature is increased or diminished. It will be remembered that in the eye the membrane on which the image of the object is produced, is always at the same distance from the back of the chrystalline lens. Now, by the definition of focus it follows that the lens of the eye must be of such a particular form that the point F shall fall definitely on the coat of the retina—neither more nor less—or the image would be seen without well-defined outlines. There is no doubt that the eye, if undisturbed by extraneous causes, is perfection as to optical value; but it is influenced by the other parts of the living organism, and thus often fails to perform its full duty. Aside from disease, either local or general, there are two conditions of imperfect action that arise entirely from configuration of the lens, one in which the focus thrown is too short, another when it is too long. The sole object sought to be effected by the employment of a lens is to refract these rays to compensate for the deficiency in form. In the first, a case of short-sightedness, it is obvious that the focal line must be lengthened; in the last, the long-sightednes of old age, it must be shortened. In cases where children are born with defective vision, arising from the first cause, there is a hope for improvement as age is attained; indeed there are reasons for believing that all children are born with a convexity of the cornea that must induce defective vision; if this were an ascertained fact the only ques-

tion would be, could not some method of treatment be devised to lesson the convexity, and thus, at an early age, prevent the evils of short-sight? That, however, is a question for the oculist to solve. The spectacle maker can only take cognizance of facts as they exist; and it must be remembered that he does not pretend to cure. His treatment is entirely palliative. It would be expected that, having determined the evil, it could be easily remedied; it could, provided the ocular lens was always in the same condition; and what is more, that the vitreous fluid remained at the same densities, for in this last fact are detected causes for deficiencies that are vainly sought in the form or constitution of the lens, provided it does not become opaque from cataract or disintegration. Now in optics, however perfect the sections of the spheres on which lenses are formed, there will always be a certain amount of color given to an image thrown on a white ground; this is caused by what is called interference of light; these fringes of color surrounding the image would be produced by the form, and if they were perceived by the retina the mind would never contemplate a true picture of external objects. Nature has compensated for this spherical aberration, as it is called, by making the light to pass through the vitreous humor. Very certainly, some cases of defective vision may be attributed to a change in the internal structure of this fluid, the nature of which we can hardly surmise, as we have, in reasoning on the subject, to take into consideration the fact of vitality which so strongly obtrudes itself in all the questions of physiology when external objects are connected with the living tissue. We go back to the lens; if we place before the pupil a plane glass, the rays would pass into the eye parallel; if, however, we should allow the glass surface to be curved in a progressive manner, we should find that the rays are more and more converged into the cornea. Now, these converging rays are still more converged in passing through the cornea and chrystalline lens until the convexity of the glass would be too strong, that is too convex, to permit the proper focus of the combined apparatus to fall on the retina. And this is precisely the process by which a pair of spectacles is chosen to suit the eye.

The reasoning is the same in short sight; the high refractive power of the two ocular lenses must be compensated for by a lens that makes the focus fall at a greater distance. The different forms of the glasses used for the respective cases are too well known to need description. But there is one case of defective formation we have not yet alluded to; it is that in which the focal power of the two eyes is unequal. The persons thus afflicted are invariably the most difficult to suit in the application of a pair of spectacles, and they are the ones who cannot see a picture in an ordinary stereoscope with anything like the distinctivenesss that gratifies the more fortunate observer. In such a case the causes may be congenital,—injury by external mechanical means, or by constantly using one eye only in the ordinary pursuit of trade, as, for instance, the watch repairer, who too often uses the glass more commonly than he should. His right eye will, after a few years' work, indicate a difference in focal length to the left. The only possible choice left in such cases is to select the focus of each glass to suit each eye; true, there would be a higher illuminated object in one than the other eye, but the size and distinctness would be the same.

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Electro-Metallurgy.

NUMBER FIVE.

The greatest difficulty the tyro will experience is to so proportion the density of the solution to the intensity of the electrical power obtained from the battery as to get the desired deposit; and the beginner may feel inclined to despair when he finds, instead of a fine deposit, he has nothing but a dead black surface, and under other circumstances he finds the surface to be an aggregation of crystals, large or small as the case may be, but still not the deposit he wishes. The true conditions are not yet theoretically known, though in practice the art has been reduced to almost a certainty. As we may well suppose, the solutions of the various metals in deep troughs will not be uniform in density from the top to the bottom; the salt, having a greater specific gravity than water, will settle to the bottom, and this is only one of the troubles that puzzles the novice in electro-metallurgy. To the watch-repairer, however, this is of little moment, for both the surfaces and quantity of solution are so mall that but little variation will be found in gilding, or even frosting a plate. In the large establishments, however, the case is reversed, for the depths necessary to take in a very large piece, such as a tureen or salver, will allow of the settling of the heavier metallic salt solution. The operator now will have to so agitate the mixture that in some way the density of the solution may be equal throughout. These precautions are not so important where the metal has to be deposited simply for the process of plating, as, in the subsequent operations of burnishing, the difference in thickness is not revealed, although an even deposition of the metal is to be desired

If the repairer would like to bring up the work equal to the original in point of gilding, nothing is more easy. In the ordinary Swiss watch the gilding is frequently found to have been *scrubbed* off the barrel bridge, leaving the surface of a yellowish white, extremely out of contrast with the other cocks and bridges. To make the surface good he needs but a small outlay, as one battery cell will suffice, though he will need two decomposition cells. The first step is to make his argento-cyanide of potassium solution in one of the decomposition cells.

He first makes a solution of the fused cyanide and attaches as a positive a large (comparatively) silver plate with a very small platinum negative. When the battery is in action the silver is taken up by the nascent cyanogen, and as the negative is too small to take it all up, a portion must remain in the solution; this can be carried on to any degree of saturation, and this process recommends itself to the repairer, both for its simplicity as well as that there is no loss of his time. In the large way, the oxide of silver is digested in a solution of the cyanide from the simple fact that time is a source of expense.

The solution thus made is all that is needed if the battery is in order; the character of the coating deposited, however, will depend on the tact and skill of the operator. If a granular, or rather crystalline appearance is desired, the current will be made to throw down the silver very slowly, and a beautiful dead white will be the result. This point having been gained, the operator will gauge the power of his battery to the requisite power.

The strength of the battery may be ascertained by a galvanometer, but in ordinary practice the strength of the current is judged of by the amount of hydrogen given off from the negative pole of the battery. There can not be any certainty when extreme accuracy is desired, but, for all practical purposes, the indications afforded by the evolution of the hydrogen are all that are required; the main point will be to watch the condition of the deposit. In the small way, this relation of battery power has to be much more closely watched than when the mass of solution is such that a slight variation in the battery power has but little effect. Then the distance between the two poles in the decomposition trough has a very important bearing on the deposit, and the beginner will find that, with a strong solution of argento-cyanide, he can control the strength of his battery power by approximating or separating the poles in the decomposition cell. The position of the articles in the cell is somewhat a matter of circumstances; for if a large surface has to be plated, perhaps the best plan is to place the object to be plated in a horizontal position, while the positive is placed over it; but in the small way such precaution is not at all required, for the small objects do not furnish sufficient surface to make a sensible amount of density in the solution. So, if we take a barrel bridge, we may suspend it on the wire from the zinc, and by observing the first film of deposit, we may so modify the power that we shall be able to deposit the metal in any state we choose.

In the silver process the articles are always covered with a beautiful dead-white coating, a real frosted surface, and, as stated before, the degree of crystallization will depend on the relative strength of the battery power, and the degree of saturation of the solution in the decomposing cell. With silver a strong solution is to be recommended, as the resistance to the power of a single cell will produce much better results than will a weak solution with a number of cells. Where the decomposing cell is very deep, the solution will require to be frequently agitated from the bottom, as the action of gravitation makes the solution of unequal density from the bottom to the top; and as water offers less resistance to the current, the electricity will pass only through the liquid in just the ratio of the density of the solution. An excess of the free cyanide of potassium will help the operator, for the salt will be more evenly diffused throughout the whole solution. In any case the quantity of silver deposited can be ascertained directly by the weight of the article itself, or by the negative method of weighing the positive pole of the decomposing cell, and it will follow that whatever the plate has lost has been deposited on the negative. The first method is adopted in the large establishments, and it is somewhat curious to see the accuracy which is attained in the weight of a gross of forks or spoons—in fact, the weight is absolute. The silvering process is, perhaps, the most certain of any of the electro-metallurgic processes, but the work is not finished when it comes from the cell, however well it may have been plated, or rather coated; for the surface is but an aggregation of small crystals that makes it dead-white.

The next stage in this operation is to bring the surface to a high polish. If the abrasive process was used, the silver would be completely rubbed off the surface; recourse is, therefore, had to the burnisher, and this is used, for the most part, by women; and here we may state, that the use of prussic acid was known to the women employed in the washing of filigree work in jewelry long before the fact of its action on gold was known to the chemists. One girl who was employed in washing this class of work in Paris succeeded in making heavy wages from the facility and speed with which the work was done; she kept her secret, however, for a long time, and it was found, after she chose to disclose it, that a few drops of prussic acid were added to the soap-suds in which the work was washed.

To the watch repairer, perhaps, no metallic deposit is of so much importance as that of gold. With one small Smee's cell he is enabled to color his repaired work equal to the original, and when he finds a watch the movement of which has been disfigured by too much brushing, he can very readily restore the pristine appearance. The equivalent of gold is very high, and therefore but small battery power is required to effect its reduction. The solution best for the purpose is the auro-cyanide of potassium, and may be made in the same manner as before described, by using a large positive plate, with a very small negative; but in coloring we have seen the very finest work done where the decomposition cell had but a simple solution of cyanide of potassium; in this case the gold was deposited as fast as the nascent cyanogen dissolved it, and the battery power was used very low. In general, however, the solution is made to a near approximation of saturation, and as the solution, if properly taken care of, does not change, the repairer need have no trouble when he has once prepared it, and the quantity required is small, and the positive as well, owing to the fact that in general the repairer is required to gild small surfaces. The ordinary size of his bath need not be over the capacity of a large tumbler, and his battery may be of the same size, though it is always well to have the battery of a good size, for then the power may be regulated by lifting up the plates or using the acids of greater or less strength. In the manipulations with gold more care has to be taken than with any other metal, for, as it is almost always used for purposes of ornamentation, color becomes a very important consideration. Aside from this fact, a very slight inequality in the solution may cause the deposition of gold in the black state; except platinum, gold is the most troublesome of the metals in regard to the black deposit.

The preparation of the surface is also of great consideration, for if not chemically clean and free from the film of air that always is attached to polished surfaces, the attachment will not be perfect. Perhaps the best illustration we can give of the preparation of a surface is to take the case of a watch plate. The surface is first got by stoning with Scotch stone; if the gold was laid on this, it would have to be burnished in order to produce any effect; but a burnished surface is not what is wanted, and again, the general surface must be matted, or frosted, as it is called. Now the face of the plate is well stoned, and then the surface is brushed with a series of scratch brushes set in the periphery of a chuck on the spindle of the lathe; but this would be a fault, for if the scratch brush moved in straight or circular lines the whole object would be defeated; consequently the ends of the wires are bent so that the blow of the ends falls exactly perpendicular to the surface of the whole plate. We copy from page 90, No. 3 of the Horological Journal, as to the mode of getting this surface in the English and American style.

The use of the sour beer is to chemically clean the surface, and at the same time remove the film of air, and thus render the attachment perfect. The two metals are absolutely welded together, and it is a singular fact that a film of air or iodine can be perfectly measured, and thus the distance that can prevent adhesion. Now in some results of the deposit it is desirable to prevent adhesion. The Coast Survey Laboratory used a solution of iodine in alcohol, and as the proportions were definite the thickness of the film of iodine could be ascertained; for instance, if ten grains of iodine should be dissolved in four ounces of alcohol, and one ounce of the solution should be evaporated from the surface of a plate of ten or twelve square feet of surface. Now, it is evident that only two and one-half grains of iodine can be applied to the plate, and if the surface was ten square feet the amount of iodine would be but twenty-five hundredths of a grain, and if the reader is willing to take the specific gravity of iodine he will find that the thickness of the film cannot exceed the $\frac{1}{2000000}$ of an inch.

There is nothing that so easily and at the same time thoroughly cleans the plate that can excel the sour beer. Vinegar may be used if a small amount of sugar be dissolved in it, and it may be that a small amount of starch, used in the same way as the sugar. As has been stated, gold having a high equivalent, the solution is decomposed with a weak battery power, and it is therefore easy to color any article of jewelry or gild a plate; but it must be understood that when the power in relation to the strength of the solution has been so adjusted that no black deposit is found, the color of the article will be under the control of the operator. The gold may be made to assume the perfect reguline state, and if then polished, or rather burnished, it will take the natural color of twenty-four carat gold; if, however, the strength of the current is changed relatively, the gold may be deposited in a crystalline form, the sizes of the crystals determining the variation in colors.

Silver Dials

Are not much in use at the present time; but when new and "white as the driven snow," are very beautiful. Occasionally the watchmaker comes across a really good watch, of the "olden time," which the owner values for its intrinsic worth, or as a relic, and would gladly pay to have the dial "blanched," which can very easily be done.

Take it off the false plate, if there be one—lay it on a forked wire held in the plyers over the flame of an alcohol lamp till it becomes slightly red hot; when cool enough to handle (or it may be cooled in water) take a stiff tooth or nail brush, and scour it clean with pumice-stone dust and water. Then, having prepared a pickle of two parts sulphuric and one part nitric acid, diluted with water till it is only *very* sour to the taste, heat it over the lamp till it boils, in a saucer, or any convenient shallow vessel of sufficient capacity to allow the dial to lie flat in it. Then place the dial in the boiling pickle, using a piece of peg-wood thrust tightly into the centre hole as a handle. Continue to boil it until it assumes a dead-white apperaance. If there remain any spots which will not come white, heat the dial again (after washing off the acid), and scour as at first, then boil again. Sometimes two or three scourings are necessary to make it come out beautifully white. If the hour figures are raised (soldered on) their surface may be very carefully burnished. Great care must be taken to wash the dial clean from acid. It may be dried by gently warming over the lamp. On no account allow the fingers, or anything else, to touch the surface. Very particularly observe one thing before operating upon it.

Ascertain whether the hour figures are painted on—if they are, blanching will entirely remove them, and no one except an artist can replace them; if they are enamelled on, they will usually stand the treament if carefully manipulated.

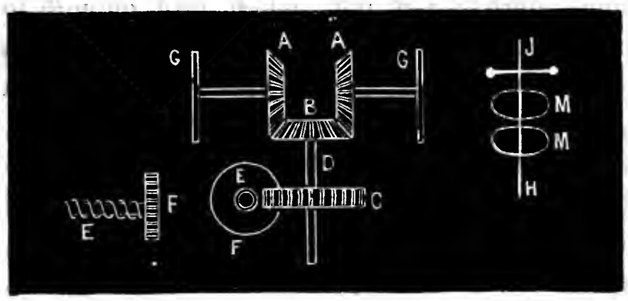
Very often the watchmaker, who is usually expected to do *anything* that no one else can do, is called upon to clean up silver filigree jewelry—frequently called Genoese jewelry—which can be blanched in the same pickle, only it cannot be scoured. The structure is too frail to endure that hardship. It usually comes very white by heating it red hot, and plunging it in the hot pickle. Care must be taken in heating it, not to melt the delicate fragile parts. A very little practice will make one almost invariably successful.

R. C.

Correspondence.

Editor Horological Journal:

I send you herewith drawing and description of my electric clock for turrets:



DESCRIPTION OF DRAWINGS.

A and B, bevelled gearing as in ordinary tower clocks.

D, shaft of wheel, B and C.

C, wheel in which endless screw works.

E, endless screw.

F, ratchet wheel worked by click on end of armature.

G G, dials.

M M, magnets put in straight line with armature, gives more power than old style for this purpose.

J, ratchet in back end of armature.

H, armature.

Connect two or four sets of hands as is now done in turret clocks, worked by weights, that is, with bevelled gearing, A and B, in the upright shaft, D, leading from clock to hands; put on wheel, C, in which is geared an endless screw, E, with ratchet, F, to be worked by electro-magnet on one side of endless screw. It will take one turn of screw to pass one tooth of wheel, C, in this endless screw. This arrangement gives great power, and is such no pressure on hands, either back or forward, can affect the motive power. But to make it turn fast enough to keep time, you will connect the circuit closer to some part of the regulating clock, which will cause the armature which operates the ratchet to work very fast. Take a lever clock, insulate one of the banking pins, connect the battery wire, and for every beat of the clock you have one tooth of ratchet moved, to which the endless screw is fastened. A jeweller's regulator, ship's chronometer, or any other time-piece, could be the regulating clock, and could be put in any part of the building or out of it. The number of teeth in the ratchet, also number of teeth in wheel in which endless screw works, would be determined by the number of times the regulating clock opens and closes the circuit.

By this plan a turret which now would not admit of an ordinary clock on account of not being steady enough, could have a perfectly reliable clock, as no outside pressure of wind, snow or sleet on the hands, or shaking of the steeple from any cause, would affect the time. But the greatest of all benefits is that such a clock could be put up at a nominal cost, for the American watch movement could control the largest clock. It is supposed that any one making a clock of this design is well acquainted with the battery and electro-magnet.

The plan of the striking part of this clock will be given in a future number, and will be very simple, powerful, and accurate, worked with the same battery as the clock, and not requiring the striking part of a clock to work it.

C. T. Mason.

Sumter, S. C.

Editor Horological Journal:

As several parties have written to me to give them some information in regard to the "Pebble Tester," I have concluded that a short article in reference to it would not come amiss in your valuable journal. As the action of this instrument depends upon the peculiar phenomena called Polarization of Light, it will be necessary to give your readers (those who do not already understand what is meant by the term) a general idea of this peculiar property of light, before they can comprehend the action of the instrument. There are several substances that will polarize light; even glass will do it if we use a number of plates, although one single plate seems to have no effect upon it.

Feldspar and tourmaline are the two most common substances used for this purpose.

Light passing through a longitudinal section of feldspar becomes polarized, and the ray of light is separated into two rays—one called the ordinary, the other the extraordinary ray. Now the effect produced upon the ray of light passing through a piece of tourmaline (also a longitudinal section) is the same, with this difference, that only one ray passes through, the extraordinary ray being absorbed or obstructed. It would be impossible in a short article like this to give anything like a fair and comprehensive idea of what polarized light is, and the many peculiarities connected with it; but I will try and make myself understood sufficiently, and, in as few words as possible, to enable your readers to understand the use of, and to comprehend why the Pebble Tester answers the purpose for which it is intended.

I do not know that I can give you a better illustration of what is known as polarized light than that given to me many years ago by my friend the author of your Astronomical and other articles. If you will take several sheets of paper and place the ends of them against your extended fingers, holding your fingers horizontal, and the paper perpendicular to them, you will find the paper obstructed; but by holding your hand still and turning the paper 90° you will see how readily it will pass between your fingers. Now, the effect of light passing through tourmaline is analogous to the above; that is, if light passes through one piece of tourmaline, and you place another piece behind the first, with its axial line or "grain" at right angles to the first, the light will be obstructed; but by simply turning one piece either to the right or left 90°, light will readily pass through both pieces.

Now, a Pebble Tester is shaped somewhat like a pair of sugar tongs, only made of iron. At the extremity of each arm the wire is bent into the form of a circle, which encloses a piece of metal with a hole in the centre that is lined with cork, in which is inserted a piece of tourmaline in each, the tourmaline being cut in longitudinal sections. Now, by carefully turning one of the pieces of metal containing the tourmaline—holding the instrument close to the eye—until all the rays of light are obstructed, thereby causing total darkness, the instrument is properly adjusted for trying your glasses or pebble. If a pebble is inserted between the two pieces of tourmaline, the direction of the rays of light is changed, allowing them to pass through the second piece of tourmaline. By carefully rotating the pebble you will find that at each quarter revolution of the lens the light is either partially or totally obstructed; this want of uniformity in the different pebble lens is, no doubt, attributable to their being cut from the stone without any regard to the axial direction of the stone.

If you place a glass lens between the two pieces of tourmaline it will have no effect upon the light, which is the test; *i. e.*, when the Pebble Tester is properly adjusted so that you cannot see through it, and you place a glass lens between the two pieces of tourmaline, you will still be unable to see through it; but by substituting a pebble lens for the glass one, you can see through it. The light will be more or less colored; sometimes you get the various hues of the rainbow, again the light seems to be of a light-brown color.

The Pebble Tester can be obtained of Burbank Brothers, manufacturers of spectacles and importers of optical goods, No. 14 Maiden Lane, New York.

Hoping that your readers may be able to understand the use and realize the value of this instrument from what I have said, and also get a vague idea of polarized light, I will close this article, hoping that Mr. S. will give us a series of articles on Light through your Journal.

Jas. Fricker.

Americus, Ga., *March* 15, 1870.

Editor Horological Journal:

Sir,—For several years past I have been engaged in investigating all the questions that are involved in the pendulum as applied to the measurement of time, and all concerning the beautiful natural laws that govern the vibrations of the simple pendulum, and the more complex and incongruous questions involved in constructing the compound pendulum, and the numerous methods of compensating it.

The object of the present communication is to point out a fact in connection with the mercurial pendulum that appears to me to be a contradiction between the relative differences in the expansion of mercury and steel as is accepted by the trade all over the world, and the amount of mercury used in the ordinary class of pendulums whether the mercury be contained in one large jar or a number of smaller ones. All authorities agree that the linear expansion of mercury contained in a vessel about two inches in diameter, is five and a large fraction times greater than steel. Ried, in his Treatise on Clockwork, makes it not quite 5.75, while, on the authority of Charles Frodsham, its greatest expansion under the same circumstances is 5.81 times greater than the *same length* of steel that usually composes the rod.

Having cited these authorities, which are sufficient for the present purpose, let us suppose that forty-two inches of steel is the amount to be compensated (it is usually more), and, for simplicity, let us assume that mercury expands *six* times more than steel; in round numbers, seven inches of mercury would compensate forty-two inches of steel. That is to say, by an excess of heat the rod has been lengthened, and the bottom of the jar let down, say one inch, while the same heat has caused the *top* of the mercury to rise one inch also, and the reverse action would be produced by cold. But it is plain that the centre of oscillation being at a point a little above the *centre* of the mercury, this point has only been altered by the action of the mercury *one-half* of what it has been altered by the action of the steel; or, in other words, while the heat has lengthened the rod and let down the whole seven inches of mercury that constitute the bob, only one-half of it rises up to compensate for letting down the whole mass.

In these approximations I take no account of the weight of steel or other material that constitute the jar, rod, etc., or the shape or expansion of the jar, nor the effect of heat or cold on the pendulum spring; all these combined have a tendency to considerably increase the seven inches of mercury that I have assumed; neither do I take into account the effect of the various escapements on the vibrations of the pendulum, but must be understood to be arguing about compensating a free pendulum, independent of the varying forces of any mechanism that impels it. And I would solicit the opinion of your readers in America or Europe on the subject.

