MACHINE BUILDING FOR PROFIT

AND THE

FLAT TURRET LATHE

1909

JONES & LAMSON MACHINE COMPANY

MACHINE BUILDING FOR PROFIT

AND THE

HARTNESS FLAT TURRET LATHE

JAMES HARTNESS

JONES & LAMSON MACHINE COMPANY

SPRINGFIELD, VERMONT, U. S. A.

1909

MACHINE BUILDING FOR PROFIT

AND THE

HARTNESS FLAT TURRET LATHE

CONTENTS

SECTION I

MACHINE BUILDING FOR PROFIT

CONTENTS

SECTION II

THE HARTNESS FLAT TURRET LATHE

MACHINE BUILDING FOR PROFIT

ECONOMICS

PSYCHOLOGY

THE navigator in preparing for a voyage carefully examines each of his instruments. He must know the present error of his chronometer and its rate of change, and its general reliability as indicated by its past record. He must also know errors in his compasses for each point, and he should have the fullest information regarding the degree of reliability of every other means on which his success depends; and, last but not least, he must accurately determine his starting point or point of departure.

In taking up the subject before us we will do well to follow his example.

In doing so, our task will be to examine two principal elements: one, the means on which we depend for interpreting the information that is available; and the other, the source and character of the information.

The means may be considered analogous to the navigator's instruments, and is no less a thing than the brain or mental machinery; and the information is simply the world about us as seen in the existing things, such as machinery, methods, popular notions, text-books, etc., all of which may be classed as environment, and may be considered as analogous to the charts and other publications of our worthy example.

Like the mariner, we must determine the degree of reliability of all these sources of information and our means for interpreting observed facts.

When we have ascertained this we will know what allowance to make from the "observed" to get the actual facts. With this knowledge we will be able to accurately determine both our starting point and best course.

The importance of considering our minds will be seen when we realize that every new fact taken in must conform to the ideas which we retain. Contradicting ideas are not assimilated. Only one of them is actually accepted. The ideas already possessed are not easily dislodged. Even when to the objective reasoning they seem false, they frequently continue to control our actions.

Since we are loaded with the popular ideas which we have absorbed from our environment, it will be well for us to begin by critically examining our environment and the process by which ideas have been taken in. This will enable us to put out some of the erroneous views, and thus prepare the mind for a more ready acceptance of what otherwise would be barred out as contradictory.

We shall not go deeply into the psychology of our subject. It will not be necessary to go contrary to or beyond the well-known facts.

We shall not try to locate the man or refer to him as the ego or inner man. We shall simply say that we know that *we* can cause our brains to think on any subject, and we can use our senses to collect information regarding any chosen subject.

Our senses and mental faculties can be directed to consider one element in a business, and for the moment be unmindful of the many other elements. In other words, we can to a certain extent manage our mental processes. Just as a horse can be managed, so may we manage our brains. A driver may carefully control the expenditure of energy and the course traveled, or he may throw the reins over the dash and allow the horse to go his own gait and route.

A faster pace will not be advocated, for the present gait is over-strenuous; we hope, however, to point out a way by which good results may be obtained with moderate effort.

If, in the past, the brain has been found wanting, its failure should not be attributed to lack of power, or any other cause, until we have seen how it has been operated.

Under some conditions its interpretations are absolutely correct; in fact, under all conditions that would be called fair in testing other kinds of mechanism.

Unfortunately, these conditions have not always existed. Opinions regarding important matters have been formed when accurate mentation has been impossible.

Our mental processes are infallible when the problem is simple, and may be correct when complex, providing sufficient time is allowed for reliable operation.

Two plus two equals four to every normal adult's mind. We agree on such simple sums and many more difficult, but we begin to have "opinions" when we undertake problems in which there are too many elements for us to "take in" and weigh.

Although there is a great difference between the capacities of the various minds for mathematical and other problems, the facts remain that each mind has its natural limit of working range or capacity, and that it cannot be trusted for accurate work beyond its normal working capacity.

If the thinking machine is pushed beyond its normal capacity, it becomes untrustworthy. This faulty action would not be of great consequence if we would disregard the conclusions which it has reached under such conditions. But unfortunately we go on clinging to these opinions, "set notions" and "convictions" just the same as if the process had been infallible.

These opinions constitute our view-point or knowledge, and we govern ourselves accordingly in the management of our affairs.