I admit, in fact I have had abundant opportunities of observing the excellent results obtained by all forms of the mercurial pendulum, with from six to nine inches of mercury in the bob, when in connection with both the Graham and gravity escapements. They could *all* be trusted not to vary but a fraction of a second from their usual rate; but the great improvements made, and increased accuracy obtained, in astronomical instruments, demand that for the purposes of astronomy this fraction of a second should be reduced and if the physical elements can be subdued enough, reduced to zero.

CLYDE.

Answers to Correspondents.

G. L. B., *Wis.*—The balls that are used as attachments to articles of jewelry are not made, as you suppose, by soldering together two hemispheres: the process would be too tedious, and therefore costly, and when you consider the price (wholesale) at which a full set of plated ornaments are sold, you will see at once that the soldering process would not answer. The real mode of manufacture is one in which much ingenuity has been displayed, and we will give such an outline of the proceedings as will enable you to comprehend it.

In the first place the metal is rolled down to a strip, the width of which is determined by the size of the ball to be made; the strip is then cut up into squares as accurately as possible, and these square bits of plate form the blanks. A punch and die is used, the die being turned out concave at the bottom, but as nearly spherical as possible; this die is so deep that when the blank is forced down, the corners of the blank are turned up straight, for the sides of the die are straight, and the punch is made smaller than the die by nearly the thickness of the plate; the blank is now laid on the die in the press, and the punch, or rather former, brought down on it. The punch doubles up the metal as it were, and forces it to the bottom of the die, where one-half of the sphere is formed by the blow; between the straight sides of the die and punch the four corners are turned up, and when the punch is withdrawn the metal will be found adhering to it. So far we have but one-half, and it remains to close the corners together; this is effected by another set of tools, consisting of a punch turned out on its end with a spherical concavity, and a die its very counterpart. The half-formed ball is now set with its rounded surface in the die; the punch is then brought down on the corners, and they are forced together; and from the very conditions the whole blank has now become of a spherical form, the approximation to a perfect sphere being limited only by the perfection of the closing punch and die. When closed, the joints are hardly discernible; but, to render the job more complete, a small piece of hard solder is placed on the point of junction, and then flowed by heat.

While speaking of the balls, we will advert to the manner in which the small gold and plated beads intended for roller bracelets are made. These have a hole through them; they are, in fact, nothing but beads, but the process of manufacture possesses some points of interest. The blanks are first punched from sheet metal in the form of round disks;

these are then placed in the press, the die of which is not only a forming, but through die; the punch is made with a tit that just fits the through hole in the die, and this is for punching the first hole. The forming part of the punch is made on the same principle described in the punch for the spheres. On the punch and die being brought together with the blank between them, the blank is stretched up in every direction, and when the punch is withdrawn from the die, the semispherical piece of metal is held on the punch; when it is stripped off, it is in the form of a cup with a spherical bottom and straight sides. It is now transferred to another press, where the hollow punch closes in the metal enough to form a bead. Now we have to consider the fact that the metal must be of various degrees of thickness after the form is achieved.

The rationale of the operation cannot be better illustrated than by a description of the process for raised forms—say a teapot. It will be understood that the forcing of the metal into shape is the very thing sought for, whether the hammer or press be used. Let us take the case of the common pen-holder—we mean the tubular, whose end and tube are of one piece. No soldering could be used when the price is so very low. The manufacturers take advantage of the fact, that while the part of the blank in contact with the punch is thick enough to stand the strain, the sides will be drawn through the die, and this operation is repeated, attended with successive annealings, until the metal tube is formed, and that, too, with a solid end.

The workman wishes, for instance, to change the plain plate into a cup; he commences with hammer blows at the centre of the plate to expand the metal at that point; if he continues he will, eventually, succeed in turning up the edges of the disk; this, however, is not sufficient. He is required to form a true hemisphere, and the judgment and eye of the operator are alone the gauges. Here we have the example of the flow of the metal; for it is evident that wherever the blow comes the metal must become thinner, and as there is no abrasion or waste of material, we can only assume that a quantity has been transferred to some other part of the sheet-metal used; if the hammer is used skilfully, almost any curved form may be produced; but in every case the edges of the hemispherical cup must be thicker than the centre. It is this very principle of the flow of the metal that enables the manufacturers of silver-plated ware to spin up the sheets of metals into the various complex forms that adorn the table.

The spinning process is rapid, and we can witness that at the plating establishment of Messrs. Adams, Chandler & Co., we saw a cup formed on the chuck in about one minute.

J. M. H.—In regard to the effect of magnetism on the time properties of a chronometer, allow us to quote from a correspondent of the *London Horological Journal*:

"The influence of magnetism on a steel balance, as described in the HOROLOGICAL JOURNAL, can only have reference to verge watches. In chronometer and lever watches, when the balance vibrates a turn and a quarter, magnetism has no influence at all. When a balance is magnetic it has a tendency to turn to some particular position, like when we adjust a chronometer in vertical positions by making the balance heavier in one part than in another. But we can only avail ourselves of this remedy when the balance vibrates more than a turn and a quarter, or less than a turn and a quarter. If it vibrates less than a turn and a quarter, we make it heavier in the side that is downwards in the position in which the chronometer goes slowest; but if it vibrates more than a turn and a quarter, it must be made heavier in the upper part, or, as it is called, adjusted reverse. If it vibrates a turn and a quarter, any of the screws, screwed out or in, produces no effect with respect to position, but only makes the chronometer go faster or slower in all positions, and for the same reason a magnetic balance has no influence on the rate of a chronometer till the vibration falls off, but will have great influence on a verge watch, where the vibration is less; and for this reason it is better verge watches have balances made of gold or brass.

"Philom wishes to know why hardened balance springs are preferable to unhardened ones. Springs in action lose strength in proportion to their hardness, and therefore lever and horizontal watches, which through the thickening of the oil in the escapement gradually go slower, ought to have hard balance springs; but verge watches requiring no oil on the pallets, and through wear in the escapement going faster and faster, ought to have balance springs made of soft wire. Philom appears to think that watches go slower in heat, only through the expansion of the balance and elongation of the balance spring. But the principal cause is that a balance spring loses in heat some of its elastic strength. If it got longer the watch would get out of beat."

We have always been somewhat sceptical as to magnetized balances; if there are only two arms, or rather one crossing, we can conceive of polarity but in a three-armed balance we cannot conceive the idea. Suppose the rim of a compensation balance to be cut, there would be evidently two points for polarity, and that such a case might exhibit all the phenomena of the effects of magnetism we will not dispute. Yet even here we may stop to inquire whether polarity could be developed in a case where the balance was simply a steel rim, with, as is usual, three arms. If one side, or indeed any portion of the web, contains more metal, or in fact if the balance is not equal, we can see a reason why polarity might ensue. Let us take an extreme case, however—a hoop of soft iron like the tire to a wagon wheel; can we conceive of any point in its circumference for polarity? Whatever influence has been exerted in regard to steel balances, we are inclined to attribute to an unequal diffusion of the mass of metal.

A. J. M., *N. J.*—If you will send your order for Notions to Mr. J. B. Phillips, care of J. B. Hyde & Co., 452 Broadway, we will guarantee you will receive satisfaction, both in regard to prices and quality of goods. The house of J. B. Hyde & Co. is a new one, of the Young America order, established in February last, and consequently their stock is entirely new, and it is also a well selected one. We have been personally acquainted with Mr. Phillips for near twenty years, during the most of which time he has been a salesman in New York, and we are sure he would take pleasure in filling any orders for the patrons of The Horological Journal.

W. F. H., *N. Y.*—"Can you tell me what rouge they use for polishing the inside of watch cases and how the buffs are made? I enclose a pay envelope for jobbing. I think the craft generally would like it did they know its advantages. Each job is put in an envelope with the name, description, number, and price. Each letter of the alphabet is kept in a miniature post-office at the left of the bench, and may be found at a moment's notice. No looking over an assortment to find a piece."

Article..

Name..

No...

Price..

W. F. HAMMOND,

WATCHMAKER and JEWELER,

No. 36 Main Street, Greenport, L. I.

You have certainly offered a good idea, and we not only give part of your letter, but a copy of your ingenious style of jewelry recording, and will try to give answer to your query as to rouge. In the first place, you must reflect that the difference in the hardness of surfaces demands a great difference in the quality, or rather abrasive qualities, of the polishing powder used. The harder the surface the sharper must be the polishing material. The rouge used for gold and silver is the peroxide of iron, and if well levigated the finest may be used without fear of scratches, provided the polisher does not run in the same place continuously, and for this the case makers reverse the motion of the polisher, and as the buff is smaller than the case, a slight side motion will give an infinite change of position, and thus there can never be two points in the same circle of revolution.

A. M. L., *Wis.*—James Ferguson was a natural astronomer, or, in plain English, he was a mechanician. The story of the string of beads is true, and it only ranks him higher, that with such a simple apparatus he was enabled to note the true and apparent movement of the stars, *i. e.*, of the earth. As a matter of course, he knew nothing at that time of the differential motion of the planets, but by repeated observations with the string of beads as his only instrument, he discovered the relative motion of the planets among the fixed stars, objects that all must refer to, though there is a great probability that they are in a condition of constant change in relation to the earth's position in its orbit.

It was from just such simple observations that he absolutely discovered the plane of the ecliptic, for up to this time he had never had a work on astronomy or even on geography. Of the beads, we shall let Ferguson speak for himself:

"I then went to serve a considerable farmer in the neighborhood, whose name was James Glashan. I found him very kind and indulgent; but he soon observed, that in the evenings, when my work was over, I went into a field with a blanket about me; lay down on my back and stretched a thread with small beads upon it, at arms' length, between my eye and the stars; sliding the beads upon it till they hid such and such stars from my eye, in order to take their apparent distances from one another; and then, laying the thread down on a paper, I marked the stars thereon by the beads, according to their respective positions, having a candle by me. My master at first laughed at me; but, when I explained my meaning to him, he encouraged me to get on; and that I might make fair copies in the daytime of what I had done in the night, he often worked for me himself."

E. B. N., *Md.*—Your idea of the balance being magnetized is correct, and now suppose you place the two cut ends between the poles of a Leyden jar (you certainly can find one in so large a city) and transmit an intensity shock, you will find that the magnetism will be instantly destroyed; but we do not assert this as an absolute truth, for though soft iron will not retain its magnetism, steel, it seems, has the property of retention. And perhaps you will allow us to ask whether all the steel tools on your bench are not magnetic? We have found that at some times we could not pick up a screw without some indication of magnetism, and what is worse, we always suffered from rheumatic pains; at those times the whole of the steel work tools on the bench were strongly magnetic. Again, we found that by continued experiments, at times while we were at at work we could pick up any small screw or piece of steel, and at times this became troublesome, for there will often occur occasions where two pieces may be taken at the same time. We will not assert positively that a discharge from the Leyden jar will alter all the magnetic conditions. We have no great amount of faith in the question of magnetism of the hair-spring, for the conditions would be equal whatever the amount of magnetism. As a matter of course, there can be no heating, for that would destroy the balance as well as the spring.

D. H. W., *Tenn.*—There can be no certain rule for the diameter of the roller jewel, or, in other words, the detent jewel of the duplex escapement. Now, as this jewel has a notch cut in it to enable the long tooth of the scape-wheel to pass, it is perfectly evident that the ruby should be only so large as to let the long tooth of the scape-wheel to enter the notch at the proper time, and more than that, the notch must be so deep that in the passage the top of the tooth shall not touch the bottom of the notch; but it must be remembered that the amount of pressure on the outside of the jewel will be as the square of the diameter, and therefore it is advisable to make the roller jewel as small as possible in proportion to the impulse diameter. You must therefore take your roller, or rather detent jewel, simply as a question of depthing, and the depth of the wheel will determine the size of the duplex roller.

A. S., *San Francisco.*—We are not aware that any especial form of vessel has been made to hold the diamond powder and at the same time protect it from dust; and what is more, we cannot conceive of anything more perfect for the purpose than a set of saucers of the common iron stone; the only quality to be observed is that the bottom of the saucers are concave, with no rise in the centre. Now, there can be but a small expense in getting tin covers to set over the saucers and thus the diamond is perfectly protected from all extraneous substances. As a matter of course, we assume that you have read the Horological Journal, and you must know how to obtain the different grades of dust; and with such a starting-point we will take the first dish for number one, and so on consecutively. The grades will be in the exact proportion of the amount of care and the patience exhibited by the operator.

H. G. M., *Iowa.*—The case you describe is very common, for in the ordinary class of English levers, the main-spring, in breaking, is much more likely to injure the barrel than the train; for the spring, when it breaks, will open the barrel, and if the spring is hooked in with the hook on the spring, the force will sometimes be enough to crack open the barrel from the hole in which the hook catches. In this case no attempt at repair will be attended with satisfactory results, for if a new head is put in the barrel the sides will not be parallel, and the chain will not lay in the same plane as the fuzee.

W. H. McC., *Iowa.*—There is a work published, written by Saunier, but it is in French, and has not yet been translated. We will give in our next number a full description of the cylinder escapement, and continue the articles up to the detached lever escapement. Grossmann has undoubtedly given a better idea of the lever than can be found elsewhere, and therefore when we write on the lever we shall invariably quote him as authority.

Subscriber, *South Bend, Ind.*—No; it is not "good workmanship to take the balance wheel of a fine watch in the fingers, and with an oil-stone slip round off the corners of the pivot ends."

In all cases we wish our correspondents to send their names.

L. F., *N. J.*—The diamantine and the Vienna lime are totally different in hardness, structure, and peculiarity of action. The diamantine is an abrasive powder, while the Vienna lime seems to act chemically on the surface to be polished.

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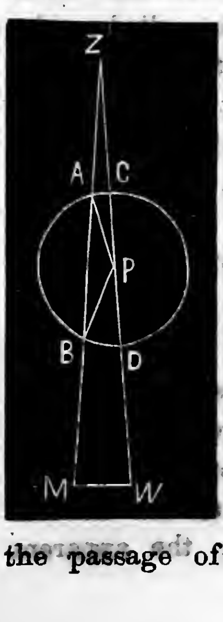
CONTENTS.

Astronomy in its Relations to Horology.

NUMBER ELEVEN.

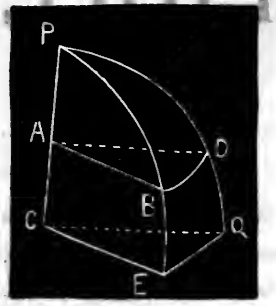
We closed up the article in the last number by a quotation from Prof. Loomis in relation to the attainment of the position in meridian by observations on the pole star. The cut will illustrate the reasoning on which the plan is based.



Now if the transit does not describe a true vertical circle, or if it is not perfectly in the meridian, it is plain that one part of the small polar circle described by the star in its revolution about the pole, will be greater one side of the line described by the telescope of the instrument. Thus if Z is the zenith, P the pole, and the circle is the orbit of the star, a line drawn from Z to W, passing through the pole, will be the true meridian. If, however, the instrument has a westing, say of as much as M W, the line of observation will fall on the circle at B and A. By mere inspection, the difference of the parts of the circle can be seen; and it is also obvious that the time required for the passage of the star will differ by the amount of westing errors; and by the diagram it is seen how the true line may be obtained, for the time taken to complete the whole revolution is exactly twenty-four hours, and therefore the passage from C to D will be exactly twelve hours.

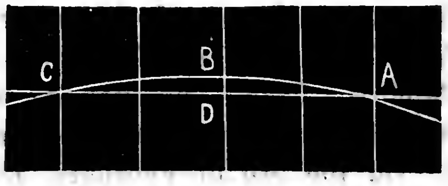
The small diameter of the orbit, and the brightness of the star, render this mode of getting meridian exceedingly easy, even to one who has not been accustomed to astronomical observations; and, moreover, high power is not required for the instrument. There is another method, which, for determining the azimuthal error, is much more correct, but a high power is needed; it is founded on the fact that there are two stars near the north pole that culminate nearly at the same time—one above and the other below the pole. These stars are 51 Cephei and δ Ursæ Minoris. These culminations may be illustrated by an example taken from Prof. Loomis. On the 9th of February, 1850, the declination of δ Ursæ Minoris was 86° 35′ 43″ under the pole, and that of 51 Cephei was 87° 15′ 26″. The transit of the first was observed at Greenwich, at 6h. 28m. 29.64s., while the transit of 51 Cephei was at 6h. 28m. 1.58s., the difference of the tabular right ascensions being 12 h. 8m. 20.99s.; reducing the observation, the result gave an azimuthal error of the instrument of $+6''.93$, and the difference in time 10.85s., which is great, and shows that the instrument pointed to the west of the meridian. The results also show that the method is extremely delicate and accurate.

If we take the transits of different stars, it can be made plain that the time occupied by the star in traversing the intervals between the wires is least at the equator, and increases with the distance from that circle. The time occupied by any star on the equator is called its equatorial interval, and when this is known, the interval for any parallel of declension may be reduced by computation. We give an illustration in the cut. Let P be the pole and E Q an arc of the equatorial plane; C then would be the centre of the earth, and A some point representing latitude; then the distance, or rather the arc will be less between B D than between E Q; but in taking into consideration the geometrical proposition that the arc E Q : arc B D : : C Q : AD : : 1 : cos. Dec. Reducing the proposition:



B D = E Q cos. Dec.

We have adverted to this for the purpose of showing the process of reasoning, and we will show its application. The equatorial difference can be got very accurately by observations on the pole star; but in this case the circumstances are somewhat different, for, unlike the other fixed stars, the pole star describes a curve in the field of the telescope thus:



and therefore the sine A D is multiplied by the cosine of the declination, the product giving the sine of the equatorial interval. From this may be deduced the mean of the equatorial sines from the mean of the wires; and, as before stated, the accuracy of the observation will be increased by a multiplication of the wires. On April 26, 1860, Polaris had a declination of 88° 30′ 27″, and the record of the observations together with the method of reduction, will illustrate all we wish to say.

Wires.	Observations.	Observed Intervals.	Equatorial Intervals.
	h. m. s.	m. s	s.
A............	0 39 48.0	−24 43.29	−38 559
B............	48 3 0	−16 28.29	−25.719
C............	56 19.0	− 8 12.29	−12.820
D............	1 4 32.0	+ 0 0.71	+ 0 018
E............	12 44.0	+ 8 12 71	+12.830
F............	20 57.0	+16 25.71	+25.652
G............	29 16.0	+24 44.71	+38.595
Mean......	1 4 31.29		

The letters in column first are used to distinguish the wires of the transit. The wires at Greenwich are designated by the letters of the alphabet in such a manner that, when the illumined end of the axis is east, the order of the wires for stars above the pole is A, B, C, D, E, F, G; but when the illumined end of the axis is west, the order is G, F, E, D, C, B A. Column third shows the difference between each observation and the mean of the seven wires. Column fourth shows the equatorial interval thence deduced. The fourth column is computed as follows:

24m. 43.29s. = 6° 10′ 49″ .35 sine=9.0320497;
cos. Dec. 88° 30′ 27″ .0 =8.4157426;

38.559s.= 9′ 38.″39 sine=7.4477923;

and in the same manner for the other wires.

It will be perceived that the middle wire differs slightly from the mean of the seven wires, which may be called the *mean wire.* It is customary, at Greenwich, to reduce all observations to the standard of the mean wire, and not of the middle wire.

With a brief allusion to time, we will close this series of articles, at the end of which we give a table of the latitude and longitude of fifty-four places in the United States, the results of the latest determinations. In relation to time we will call attention to the fact that the earth moves in its orbit, and that therefore the sun's place must change in relation to the vernal equinox a certain amount each day; but the fixed stars are so distant that no perceptible change in their position can be observed during the entire year. The interval between two successive returns of the vernal equinox to the same meridian is called a sidereal day, and the measure of the longitude is exactly twenty-four hours. But in consequence of the earth's motion in its orbit, an arc of the equator, equal to 360° 59′ 8.33″, is a mean solar day, while the sidereal day will only give 360°. The proportion of the two days then may be thus expressed:

360° : 59′ 8.33″ : : one day : 3m. 56.555s.

It follows then that 24 hours of mean solar time = 24h. 3m. 56.555s. sidereal time. The mean solar day has been adopted by astronomers; but the earth's motion around the sun is not uniform, and although the apparent revolution is completed in 365d. 5h. 48m. 47.57s., owing to the difference in the motion the sun will arrive at the meridian at unequal times from day to day, and to compensate for this the time has been equated for every day in the year, and our table, which we give at the last page of each number, is the result of the computation. The following is a table of longitudes by which the observer may take the time at the nearest station to his meridian, and thus compare the time at his locality.

LATITUDES AND LONGITUDES OF PLACES IN THE UNITED STATES.

West Longitudes are considered as positive, East Longitudes as negative.

PLACE.	Latitude.	Longitude from Washington in Time.	Longitude from Green wich in Time.
	° ′ ″	*h. m. s*	*h. m. s.*
Burlington, Vt.	44 27	−0 15 31	4 52 40
Middlebury, Vt.	44 0	−0 15 39	4 52 32
Brunswick, Me., College	43 54 29.0	−0 28 21.6	4 39 49.6
Hanover, N. H.	43 43 30	−0 19 19	4 48 52
Rochester, N. Y.	43 8 17	+0 3 13	5 11 24
Clinton, N. Y.	43 2	−0 6 15	5 1 56
Schenectady, N. Y.	42 48	−0 12 31	4 55 40
Williamstown, Mass.	42 42 49	−0 15 18.6	4 52 52.6
Albany, N. Y., Capitol	42 39 3	−0 13 11.9	4 54 59.3
Beloit, Wis.	42 32	+0 47 53	5 56 4
Cambridge, Mass., Observat.	42 22 48.6	−0 23 41.5	4 44 29.7
Amherst, Mass., College	42 22 15.6	−0 18 5.2	4 50 6
Boston, Mass., State House	42 21 27.6	−0 23 57	4 44 14
Ann Harbor, Mich	42 17	+0 27 1	5 35 12
Chicago, Ill.	41 53 10	+0 42 20.9	5 50 32.1
Providence, R. I., College	41 50 16.7	−0 22 36.6	4 45 54.6
Hartford, Conn., State House	41 45 59	−0 17 28.2	4 50 43
Middletown, Conn., College	41 33 8	−0 17 35	4 50 36
West Point, N. Y.	41 23 25.6	−0 12 23.1	4 55 48.1
New Haven, Conn., Coll. Sp.	41 18 27.7	−0 16 29.6	4 51 41.6
Nantucket, Mass., Mitc. Obs.	41 16 57.2	−0 27 48.6	4 40 22.6
Hudson, Ohio, Observatory	41 14 42.6	+0 17 32.1	5 25 43.3
New York, City Hall	40 42 43.2	−0 12 11.0	4 56 0.2
Princeton, N. J., College	40 20 52.1	−0 9 34.2	4 58 37 0
Canonsburgh, Penn.	40 17	+0 13 5	5 21 16
Carlisle, Penn.	40 12	+0 0 41	5 8 52
Crawfordsville, Ia.	40 3	+0 39 5	5 47 16
Philadelphia, High Sch. Obs.	39 57 7.5	−0 7 33.6	5 0 37.6
Jacksonville, Ill.	39 45	+0 53 1	6 1 12
Oxford, Ohio	39 30	+0 30 53	5 39 4
Athens, Ohio	39 21	+0 20 17	5 28 28
Baltimore, Wash. Monument	39 17 47.8	−0 1 44.6	5 6 26.6
Bloomington, Ia.	39 12	+0 37 41	5 45 52
Cincinnati, Ohio, Observatory	39 5 54	+0 29 46.9	5 37 58.1
Annapolis, Md., State House.	38 58 40.2	−0 2 14.6	5 5 56.6
Georgetown, D. C., Observ.	38 54 26.1	+0 0 6.2	5 8 17.4
Washington, D. C., Observ.	38 53 39.3	0 0 0	5 8 11.2
St. Louis, Mo.	38 37 28	+0 52 49.5	6 1 0.7
Lexington, Ky.	38 6	+0 29 1	5 37 12
Charlottesville, Va., Univers.	38 2 3	+0 5 54.7	5 14 5.9
San Francisco, Cal., San. José	37 48 23.6	+3 1 27.4	8 9 38.6
Monterey, Cal., Observatory	36 37 59.9	+2 59 26.3	8 7 37.5
Nashville, Tenn., University.	36 9 33	+0 39 5.0	5 47 16.2
Chapel Hill, N. C.	35 54 21	+0 8 59	5 17 10
Santa Fe, New Mexico	35 41 6	+1 55 54	7 4 5.5
Columbia, S. C.	33 57	+0 16 17	5 24 28
Athens, Ga.	33 54	+0 25 37	5 33 48
Tuscaloosa, Ala.	33 12	+0 42 37	5 50 48
Charleston, S. C., Gibbes' Obs.	32 47 5.3	+0 11 32.8	5 19 44.0
San Diego, Cal., Observatory.	32 41 58.0	+2 40 42.3	7 48 53.5
Savannah, Ga., Exchange	32 4 53.4	+0 16 9.9	5 24 21.1
Mobile, Ala., Episcopal Spire	30 41 26.2	+0 43 54.7	5 52 5.9
New Orleans, City Hall	29 57 30	+0 51 48.8	6 0 0
Galveston, Tex., Court House	29 18 14.5	+1 10 55.0	6 19 6.2

Manufacture of the American Watch at Waltham.

NUMBER TWO.

The extreme delicacy of the punches and dies will be realized when we come to the subject of wheel cutting. The complicated punch and die that we treated of, used for crossing the wheels, are probably the finest of the whole range of punched work; for the web must be so true that it shall fit the arbor of the cutting engine, and at the same time it is necessary that the centre of the wheel should be supported.

The next stage will be to reduce the punched work to an uniform thickness, and this brings us to the frame work. Here we must diverge somewhat, for the whole process is dependent on the truth of the lathe as well as the truth of the chuck that takes the punchings or blanks; the blanks of course are of very *nearly* the same size, and when we make this remark we must be allowed to explain that even in punching, the sizes will vary slightly, owing to the density of the metal as well as the hardness. No bar or ingot of brass can be rolled with perfect truth for thickness.

We have spoken of having the stock brought to gauge, and here begins the very first principle of accuracy in the American watch. It was absolutely necessary that the materials when furnished should be of the same sizes, and this introduces the whole subject of gauges; and the first of these is obviously the calipers by which the diameter is approximated, but only that. No certainty is got, more especially in small measurements, for the reason that the human touch is not delicate enough to make a distinction between the $\frac{1}{100}$ and $\frac{1}{1000}$ of an inch, and it then is required that for correct measurements the size or thickness should be recorded, so that the eye may take the place of "feel." Various have been the devices to effect correct measurements, and we shall give in a brief outline the general principles on which all the said devices are founded; it being premised that multiplication of the size is most generally used.

This is effected in most cases by leverage;

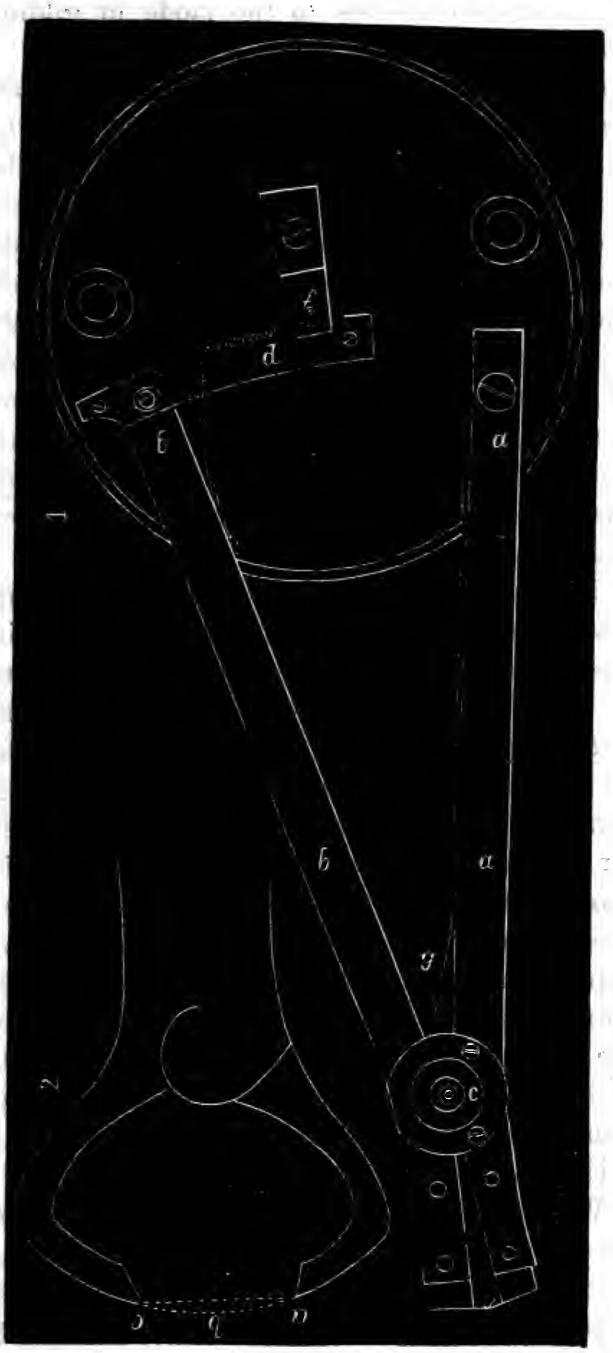
and a still further multiplication is effected, sometimes by a chain on a centre arbor which carries a hand or index, and at other times by a rack and pinion; and therein comes a little device that is admirably adapted to the purpose, which we shall show in a drawing; for, to the watchmaker the whole idea will be apparent if he will refer to the maintaining spring on the fuzee of an English watch. Before, however, we go into the micrometric gauge as now used, we must consider gauges that have been made by other parties, and we cannot refrain from an expression of thanks to Mr. Whitworth for his admirable system of gauges founded, as we will explain, entirely on the principle of gravity, combined with the screw. As Whitworth's gauge has become a standard, we shall offer no apologies for a full description.

Whitworth's celebrated gauge was got up on the principle of gravity, and therefore independent of any human errors, for Nature was to be the great arbitrator, and the mensuration was to be decided according to immutable laws. We will try to illustrate, so far as words can do. Suppose we have two fixed points; the distance between the two would be constant except for the errors occurring from expansion, and the subsequent contraction, owing to changes of temperature. But this space would be constant, and we would have but one size; the split gauge, as represented in one of our previous numbers, will give an idea of *fixed* gauge, but in this case no two people can measure alike.

It will depend entirely on the fact of mechanical arrangements that shall be automatic; and in this regard the Whitworth gauge comes in pre-eminently, for he has devised the idea of gravity. A steel bar, with two upright heads, is prepared; one of these heads is movable and a very finely made screw of a determinate number of threads, say 20 to the inch, or any other number that can be made decimal integers. Now, suppose we take that steel bar having one solid head with another head on it that can be moved a certain amount by the means of the screw, and it will be plain that if the screw is turned (calling it 20 to the inch) one-fifth of a turn, the result will be that we have very accurately measured the $\frac{1}{100}$ of an inch; this can be carried out indefinitely, for a worm gear can be (and indeed is) used by which the mensuration can be made to the $\frac{1}{1000000}$; but how can we detect such a small quantity—a distance that the microscope could only detect.

Nature here steps in to assist the artisan; for if we consider gravity at any one place a constant force, always equal under the same circumstances, we have a true standard, and Whitworth effected this in the following manner. Taking a bar on which there is a stationary head, he fitted to the bar a movable head that could be securely clamped to the bar. In the stationary head, and also the loose one, a pin was inserted of the hardest steel, with convex ends. The screw that moved the loose head being known as to pitch, the instrument was ready. The next step was to prepare several plates of hard steel, truly parallel, and the loose head is to be screwed up until it will firmly hold the steel plate between the two pins. Here the contact must be perfect, and it is evident that the least turn back of the screw will release the plate; and the amount of turn being noted, the size is attained in any fractional part of an inch, the value of the fraction being determined by the fineness of the division on the head of the screw. We need not go into the calculation minutely; but if a worm gear is used for the head of the screw, with say 100 teeth and a screw with a pitch of 20 to the inch, it is plain that a full turn of the worm screw will give but a hundredth of a turn to the measuring screw, and that would give an end-long motion of only the $\frac{1}{2000}$ of an inch. As a matter of course the worm may have a divided head, and thus the motion may be made extremely small; for if the worm should be turned only the one-hundredth, it would move the gear only the $\frac{1}{2000}$ of an inch, while the main screw would advance only the $\frac{1}{20}$ part of that.

This gauge, however fine, is hardly adapted for watch work, and another device has been adopted that combines extreme accuracy with rapidity of action. The instrument made is called a micrometer, and we feel that we can do no better service to our readers than to give a diagram, together with Moritz Grossman's description:



"It shows a pair of small steel-tongs, *a, b,* the one half of which is fixed solidly upon the plate, while the other half is fastened to the end of a lever *a,* movable on two pivots round the point *c.* For multiplying the movement of this lever, in order to make it more perceptible to the eye, the lever *b* carries a rack *d,* fixed on it concentric to the point *c.* This rack gears into a pinion *d,* on the arbor of which is mounted the small rack *e*; this latter drives the centre-pinion, which carries the hand on its projecting pivot. These two elements give a total multiplication of 180. The dial is divided into 200 parts, so that half a revolution of the hand indicates the size of one mill. But there would be no reliability on the registrations of the hand on the dial, if the shake which the centre pinion must necessarily have for free action, was not removed, because the hand would shake more than one degree, and thus destroy all accuracy of measuring. Therefore the second small rack *f,* pitching also into the centre pinion, has a pendulum spring mounted upon it, with a tendency to move the centre pinion back. An angular spring, *g,* projecting at the outside of the case, serves to open the tongs. The object to be measured must be inserted between the opened tongs, and when the lever *g* is let loose, the tongs will hold it, if it is not too heavy, by the tension of the pendulum spring constantly acting in a direction so as to shut the tongs. The hand on the dial shows the distance, at which the two parts of the tongs are kept apart by the object between them, or, which is the same, the thickness of this object. The total opening of the instrument is 6 to 8 m. The hundredths of a millimetre indicated by this micrometer are commonly called degrees by our workmen, and this degree is the unit for pivots and other small objects.

"A measurement by hundredths of mill is a very minute one; for the thinnest measurable object, the human hair, for instance, measures 4 to 6°. The thinnest paper shows a thickness of 3°.

"This instrument, as well as the tenth-measure, has a mathematical defect, because it measures the arc described by the tongs, and not the chord of this arc, which latter is the true thickness of the measured object. This error increases with the angle of opening. Of course it will be of much more consequence in the tenth-measure, as shown by the diagram; *a c* being the chord, or the size to be measured, and *a b c* the arc measured instead.

"For the micrometer this elimination of the error is impossible, but happily it is not of so great consequence, because its angle of opening, *a c,* supposed to be = 6 m., amounts only to 6°, while that of the tenth-measure, with the full opening of 10 m., is about 36°. The error arising out of the difference between the arc and chord of an angle of not more than 6°, is very trifling, and may be neglected altogether, even where great accuracy is required.

"The nicety of measuring with the micrometer may be tested by an experiment:

"Take a piece of brass wire, about 1 in. thick, put one of its ends between the tongs of the micrometer, support the other end, and put a lamp under the wire at about 1 to 1½ inches distance from the tongs, and heat the wire to a low red heat. The expansion of the wire will be indicated by an evident movement of the hand, and the subsequent contraction through the cooling of the wire will cause the reverse of this movement."

We have given the above extract, for it is a masterly description and applies directly to the subject. The whole system of the American watch manufacture requires all the accuracy of size that can be attained by the use of such fine instruments, used as standards for measurement. The gauges used are substantially the same as above described. It would not be possible, however, to measure the parallelism of a plate with such an instrument, therefore an upright gauge was devised, but founded on the same principles; the only changes being made in accordance with the circumstances. Thus, suppose a light spindle, moving in a guide, and firmly fixed in a perpendicular position to a plane, to be attached to an index. It is evident that if the degrees were marked on the spindle, no multiplication could be obtained, but if a lever were attached to the spindle with a rack and pinion, a small degree of motion could be registered as finely as in the horizontal gauge; but for the thicknesses the lever principle will not apply, for the simple reason that the motion required is too great. If now we place a pulley in the upper end of a spindle and draw over it a chain with one end firmly attached to the solid part of the gauge, and the other end wound on a centre arbor on which is a retaining spring to take the lost motion, we can closely approximate the truth of the micrometer, in delicacy of touch as well as in facility of reading; for on the arbor an index may be placed that will further multiply the motion.

Having indicated the system of standard gauges, we will in our next number proceed to the mode of applying them in the frame making.

Electro-Metallurgy.

NUMBER SIX.

We shall, in this last article on this subject, confine ourselves to the mode of gilding watch work, with a detail of the methods of coloring; for, as we observed in a former number, almost any degree of color can be attained by care and attention. It must be remembered that the deposit will in all cases be of just the color of the quality of gold held in solution; for if we should use a solution of eighteen carat gold, alloyed simply with silver, and in connection a positive pole of the same carat, and alloyed in the same manner, we shall, under these circumstances, have a deposit of nearly the color of eighteen carat gold, and within certain limits the color can always be assured.

There are two different modes of gilding watch work, the variance consisting only in the mode of producing the frosted surface, as at the present day the highly polished fine gilt surface is utterly discarded. The Swiss, as we have before stated, effect the matting entirely by crystallization; and were it not for the perishable nature of the surface, this process would be the best that could be devised; but it is plain that two coats of electro-deposit cannot be so firmly attached to the metallic base as one. It is from this fact that the watch repairer often finds a Swiss watch with the gilding so much rubbed off by brushing as to exhibit a dirty white instead of gold.

We will give the process, however, for it often happens that the repairer wants to renew the gilding so as to make the general appearance of the watch the same. We will take the pillar plate and the barrel bridge as examples, assuming that by diligent brushing with chalk, some so-called watchmaker has taken off the delicate gold surface. The centre hole should be filled with wax to prevent any action of the acid, and it would be well to stop up all the steady pin and screw holes for the same reason; and as the trouble is not much, the precaution is well worth taking. These preparations effected, the next step is to suspend the plate in a solution of silver (cyanide). The battery power must be so regulated that, if the surface is uniform, a clean deposit of crystallized silver shall be had; for it must be understood that the deposit will be in exact proportion to the strength of the battery current and the solution. Having thus obtained a crystal surface, the article is immersed in the gold solution, and a coat of reguline metal deposited; if properly performed, this process will give the beautiful frosted surface of the Swiss work.

This is a very easy job, and the cost to the watchmaker, both in apparatus and time, is so very small that it is almost inexcusable to neglect such a simple means for doing up good work. Previous to silvering, the work may be washed with sour beer and a brush in order to get a chemically clean surface, but nothing has to be done to the silver surface if it is transferred directly to the gold solution. Hardly any amount of description will enable us to give definite instructions as to the management of the battery-power; but some general observations in addition to those in former articles may enable the beginner to make more rapid headway in his experiments. In the first place, if the solution is strong the resistance is greater than when weak; in proportion, then, to the density of the solution, the battery-power must be accommodated, and by a few trials the experimenter will be enabled to find the proper proportion. Again, the size of the positive plate in the battery must be in proportion to the object. The smaller the article the less the surface of the positive plate must be; and this may be accomplished by using the same positive plate for either the large or small, by simply immersing the gold or silver plate more or less in the solution. The distance between the plate and object will be regulated by the resistance, and observation as to the effect and the character of the metal deposited. A few trials will determine this point. The temperature is another important element, and trial will be necessary to get just the relation of the strength of the solution, and the temperature.

The beginner need not despair if he fails at first to get good results, for a very little experience will enable him to judge pretty accurately on these points. The English and American watches are matted in a totally different manner. Here what is called the brush is used. It is a face plate of wood turned up truly in a lathe, the periphery pierced with holes at equal distances, and in these holes are inserted scratch brushes, which are left projecting a greater or less distance from the block. The work is well warmed, to soften the metal, and is then exposed to the action of the brush, while a small stream of sour beer is allowed to trickle on the brushes. In the revolution the brushes strike on the work, but a block is held directly back of the work to enable the wires to strike with their ends, and to prevent them from dragging across the plate. The surface will then be pitted with innumerable small indentations, and when matted enough it is taken to the decomposing cell, where it is gilded.

It sometimes happens that an article is to receive a deposit which is not a good conductor, and therefore, unless prepared in some manner, the deposit could not be effected; but if the surface is coated with a thin film of finely divided plumbago, and the wires so attached as to be in contact with the coating, it is easy enough to get a deposit on the plumbago, which is a good conductor. As a matter of course the metal is not attached to the surface; indeed, the object is to get a copy in metal.

Sometimes it is desired to copy fragile articles, or such as would be injured by the solution, and, perhaps, nothing in the range of galvano-plastic science has called out more ingenuity than to get some impression of the object. If very frail, the best method is to use wax for the mould, as it may be melted, and the object introduced into it. When the wax has become cold the article is removed, and the mould thus made filled with plaster of Paris, which, in its turn, is removed, and the surface brushed with plumbago. As the plaster would absorb the solution to a certain extent, it will be well to soak the plaster in melted wax until it is saturated with the wax, and the porosity destroyed; but only so much should be used as will leave the surface free from wax after cooling.

The surface may now be brushed with the plumbago, and the model introduced into the solution, and the copper (for copper is most generally used) deposited in the reguline state. When thick enough to answer the purpose it is removed from the model and a reverse impression of the original is obtained. This, again, is attached to the pole and a true model in copper is obtained.

It is impossible to conceive of the beauty as well as exactness of these galvano casts. Where the object is of wood, it is customary to use Rose's fusible metal by what is called the Cliché process; that is, the metal being fused, it is applied with a quick and forcible jerk of the hand if a sharp impression of the original is to be obtained. It requires some little knack to do this, and sometimes the nature of the article is such, even in wood, that the process is inadmissible.

There is another substance that is superior to any we have mentioned. We refer to the pure gutta-percha, which is now used extensively for making moulds, and is distinguished for the sharpness of impression and the truth with which the details are copied. The mode of using it is simply to heat it in hot water, when the gutta-percha will become so soft that, with the exercise of but little force, it can be applied to the object. The subsequent manipulations are similar to those described for wax. If the object is much undercut in its details, glue and molasses, such as is used for printers' inking rollers, is used. After the mould has set, the elasticity of the glue enables the mould to be taken off the object, and when the plaster cast has set, the glue can be peeled off. There is one other set of objects that can be coated in the solution, and in this case the deposit is to remain. We allude to coating vegetables, fruits, leaves, etc., and plumbago is then used. If a bunch of grapes is brushed over thoroughly with plumbago, and then placed directly in the solution, a deposit of copper will be effected. The beauty of these objects is somewhat marvellous. They resemble copper castings so perfectly that the eye is deceived, though the weight would detect the deception. Some specimens that we have seen were made by a lady who takes a great fancy for the art; apples, and indeed almost every fruit and leaf, she has coated with every success. The whole process is so enticing that the wonder is that more persons do not cultivate a knowledge of it, if only for amusement.

Watch Repairing.

NUMBER SIX.

The preceding articles have been devoted mostly to tools, with directions as to the making of some, and use of others. We shall continue to do so, for until the bench is well and completely furnished with tools the repairer is working to a disadvantage, for the simple reason that time is more valuable than the cost of the tools; and we will insist that the apprentice can do more with his spare money if he invests it in tools than he can if he expends it on dress. With these remarks we will resume the question.

It often happens that even with a good stock of material on hand there may come in a job when the repairer cannot find in his whole stock the piece he wants to do the work, that is of the right size, or, if a wheel, of the right pitch for the pinion into which it depths. Taking the wheel, then, for example, what can the workman do without a cutting engine? We admit that the occasions are rare where the engine is required ; but they do occur, and we have seen many cases where a new wheel has been put in, that the workman has selected the nearest in size and pitch he could select out of his stock, or possibly out of the trunk of the travelling material dealer, and yet the train will not move freely when the wheel has been put in, and the customer and repairer are both dissatisfied.

The cutting engine is not a very expensive tool, and if there is a lathe on the bench the labor of cutting a wheel is reduced in relation to the speed attained in the cutter. The engine may be placed just back of the lathe, and a second band from the pulley on the lathe arbor may be led to the cutter arbor of the engine.

The most common engine in this market is the Swiss, of various sizes and qualities. Some are fitted for cutting scape-wheels for cylinder escapements; generally, however, they are intended only for plain work. The cutters furnished are supposed to be suitable for the ordinary class of work in all its varieties; but the workman will find that there will be occasions where they fail, and he must resort to others of his own make, and if he has no cutter, or, as it should be called, a milling tool, he may make an extra mandrel to the engine; to this we will refer again.

Without a description of the ordinary mode of cutting wheels we would only lead the reader astray; for in the Swiss tool some little management is required, for the wheel to be cut must be centred by the hole that takes the pinion. It, in many cases, happens that the wheel is merely driven on the pinion arbor, while in other cases the wheel is staked on the pinion itself.

Now the cutting engine has a pump centre that takes the hole, and when the dividing plate is true there will be no difficulty in cutting a good wheel; but in the first place it is as well that we should describe the instrument, not in detail, but enough to give the idea as to the working. The pump centre takes the hole and the cutter arbor is carried in a swing frame that is brought up to the central arbor by means of a screw feed, and the blank is held between two pieces of metal that leave space enough for the depth of the tooth. The system of centring is essentially different from the American—not so accurate, but far more universal in application, as any sized wheel may be cut. In the American watch factories the arbors that hold the wheels by the inside of the web are costly, and can be used but for one size each; but it is plain, however, that the wheel, in this case, will have a true web.