Just as we possess the "fixed opinions," "set notions," etc., regarding the greater problems of life, so we possess a million of set notions regarding the best form of machinery and best methods of conducting a manufacturing business.

Many of these notions have been acquired without careful thought. They have just been absorbed from our experience and environment. In some cases we may have assumed that someone has previously given the matter proper consideration, and that the existing conditions are the result of their conclusions. As a matter of fact, many of the conditions now existing in the machine shop are the result of allowing old practices to continue after conditions have changed, and this has taken place without the attention of anyone.

There is no desire to belittle the opinions of others; in fact, we must depend on others for most of our opinions; but there are so many things that have been left to "others," apparently by everybody, that it is well for us to do some independent thinking, especially on our own immediate problems, and cast a glance at least at some of our notions, just to see if they bear proof of having been thoughtfully produced, or unthinkingly allowed to take form.

We can neither regulate the complexity of our environment nor the number of problems which we must settle within a given time, but we can improve the conditions very much by avoiding over-concentration on unimportant details. The brain's best time and energy should be reserved for our own immediate problems; it should not be hampered by details of others.

The various officers of a machinery building organization should know the ins and outs of the thinking machine on which they depend for guidance. With such knowledge each brain will give the greatest results, and without such knowledge the best brain may be untrustworthy.

One of the important characteristics of the mind is its tendency to lose sight of everything except the subject in mind. One danger is dodged by jumping into another which we have not seen. Both dangers were plainly in sight to anyone who had not concentrated on one of them.

In the regular every-day business life, we seem to have ample time to consider each problem, but in reality our great length of time is offset by a greater number of elements to consider, and a profounder effect of long-continued teaching or moulding of our environment.

For years engineers have concentrated energies on the steam engine of the reciprocating type. The master minds have made important improvements in the design, and many have given up their entire existence to the science of analyzing the effects of each variation in conditions of working the steam.

Our text-books, our teaching, our observation, all concentrated our attention on this type.

For some reason Gustav De Laval and C. A. Parsons broke away from this spell, and we have the steam turbine engine. These two individuals are endowed with master minds, but the task of producing the turbines was probably no greater than the task of others in improving the reciprocating type.

In one case a great step has been taken; in the other, we have an example of men of undoubted ability laboring hard for entire lifetimes with relatively small gain.

This example applies to more than the inventors' world. It has many parallels in the cold business management of a manufactory or one of its departments. Business management requires the same kind of reasoning and getting away from the spell of environment.

But this phase we shall consider later under another head. The point to be brought out here is the effect of the spell of environment in magnifying the importance of existing views and methods, and the deceptive part this trusty brain plays in binding us to unnecessarily hard work.

The tendency of the mind to see only one thing at a time, is at once most valuable and most menacing. It is valuable because it enables us to forget all but one subject, when we wish to concentrate our energies; and it is most menacing when this concentration is continued too long, to the neglect of other subjects.

One example of the unreliability of the normal mind is its proneness to accept as true almost any statement that is repeatedly uttered. Advertisers know this. We rebel when they overwork the method, but nevertheless the main fact is true, that we are swayed by reiterated statements.

This peculiarity of the mind to be influenced by repeatedly uttered thoughts is only an example of the many ways in which our environment affects our views.

Our political and social views usually conform to those of our family or section of the country and world.

We generally accept as good and right almost any long-existing condition of affairs.

Of course, we may dissent more or less, but the normal man does not get very far away from the effects of his environment.

Another characteristic of the mind is its inclination to concentrate on some apparently self-selected subject of the most trivial nature. This concentration may not be consciously entered into; it may not appear to be intense, but it partially or wholly inhibits the view of other subjects. It usually magnifies the subject in mind and makes all others appear very small or of little consequence.

All this may seem very trivial and of little significance to the man in the machine shop or office, but it is not trivial. If the principle is understood and used it will reduce the effort required for a given result.

All will assent to the importance of the subject; some may agree with the statements, but it must be borne in mind that no good results will come from simply agreeing. In fact, there seems to be good reason for believing that the mere mental acceptance of a truth does not constitute useful knowledge. The mental acceptance undoubtedly precedes the full useful assimilation of the facts, but it does not produce a change in the actions until it is fully assimilated. The unsuccessful may *know* as much as the successful—the difference is in their use of their knowledge.