In the common engine the wheel is centred by the hole and held between two surfaces that take the web; thus it sometimes happens that the cut edge of the wheel will be out of true, and where the wheel is forced on the staffs this would be of importance; but the truth of the centring becomes a matter of the highest consideration where the wheel is staked on the leaves of the pinion. As a matter of course, with the cutting arbor in a swing the cut cannot be in a perfectly straight line, for it must be in the curve which the centres of the swing and the periphery of the cutter will describe. As a wheel is very thin, this perhaps is of little account; but when the main wheel has to be cut the error may be serious, for there will be but two bearings on the centre pinion leaves, and it follows that the points of bearing will get worn down in a very short time, and the depth will then be wrong. With the exception of the main wheel the swing is good enough, for the small arc travelled by the cutter is hardly an appreciable quantity.

There may be occasions where the repairer is required to replace a cylinder escapement wheel in consequence of a broken tooth. The question then comes up, how to cut the wheel if he cannot find in his stock a wheel of the requisite size.

Flow of Metals.

We have been queried by a correspondent as to what is meant by "spinning" metals. He could conceive the spinning of wool or any other fibrous materials, but wonders how the process can be made applicable to sheet metal. We have chosen to answer the query in the form of an article, in preference to the usual mode of answers to correspondents, for the subject embraces a wide range of inquiry, commencing at the hammer and ending with tube drawing by a punch and die. The query was elicited by a reference to the rapid spinning up of a cup at Adams, Chandler & Co.'s factory, in Brooklyn.

Now we must premise that in the metals, at least, we do not recognize the idea of stability of molecular constitution, for the same metal may be in different conditions of strain at different parts, and therefore assume new properties. Let us take the spring on a lomotive and the one that impels the movement of the watch, and still farther extend our example by the hair-spring that is in a constant state of vibration. The conditions of the molecular arrangement will be modified, first, by the frequency of the motion, the character of the shock, and the amount of vibration. This hardly can be called a "flow of the metal," though the facts prepare us to believe that no metal is absolutely solid in the strict sense of the word. For instance, if a plain plate or sheet of metal is placed on an anvil, and a blow of a hammer is made, there certainly will be a condensation of the material at the point where the blow comes; that is, the sheet will be thinner at the point struck by the hammer than at any other. We must assume that some particles of metal have moved in a lateral direction, for the plate will be of less thickness at that point than any other after the blow; and that this effect produced by the blow with a hammer is not confined to any metal, or even to glass, for pressure on some one particular part will deflect the glass, so as to show an entirely different angle of reflection.

It is evident in the last case that some change of molecular arrangement has been effected. We can only accept the facts, while we are lost in our efforts to trace the motion of the particles, for who can comprehend the idea that the particles of the glass move on each other; and yet such is the fact, as we will try to demonstrate. If we take a piece of plate glass and hold it by the centre in a screw-press with two points opposite to each other in the line of pressure, we shall find that the plane of the surface, however true in the first instance, has been changed in regard to reflection.

Again, let us take the case of rolling any metal; it is evident that preceding the rolls the metal must be thicker than on the other side. We will stop here to think of what becomes of the particles in front of the rolls. It is plain that the metallic strip or sheet is thinner when it has passed through the rolls. Have we then piled up the particles the same as if we had run through a piece of putty? And this affords us an illustration, for the mobility of the particles gives a good idea of the motion in the molecular arrangement in any other substance; the only difference is that some substances are more easily displaced than others, and therefore the change is not readily detected.

Suppose we take a nail rod, the softest condition of iron we can obtain, and submit it to the action of the rolls. It is thinner when it passes through than it was before, but it is longer and wider. We must take it for granted that the particles of iron have changed in their relative positions, and we may assume that while the greater number have been forced back, a small number have submitted to a lateral flow and thus increased the width, but not in the same amount as in length. The question must be asked here, where do the particles go that are not in the thin part?

Just so in drawing wire, the metal is evidently forced back from the hole and a displacement of particles must take place, for the wire has to be reduced in size and therefore the particles are driven backwards. If, in wire drawing, we should take an iron wire covered with silver, the relative hardness of the two metals will determine the amount of extension of the silver beyond the iron. For instance, suppose we take a tube with a steel mandrel and commence drawing hollow wire; we shall find that the silver, if only of six inches in length, may be made to extend and cover the whole of the mandrel, and sometimes, in proportion to the quantity, the silver may extend beyond the mandrel.

We can well imagine in a case of this kind that there has been a mobility of the particles that renders our ideas of solidity somewhat shaken, for if a metal is not solid, and not subject to change, we may well ask what is? Again, if we take a piece of quartz, we shall find that the particles are also disturbed in their relations, only the nature of the substance does not admit of the striking exhibitions afforded by the metals.

We have assumed in all these cases, that the material was cold, for it would be nothing to say that cast iron can be poured or lead pipe forced through a die while in a state of semi-fusion, by hydrostatic pressure. Still another instance may be cited where the pipe is lined with tin (block); in this operation a cyinder of solid tin, having a hole through it of about the dimension of the inside of the pipe, is placed on the bridge of the die in the reservoir of the hydraulic press. The lead is now introduced and the plunger of the press is forced down; here we have a solid and a fluid, and it was an ingenious idea that suggested the process, for the tin is actually forced out of the die in the solid condition, while the lead that surrounds it is semi-fluid until it has cooled down by the abstraction of heat incident to the long die through which both of the metals are forced in order to make the tubing. A still greater advance on the process has been made, for at the present day the cold lead is forced through the die by powerful pressure. In fact, the limit to the motion of the particles of a metal on each other is only reached when the limit of power is.

In the answer to G. L. B., Wis., in number 10, we adverted to the spheres that are used for jewelry. If our readers will revert to that they will see, by a little reasoning, that the bottom of the hemisphere formed by the first punch and die is the thinnest at the end of the punch, and that the metal or some portion of it has been thrown into the four corners, for the plate originally was of equal thickness. Again, when the corners are closed over to complete the sphere, the metal must again be forced back to the hemisphere. This is really the fact, and the metal in this case has been flowed in both directions, that is, backwards and forwards.

Another instance of the flow of metal can be seen in the planishing of the ordinary skive for cutting stone. Here we have a disk of sheet-iron; the operator commences with the mallet at the centre, and by a gradual diminution of the thickness of the metal from the centre he is enabled to get a dished form to the disk. Again, we may refer to the tubes that hold the colors of the painter; here the metal has been entirely changed in its molecular condition, the top where the screw is put on must have been condensed, while the sides of the tube are nearly uniform in thickness.

We will go still farther. The solid metal m y be flowed, as is seen in the case of straightening saw blades after they have been tempered; this is effected by the blows of a hammer judiciously applied. No one could do it except he has had long experience, for the least stroke of the hammer wrongly directed would still further disturb the blade of the saw.

There is still another form of manipulation that causes a flow of the metal—we allude to the setting of a jewel. Here the brass is cut away and a sharp edge left. If now the burnisher is skilfully applied the thin edge may be turned down over the face of the stone, and here comes in our first instance of spinning metal. In this case we have but a very thin edge to turn over; but what shall we say when we take the case of a brass kettle? Here a blank punching of the brass plate is made and then put up in the lathe, with suitable chucks to enable the workman to give it form and shape.

Perhaps we can do no better than to describe what we saw at the factory of Adams, Chandler & Co., in relation to the flow of metal on the end of a mandrel. We will take a common cup for our starting-point. Imagine that on the live spindle there is a chuck turned upon its face just large enough to form the bottom, the back centre having a block fitted on it that is the form designed; it is evident, then, that if a sheet of metal soft enough to come within the power of the burnisher were placed between the two blocks, the sheet might be drawn over the block on the back centre.

The plate of metal is firmly held between the two ends of the chuck, if we may so term the wooden form on the back spindle. In the first instance the plate will run in the lathe like a circular saw; if now a burnisher is brought up to the plate from the back side the plate will be bent over towards the form (wooden) of the back centre. If now the burnisher is slowly carried back by means of a pin in the rest, we should bend the plate towards the back centre.

There can be no adequate description given of the art of spinning, more than we have already endeavored to afford. To realize the ease with which a form, say cup, sugar bowl, or any other form from which a solid mass can be withdrawn, any one of our readers can, if in the city, witness the fact that we did, as we are authorized to extend an invitation to any of our readers, by Messrs. Adams, Chandler & Co., to visit their factory in Brooklyn, and see for themselves the quickest displacement of material in the process of spinning. A plate of the composition was placed between the two pieces, and by a little tact was brought true, and then the back centre brought up to hold it firmly. The ordinary hand rest is used, only the T has a number of holes into any one of which a pin may be dropped. With this pin as a fulcrum the operative works, with his burnisher *from* the mandrel, flowing the metal over the block held on the back centre.

The block held by the back centre must be slightly tapering, or the work could not be stripped off after it has been flowed. No description can be satisfactory, and we advise our readers to call and see for themselves.

American Horological Journal.

Two weeks only, and the twelfth number of the first volume of the HOROLOGICAL JOURNAL will have been issued, and we deem this a fitting occasion to make some observations in regard to ourselves. Previous to the establishment of our JOURNAL, there had never been an effort made in the United States to publish a purely Horologico-Scientific Journal, devoted to the interests of the practical watch-repairer. There was nothing extant that gave a *live* treatise on watch work; something like Ried could be found, but it was too general in its application, while each successive author seemed to vie with the preceding one as to how obscure he could make the subject of watch and clock repairing; and still later a few small volumes have been published, but they were intended only as an advertising medium for some special interest.

Believing that the wants of the trade warranted something of a more practical character than had hitherto been offered, we established the JOURNAL for that specific object, and that we have in a great measure so far supplied that want is evidenced by the general tone of the letters received from our patrons. And we will here make the assertion that no publisher in this city can show as many letters from his patrons advising an advance in the price of subscription as ourselves.

We have endeavored to fill a want in mechanical literature that certainly existed, by giving a species of information that could only be obtained from the accomplished workman, and we leave our readers to judge whether we have fulfilled our object. True, the educated mechanician or the practical astronomer may think that we have at times gone somewhat too minutely into minor details, but it must be remembered that it was our aim to not only be a medium of intercommunication for the skilled workman, but of instruction to those who, just starting in the business of repairing, would find the hints and facts we give to be of great benefit; and the best workman, in *his* early days, would have prized the information we try to afford. During the time of trial that the AMERICAN HOROLOGICAL JOURNAL has had, we have never had a word of censure; and now we may throw our enterprise on the Horological public with perfect confidence.

We make no bombastic promises of immense improvement, leaving the present volume to tell for itself, and vouch for the future; but we have the proud satisfaction that the most intelligent class of watchmakers have not only become subscribers, but have interested themselves in our success by contributions, hints, and correspondence, and can therefore safely promise that its high literary and scientific character will be fully sustained.

We can hardly be charged with egotism when we say that the amount of information furnished by the JOURNAL could not be got elsewhere. The knowledge of detail is scattered, and if the artisan wishes to obtain information he must seek it from so many different sources that he is apt to despair. We have concentrated this knowledge, and in the columns of the JOURNAL, that ends a volume with the next number, we venture to say that the trade has more *practical* information than can be found in all the treatises on Horology extant. In the coming volume, in addition to our present contributors, we shall be in receipt of regular European correspondence from prominent Horologists.

We have offered this address to our readers for a special purpose, and that was to gain time in making up our subscription books for the coming volume.

We would be much obliged, then, to our subscribers and friends, if they would send in their subscriptions as early as possible, thereby enabling us the more easily to effect our business arrangements before commencing the second volume. Having established a success, we have no hesitation, as we had when, alone and unknown, we offered a technical journal to the Horological public, and confidently rely upon a largely increased list of patrons, thereby enabling us to still farther extend our efforts for their benefit.

The terms of subscription, will be, as heretofore, two dollars and fifty cents per annum. Remittances should be made by P. O. Order in all cases where it is possible to do so, as that avoids all risk of loss.

Address

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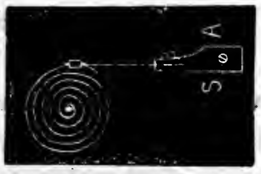
Isochronism.

NUMBER TWO.

In reasoning on a subject that is so very dependent on the mechanical construction, we must be allowed something of a range in the discussion. Suppose we take in the first instance a flat spring with a terminal curve where it enters the collet. The spring is pinned to the hair-spring stud at just its semidiameter, and it is evident that if it has been adjusted so as to be central for a given vibration, any increase in the arc will make it become eccentric. Yet even here we can provide for the greater vibration, by making the hair-spring stud a spring of itself, as the cut will show, and we give Saunier's idea of it:



"The great trouble with the common spring is the distance of the centre of the arbor from one of the connecting points, obliging the body of the spring to throw itself suddenly to one side, thus producing a distorted form which hinders the development of isochronism. This can be remedied by fastening this spring to the extremity of a straight spring fixed by a screw to the pillar plate. This arrangement is called the spring or movable stud."

With this form of stud we have a compensation for the lateral spread of the ordinary level spring; for when the vibration of the balance opens the coils, the spring on the stud moves slightly away from the centre, thus giving the coils a chance to open centrally; the reverse taking place when the return vibration closes the spring. There are some difficulties attending the plan, which is the idea of Messrs. Young and Hardy. The great obstacle is to determine the exact length of the spring of the stud, and of course the proper amount of elasticity to be given to it. And again it will strike any reasoner that the point of attachment must be nominally without weight, for if the spring were so heavy as to be influenced by its weight, the spring, however well isochronized, will not retain the quality when the watch is placed in the vertical in such a position that the stud is horizontal. Mr. C. Frodsham, of London, adapted this plan to a marine chronometer, and attained a perfect success in the isochronism of a level spring.

It will be seen in this connection of the pendulum spring to a secondary spring, that the watch may be put in beat without unpinning the spring. Here are two advantages gained, for the spring takes up all the motion of the side vibration of the coils, and at the same time we are enabled to lengthen the spring proper without unpinning. A glance at the cut will enable the repairer to understand our meaning, and we will now state it as a fact, that no spring can be let out and the isochronism preserved. In a general way, we will assert that no spring that has been pinned in the hair-spring stud can be let out and yet preserve the same motion; for the pin, in holding the spring, has, if we may use the term, crimped it in the stud, and then, when the part is let out, it becomes the hair-spring stud itself, as it were, for the form of the spring has been changed by the pressure of the round pin, and becomes corrugated; true, the amount is minute, but it is sufficient to influence the vibration of the last coil; and this remark applies as well to the attachment to the hair-spring collet, for the spring, to be free, must have a good curve, and the pin that holds it by the force of the pressure will make a change in the character of this interior terminal curve.

The main point to be attained is, first, uniformity in the elasticity of every portion of the spring; secondly, that the spring shall be so put in that at each vibration of the balance the openings of the coil shall be equal on every side of the balance staff; and thirdly, that no strain shall come on the spring from pinning. In the spiral helix the isochronism may be attained for a wide range of arcs of vibration, provided the terminal curves are made equal, and the points of attachment equally near the centre of motion. The return spring is next in value, though some allowance is to be made for torsion, the spring not being in the same plane when the commencement of the return is made. The Brequet spring, with the elbow, is, perhaps, the best for general purposes, though the elbow, as stated before, is an obstacle to the attainment of isochronism.

We will close this subject with a remark on the relative force of springs of different dimensions, both as to thickness and length, giving as authority M. Phillips, a French author. He first gives the general formula, and deduces from it that if the size of the wire is increased twice, three times, and so on, the force is increased in the same ratio. If the spring is lengthened twice, etc., the power is diminished in the same ratio, and the power of the spring will be proportional to the arc of vibration, and the number of vibrations are (in a given time) inversely as the square root of the length of the spring.

The Cylinder Escapement,

Though almost superseded by the lever, the cylinder is not to be despised if we take into consideration cheapness of make and the close approximation to good time that can be had where any ordinary care is taken to have the angles of impulse on the wheel teeth correct, and the edges of the cylinder being well finished. We have seen jewelled cylinders that performed remarkably well, but the great objection in this case is the excessive fragility of the cylinder, and its consequent liability to injury. And, again, we have seen plain escapements that kept good time and gave good satisfaction to the owners.

There are some objections to the cylinder escapement, such as the amount of friction produced in the locking, and next, the liability to breakage. It is somewhat expensive to replace either a wheel or a broken cylinder, and as the balance banks at its full turn, the liability to breakage is still further increased. But a greater difficulty ensues from the fact that the two detents and impulses are unequal, for one detent takes in the inside of the cylinder, while the other takes the outside, the whole difference being exactly the thickness of the metal of the cylinder; or, to speak technically, the radius of one locking is not equal to the other.

To illustrate this point, take the diameter of the outside and then the inside; as a matter of course there is a shell of material of whatever it may be, and as the tooth of the wheel has to pass into the hollow of the cylinder, and then give its impulse, it is evident that the locking surface of the inside must unlock easier than that of the outside; and, again, the inside edge will give a larger vibration than the outside, on account of the difference of leverage between the two points of contact for impulse. As the impulse is given entirely by the wheel teeth, we can imagine that, as in some forms of the pallet, the strongest locking is on the side of the smallest amount of impulse; but this same impulse is stronger, as the radius of the outside of the cylinder cannot be the same as that of the inside. There is another difficulty—the change of the oil; but this is incident to all escapements with frictional surfaces.

Let us, however, hear the other side of the case, in defence of the cylinder. We were assured to-day by a very eminent repairer in this city, that he had passed through his hands for cleaning, an English cylinder that had been carried by the same party for over fifty years; the wheel and cylinder were steel, and yet there were no marks of cutting on either the locking surfaces of the cylinder, or the edges of the half circle where the impulse is given, while the impulse faces of the wheel teeth were perfect; and furthermore he assured us that when cleaned and put properly in beat, by allowing for the difference of impulse, the watch performed with remarkable accuracy.

With such evidence brought before us, we may begin to consider the true action of the wheel and cylinder. It is true that the balance must not make more than a full turn, for if it did the wheel tooth would enter twice on that vibration going in the same direction, and the watch would be stopped, for the hair-spring, even though spread out to its greatest extent, is incapable of overcoming the lock of the next tooth that has taken so far back on the cylinder; therefore a banking pin is required, and then it is obvious that the balance cannot describe a full turn even by the thickness of the stop that takes the banking pin in the rim of the balance. Now, this banking pin is not required on account of any increased impulse or power, but only to counteract any sudden jar or rotation of the watch in winding; and herein comes up a very strong argument in favor of the cylinder, for any change in the motion will have but very little effect on the extent of the angular motion of the balance.

In our next we will further argue the case, with such cuts as will prove the truth of our theory.

Spring Lever for Watches.

We give an extract, with a cut from *The London Horological Journal*, of a system of spring banking. After carefully looking over the subject, we can hardly see any advantage, for if the vibration is so great as to bring the impulse pin on the outside of the fork, the resilient action of the spring would throw the fork and guard pin past the notch of the roller on the other side of the impulse pin. Now, the spring on the fork must be light enough to allow of the shock of the impulse pin, but strong enough to prevent the pallet entering too deep into the wheel. Under such circumstances, it can be readily conceived that the rebound of the pin from the action of the fork spring will leave a chance for the guard pin to enter the notch in the roller, and thus make a false beat. The idea is an old one, and though now patented, we are persuaded will not accomplish the purposes sought. However, we give the extract, for the reson that anything new in Horology is of importance to our readers:

"It sometimes occurs in this mechanism that by a greater than ordinary impulse imparted to the balance-wheel, from any cause, the ruby pin, after the lever has been moved over into the one position, is carried sufficiently far round to cause it to strike the outside of the fork of the lever in the same direction, whereby, as the lever when thrown over is in contact with the one banking pin, and cannot, therefore, yield to such striking of the ruby pin, it sometimes occurs that the ruby pin is fractured, or the balance wheel or pallet staff pivots are broken or bent. Various contrivances have been proposed to obviate these inconveniences, but all have been either too complicated, and consequently expensive in their construction, or too uncertain in their action for general adoption. The present invention has for its object to provide both an efficient and a simple means for preventing the above liabilities. It consists in placing the banking pins at the tail of the lever, and in so forming this tail as to act as a spring instead of making it rigid, as heretofore; such spring being sufficiently stiff, in coming in contact with the banking pins, to limit the ordinary motion of the lever to the required extent, while it is sufficiently elastic to allow the lever to yield to the before-mentioned second blow of the ruby pin, and to assume its correct position after the ruby pin has passed it.

"The balance wheel, with ruby pin, works in the fork of the lever *c* in the usual manner. The escape wheel, and the pallets carried by the pallet staff and secured to the lever, are as usual. The tail c^1 of this lever is formed quite thin, as indicated in the accompanying figure, so as to act as a spring, and works between the banking pins *g*, *g*. If now the balance wheel, having received the impulse given by the action of a tooth of the escape wheel on one of the pallets communicated through the lever, should, from any cause, be moved so far round that the ruby pin strikes against the outside of the fork of the lever *c*, the tail c^1 of this lever resting at the time against the one banking pin, will, through its spring action and the shape given to the fork end of the lever, allow the ruby pin to pass by, when the spring tail will immediately cause the lever to regain its correct position for the ruby pin to act upon it in the contrary direction. The tail c^1 is, however, made sufficiently stiff to limit the ordinary motion of the lever by coming in contact with the banking pins.

"Another modification of the lever *c* is proposed, in which, in place of forming the spring tail c^1 on the lever itself, such spring is formed separate from the lever, and is secured to the pallet staff, and to the lever."

Could we get isochronism with such an arrangement?

Electrical Mensuration.

With such a mysterious power it would seem almost impossible to measure its strength. But the electricians have devised, as it were, a table of weights and measures, and these values expressed in terms of the standard unit have been adopted by the British Association for the Advancement of Science, and as the system has been generally acquiesced in, it may do our readers a service to give the table. The elements of this table are derived from the absolute electrodynamic units of Weber by multiplying them by such powers of ten as shall refer them to a convenient scale:

"The unit of force f is that force which, acting during 1 mean second upon a mass weighing 1 gram, would impress upon it a velocity of 1 metre in 1 second. It differs from the metre-gram, which is the force requisite for lifting a gram through a metre in a second, and is 9.80868 f.

"The unit of current c is that current which, acting through 1 metre, at 1 metre distance exerts the force f upon a similar current. It decomposes about 92 milligrams of water in each cell in a second, consuming about one-third of a gram of zinc.

"The unit of resistance r is the resistance of the conductor which transmits the current c in 1 second.

"The unit of electromotive force e is the tension which maintains the current c with the resistance r.

"The unit of quantity q is that amount of electricity which flows in the current c during 1 second.

"These measures, 'absolute' in so far as they depend only upon the gram, the metre and the second, are referred to convenient scales in the British Association's system; the measures adopted being named in honor of eminent discoverers in electrical science, in accordance with a suggestion of Mr. Clark.

"The measure of electromotive force is $10^5 f$, or one hundred thousand times the absolute unit.

"This has about 0.927 the tension of a Daniell's cell, and is called a *volt*.

"The measure of resistance is $10^7 r$, or ten million times the absolute unit.

"This is about 1.0456 times the unit adopted by Siemens, and is called an *ohm*. The measure of quantity is $10^{-8} q$, or the hundred millionth part of the absolute unit.

"This is called a *farad*.

"Consequently, with a tension of one volt, and a resistance of one million ohms, the quantity of electricity would be one farad in each second.

"Moreover, since the volt-farad is $10^{-3} f. q$, we have 1,000 volt-farads=the absolute unit of work; or 9,808.08 volt-farads per second= the metre-gram.

"One million of ohms is conveniently designated as a *megohm;* and one million of farads as a *megafarad*."

In connection with this we will give another form of the battery, but good only for constant power for telegraph purposes, and we quote from Dr. B. A. Gould's report on the telegraphic cables of 1865 and 1866:

"The battery employed by the telegraph company was composed of what are known as Minotti's cells; these being a modified form of Daniell's, in which the zinc rests upon a column of wet saw-dust at the bottom of which is a layer of sulphate of copper, and a copper disk being at the base of all. My friend, Mr. M. G. Farmer, to whom I applied for information, found by experiment the electro-motive force of one of these cells to vary from 0.75 to 0.95 volt, averaging 0.84: while the average of four Daniell's cells of ordinary construction gave 0.923 volt. Hence he estimates that, after the full strength of the current is developed, one cell should give, upon one cable with earth connection, about 110 farads in a second."

We have introduced this form of battery for the use of those who desire to take electro-casts, for it might be very useful and cheap. But our sole object is to ascertain the velocity of the current, in order to obtain longitude, and this velocity on the land wires, it is now somewhat definitely settled, at the rate of about 16,000 miles per second. It would seem, however, that with submerged wires the conditions are entirely changed, as the cable itself becomes simply a Leyden jar, and any disturbance at one end by however feeble a power, will suffice to induce a disturbance at the other end. We will quote again in support of the assertion:

"During my stay in Valencia, messages were effectually and distinctly transmitted in each direction by the use of an electromotor formed by a small percussion-cap containing moistened sand, upon which rested a particle of zinc. The current here evolved could scarcely have amounted to more than six or seven farads, so that nearly two minutes would have been requisite for charging one cable; yet the transmission-time was certainly small, although it was not definitely measured."

But still more wonderful is the fact that without a battery signals have been transmitted on the cable. We leave the Professor to finish the article:

"As showing the continued existence of currents (doubtless engaged in establishing equilibrium) during the intervals between the signals, it may be of interest to mention that on one occasion when the two cables had been joined at Heart's Content, without battery, and while the Valencia battery had been temporarily disconnected, signals from Newfoundland were distinctly received. They were weak, and the deflections of the needle were scarcely one-fifth as large as usual; yet they were none the less distinct, and a complete set of signals, ten in number, at proper intervals and preceded by a 'rattle,' was recognized at Valencia. No other record of them was made, than the fact of their transmission by alteration of the make-circuit and break-circuit signals, although no battery had been connected with the cable for several minutes."

———o———

Polarization of Light.

A valued correspondent in the last number described the pebble tester, and expressed a wish for a series of articles on Light. We comply with his request, as the subject is one we can write upon *con amore*, for it is one of strange and almost marvellous facts, which when known, explain many phenomena of light that previously to the discovery of polarity were totally incomprehensible; and it was impossible to reconcile them to either theory or practice.

The whole subject has been thoroughly studied by the most eminent physicists of Europe and America, and though demonstration can be made with the greatest ease, yet it was not until 1808 that the property of polarization was detected by Mr. Malus, and the discovery was purely accidental; but luckily Mr. Malus was possessed of a mind capable of drawing the gravest and most profound conclusions from the mort trivial incidents. This gentleman was viewing the effects of a brilliant sunset reflected from the windows of the Luxembourg Palace in Paris, with an instrument called a double refracting prism. He accidentally rotated the prism and found, to his astonishment, that at certain planes the light was received in all its brilliancy, but on revolving the axis he could see no light at the quadrature; this was a phenomenon that such an analytical mind could not overlook, and from his investigations has sprung up this most refined and elegant branch of physical science. Not only that it has, as our correspondent states of the "tester," this property of light, but is used to a wide extent in chemical analysis; for it seems that substances in solution are capable of diverting the ray according to their purity. Thus, a solution of pure cane sugar will give a different result to one of grape sugar, and as this difference is constant the polariscope has added to the chemist's facilities for analysis.

There is a wide range of substances that may be detected of adulteration by this means, and to-day the polariscope is as much required in the laboratory as the retort or test tube, and in many instances it affords results more accurate and delicate than any other process of analysis by reagents. Again, in the demonstration of the undulatory theory of light it has rendered very essential service by putting the matter beyond a doubt.

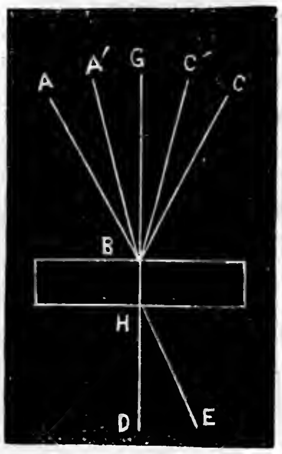
Now what is polarization of light? The term given was very inappropriate, for we cannot conceive of polarity in a beam or pencil of light in the same manner we can of polarity of the needle. We may state that, though originally adopted from an imaginary analogy to the poles of the needle, the name does not express the idea, though it is still retained in all the best works on Optics. Light is called polarized, which, by being once refracted or reflected, is rendered incapable of being again refracted or reflected at certain angles; the phenomena of which, in the words of Sir John Herschell, "are so singular and various, that to one who has only studied the common branches of physical optics, it is like entering into a new world; so splendid as to render it one of the most delightful branches of experimental inquiry; and so fertile, in the views it lays open of the constitution of natural bodies, and the minuter mechanism of the universe, as to place it in the very first rank of the physico-mathematical sciences, which it maintains by the vigorous application of geometrical reasoning its nature admits and requires."

Ordinarily, when a ray of light is reflected from the polished surface of a piece of plate glass or any other surface, it may be again reflected from another surface, and it will be found to be freely transmitted through any transparent substance. The case becomes very different, however, when the ray of light falls on the first reflecting surface at an angle of 57°, for if another surface is presented to the pencil of light in certain positions, the ray will not be reflected or transmitted, but may be completely reflected by the second surface in another position. This pencil of light will also lose the power of being transmitted by transparent bodies in certain positions, while in others it freely passes. This pencil of light is said to be polarized, and the effect is produced by reflection; but another, and quite as effectual a mode is by refraction, and we shall take up this branch first, for it gives the rationale of the pebble tester.

If we take a prism of the brown tourmaline (and it generally crystallizes in that form) and cut from it plates, say the one-thirtieth of an inch thick, but always making the cut parallel to the axis of the prism, and polish them highly enough to allow the light to be transmitted from any luminous object, it may be seen through them as through a piece of colored glass. Now, if only one piece of the tourmaline is used, no particular effect is produced on the transmitted ray, and if we take two of these plates and transmit light when the optical axes are parallel, we have yet produced no effect. If, however, we fix one of the tourmaline plates, and then receive the light of a candle through the other, it will be found that when the two optical axes are at right angles, no light is transmitted, while when they are parallel the whole ray is seen.

Our correspondent gave the correct idea by his illustration with the sheet of paper, but we will try to improve on that. Take two frames with two parallel wires in each, and at equal distances; now when the four wires are parallel a piece of paper can be slipped through both sets, but if we revolve one the whole conditions are destroyed; for when before we could use a width of paper equal to the length of the wires, we are reduced to a point where the intersection of the two sets of wires occurs, and this would imply a diminution in width as the rotation progressed, until when the wires are at right angles the paper could not be passed at all. This is a very coarse method of illustrating so very subtle a motion as light, but it tells the whole story; for if the two pieces of tourmaline are considered as having only one plane of refraction, and that plane equal in each, it is evident that at right angles the whole amount of light would be transmitted when the planes become parallel; that this is the case may be proved by any two thin plates of tourmaline.

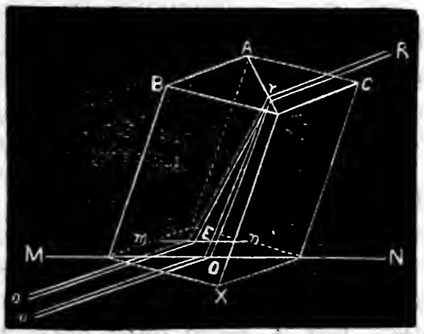
The change that takes place in the nature of the light as the rotation progresses is remarkable, varying through all degrees of brightness down to darkness, just as the paper would have to be narrowed as the wires were rotated; and, as a matter of course, when the optical axes are at right angles the light will vanish, but appear again, as the motion goes on until it reaches its full illumination at parallelism, and our readers will easily see the aptness of the illustration by means of the wires and paper. We can give analogous instances in the cases of sound and heat. When a ray of light falls on the surface of a transparent medium which has the same molecular construction throughout, is of uniform temperature and density, such as fluids, gases, glass, and a number of regularly crystallized substances, the pencil of light is refracted according to the laws of ordinary refraction—that is, the pencil, in passing through the medium, always maintains a plane perpendicular to the surface of incidence. The cut will illustrate our meaning.



If the ray A S falls on the surface at the point S it will be refracted in its passage through, but the refracted ray will fall in the plane H S; emerging, it will take the line H E, parallel to A S. Here is a case of simple refraction through a uniform medium, as before stated.

The case is different, however with most other bodies—crystals, gums, resins, jellies, or solutions, and all bodies having unequal tension, whether from inequality of temperature or pressure. These bodies possess the property of doubling the image, or apparent position of the object, when the ray is transmitted in certain directions.

The reason of this is, that the pencil or ray of natural light does not move entirely in the same plane, but is divided by refraction into two pencils, one of which is in the perpendicular plane, and the other diverges to one side. We will try to make it clear by a diagram.



The cut represents a rhombohedron crystal of the Iceland spar, one of the many hundred forms of carbonate of lime; and perhaps we could have taken no fairer example, for the divergence of the two pencils is seen in an eminent degree. To test this quality, or rather to measure the amount of double refraction, we may make a large pin hole in a piece of paper, and paste it on the side of the crystal opposite the eye. Now, this one hole will appear double when held to the light. This is caused by the double refraction of the pencil R *r* on the plane of A X. By inspecting the diagram, it will be seen that, while one ray is directly in the centre of the plane in the line T O, the other ray is eccentric in the plane *m n*. Now, it is evident that the two rays cannot correspond at any time; one of which, the central, is called the ordinary, and the other the extraordinary ray.

If we revolve the spar in the same plane, we shall find the two images of the hole equally bright; the extraordinary revolving around the central optical axis. Extending our investigations farther, we find if the piece of spar is held stationary, while we view the images through a piece of tourmaline, that the images change their relative positions and intensity in a very marked manner, for on revolving the tourmaline the images will vary vastly in their relative brightness;—one increases in intensity until it arrives at the maximum, the other decreasing in the same proportion inversely, until it vanishes entirely, and this goes on alternately at every quarter revolution. The only conclusion in this case is, that both rays are polarized. We reason thus, for in one position tourmaline transmits the ordinary ray, and reflects the extraordinary ray, and the reverse takes place when, in the course of rotation, the tourmaline has reached 90°.

It would seem from this that polarized light cannot be divided by double refraction, in all the positions that common light would be in passing through a double refracting medium. Tourmaline possesses an additional value for polarizing purposes, as, unlike all other double refracting substances, it absorbs the ordinary ray and transmits only the extraordinary, thus giving but one image. For this reason this mineral has been selected as being peculiarly adapted for the analysis of polarized light, which shows nothing wonderful until transmitted through the polarizers.

We have stated that the two rays were polarized at right angles to each other. We will try to explain our meaning more fully, for on this assumption rests the whole theory of polarization. We will, then, go back to a ray of common light, assuming the undulatory theory to be good; in this ray, the vibrations take place in every possible plane, and these undulations are at right angles to the path in which the ray is moving. When, however, this ray of all possible planes strikes the surface of the Iceland spar, only two of all the planes pass through, and these two are perfectly at right angles. The idea may be better conceived by imagining the position of two rulers, one of which rests with its flat side on the edge of the other, and if, in place of the wires, we substitute pieces of card-board with a slit in the centre, we have the whole idea of the polarization, for it may be seen on turning one of the cards, the ends of the rulers being presented to the slit, that alternately one of the two planes will be exhibited in every position the card assumes up to quadrature.

It does not follow that the ordinary pencil of light is divided into two planes exactly at right angles, for various minerals are possessed of the power of changing the plane of undulation relatively. But as the discussion would lead us to take up more space than we can spare, the subject will be resumed in the next number.

* * *

Epitaph

On a clockmaker, in Lydford church-yard, Devon, England, written by himself.

Here lies in a *horizontal* position the *outside case* of

GEORGE ROUTLEIGH,

Watchmaker, whose abilities in that line were a credit to his profession. Integrity was the *main-spring*, and prudence the *regulator* of all the actions of his life. Humane, generous, and liberal, his *hand* never *stopped* till he had relieved distress. So nicely *regulated* were all his *motions*, that he never went wrong, except when *set agoing* by people who did not know his *key;* even then he was easily set right again. He had the art of disposing his *time* so well, that his *hours* glided away in a perpetual round of pleasure and delight, till time, in an unlucky *minute*, put a *stop* to his existence.

He departed this life Nov. 14, 1802, aged 57, *wound up* in the hope of being thoroughly *cleansed* and *repaired*, and *set agoing* in the next world.

Correspondence.

EDITOR HOROLOGICAL JOURNAL:

Permit me, through your JOURNAL, to present a few ideas to your numerous readers on the subject of compensating pendulums.

Graham's (or the mercurial pendulum), now quite common in use, cannot be a very reliable pendulum, for the reason that a mass of mercury two inches in diameter and about seven inches high, cannot change its temperature in the same time as the rod which sustains it, which is only about $\frac{1}{4}$ of an inch in diameter or square; hence in sudden changes of temperature the rod may expand and contract again before the mercury is sensibly affected; and in the mean time the clock may have lost or gained several seconds.

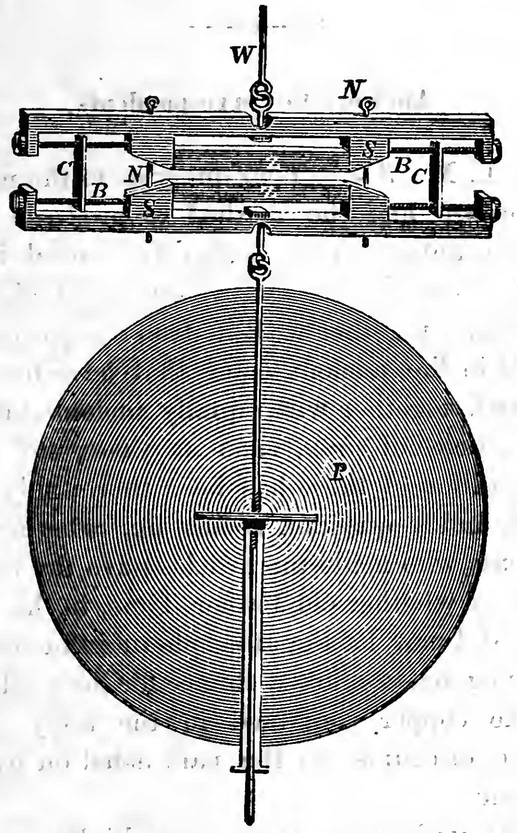
If I were to make a mercurial pendulum I should want the diameter of the sustaining rod the same as the diameter of the column of mercury, and then they would be similarly affected by any changes of temperature which would affect a small rod much quicker than a large one. Consequently all the pieces of the compensation apparatus, and the pendulum rod, should be of the same diameter, whether round or square, and then they will be affected alike and at the same time; and unless this is the fact, the compensation must be imperfect.

The Harrison, or gridiron, pendulum is generally conceded to be the best in use, and yet in Reid's work on clocks and watches, he says that upon a trial this pendulum kept mean time during the temperature from 46° to 48° of Fahrenheit's thermometer, while a temperature 10° lower made the clock gain nearly half a second per day, and 10° higher made it lose at about the same rate; then with this pendulum the house must be kept at the same, or very near the same, temperature. If we could keep the room at the same temperature, we would not need any compensator. (See Reid on Clocks and Watches, page 364.) The Harrison pendulum is also difficult of construction and expensive. Many other plans have been resorted to, in order to get a perfect compensation, but I have only noticed those called the best, and generally adopted in this country.

It is said by philosophers that a rod or bar of metal, suspended vertically, with a tolerably heavy weight attached to it, will expand with every higher temperature, and contract with every lower change, but does *not quite* get back to its original length; if this be true, then the gridiron pendulum cannot be a permanent compensator, for its rods are all vertical and sustaining a load at the bottom.

So much on the general principle of compensating pendulums, and I will now proceed to give you a description of my compensating apparatus.

The nature of my invention consists in the combination of two metals of different degrees of expansibility, so arranged as to completely overcome all the expansion and contraction of any simple pendulum rod, and can be used in any pendulum clock. One very important advantage it possesses over all other devices for the same purpose is, that it is perfectly adjustable, and can be altered so as to compensate more or less by simply turning the screws arranged for that purpose.



S Wrought steel ⅕ of an inch thick.
Z Zinc ⅕ of an inch square (cast).
C Any common metal.
B Screws for adjusting.
N Steady pins.
P Pendulum ball.
W Pendulum wire.

In its construction I have used two pieces of good hammered steel (*S*) filed and dressed nearly square, and filed away at the centre about ¾ of its thickness so as to be slightly flexible at that point, with an angle turned at each end, corresponding with shoulders toward its centre, between which a bar of zinc, corresponding in size with the steel bars, is placed and fixed permanently by soldering or pinning, or both. The adjusting screws A pass through the arm at the end of the steel bars running to the shoulder and entering it far enough to hold the end of the screws securely. On the adjusting screws are hung suspenders *C C* made of brass, through which are cut screw threads fitting the screws on which they hang.

The operation of my apparatus is as follows:

Suppose, when first hung into a clock, the weather to be temperate and the steel bars to be straight; when the temperature is raised, the zinc expanding three times as much as the steel, the bars would not be straight, but the ends of the upper bar would be raised above the level of its centre, and the ends of the lower bar would be depressed below a level of its centre; the ends of the steel bars, or nearly the ends, being confined by the suspenders *C C*, could not separate, consequently the centres of the two bars must have approached each other, and the same change of temperature which brought the centres nearer together would also elongate the pendulum rod, and *vice versa* when the temperature is falling.

The nearer the centre the suspenders *C C* are placed, the less the compensation, and the further from the centre, the greater; hence, by revolving the screws either way, as the case may require, a perfect adjustment can be effected.

Yours truly,
W. L. Coffinberry.
Grand Rapids, Mich.

Editor Horological Journal:

In your article on watch repairing — last number of the Journal—you speak of the importance of obtaining a *round* pivot, and the difficulty of so doing by means of the "live spindle." As I have had several years' experience with the foot lathe, I will give you my method of pivoting a staff or pinion, which will in its results compare very favorably with the work done on the "turns," and in point of time there is no comparison. In making either straight or conical pivots it is of the utmost importance that they should be turned down to as near the size as possible with a graver, leaving just excess enough of stock to enable one with the steel polisher and oil-stone powder to give it a proper surface ready for the final polish.

In putting in a new pinion, the first thing to be considered (after selecting the proper size) is to get the *centres* concentric with the circumference of the body or leaves of the pinion, which is done in the following manner: Centre your chuck properly and then apply shellac sufficient to hold the pinion, which you will now put into the cement, pressing it down to the bottom of the hole or centre in the chuck, holding a piece of pegwood against the outer end of the pinion, so that the opposite end will not leave the centre of the chuck; now, just before the shellac gets hard, turn up by *the outside of the leaves.* After the shellac gets hard, turn a centre on the end of the pinion, after which reverse the pinion and proceed as in the first instance, getting your final centre by the leaves. It sometimes happens that the pinion will have to be again reversed before we are certain that our line of centre is parallel with the outside of the leaves of the pinion. Now, turn down the pivot to its proper length and a trifle larger than it will be when finished, leaving but little to be taken off by the abrasive process. After the pivot is turned down as small as necessary, it will be *round*, provided the lathe is a good one. Now take a piece of square steel wire from one-eighth to three-sixteenths of an inch thick, and file up two contiguous sides to an angle of about 85 degrees, which will enable you to keep the shoulder of the pivot square; now by the judicious use of a little oil-stone powder mixed with oil, applied to the polisher, and moved gently to and fro across the pivot while the lathe is in motion, it will reduce the pivot very uniformly. The pivot should be ground in this manner until it will just pass into the hole of the jewel, but *not* tight. Now thoroughly clean off all the oil-stone, and use a piece of bell metal, same shape as the steel polisher, on which use sharp or crocus; again clean and use another polisher of bell metal with very fine crocus; again clean, and use a finely polished burnisher, which will produce a brilliant and *hard* surface to the pivot. You will now have a pivot that will compare favorably with any that are made on the "turns." In fact there are but *few* watch repairers that can by the ordinary "turns," and Jacot or English lathe, make a pivot that will begin to compare with my method. It of course requires care through each and every stage, otherwise good results cannot be expected.

In making conical pivots, turn with the graver the pivot to its proper shape, and *nearly* down to its intended size; use polisher as above, only with the corners *rounded* instead of the angle as above described; instead of the steel polisher, a piece of oil-stone slip with the corner properly rounded will answer, then finish up as above.

In putting in a staff I always finish the lower part complete before removing it from the lathe, then reverse, and finish the other end; fasten the balance on before taking it from the lathe. The staff is now finished, with the balance in, and not over one hour's time consumed. How many workmen can put in a staff finished up nicely in all its parts, properly fitted, in one hour by the "drill bow?"

I use Vienna lime for a last and final polish to all steel work; the only objection to its use is that workmen will not unfrequently neglect to polish their work properly with crocus before using it, as it will so readily put on a *gloss*.

In putting in a staff by means of the foot lathe you can be certain of having good steel, as one can be turned down from a piece of Stubbs' steel wire, to nearly the size wanted, in a few *minutes*, then harden, temper and finish up. A majority of the rough staffs sold by the material dealers are made from very poor steel, and not fit to be used.

JAS. FRICKER.

AMERICUS, GA., *April* 8, 1870.

Answers to Correspondents.

A. L. M., *Wis.*—Your query as to the nature of bronze and the method of producing the bronze antique color suggests several ideas. And, in order to answer, we must give a history of bronze, together with its true composition as found in the ancient coins that have been recovered, together with equally ancient statuary and articles of *virtu*, such as vases, etc. The composition of these has been thoroughly analyzed, and a question comes up, whether the ancients who made the articles gave the bronze color, or whether old Father Time, in his own way, did not let the atmospheric influence, or other agencies, allow a chance for the oxidation of the copper contained in the alloy. We allude, of course, to the part acted on by the oxygen.