In the succeeding chapters an effort will be made to indicate some of the important points to be considered. There will be no attempt to tell anything new. The main object is to urge action along lines that are known to all to be the best and to do so by stating well-known facts in a way that will give the fundamental principles due proportion without eclipsing any important phase.

BIRDS' EYE VIEW

RELEASE FROM THE SPELL OF ENVIRONMENT

We can get a birds' eye view of our field by imagining a view-point of an entire stranger.

If we, as a stranger, should enter any of our representative machinery building plants, we should do so with a profoundly respectful mental attitude. We would undoubtedly show a full appreciation of the fact that the machine shop has been a means for betterment of all the conditions of life. We would know that the printing presses, the machinery for agriculture, our looms, and, in fact, everything that is a machine, or the product of a machine, is the direct result of the work of the machine shop; that without the machine shop there would be no printing, no machine-made cloth, no machine-formed wood, no mechanical means for transportation; in fact, none of the material things that have made the last century a record breaker.

With such knowledge, our respectful, yea worshipful, attitude would seem most fitting.

It is not for us to say one word to detract from the credit due to these makers of machinery. Even in seeing the results of their labor accredited to others, we know that it is so well marked with the real builders name, that they can continue their work of making history, apparently disregarding the fact that the world's laurels go to others.

Our profound admiration for the machinist would not be lessened by our knowledge that the machinist deals with ideals only when they are practical; that "heaven born inventors" have no chance for success if lacking in earthly knowledge; that the engineer deals in material things, and must make things "go."

The engineer may have his ideals, but they must stand the test of reduction to practice. In the machine shop the material and practical tests are applied to every ideal. No beautiful theory can live without some other characteristic than beauty.

All of these facts would not disturb us. We would still be deeply impressed by the real material greatness of the machinery building world.

As a stranger we might be interested to know the prime motive which established the business. By inquiry we might find several reasons: Man's natural industry—his desire to make a machine of some kind, or to build up a large business for the glory of it, or from some altruistic motives,— and it is possible, yea probable, that we would discover the ruling incentive to be the desire for the so-called worldly gain; but whatever might have been the motive, we would know that it could not succeed without correct economic management.

The birds' eye view then would reveal the importance of the economic side; that in order to carry out any plan based on any of the various incentives, the problem of profit and loss must not take second place.

It would seem childish to make such commonplace statements if the facts before us were not so full of proof that many of the officers, foremen and workmen, as well as owners, sometimes forget this important fact.

It is neither necessary nor desirable that every one should take an active part in the general management of the business, but since various workmen, foremen and officers are the real authorities who decide the character of the machine equipment of a plant and the general methods of work, it is necessary from the profit and loss side of the question that all should know something more about this question than is generally known.

FINANCIAL HAZARD

The money invested in a business is secure if the management is active on the best lines for the time.

The best plan of management cannot be obtained from history.

The vast store of data of correct practice of former times will not serve the purpose. A record of the practice of even the last decade is inadequate, for rules of the game are continually changing.

The investment in a machine building plant and business is not wholly protected by fire-proof buildings and ultra-conservative management. The security must be protected by conducting the business on profitable lines.

Safeguarding the money tied up in machinery equipment and buildings is important but should not lessen the consideration of elements which have to do with the expense of operating.

A plant and business is useless when not in motion, and when under headway requires money. Money must be poured into it steadily. The amount every year generally equals the total capital in the business.

Much time and energy have been consumed in careful consideration of the cost of the plant, but not enough thought has been given to the money tied up in the business in other ways.

SOME OF THE CONDITIONS THAT AFFECT THE HAZARD

The hazard of investment is enhanced because the investors are inclined to be over-sanguine in starting in or in considering any new move.

Frequently the investors do not understand the practical side. The practical men do not understand the financial, and even when financial and practical men combine, the combination of their knowledge is not perfect. There are many important elements omitted.

There is always a feeling that *now* we have arrived at a time when it will pay well to go deeply into greatest refinement in shading the last mill of the last cent on labor cost of this or that piece, by the introduction of some marvelous line of machine tools. This is a case where Hope triumphs over Experience; for surely the world is not yet finished. There are a few changes that must yet be made.

All the machines are not yet to the last stage of perfection!

If we stake our faith on this or that as a "sure thing," we may discover some fine morning that our "sure thing" is a back number.

Of course, we know that under some conditions we can continue to make and sell a thing that is a back number many years, providing we keep up our organized work for new business; but this period should be used in getting ready for a change; it should not be frittered away. Much time is required to get out a new product or to modify the old.

The perfect machine may be the one that is to be tried next week, or one that has been running a few weeks or months or years. The optimist thinks it is his own machine, and the pessimist that it is the machine built by his competitors.

The capital invested in the business is not safe if such erroneous notions are allowed to affect the management.

Perhaps it is the beneficent law of nature that people are slow to reject back numbers. Surely it has saved many a wreck in the past among builders of machinery, although it has undoubtedly been rather disastrous for the users of the back numbers, and equally beneficial to any of their competitors who may have been non-users of said back numbers.

Danger also lurks in pessimism, whether it relates to the character of the product or the permanency of the market.

When we are over-sanguine we are inclined to forget what we have been taught by experience.

Experience has taught us that the only perfect machine is the one we do not fully know.

The kind of forgetfulness that produces the optimist is preferable to that which produces the pessimist, but neither produces the true view.

If in the past we have found it desirable to make changes in our machine design and method of manufacture, it is probable that we will do so again.

The "perfect" machine will be found wanting in some respects, and alterations will be necessary; therefore, the business will be more secure if all moves are made with this fact in mind.

THE GREAT VALUE OF SPECIALIZATION

THE HAZARD OF DISSIPATION OF ENERGIES

We find two extreme types of men in the optimist and pessimist. Either one is better than the man who vacillates between these extremes.

Over-confidence in one's own product is not wholly bad, and, if it induces an adherence to that one thing to the exclusion of other schemes, it may bring good results even if the scheme is more or less faulty. A faultily designed machine, well made, may be better than a poorly made machine of good design. It takes practice to produce good work, and the sticking to it gives the practice.

In the pessimist we have one who is ever-ready to lose faith in it as soon as he finds it is faulty.

This procedure leads to dodging from pillar to post, and frequently from the frying pan into the fire.

The wavering faith in any one machine generally results in the addition of one after another and the retention of all. This proceeding dissipates the attention, and no one machine receives the development that comes from undivided attention.

But whether the lack of constancy tends toward a variety of types or an unnecessary increase in number of sizes of a given machine, it is invariably excused by the assertion that there is not enough business in a lesser number. This statement is frequently made, when it is common knowledge that there are from six to fifty makers who are making the same range.

Money invested in a machinery building plant is not very safe if there is a tendency to squander the energies over too many problems.

We have seen that there is a tendency to increase the number of machines manufactured, which is due to the readiness with which the average man accepts a new machine as better than the old. He knows the faults of the old, and he does not know all of the faults of the new.

The manufacture of a great variety of machines in response to a demand by the selling organization of a company is a relic of other days. Our notions about methods for selling must be changed over to fit the modern scheme. They must be kept up-to-date.

There are some very successful large companies which turn out a large variety, but even the large companies are trying to reduce their line of machinery, and to "specialize." Their success will depend on whether they lead or follow in efficient specialization.

The survival of the fittest will eliminate all, excepting specialists or groups of specialists.

The largest plants may continue by concentrating a battery of specialists on both the business and mechanical side of each subject, the necessary degree of subdivision depending on the competition, for the combined force on one given machine must be the largest in order to be the most efficient.

The great variety or full line of machines seems to be a necessity from the mercantile point of view, but it is a woeful handicap to progress and profit to the manufacturing plant. The market conditions must be met, but it is best to know the disastrous effect of making just one more size or another line.

The entire cost of conducting a machine building business may be lowered by simply continuing along with the same men.

This applies to the entire organization, from the workmen to the salesmen.

Changes should be made to keep up a wholesome spirit of progress.

Men should be advanced from position to position as the opportunities afford and their endowments allow. Others unfortunately must be dropped out from the organization ; but both the advancements and the weeding out must be carefully considered.

AMBITION MANIA

Advancements cannot be made to meet the requirements of this age of over-stimulated ambition.

We preach that every boy born in this country may stand an equal chance for every position from the Presidency down.

Young men are told to study and qualify for great things. This is good kind of preaching — it is the kind that should be heeded,— but in some instances it is taken into the mind as meaning that every one is endowed for this or that great position. Then the ambition becomes the predominating idea, and the work of preparation is secondary. Then the individual fails to measure up his own qualifications. Then he becomes obsessed with an idea of his fitness for things greater than nature ever intended; thus he gets beyond a condition of usefulness to an organization, and should be dropped out with the disgruntled. It is one of the tragedies of life that we should try to prevent, but should never postpone.