This verde antique was very highly prized, it having been supposed that the color was an indication of age; but we will show that the same color may be attained by the workman on the surface of the material that has no copper in its composition.

The tombac of the Chinese is a pure bronze, and, if left to the action of oxidation, in time would probably assume the highly prized color; but the Chinese are too busy a people to leave much waste metal lying around loose. We have no examples in their line. Now, in all these ancient bronzes we find by reference to the various analyses of the French chemists that they are almost uniform in composition, there being rarely a variation from some given standard, say of from 20 to 30 per cent. of tin with some slight traces of zinc; but the proportion is so small as to lead us to the belief that its presence was accidental.

At the present day, except for very fine work, bronze is not used; or we may vary the statement by saying that a vast majority of the articles offered to the public are composed of brass (zinc and copper), and some of zinc alone. They have the requisite color, and we will now try to show how this is attained; and as beauty of design and durability can be attained in either the brass or zinc equally as well as in the true bronze, we will give you the various processes of coloring the surface to imitate the antique. We may take for the first instance a brass casting.

The first process is to remove all grease from the surface, and then brighten by means of the file or sand-paper. If the work has a very elaborate ornamentation, so much so as to preclude the use of the abrasive action of the file and sand-paper, it is boiled in a solution of pearlash (carbonate of potash) until there can be no doubt that all traces of foreign solutions have been removed; for in the course of manufacture the surface must necessarily have been soiled by the hand of the workmen. The article having been thus prepared is dipped in vinegar or dilute nitric acid, or, what is still better, a solution of sal ammonia in vinegar, say three or four ounces to the pint This process yielded good results, but is too tedious; so a mixture of the sal ammonia with nitric acid, diluted by two parts of water, can be used with more effect. This process is cheap, but becomes tedious from the fact that two hours are sometimes required to develop the color.

Still another method is by the use of a solution of the bichloride of mercury in vinegar —one ounce to sixteen. This gives a rich deep color in about fifteen or twenty minutes. There is another plan, depending somewhat on galvano-plastic principles, that though more expensive is altogether the best and most rapid. The solution by which it is effected is called technically chemical bronze, and is made by the solution of platinum in nitro-muriatic acid (one part nitric and two parts hydrochloric); to effect a very quick bronze the solution should be saturated. According to the size of the article to be bronzed, it is either dipped in the solution or brushed over with it until the work is of a deep brown black; the coating must be uniform—that is, without streaks; if the solution does not take action readily, slightly warming the article will hasten the process. When the proper shade has been attained the work is washed in pure water by dipping, and then dried; after this it is dusted with black lead and brushed like a stove until the surfaces are well polished. Nothing more remains than to use a green lacquer.

E. L. M., *O.*—Why not make your own negative (the platinized) silver. You will find it of but little trouble or expense, provided there is a rolling mill where you can reduce your silver to the form of plate, and you can obtain a few scraps of platinum from almost any dentist. Now for the how to do it.

We will suppose that you have a silver plate of the proper thickness, say the $\frac{1}{32}$ of an inch ($\frac{1}{64}$ would do, though trouble will be found in the after processes); the surfaces are to be rubbed with fine glass paper until a perfectly uniform surface is produced. The scraps of platina you will put in a Florence flask, and pour on them a mixture of one part nitric and two parts hydrochloric acid; the commercial acids are quite good enough for this purpose. By the application of a gentle heat the platina will be dissolved in a very short space of time, the result being a chloride of platina. We are now prepared to platinize the silver.

We will take a piece of plate zinc (the purer the better), and cut out a size a little longer than the silver plate, but of the same width; adding a little water to the solution of platina, we introduce the silver, with its top edge in contact with the zinc, which also is immersed in the solution at the same time. The zinc must be bent, so that when in contact with the silver the two surfaces of the silver and zinc shall be parallel, and about one-quarter of an inch distant from each other. On plunging the two, connected at the upper ends, into the platina solution, the silver will almost instantly receive a coating of the spongy black of the platina that has been held in solution. We neglected to say that the silver surfaces should be dipped in a dilute solution of sulphuric acid after the sand papering, to remove all impurities.

M. B. J., *Ky.*—As to the cutting of seals, we will be very happy to give you all the information that can be conveyed in a verbal description of an art that depends almost entirely on the skill and taste of the workman. The only tools that are required are, first, a small lathe-head of somewhat peculiar construction; the question of truth in the mandrel being of secondary consideration. The other appliances consist of very small mills, or rather laps, that can be used with diamond powder for effecting the cut. It is obvious that the various dimensions of the cuts on the face of the seal ring, or rather stone, will require an equal variety as to sizes in the small iron laps used by the engraver. This being the fact, the mandrel of the lathe is bored with a taper hole, and a corresponding hole is made in a brass block with the same reamer; the pieces of iron wire which are to form the laps are placed in the brass mould, and then the cavity is filled with lead or common soft solder; this enables the artisan to multiply his chucks, as it were, with great ease. The face of the stone is generally deadened in order to render the drawing of the required design to appear to better advantage when laid out. The seal engraver now proceeds to cut out the design, either with the end of the mill or its edge, as a matter of course choosing the size suitable for the work. He uses diamond powder for the cutting, and if the stone is hard, also for the polishing of the bottom of the lines; otherwise, as with an amethyst, or cornelian, he can polish with tripoli and water, with lead laps.

The whole art, as stated before, is one of personal tact and education; the main features are easily understood, but the skill required to do the work well is not so easily acquired.

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Polarization of Light.

NUMBER TWO.

In point of fact the two planes of undulation may lie parallel in the cross section, but at an angle in direction of the optical axis. We may illustrate all the various planes by taking two cords parallel to each other, but not falling in the same line; if now one of them be vibrated in a vertical plane and the other in a perfectly horizontal plane, the relation of the two planes of the Iceland spar can be realized. Now the cords, like the wires of a piano-forte, move in perpendicular planes; but by the very construction of the instrument the wires lie at an angle to each other, therefore the planes of vertical vibration will be at the same angle as the angle of the strings, provided the hammers strike in the same plane perpendicular to the bed of the instrument. Now we can conceive that the vibrations of the strings can be made in every possible plane relatively to each other.

The pencils of light, though changed in their course through the spar, are parallel when they leave, but it must be remembered that the extraordinary ray has to pass through a greater distance than the ordinary. Of course the undulations of the two rays do not exactly equal each other, and this difference is found to be the least when the planes of vibration of the two pencils are perfectly at right angles, and the greatest when they lie parallel, but with the two planes at an angle to the optic axis. Between these extremes the velocities are various; and yet, with such a subtle thing or force as light, it may be proved that the variations of differences are according to a determinate law.

Now this difference in the times of the rays plays the all-important part in producing the very beautiful and remarkable phenomena of colored polarization; and here we must step aside from the main subject of discussion, to take into consideration some of the laws that govern the interference of light, as a full exposition of the polarization could not be had without such a discussion.

All of our readers have undoubtedly noticed that when the strings of a violin were not in tune, that is in perfect harmony, a jarring sound was the consequence, and if listened to attentively the auditor would have found that these jars or periods are produced at regular intervals, the length of the intervals being greater or less as the instrument is more or less out of tune. This interval of silence, for such it is, can be more distinctly perceived in the organ when not in tune. Now, let us illustrate the interference of rays of light by the theory of sound; let us take two strings in vibration; it is clear that if they communicate an equal number of vibrations in the same time, they will be in unison, and the result is double the force of the sound; but if one string has one hundred vibrations to the other string's one hundred and one, it is evident that at some time one set of undulations must have gained on the other, and that, although the vibrations started even, at the fiftieth one series must have overlapped the other by just one-half a vibration ahead of the other; this one vibration superposed over two of the other string will produce perfect silence for an instant. The sound will be gradually increased until the one-hundredth vibration, when the two waves will combine and produce double the sound, until, as before, the waves are not coincident at the next fiftieth vibration. These intervals of greatest intensity and silence are called beats; if the notes differ much from one another, the effect produced on the ear is that of a sound from a rattle. When the strings are in unison of vibration no such effect will be produced, for the waves coincide throughout. The same reason applies to the organ, whose pipes if not in unison will produce a series of beats that offend the ear.

Here is a clear case of interference; that is, that one wave has destroyed the other, and the example applies to light as well, for it must be remembered that a ray of sunlight, though white, is a mixture of colors, each having a definite velocity of vibration pertaining to itself, and each differing from the other; but when unobstructed the pencil will show a pure white light, for whatever may be the difference in the number of vibrations of the several colors, their rays arrive in equal times, and thus no interference is found. If a ray of light, however, is intercepted by any obstacle, such as a prism, or even a knife edge, the ray is no longer homogeneous; some portions of the ray, by the interception, travel farther than others, and thus the different portions will fall at unequal times on the screen.

Perhaps we can show our meaning more plainly if we cite one simple experiment that any one of our readers can try for themselves. Let the room in which the experiment is to be tried be closed, and a hole made in a shutter of the room; it will be plain that a single beam of light will pass. Now, if the aperture be but a pin hole and a fine wire be held up a short distance from the aperture through which the light is admitted, some very singular results follow.

If the image of the ray is received on a sheet of white paper, the wire will cast a shadow having for its centre, immediately under the wire, a bright white bar or stripe; on either side, however, there will be found alternate black and highly colored bars of light. This curious effect is produced by the interference of the waves, just as the beats we have mentioned are produced by the same cause. The central bar of white light is produced by the bending of two rays around the wire, and as the distances are equal for each ray they then superimpose on each other—the dark bar being caused by unequal arrivals of the undulations.

Now, this can be shown to be no matter of chance, but the subject of a general law—the whole thing having been the subject of most careful mathematical analysis; and the reasoning corresponds with the facts, and in its turn confirms the whole theory of undulation, for it is impossible to conceive that any two particles of matter, however minute, could annihilate each other. We shall have occasion to refer again to the interference of light, and therefore will leave it for the present, while we return to the immediate subject of our article. It has been inferred from the action of a doubly refracting substance like Iceland spar on light, that in all doubly refracting substances there would be the ordinary and the extraordinary, the one following the general laws of refraction, and this was very difficult to disprove. But M. Fresnel has demonstrated, by the most profound mathematical inquiry, that the extraordinary ray must be wanting in glass and all other substances that, while permeable to light, are uncrystallized; and the inquiry enabled him to predicate that the ray must exist in carbonate of lime and quartz, and numerous other substances having an optical axis; but he also proved that there was a numerous class of bodies that possess two optic axes, and that in these, both of the rays must undergo extraordinary refraction, so that both these pencils deviate from their original plane, and his reasoning has been confirmed by subsequent experiments. We cannot part here with M. Fresnel without an humble tribute of admiration, and of sorrow at his early death. He has left a name that cannot be separated from the subject of light and its laws. Though his lamented death cut off his researches, he left enough to give an impetus to a study of the whole subject, and his generalization of the laws of refraction have become as much a stand-point in the discussion of the subject as the generalization of the laws of gravitation. He has a fitting monument to remind us of his memory in the hundreds of light-houses that have the lenses cut on Fresnel's theory, and no better has yet been found.

Although we have left the pebble tester far behind, we have not forgotten it, and will now make an application of Fresnel's law, that all homogeneous bodies like glass would have no effect, but that it must necessarily exist in the quartz, and, in fact, in any body having an optic axis; and this shows plainly why the glass placed between the two pieces of tourmaline, as described by our correspondent, cannot deflect, or rather produce an extraordinary ray; while it follows that a quartz or pebble must have it, and thus the quality of the object under inspection is ascertained.

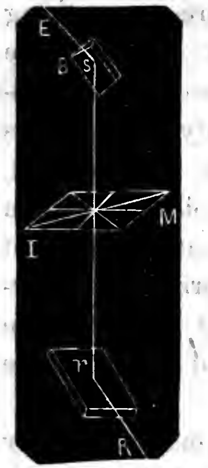
Glass being homogeneous, it will not polarize a ray unless certain conditions are fulfilled, and these conditions are determined by the following properties of light: When a beam of common light is partly reflected at and partly transmitted through a transparent, the reflected and refracted rays into which the beam has been divided will each contain equal quantities of polarized light, and the planes of polarization are at right angles; hence a pile of panes of glass will give a polarized beam by refraction, for if a ray of common light pass through them, a part will be reflected and a part polarized when it reaches the second surface, or rather plate, and this plate in its turn will act on the ray in the same manner, and in succession the whole number of plates will do the same, until a pencil of polarized light will be obtained, which is what is left of the original beam; for repeated reflections and absorption have diminished it.

So far, we have regarded refraction as the originator of the polarized ray; fortunately for the amateur, as well as the optician, by far the most convenient method is to polarize by reflection. The simplicity of the apparatus required, and the pleasing results obtained, recommend this mode to the spectacle-dealer or buyer, for it can be prosecuted by the merest tyro, and the expense will not exceed a dollar.

If a plate of glass be varnished black on one side with the material used in the ambrotype process, and a jet black be obtained, we shall have what is called the polarizer. Now, if this polarizer is laid with its blackened surface down on a table in front of the window, we shall see at any angle a bright surface produced by the reflection of the light. If a plate of tourmaline, having a vertical optical axis, be held between the eye and the blackened glass, the appearance is instantly changed, for the glass will present nothing but a cloudy spot, having its centre quite dark; but on rotating the plate of tourmaline (which is called the analyzer), curious effects will be observed. The cloudy spot, with its dark centre, can be obtained when the incident ray on the glass is at an angle of 57°; that is, by raising or lowering the tourmaline, the line of sight must fall at some part of the motion at an angle of 33° with the surface of the glass.

If now we turn the tourmaline slowly around in its own plane, we shall find the cloud to gradually diminish until it disappears entirely, and when the axis of the tourmaline becomes horizontal, then every part of the glass plate will be equally illuminated. As the tourmaline is still further revolved, the illuminated surface in its turn will gradually vanish, until at a perpendicular position the cloud will again be perfect; and this effect will follow at every quadrature of the analyzer. It follows from these observed facts, that with the ray incident at an angle of 57°, it will be polarized; and that the reflected ray is incapable of piercing a plate of tourmaline whose axis is in the plane of incidence.

We may reason from this that the ray has acquired the same character as if it had been polarized by transmission through a plate of tourmaline with its axis at right angles to the plane of reflection. Subsequent observations confirmed the opinion advanced by Fresnel, that this is incapable of reflection at certain angles and in certain positions of the incident plane. This can be proved by using another plate of blackened glass; if it be placed at the angle of 33° to the reflector it will produce all the effects that can be obtained by the tourmaline; then, if we revolve the second plate (analyzer), all the appearances will be observed that were seen with the tourmaline, for the image of the first plate of glass will be reflected, but will be alternately illuminated and obscured on rotation of the second. The relative positions of both the tourmaline and glass polarization may be seen in the cut.



Here R r is a ray of light falling on the darkened plate of glass at r at an angle of 57°; the reflected ray r S is polarized, and the point may be analyzed by looking through the tourmaline or by reflection of the polarized ray from S to E; between r and S the real phenomena of the ray take birth. Of this we shall write subsequently; but the fact of the second glass producing the same effect as the plate of tourmaline, and as it happens by whatever means the light has been polarized, we may deduce the general law that a ray of polarized light is incapable of reflection in a plane at right angles to the plane of polarization.

Though all reflecting surfaces are capable of polarizing light, the angle of incidence will vary with the substance. With plate glass the angle is 57°, while with crown glass it is 56° 55′, and water takes the smaller angle of 53° 11′. Sir David Brewster, from his experiments, arrived at a generalization enunciated in the following simple and elegant law, how to find the angle of polarization for any substance: "The tangent of the polarizing angle is equal to the sine of the angle of incidence divided by the sine of the angle of refraction of the medium." It follows, then, that a very highly refractive substance would give but poor results, and we find the law holds good, for the diamond polarizes very imperfectly.

We have the polarized ray from S to r, and now comes up a curious phase of the subject, for if we interpose any biaxial substance between s and r, the whole aspect of the thing is changed; and if a pebble were placed in to intercept the ray on rotation, it will be found that the pebble is biaxial, while with a glass lens no effect whatever would be produced, on account of its homogeneity—that is, uniformity of structure—and therefore the dealer or buyer of spectacles at the expense of a very few cents can construct an apparatus to detect the good from the spurious. We shall advert to this subject in our next volume, as it possesses points of interest that can hardly be imagined until the experiment has been tried, and we think that with the cut we have given all that is required to enable a person to make a polariscope.

* * *

Manufacture of the American Watch at Waltham.

NUMBER THREE.

The next step we are to consider is the making up of the frames according to the strict gauge, for in all future operations the pillar-plate becomes the guide. Now it must be remembered that, though rolled, the brass is not of equal thickness, and therefore it becomes necessary to so arrange the tools that absolute truth, or nearly so, may be attained. Even the punch does not furnish blanks of just the same size from the same sheet of metal, as the composition of the latter is not of uniform density; and again, on turning off the outside edge a slight variation is liable to occur from two causes—want of truth absolute in the metal, and the spring of the tool; and we might add, where large numbers are being done, that the wear of the tool will affect the size.

Many experiments were tried to effect the elimination of these sources of error; in other words, to so construct a lathe with its rest that it should take in slight variations in sizes with equal truth. It is plain also that the face of the chuck must always be in the same place; if it is not, the smaller sizes will be drawn away from the rest, and therefore be thicker. The reader will comprehend our meaning farther on.

The first requisite of a good lathe, is that the mandrel shall have no end-shake; and this result has been effected so closely that the shake has been found to be as small as the $\frac{1}{5000}$ of an inch, when measured on the large standard gauge. So far we have reached a very satisfactory result. The next step for consideration is as to the manner of holding the stock while the tool is cutting it. To make our meaning perfectly plain, we refer our readers back to the article on the Lathe, in No. 2, page 48, of the Horological Journal, calling attention more particularly to the cut. Here will be seen the chuck, 3, and the hollow mandrel, 2, which is supposed to have the least possible amount of end-shake. If now the chuck is put to its place and in connection with the inside spindle, 4, it is evident that an article introduced into the nose of the chuck will be firmly held when the screw is brought up to its place.

Here, however, steps in a source of error, for the nose of the chuck will not be at the same distance from a fixed point (say the cutting tool), when different sizes are held in the chuck, for the screw will draw the chuck farther in the mandrel in proportion to the smallness of diameter of the work held. To remedy this fault, a very ingenious device was resorted to. Imagine a lathe head with three uprights instead of two, the back one of which is intended to receive the hollow spindle that takes the chuck; but this spindle has a collar turned up near its end, and this butts back against the bushing in the last standard of the head; a screw is cut upon the end of the inside spindle to take the check nuts which are intended to draw the collar against the face of the bushing. The other two standards or uprights are bored for a much larger arbor, and these holes are made true with the one holding the bushing; the larger arbor is hollow, and of an inside diameter just to fit the inside spindle; on the back end a left-handed screw is cut that takes into a nut so made that it is free to turn on the inside spindle, and yet preserve a true centre; on this nut a hand-wheel is placed, by which the arbor may be moved backward or forward a limited amount. Now let us see what is the action of this arrangement, premising that chucks are fitted in the same way as described on page 48, No. 2. Now, having screwed one of the chucks up to its shoulder in the inside spindle, it is evident that on turning the hand-wheel and nut the outside spindle will be pushed out and force the jaws of the chuck to a common centre. These chucks are made with recesses in their faces that are just fitted to take in the blanks of every description, and the closer the fit the truer will be the work, for the jaws will have so little distance to move when the spindle is forced out to grasp the work. The rest is constructed like any other slide rest, but fitted with strong stops, for both the motions and the tools (cutting) are fitted with great accuracy, so as to render them firm and not liable to spring.

The operator takes his work and placing it in the jaws of the chuck closes them up. From this point the operations are precisely like those on any other lathe; the results for thickness being much more accurate. Having finished a large number of frames, the next step is to put in the holes in the plates for the pillars and those for the dial feet, of which we shall have considerable to say, as the truth of all the depths depends entirely on their accuracy. The next stage of the proceedings is to rivet in the pillars and put on the potance plate and screw the two together. We have now an approximation to a frame, but owing to the thinness of the potance plate the edge has not yet been turned off true with the pillar plate; to effect this the last is chucked with the upper plate on; it is easy now to finish the edge.

It will be obvious that many and nimble fingers must be busy to carry out these operations. The steady pin holes have been drilled before, for we are now taking the case of a full plate movement, and in order to turn up the barrel bridge it was necessary to put in the steady pins, the screw heads being countersunk only so far that the screw head takes on the barrel bridge, and at the same time pass through the plate to take into the pillars, thus holding both. The potance is now put to its place with mathematical certainty, as is the third bridge also, and now the frame is ready to proceed a step farther in course of construction. The various screw holes are drilled and the cock fitted, and now comes the question of depthing.

Five hundred watches a day would tax to the utmost the mechanical skill and assiduity of quite a small army of workmen. The plan by which it is effected with so much ease involves in the outset the exercise of skill, good judgment, and patience; for a mistake may run through a vast amount of work before it is discovered, and thus involve a loss of many thousands of dollars.

We have mentioned before that a model watch is first made, which is to be the standard for all the subsequent make from that model. Now, if we have a lathe with a face plate and a true centre turned up in the form of a cylinder, we may imagine that a brass plate might be centred on the cylinder for each hole in succession, and with but one screw to hold it against the face plate. We will try to explain our meaning more fully, for the uniformity of depthing in the American watch is one of its chief merits. Take, say, the centre holes; it is desired to true them up, both for upright, size, and parallelism. Now, taking the same brass plate, we shall be right if we can succeed in holding the frame always in the same relative position. But the question now springs up, how shall we do this? The whole thing devolves on the dial feet holes.

We have mentioned before that on the truth of these holes the accuracy of the results depended. Let us see why such is the fact. In the first place, it is obvious if three holes could be drilled in one thousand or ten thousand plates at some certain relative point common to the train, that we have a guide. Now, if, as in the case of the centre holes, we could place pins through the plate and into the face plate, corresponding with the dial feet holes, there would be no difficulty in obtaining a tolerable degree of accuracy for any one of the ten thousand watch plates. This would, however, hardly be true enough, and we will try to elucidate the matter.

The dial feet holes are planted in the pillar plate always with reference to the centres of the train, and, as a matter of course, with the pillars and the relative position the train is to take in the watch. Having determined this, the brass plate which holds the movement to the lathe is divided off with holes to correspond to the holes in the watch plate; in these three holes finely hardened and tempered steel pens are placed projecting far enough to take the pillar plate, but not quite go through the pillar plate.

Thus prepared we have the means of holding the pillar plate in one position, but we have not yet got our depths. We have mentioned a cylindrical centre turned up truly, and this becomes the next important item, for if the brass face plate be laid off for depths as accurately as the specimen watch, each hole from the barrel to the balance may be turned out large enough to fit the cylinder tightly. Having thus got the holes, suppose we make a trial of this apparently simple job by placing the brass plate with any hole on the centre of the latter (say the fourth) and screwing it firmly down to the face plate of the lathe, presupposing that the faces are parallel, and that the face plate of the lathe revolves in a plane truly at right angles to the axis of rotation of the lathe mandrel. If now we place on the pins a pillar plate of the original watch, and revolve the lathe, we shall find that the fourth hole of the plate is perfectly in the centre of rotation, and, consequently, that the depth must be right; trying the rest of the train, if we find the same degree of accuracy, we may be sure that the depths are according to the pattern. The pillar plate is first laid off, and the holes cut through for the shoulders of the settings of the jewelled holes, while all the plain holes are simply made to size; of course, the general operations are conducted through a large number of frames, taking each centre or hole in succession, without changing the plate, except for the different centres. That is, if the plate has been set for the barrel, the whole number of frames will be drilled and tried for the barrel arbor.

There must, of course, be, after the pillar plate has been laid off, some provision for getting the potance plate holes absolutely in the upright. Now we will leave it to our readers to say if they ever saw an English watch with the whole train upright. There is always some default, even in the best; for from the very mode of putting in the train, something must be defective, for if the two plates are centred separately, the centres of some of the holes will be out of upright. We had some troublesome experience in this matter some years ago, being then in partnership with Mr. James Queen. An English house (J. & J. M. T. Leavitt) had shipped a large invoice of plain movements to their agent in New York, and a plain movement not being adapted to the American market, the consequence was no sales. To send them back to England to be jewelled would involve too much expense, and therefore we were offered the job of jewelling them here in New York.

We found, in jewelling the first movement, that we had altered the escapement; how to account for it was the question, for with one of the best and truest upright lathes we ever saw, we found that the potance plate holes would run out of true when fastened as carefully as possible to the face plate. We could make the hole in the single plate run true, and therefore we were compelled to cut out the plates for the jewel settings by centring each plate separate, and centring by the pump centre; after that there was no trouble, but when the watches were set up it was amusing to an American to see the want of upright; and we will state here that no one out of the factory ever saw a wheel staff or arbor out of place in the American watch. This result, of course, has been attained by the plan of fixed centres and a positive base.

Now, through all the processes that have been had to get out the plates and pillars the fine gauge is the first requisition, and although we have the lathe, as we have attempted to describe the operation, it is required at intervals to gauge the piece as it comes from the lathe, to ascertain whether any change has occurred since the original adjustment of the rest and tool.

All the separate parts of the frame go together with steady pins. We forgot to mention that the cock was secured on at the same time as the barrel bridge when the edge of the upper plate is turned off to size. The steady pin is a troublesome animal if means are not devised to do the work rapidly by an almost automatic machine. The holes having been drilled in the pieces, they are tapped in a tapping tool, and then progress to receive the steady pins. These are cut off from a long piece of wire passing through the hollow spindle of a lathe; the wire being projected far enough from the nose of the chuck to suit the purpose, a die is brought up to the end, and a thread is cut just so far (the thickness of the piece), and then in a trice a cutting tool comes up to the wire and cuts a groove; the piece is now presented to the screw and the screw is run home when the wire breaks in the neck of the groove, and the pin is submitted to a milling tool in order to round the ends.

We are aware that our description must be somewhat vague, but the reader must reflect that were we to go into a detailed description of only one of each class of tools, we should crowd our columns. We have a desire in our next to describe the screw cutting lathe, with its tiny slide rests and revolving tail stock, and we think our readers will not be offended by our prolixity in the description.

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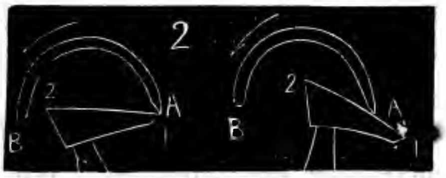
The Cylinder Escapement.

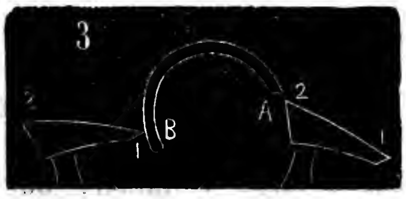
NUMBER TWO.

Towards the close of the article on this subject and on page 339, a mistake will be found in the lines, "for any change in the motion will have but little effect on the angular motion of the balance." What we meant to say was, that any moderate change in the *motor* force would have but little effect on increasing the vibration. We will try to explain the reason before we go into the theory of the wheel teeth.

By inspecting the cut, it will be seen that the detent or locking end of the wheel tooth is just resting, or about to rest, on the outside of the cylinder, while the heel of the impulse angle is just passing the edge; the balance will have received its greatest impulse when the tooth has completely passed, and if the wheel should be stopped on the instant, there would occur a large vibration; but as the wheel does not stop, the locking point of the next tooth drops on the outside of the cylinder with a force proportional to the power of the main-spring, and the pressure thus applied to the surface of the cylinder tends to serve as a break acting by friction; the same is true of the inside locking, and it naturally results that the greater the impulse the greater will be the resistance — thus confining the balance within a narrow range of vibration. We give here a cut of the several positions of the tooth and cylinder while in action.

In the cuts we give we exhibit the positions of the wheel tooth in relation to the cylinder. In Fig. 1 we see the tooth just entering the cylinder. Now we must discuss somewhat the subject of the amount of impulse, for the face of the impulse tooth, 1, 2, will follow up the edge with a speed proportional to the inclination of the impulse angle and the amount of opening in the cylinder. By referring to a cut towards the end of this article, the amount of displacement of the edge, *b*, can readily be discerned. Now, we will suppose that the tooth has passed, and the point takes, or rather locks, on the inside of *a*; it is evident that the diameter of the interior must be such as to admit, as in Fig. 2, the cylinder to pass behind the heel of the tooth fully and clearly. In this position the point, 1, of the tooth is just entering into lock, while the same tooth in Fig. 2 is seen with half the impulse given. In Fig. 3 we have just the position of the escapement, with the spring in repose, ready for the entering impulse at *b*. Fig. 4 is adverted to further on in the article, and shows the position of the wheel tooth and cylinder when the vibration has been so great as to over-bank.



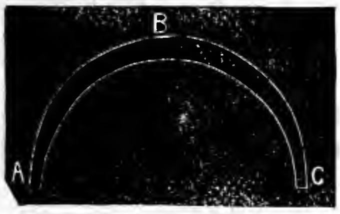


Now it will be understood why the banking pin is required; for if the vibration should extend so far as to allow the second tooth to enter the cylinder, as is represented in the annexed cut, a dead lock has taken place that cannot be overcome by any power of the hairspring. The nicety of depthing required between the scape-wheel and the cylinder is somewhat of a trouble to the repairer, but this difficulty is compensated by the fact that in all the Swiss movements the depth can be varied. This does not apply to the English style, where the wheel and balance are permanently planted.

We prefer the movable cock and potance to the permanent, for the adjustment can be made much finer, and when made, securely fixed. Two elements are to be considered in this escapement—the impulse angle and the amount of drop; and the last is of as great importance as the first, for if the wheel tooth falls on the cylinder, either inside or outside, with too much drop, the tendency is to break either the cylinder or the pivots, and at the same time something is lost in duration of the impulse. The first point, then, is to so proportion the thickness of the cylinder with a view to strength, and at the same time render the drop as little as possible. Of course, the interior of the cylinder has got to be of sufficient diameter to admit the wheel tooth freely without any chance of the impulse edge striking the heel of the tooth as it makes its return vibration—a result that would happen if in a very closely fitted tooth and cylinder the side shake should be too great.

The outside diameter of the cylinder should be a trifle more than its thickness, equal to the space between the teeth; and this will give just about drop enough, and none too much. We need not say that the parts should be well and smoothly finished in order to reduce the friction to a minimum, as the less the friction the less power will be required to move the train, and the freer will be the action.

We will now consider the parts in detail, commencing with the cylinder as the central point of action. As is well known, it consists of three pieces—the two plugs, with the pivots, and the main body of the cylinder itself; the two plugs are put into the ends of the cylinder tight enough to hold, but not so much so as to strain the metal—especially the lower one; and again it is requisite that the two pivots, when seated, shall be exactly in the centre of rotation. It is easy enough to effect this with the upper one, as the plug has such a long bearing in the cylinder, while the lower plug, being restricted in length, has to be fitted much more closely, and is more troublesome to get in true centre. The body of the cylinder is supposed to be a hollow tube of equal thickness at any point of the circumference; this implies that the interior circumference is concentric with the exterior, and this condition is absolutely required, as the cut will show, for if the wheel tooth takes on the locking side *a*, it follows that there would be a recoil arising from the difference of thickness from *a* to *b*; if the pivots are in the line of axis of the interior, there can be no injurious action to the tooth which we suppose has passed *c*, but the reverse will take place should the opening of the cylinder happen to come in the thickest part, for then the second tooth would advance till the return vibration, when the balance and spring have to overcome not only the friction but the recoiling back of the wheel; this is true of the first case also. Absolute truth of thickness, then, is required, for the impulse on the thick part of the shell will be more than on the thin. The effect of having the pivots out of centre is obvious; for, let the eccentricity fall on whatever part of the cylinder it may, the beat cannot be good, and therefore the watch will not perform well.



The interior as well as the exterior of the shell must be polished to the highest point, in fact it is impossible to get too high a finish, as the friction will be diminished in proportion, while the impulse remains the same, thus allowing a greater freedom of vibration; though the best authorities, as Saunier, Berthoud, and others, have laid it down as a maxim that no good results can be obtained with a vibration of over 280°, as at that point the greatest result is obtained; very few cylinder escapements attain that point, and more fall below 230°.

Having put in the plugs and centred the whole thoroughly, the next step is to file out the opening of the cylinder through which the teeth are to pass. Now the size of this opening will be determined by the wheel tooth and somewhat by the depthing. The best makers, such as Berthoud and Jergensen, have determined that the best possible conditions are obtained when the opening leaves 200° of the cylinder with 160° of opening. In this case, with a well-formed tooth the action of the impulse is much easier and freer. When the opening has been filed to the proper degree, the next step is to see what we must do to make any improvements; for it must be obvious that in filing, the two edges of the cylinder will fall in the line of the chord of the arc that has been filed away, and as that line does not fall in the centre, the leaving tooth will have to take a sharp angle, while the entering tooth will fall on an obtuse angle; it is customary, therefore, to file this sharp edge carefully away, but cautiously bevelling it in toward the centre. The bevel must be very slight, for if it is carried too far there will always be danger that the wheel tooth will fall on that for a locking instead of the inside surface of the cylinder. It is needless to say that these surfaces should be perfectly polished.

Some makers have made these edges thus: the leaving edge rounded toward the centre, and the entering edge being made in the form of a semicircle, which more nearly equalizes the amount of impulse for the two sides. Of the larger cutting it is necessary to say only that it must be wider than the thickness of the web of the wheel, and be cut so far that only a little more than a quarter of the cylinder remains. As this opening performs no part whatever in the action, no pains need be taken, though no good workman would leave the edge unfinished.

We have now the cylinder complete, and come to the formation of the wheel tooth, for here all the action will be had and the impulse given. In the cut, we have given the present generally adopted form, though through the course of improvements every form from the straight line to a regular curve has been used; but as all have been discarded for various reasons we have given the above. Let *c* be the point, and *a* the heel of the proposed tooth; the amount of impulse may be seen by the lines that are concentric with the centre of the wheel. A simple inspection will show the whole thing at once, for if the impulse face of the tooth is in the straight line from *a* to *c* it will be faulty when the action goes on, from the change of position; however, the best form, and the one almost universally adopted, is by the curve *a b c*; the concentric lines show, also, how to lay off the amount of curvature.

In all cases the faces should be exactly parallel with the edges of the cylinder, and the back of the heel of the tooth cut away enough to allow of an accidental increased vibration where the entering edge might touch at the back corner of the heel of the tooth; a very slight angle is all that is required, for as the entering tooth passes, the edge of the cylinder will follow up the motion, but not quite quick enough to catch on the back corners, for the tooth in passing will move with greater speed towards the locking inside of the cylinder, and it thus happens that the tooth should be a trifle short of the interior diameter; and this will, if the thickness of the cylinder is well proportioned, give perfect freedom to the locking.

We shall in our first number of the next volume resume the discussion, with diagrams to show the amount of impulse as well as the drop. We have not hesitated to take up the cylinder, for it is in the hands of thousands, and it may happen that very many repairers may be benefited by the very familiar way in which we have treated the subject in these articles.

Fork and Roller.

Having introduced the spring-fork in our last number, copied from the *London Horological Journal*, we deem it fair, as well as of great advantage to our readers, to give M. Moritz Grossman's ideas on banking, and we can do no better than to offer those ideas in his own words, as follows:

"The parts which transfer the motion created by the action of the wheel and pallet to the balance, have been constructed in a variety of different ways, and their action is commonly called the fork and roller-action, because in almost all lever escapements the intervening lever is, at the extremity, turned towards the balance, worked out into a notch, which gives it some resemblance to a fork. The roller in most of the lever-escapements is a steel-disc, carrying a pin to fit the notch in the fork. This pin is commonly made of a ruby, in order to diminish friction, and giving greater durability to the acting parts.

"The fork and roller-action can be divided into two distinct functions, in which the two parts act alternately the one upon the other. These functions are the *lifting* and the *unlocking*. In the lifting, the lever-fork impels the ruby-pin in the roller, being impelled itself by the lifting of the wheel-tooth on the pallet, which latter is solidly joined to the lever, so as to form but one piece with it. This impulsion of the wheel on the pallet and the impulse of the fork on the roller, arising from it, continues until the wheel-tooth drops from the edge of the driving-plane, which causes the corresponding tooth to fall against the locking face of the other pallet-arm. The pallet and fork are kept in that position, while the balance makes its excursion to the same side. On its return, effectuated by the tension of the pendulum-spring, the ruby-pin has to perform the other function, in which it plays the active part, the function of unlocking. As soon as in this returning vibration the ruby-pin touches the fork, this latter (and also the pallet) follows the impulse a little way, thus withdrawing the locking-face against which the wheel-tooth is resting. The tooth, immediately after having left the edge of the locking-face, begins its lifting on the driving plane, which is transferred by the pallet and lever to the roller and balance;

this lifting continues till the tooth has slided across the driving-plane and dropped from the edge of it, after which the corresponding tooth rests against the locking-face of the opposite pallet-arm. This play of the escapement is constantly repeated, so that the ruby-pin is *driving* a short way at each vibration, and *driven* immediately afterwards.

"It is a peculiar feature of this part of the escapement, that it is quite out of action during the greatest part of the vibration of the balance, and but a very little arc of the whole vibration keeps the roller in connection with the fork.

"This circumstance on the one side constitutes the lever escapement a detached one, and endows it with all the valuable qualities of such escapements. But, on the other side, it produces a tendency to frequent disturbances in a portable time-keeper, which must be prevented by an arrangement of the parts, called the *safety-action.*

"It has already been mentioned in the description of the wheel and pallet-action, that the locking-faces of the pallet cannot be made circular, or at least not concentric circles to the centre of the pallet, but must deviate from that circle so much, as to produce a locking tendency, by which the pressure of the wheel-tooth on the locking face draws the pallet farther into the wheel. But this alone would not be sufficient to prevent the pallet leaving its state of rest, in case of the watch being exposed to sudden external motions.

"The results of such uncontrolled motion of the pallet and lever would be, that the lever would not present its fork to the ruby-pin of the balance roller when returning from its excursion, but the pin would fall against the outside of the fork and the watch would stop immediately, requiring the aid of a watchmaker to put it right again. It is therefore of the greatest importance to secure continuous motion in watches with the lever escapement by a careful safety-action.

"There is still another function which the lever has to perform in all the usual constructions. It has already been observed, that the deviation of the locking-faces from the concentric circle produces a tendency of the wheel to draw the pallet-arm towards its centre. This tendency would of course draw the pallet-arm in, until arrested by the circular rim of the wheel between the teeth. But this excess of drawing motion would occasion a great loss of power in unlocking, or even cause a butting of the ruby-pin against some part of the lever not prepared for its reception. For this reason it is indispensable to reduce the motion of the lever and pallet to the amount required for the safe escaping of the wheel. This limitation is technically called *the banking.*

"This purpose can be attained in different ways. In many watches, especially in the English ones, there are two upright pins, planted into the plate at convenient distance and on each side of the lever near the fork-end of it. (*Banking-pins.*)

"In the greater part of the Swiss lever-watches, the lever and the wheel are sunk into the plate, and the fork-end of the lever is banked against two projecting corners produced by the intersection of the sinks for the balance roller and for the lever.

"In some watches we find also the banking-pins near the other end of the lever.

"The banking of the lever, though indispensable for the good performance of the escapement, is at the same time a source of very disagreeable irregularities. When by a sudden circular motion of the watch in the plane of the balance (a very frequent occurrence when wearing the watch, or winding it up in a careless way), the vibration increases to more than two full turns, the impulse-pin strikes against the outside of the fork, which cannot yield, because it is leaning against the banking-pin or edge. By the violence of this percussion there is some danger of injury, not only to the ruby-pin, but also to the balance-pivots, which are often bent or broken by the reaction. But more than that, all such cases are accompanied by a considerable acceleration of the rate of the watch, producing under unfavorable circumstances great differences in its time-keeping. (*Banking error.*)

"Of the three described modes, the banking between two pins is decidedly the best, provided the pins are not too thick and are as near the fork-end as possible, thereby avoiding any essential part of the shock being communicated to the pallet axis. The elasticity of thin and hard pins proves to be a tolerable safeguard against the danger of any injury to the ruby-pin or balance pivots. But such pins are very easily bent when cleaning or repairing the watch, and then the banking will be too wide, or which is still worse, too narrow, producing a want of freedom in the action of fork and roller, or in the safety-action, or not allowing the wheel-teeth to drop freely from the driving planes.

"The banking against solid corners of the sinks in the plate is not liable to such disturbances, and with such solid bankings the balance will not continue to strike against them so long as it does with the elastic banking-pins, but at the same time the danger of injury to the delicate parts of the escapement is greater. Besides, it is advisable to make these banking-corners sharp and not obtuse or flatted, as is often seen in such cases, where the banking was originally not wide enough. The consequence of such flattened corners is an adhesion between fork and corner, when the parts are not perfectly clean, and this adhesion is an increase to the unlocking resistance.

"The worst system is that of banking the other extremity of the lever between two pins or otherwise, because by this arrangement the lever transmits about double the banking-shock to the pallet axis, and indeed, if somebody wanted a machine for the express purpose of breaking the anchor pivots, he could not invent any better construction than this, with a pair of thick pins and a strong unelastic lever."

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☞ Messrs. Quinche & Krugler, who have for some years occupied the premises Nos. 8 and 10 John street, have followed the inevitable laws of attraction and gravitated into Maiden Lane, No. 15, up stairs, which step was rendered a necessity from their largely increasing business. The secret of their success lies in the fact that they have a first-rate watch, and make the introduction of it to the trade a specialty. And the additional fact, that they understand a watch, practically, makes it pleasant to call and see them. And then again they are straightforward, upright business men, as truthful and reliable as one of their own watches; and when you find such a firm "make a note of," and deal with them.

Brushes

Are a constant accompaniment to the watch bench; nothing except plyers, screw-driver, and tweezers, is in more constant use; and how few use them properly—or rather, how few keep them in proper order for use. A soft brush for rough work is quite useless, a hard one for fine work is ruinous, and a dirty brush of either kind is a nuisance.

The methods adopted for cleaning them are nearly as various as the workmen that use them—and there are some who never make even the attempt. Some clean the brush with dry bread; some lay a piece of tissue, or other paper, across the wide open bench vise—the sharp corners formed by the jaws taking off on the paper a *little* of the dirt; others vigorously brush a piece of clean cork, and one man I knew, who used his knuckles for the same purpose. All these various modes are imperfect, and some of them very slovenly.

The only good way to clean a brush is with soap and water—warm water being preferable, if convenient. Wet two brushes, soap them, and then rub them together in plenty of water, and the job is done. The only objection to this way is the delay by drying; but this need not be, for six brushes assorted will give you three clean ones to use while the other three are drying, and the workman who can't *afford* half a dozen, at $4 50 per dozen, had best seek some more lucrative occupation. More damage to the appearance of the movement is done by injudicious brushing than by any other means. The watch may not be injured in its quality as a time-piece, but it grows prematurely old in looks by such severe treatment. R. C.

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☞ A good and reliable key for the pocket or the bench has long been a desideratum, and we think the vacant spot has been filled by Mr. J. S. Birch, in his self-adjusting watch key. For the bench there is no question of its superiority over all other adjustable keys that we have seen; while for the customer the pocket key is the best, for it can get no dirt in it except what will fall out when the key is opened; and will suit both squares of any watch. We can recommend them to our readers.

American Horological Journal.

The present number completes the First Volume of our JOURNAL, and we avail ourselves of this occasion to return our sincere thanks for the many favors we have received, and the liberal encouragement extended to our enterprise. Previous to the establishment of the AMERICAN HOROLOGICAL JOURNAL there had never been an effort made in the United States to publish a purely Horologico-Scientific Journal, devoted to the interests of the practical watch-repairer. There was nothing extant that gave a *live* treatise on watch work; something like Ried could be found, but it was too general in its application, while each successive author seemed to vie with the preceding one as to how obscure he could make the subject of watch and clock repairing; and still later, a few small volumes have been published, but they were intended only as an advertising medium for some special interest.

Believing that the wants of the trade warranted something of a more practical character than had hitherto been offered, we established the JOURNAL for that specific object, and that we have in a great measure so far supplied that want is evidenced by the general tone of the letters received from our patrons. And we will here make the assertion that no publisher in this city can show as many letters from his patrons advising an advance in the price of subscription as ourselves.

We have endeavored to fill a want in mechanical literature that certainly existed, by giving a species of information that could only be obtained from the accomplished workman, and we leave our readers to judge whether we have fulfilled our object. True, the educated mechanician or the practical astronomer may think that we have at times gone somewhat too minutely into minor details, but it must be remembered that it was our aim to not only be a medium of intercommunication for the skilled workman, but of instruction to those who, just starting in the business of repairing, would find the hints and facts we give to be of great benefit; and the best workman, in *his* early days, would have prized the information we try to afford. During the time of trial that the AMERICAN HOROLOGICAL JOURNAL has had, we have never had a word of censure; and now we may throw our enterprise on the Horological public with perfect confidence.

We make no bombastic promises of immense improvement, leaving the present volume to tell for itself, and vouch for the future; but we have the proud satisfaction that the most intelligent class of watchmakers have not only become subscribers, but have interested themselves in our success by contributions, hints, and correspondence, and we can therefore safely promise that its high literary and scientific character will be fully sustained.

We can hardly be charged with egotism when we say that the amount of information furnished by the JOURNAL could not be got elsewhere. The knowledge of detail is scattered, and if the artisan wishes to obtain information he must seek it from so many different sources that he is apt to despair. We have concentrated this knowledge, and in the columns of the JOURNAL, that ends a volume with this number, we venture to say that the trade has more *practical* information than can be found in all the treatises on Horology extant. In the coming volume, in addition to our present contributors, we shall be in receipt of regular European correspondence from prominent Horologists, and shall from time to time introduce new features as the wants of our patrons may require.

We would be much obliged to our subscribers and friends if they would send in their subscriptions as early as possible, thereby enabling us the more easily to effect our business arrangements before commencing the second volume. Having established a success, we have no hesitation, as we had when, alone and unknown, we offered a technical journal to the Horological public, and confidently rely upon a largely increased list of patrons, thereby enabling us to still farther extend our efforts for their benefit.

The terms of subscription will be, as heretofore, two dollars and fifty cents per annum. Remittances should be made by P. O. Order in all cases where it is possible to do so, as that avoids all risk of loss.

Address

G. B. MILLER,
P. O. Box 6,715, N. Y.

Watch Repairing.

NUMBER SEVEN.

To afford the facilities to do so, some of the finer Swiss tools have an upright attachment, consisting of a small lathe-head with a spindle on which is a pulley or collet, the spindle is capable of an up and down motion, and the lower end is so bored out that cutters of many different sizes may be inserted and run true. These cutters differ entirely from the cutters for ordinary wheel teeth; they are cylindrical, being in fact nothing but a fluted reamer, with the lower end made taper and terminating in a drill.

The action of this is obvious; the blank wheel having been turned up and the recess made to allow the semidiameter of the cylinder to pass over the bottom of the recess perfectly free, it is placed on the pump centre on its seat on the mandrel and clamped down, and the reader will at once see that on bringing the tool down while in motion a milling operation takes place on the inner side of the flange, which is the stock from which the little anchor-shaped teeth are formed. By careful pressure and milling, a round hole will be made through the steel, and on further pressing down the cutter the hole will be enlarged until it opens at the edge of the wheel, and the opening is made large enough to almost take in the greatest diameter of the cylinder for which the wheel is intended. The index plate is now turned ahead one division on the circle of fifteen, and the same process is gone through with in succession. As the shanks of the teeth are very weak, it is, in every case, better to form up the impulse angle on the edges of the teeth before the milling out is done, and the crossings should be done before the teeth are cut.

If the old wheel is on hand, the repairer who has an universal lathe may easily turn out a gauge in a piece of brass plate; the fitting should be very accurate, and in turning up the blank he has a guide for correct diameter, and so may copy the old wheel. We will now leave the subject of the tools used for repairing, and commence at the prime motor work of the train, and this motor includes the barrel, arbor, ratchet, and stop work. We will commence with the barrel arbor, as this is the centre of the old system. There are two kinds only of this arbor: one where the arbor and hub are one solid piece, and another where the hub is a separate piece, and pinned or screwed on the arbor. This last form is adopted only where the whole of the barrel rests on and is held by the barrel bridge, and the ratchet, which is solid with the arbor, is sunk in a recess in the bridge and there held down by a cap with four screws. This style is abominable, and should never have been used; but very thin watches were in demand, and to satisfy the market the Swiss makers sacrificed much of the quality and durability of their watches. Aside from the instability of the main wheel, the ratchet once being broken, an entire new arbor must be put in, which involves expense to the customer and sometimes great vexation to the repairer, who finds that the job has not paid him for his time, labor, and material.

The question is, how to replace one of these arbors where the ratchet teeth are broken so badly that no filing can repair it. If the repairer has a large stock of arbors he may find one that has the ratchet of the size of the recess in the barrel bridge; the arbors are generally centred pretty true, and the mode of finishing the work will depend entirely on the tools and facilities the workman possesses. For instance, if he has a lathe with a back centre, he may commence by dogging the end that is to constitute the square; and, putting the work in the lathe, the workman first faces off the ratchet on the underside, at the same time turning up the shoulder that takes the barrel bridge; only some judgment is required to leave it large enough to be polished to a fit. The under surface of the ratchet should be perfectly flat and at right angles to the line of centres. In grinding and polishing there is apt to be left a rounded corner. We have found in our experience that if a very fine groove is cut in the corner, the grinding and polishing will bring the corner perfect.

We now turn up the shoulder of the bridge bearing until the barrel comes to just the right point of freedom from the bridge. It is well, though, to leave a little more freedom than is wanted as the bearing for the barrel has yet to be turned, it may happen that the shoulder will be cut away in the polishing and thus bring the barrel too close to the bridge. Having polished this last bearing, the barrel, with the bridge, should be tried by putting them together and screwing on the hub, and if the work is right the barrel will be somewhat firmly held in a lateral direction, but be free to rotate; if, however, there is the lateral shake it shows that the hub when it butts against the shoulder is too far from the central boss on the inside face of the barrel. Of course the shoulder is to be turned up farther, and the neck may be made equal to the bottom of the thread that takes on the hub, and there may be a little allowance made, for the arbor is strong enough in this part.

Having satisfied ourselves of the proper degree of freedom between the hub and the shoulder of the part coming through the bridge, we next pay attention to the lower pivot that takes the barrel head; and here we will remark that the shoulder should be so turned that when the head is sprung in the barrel the hub should be exactly in the centre of the rotary plane of the barrel. If the workman has been successful in getting his lengths so far, he may reverse the arbor in the lathe and face off the upper side of the ratchet perfectly parallel with the lower side, and of course of such a thickness that when the cap is screwed down there will be an equal bearing over all the surface the ratchet is intended to embrace. As the ratchet and arbor do not move except when winding, the truth of the two surfaces of the ratchet is of more importance than high finish, and there is a surface below the highest polish that will give as good results when used on brass for a horizontal bearing. The upper part of the arbor is now turned down to the proper size for the square, and the arbor is finished in all except length; as the lower end is to be squared to take the stop-work, the metal may be taken off smaller than the part that is to form the square for the stop but it will be quite as easy to square up the whole length, and when the parts are put together, to drill the hole for the pin that holds down the stop. To produce the squares we refer back to page 206 of this volume, and the only thing that remains to be done is to cut off for the length, and polishing the end of the square; the last may be done in various ways—in the lathe, or by the burnish file, though in a watch that has any pretensions to quality, the repairer would or should like to finish the upper end as finely as any other part of the steel-work in the watch.

It is not necessary, however, to have a live spindle lathe, for all the same operations can be done by a dead centre, with a collet and the bow; and perhaps in the polishing the bow is the best, from the frequent changes of position insured by the backward and forward motion.

We have now got our arbor for this class, and it becomes necessary to harden and temper; as the arbor is short, it will hardly warp in the hardening, but it will become necessary to take off the thin film of oxide that has been formed in the heating. We may confidently assert that the whole may be hardened without detriment to the surface, if, in the first place, the piece is carefully covered with clay, or any other substance that will prevent the access of the oxygen of the atmosphere, and then heated to the proper degree; on plunging in cold water, the clay will flake off, and the arbor will be hard, with little oxidization of surface. Of course, too much clay must not be put on; and, again, the whole must be thoroughly dried before it is exposed to the heat for hardening. It is better to do the hardening before the centres are cut off, for when the work comes from the fire, or from under the blow-pipe, a leaden blue will be found on all the polished surfaces; now polish some one part again, and draw the temper down to the point you wish. We prefer a deep straw color; and, getting this, the arbor can be put up in the lathe, and by the use of a hard graver the ends may be cut off after the polishing has been effected.

If the lengths and side shakes have been made right the arbor is ready; but in polishing the upper side of the ratchet it must be observed that the face of the same must come perfectly level with the edge of the recess into which the cap that holds the ratchet drops.

Polytechnic Institute.

On the evening of the 22d of April we had the pleasure of listening to the reading of a very interesting paper by Mr. W. D. Bradley, of this city, before the Polytechnic Institute, on Ancient and Modern Time-keepers, and we regret that want of space prevents our making extracts therefrom.

Commencing with the various definitions of Time as given by the Ideal and Practical, the lecturer proceeded to the various methods of dividing and measuring it.

At the commencement of History we find the Chinese began and ended the day at midnight, and, through various changes, this method is still used.

The sun-dial was the very first attempt, requiring only an open and level plot of ground, and a straight and smooth post, from 15 to 20 feet high, erected near its southern centre. Next a meridian line, drawn by the aid of the North Star; and lastly, a series of equidistant semicircles to gauge the length of the shadow.

As an improvement on this rude method came the Clepsydra, the simplest form of which we find to be a copper bowl, with a small aperture at bottom, which is left floating on the water. When filled it is emptied and the hour struck on it with a wooden hammer, thus combining clock and bell. The most complex form of Clepsydra, invented by Ctesibus, 200 B. C., consisted of a cylindrical shaft standing on a square pedestal, within which the machinery was concealed. This column turned on its axis once in 366 days, and had the hours marked on it by circles, varying to show the long and short days and nights, or winter and summer. Beside this column stood two boys, one of whom was weeping bitterly. His tears dropped into a basin, crossed the pedestal in a concealed way, and fell into a large vertical tube closed at bottom. The other boy stood on the cap of a rod, attached to a float in the tube, consequently rising, as the water came in, to the height of the tube every 24 hours.

Then a siphon discharged the water from this tube into a bucket of an overshot water-wheel. This wheel, having only six buckets, performed a revolution every six days. On its axis a six-leaved pinion drove a wheel of sixty, attached to a vertical shaft; this in turn had a pinion of ten, driving a wheel of sixty-one leaves on a shaft attached to the column, thus turning it completely around in 366 days.

Here we have carving, turning, founding, an overshot water-wheel, the transmitting motion, and changing its direction by toothed wheels and pinions, as well as the application of the siphon. The eye of the weeping boy was fitted with a pierced jewel, to prevent its enlargement and fouling.

The Hour-glass came into use with the commencement of the Christian Era, and has remained unchanged.

The lecturer noted the improvements which have gradually resulted in the exquisite and almost perfect time-pieces of to-day. Glancing at the oldest piece of Horology in movement—the clock in the north transept of the Cathedral at Rheims, which is clearly traced to the 16th century—he proceeded to give a vivid description of the most wonderful one in the world—the Cathedral clock at Strasbourg.

With interesting accounts of other remarkable time-keepers, the speaker closed, too soon, his most entertaining and instructive lecture with the mention of the antiquarian, Doctor Bigsley, who, seeing an old, curious-looking clock, asked its nationality. "English," said the Cockney proprietor, "and made by Tummas Fudgit; I've often seen clocks of his make." The Doctor was puzzled, but on close examination saw, in the corroded steel, the oft repeated warning *Tempus Fugit!*

Correspondence.

EDITOR HOROLOGICAL JOURNAL:

Referring to a circular addressed "To the Watch Trade of the United States," issued some time since, in which we replied to an attack made upon us by the National Watch Co. of Elgin, Ill., we beg to say that that company still continue their misrepresentations in regard to our manner of doing business, and are now making every effort that rivalry can suggest to put us in antagonism with the trade. The object of course is to get the trade to recommend their watches instead of ours. To this we have no objection provided fair means only are used. We object, however. to false statements, insinuations, and other contemptible tricks, which only impose on those who do not take the trouble to examine the matter for themselves. Their only design is of course to USE the trade to give popularity to their watches, so as that their watches will sell themselves as ours do; and, when this point is achieved, all this affected zeal for the interests of the trade, this instituting ostentatious lawsuits against those who choose to sell watches for cash on delivery at small profits, will be dropped for the simple reason that it is no longer necessary.

The Elgin Co. may for a time insure to their dealers larger profit on their goods than can be commanded on ours, but as their goods become more generally known, the evils of competition will set in, and no lawsuits or rules of any kind will prevent dealers from selling their goods at any price they may be able to get for them, nor will any regulations prevent the trade from purchasing on the best terms.

The attempt to stigmatize certain dealers for selling goods C. O. D. is ridiculous. What merchant in the country is there but sells for cash on delivery, or C. O. D., daily. For us to refuse to sell Howard & Co., merely because they sell goods at too small a profit, would be as absurd as to make a schedule of prices for the retail trade throughout the country, and to insist that under no circumstances it should be deviated from. If we had refused to sell C. O. D. parties it would have had no effect on their business, as they could obtain our goods from others on the best terms, as they did those of the National Watch Co. Again, we have several good customers, who advertise and sell watches C. O. D., that make good round profits on all their sales. To throw discredit on this class by advising the public not to deal with them, would be as unjust as impolitic. There are other considerations of a general nature that influenced us; such as the fact that we have no time or inclination to follow up the sale of every watch and see that whoever sells it makes a good profit on it. We think that a man's own interest will always dictate to him at what profit he can afford to do business. In any event we don't propose to employ detectives, to watch the trade throughout the country and see that our watches are sold at uniform prices.

The object of the Elgin Co. in suing Howard & Co. was of course to curry favor with the trade, and the attempt to implicate us in the matter was for the purpose of bringing us into disfavor with the trade. The suit in itself was a failure. It did not implicate us, and the injunction against Howard & Co. was modified, so as that the latter are at liberty to sell Elgin, or any other kind of watches, at whatever price they please. In making these observations we must not be understood as being partisans of Howard & Co., or of any other C. O. D. parties. We merely contend for the general principle that one may sell his own goods at his own price; and common sense and the law decide that he can do so. If it would pay to sell Elgin watches in that way—that is, to advertise them widely and sell them at small profits, there would be plenty of dealers to engage in the business, and they couldn't be prevented. The evil of selling at too small a profit will always correct itself. As we predicted in our former circular, "The business with its great expenses of advertising and small profits cannot be lucrative to those engaged in it, and that we do not believe the annoyance from these parties will be more than temporary." The disastrous failure of Howard & Co. has verified this prediction, and neither they nor any other C. O. D. parties will be likely in future to sell watches at such ridiculous profits.

That such has been the effect of the failure of Howard & Co. is evidenced by the fact that already the one or two remaining C. O. D. dealers who have been selling at small profits have advanced their prices, so as that they now realize from 30 to 35 per cent. profit on all their sales. With only such competition to contend with we see no reason why, with the natural advantages local dealers always have, they should not be able to sell Waltham watches at a satisfactory profit.

We have been led into the foregoing remarks, not for the purpose of attacking any of our competitors, but in defence of ourselves. We know that there has been some misunderstanding as to the manner in which we are supposed to conduct our business, but it has chiefly arisen from the great competition in the scale of our watches on the part of the trade themselves, and the advantage this circumstance has given our competitors to misrepresent us while extolling their own new-fangled ideas of doing business.

We are not willing thus to be represented as being antagonistic to the trade, and we beg to say here once for all, that it is and always has been our sincere desire so to conduct the business of the company as that all classes of our customers shall be reasonably satisfied; or, if that be impossible, that they shall be convinced that their dissatisfaction does not arise from any indifference on our part to their interests. We estimate at its full value the advantage of having the good will of the trade at large, to say nothing of the pleasure it affords us to do business in a friendly manner with all correspondents and customers.

And now a few words as to the principles that guide us in disposing of the products of the company for whom we are agents, and we hope the following statements will set at rest some of the misunderstandings to which we have referred.

In the first place we sell to ALL *classes of dealers, making such distinction in price as is usual between jobbers and retailers. We never retail, nor even name a retail price, but refer all applications for single watches—even those from personal friends—to retail dealers. This has been our practice for years. We have no connection, direct or indirect, with any C. O. D. dealer in the country, or in the city, neither pay for their advertising, share in their profits, nor aid or encourage them in any way, as has often been insinuated.*

We have further to say, that in all our advertising our aim has been to point out to the public the advantage of buying our watches, and our advertisements have always been addressed to the public, for *they*, after all, are the real customers, and the parties to reach.

If we have used the argument that our products are sold at less profit than those of other factories, both to ourselves and the dealers, it is because it is the very best argument that can be used with the people. All this makes our watch popular and a ready sale, while at the same time the moderate profit on each watch is of but little disadvantage to the retailer, for if it leads to the sale of two watches instead of one, it is equivalent to selling one watch at a double profit. Many dealers take this view of the subject, and their profits are not unfrequently enhanced by the refusal of other dealers in the vicinity to sell our watches at all, thus giving the former a certain monopoly of the business.

We have but a few words more to say before bringing this communication to a close. Our sole object in making it is to set ourselves right with that portion of the trade who honestly believe that we are indifferent to their interests, and do not try to secure them better profits. We have, we think, correctly pointed out the cause, and have suggested the cure of this state of things, and we trust that in the future we shall be acquitted of any deliberate design to diminish the legitimate profits of the trade. We do not believe that any large portion of the trade really entertain any such ideas, for our business for the last two years has far exceeded that of any other two years in our existence as a company; and, so far, this year is in excess of last year, nothwithstanding the unusually depressed state of general business throughout the country. This only proves that those who decline to sell our watches from any cause whatever, merely throw the trade into other hands.

Robbins & Appleton,
General Agents.
182 Broadway, N. Y.

Answers to Correspondents.

☞ In closing this volume we wish to make an explanation of our method of answering, or rather what queries we do or do not answer. First, if the query is for the individual benefit of the correspondent we answer by mail. If, however, it may be of general utility, we take all the pains we can to get the information, and thus distribute broadcast the very facts that many, very many, of our readers are in search of.

Throughout this volume we have given to our correspondents answers *in extenso* on the subjects suggested. We are pleased to get an inquiry, and we shall, as in the past, always answer promptly; that is as soon as we become perfectly well acquainted with the matter in question. We think that some good can be done by these answers, as we make it a point to investigate each query, and consult with the best workmen in the United States if we do not feel competent to decide at once. As this is the closing number of the year we sincerely hope that in our multitudinous answers we have made the various subjects treated as nearly plain as any mechanical subject can be made with mere word painting.

We have some thanks to extend to those who, in the first volume, have, perhaps unconsciously, helped us to make up the matter. A question asked, or a suggestion made, may in many instances lead to good results.

With the July number, Vol. II., we should be pleased to have a host of letters. We do not expect many queries from old, experienced workmen; but there are hundreds of young men who have hardly got to the point of even decent workmanship; and it is this class of repairers we wish to have queries from, for it may happen that we can offer some information that will be of great value. This volume is the best evidence that we have tried and succeeded in reaching just this class; and we venture to say that we have met the wants of older workmen as well. With thanks for the queries of the past year we will give in this, the closing number of the volume, our answers to correspondents.

C. J. L., *Me.*—You ask, "what is the aurocyanide of gold?" We thought that we had given a full account of that marvellous mixture on page 307, No. 10; and if the querist will take the trouble to read over the next to the last paragraph on said page he will get a good idea of how an argento-cyanide is made. On page 308 we have stated that "the auro-cyanide of potassium may be made in the manner as before described." We referred directly to the paragraph on the preceding page, which gives the method of making a silver solution. The auro, or gold solution is the same, substituting the gold for the silver. This process of getting a good solution is the very best for any operations in the small way, such as repairing, coloring, etc. So far as the bright color is concerned you will see that it depends more on the surface on which the metal is deposited than really on the deposit itself on the plate, for it is so thin that the brilliancy is attained in the decomposing cell, without any subsequent manipulations. Your query as to springs would lead us into a province that has been deemed worthy of an article, which is in course of preparation and will appear in some subsequent number. So far as the set is concerned, if the springs are tightly wound up in the box, our inquirer will find that the set has been attained at whatever color, but more perfectly with the deep blue.

F. M., *Mich.*—Your question hardly comes within the scope of the JOURNAL, and yet there may be many who, like you, engage in surveying as well as watch and clock work. We, therefore, will give some idea of the best methods of linear measurements. In the first place, the ordinary iron chain is well known, and just as well known is the fact that it is unreliable. The best is the light steel chain, with split adjusting rings. This chain is capable of very accurate measurement, but still is defective, although it is the very best for running through the woods. We speak of this with the greater satisfaction, as it brings to mind many a pleasant day in the woods, with the compass and chain, or more often, the portable transit; and even when the snow was on the ground, it was no drawback that we had to scrape off it until we came to the dry leaves, and then, with a roaring fire before us, turn in in our blanket, and forget all the world in a few minutes.

In clear field surveying can be more adaptable than the steel-web tape line. It is so light and at the same time so strong that, with care, a line of forty chains can be measured twice, and the difference will not exceed one-half an inch, and this amount may be still further reduced by exercising more patience in the measurement. These are the chief articles in use, and although they are not perfectly accurate, they answer every purpose for common land surveying, but not in trigonometrical surveying, as in measuring the base for the proposed triangle exactness is required. The United States Coast Survey uses for the instrument of measurement an iron rod four metres in length, encased in wood to protect it from variations of temperature, together with sundry appliances to insure accuracy of measurement. On Dauphine Island a line of 189 bars, or nearly half a mile, was twice measured, and the results agreed to within two-tenths of an inch.

L. L. G., *Wis.*—The repair of the ordinary Yankee clock, as it is called, is a very simple matter. In the particular case you describe, no doubt the rivet that fastens the pallet cock to the plate was loose, and that the pallets had been crowded off. Your idea of putting in a new wheel is erroneous, for the only thing you have to do is to first top up the wheel teeth, and next, with your plyers, gently turn the cock with the pallet in its place, and then re-riveting until it is firmly fixed. As they come from the factory, very few out of the hundred thousand are deficient in the depth of the pallet, but the subsequent action of the wheel may, in time, force the pallet off, if, as we stated, the riveting is not well done. Again, it may happen that by accident the wheel teeth may have been topped off. In this case you can adopt either of these two methods: Spread out the wheel-teeth, turn them up true in the lathe with a smooth file, and then dress them up to the proper thickness; or, by the other method, dress up the teeth after truing them, and then close in the pallet to the wheel. Of course, either plan will be adopted, according to circumstances. We have seen wheel teeth so much cut off that, if the pallet was turned in, the whole escapement would have been destroyed.

M. B. S., *N. Y.*—As we have had some two or three communications in relation to our idea of fluting the very small taps for the watch repairer's use, we will answer you for your and their benefit. Now, no one would imagine that a large space could be devoted to the flute, and therefore the cutter must be brought down to the finest edge, and proportionally thin as to the taper or bevel of the cutter; the milling can be easily effected, even by hand, though a slide rest is preferable. There is another mode of making a tap that affords fine results. Suppose we take a piece of wire (steel), and file a very slightly taper square on one end; on using the plate there will be some portion of the square that will take a full thread, and even with a jam plate there is very little danger of breakage, for the frictional surface is so small. The result of running the tap or square through the plate is to obtain a full thread on the corners, and as the metal has been forced out there will be a burr just the depth of the thread over each square. If now the back side of the thread be filed away, we have a fine, easy-cutting tap.

M. H. B., *N. Y.*—You are right in your supposition that the spinning of the metal can be done in complicated forms, and at the same time the forming block can be removed. For instance, suppose we were asked to spin up a teapot. It is evident that the former, if solid, could never be withdrawn, but the hat-block, and boot-lasts and stretchers give the key-note. The chuck is made up of parts, with a central plug, on removing which the pieces can be taken out one by one. In this way very complicated forms can be worked up, or rather spun up.