Ambition should exist, but it should not be the sole qualification for promotion.

The management's chief business should be to take men as they are found on earth; mould as much as possible, and place each one where he will accomplish the best results for both the organization and the individual.

Barring the disgruntled, the uncongenial and the habitually inattentive, almost all men may be and should be profitably employed, the prime requisite being reasonably close attention to business. The thoughts must not habitually wander away from the work.

The intrigue disappears when the management quits looking for it, and assures everybody, by the general method of conducting the business, that there will be no chance to oust this or that man; that each man will be retained in his place if he will but give reasonable application to the general interest of the organization and the particular work of his office.

The management does not "manage" if it perpetually changes its men. It should bolster up the man who lacks self-confidence; it should puncture false ambitions, and it should use men as they are found in the organization. It should not be inclined to "go back on" a man who has blundered or who has been found lacking in understanding.

It should not be over-ready to embrace a stranger just because his faults are not known.

The financial hazard of a business enterprise is greatly minimized by using men as they are found, and properly placing them at work or in offices for which they are qualified.

SUPERIORITY OF THE IMPERFECT

FINANCIAL HAZARD DUE TO LACK OF CONFIDENCE IN PRODUCT

What has been said regarding the optimist, the pessimist and the vacillating man, from the designing and manufacturing point of view of a machine business, applies with equal force to the business organization.

The business is pushed forward by men who have confidence in the project and in the product. If these men lose their faith in their own business, they not only lose their usefulness as pushers and managers, but they become drags on the industry, and remain so until restored to normality. The hazard of investment is greatly increased by such conditions.

Instances without number have been observed in which men who have been successful have become unsuccessful through loss of confidence due to acquiring the "dangerous half-knowledge."

The man who has acquired the dangerous half-knowledge should take a post-graduate course in some institution where men are treated by all the most powerful agencies known to science.

There may be no institution of this kind in existence, but the great need will doubtless bring the establishment of many.

The men who have lost faith in their own machinery should be told that no company can survive the effects of weak-kneed advocates. Any company is better for a certain amount of aggressive competition. Any company can stand more or less opposition from its friends the enemy, but no company can continue to exist under the blighting effects of one who has lost his confidence.

The post-graduate course for restoration of the near-wise man should include educational means of all kinds.

The means should be especially adapted to the need of each student or patient.

There should be a phonograph in each room, which should work all night and all day. This machine should repeat over and over a few short sentences like the following:

"The only perfect machine is the one you do not know."

"Study the machines offered by your competitors, just to get the same degree of knowledge of the 'other' machines—not for the purpose of slandering or even mentioning—but just to restore your confidence in the relative value of your own machine."

"Don't try to get back your belief that your own machine is perfect—that has gone forever—only look at the other machines and learn that your own is the best."

This kind of confidence will not be as exuberant but it will have efficiency in the cold gray world in which you are to again try your strength.

CONFIDENCE IN EXISTING THINGS

The new confidence acquired by this treatment is born of a knowledge of the *superiority of existing things* —things that may not be perfect but are nevertheless best.

This treatment will forcibly impress on the mind that every machine requires a complete organization, which combines and includes the inventor, the business managers, the manufacturing officers, and last, but not least, the men who do things, the workers in every department, and on every detail of the work necessary for the construction, shipment, and operation of the product.

The inventor may have had almost complete knowledge regarding the best way to make each part, just how each fit should be made, and just how the machine should be operated under each combination of conditions, but it is more probable that the inventor never had all this wonderful knowledge.

If he knew all this, it would be of value providing he had some perfect way of imparting his knowledge to each individual worker. We know, however, that this is impossible, even with the most thoroughly organized companies.

It takes years to get each piece made as it should be made, even with no change of design, and this is not accomplished by any other process than continuous practice, which is only acquired by making these pieces. The quality and speed of production increase with this experience, and are not acquired without it.

The art of assembling and operation of the machine is developed in the same way. There are other means that facilitate, but nothing that takes the place of practice.

The knowledge of the machine must be not only in the inventor's head; it is not even enough to have it thoroughly known by all the officers, including foremen. It must be patiently transmitted to the real workers.

A wonderful invention is only of material value when it has been in active use long enough for many men to have acquired knowledge regarding it, and skill in production of its various parts, assembling and operating.

It may have a prospective value, and that may be something salable, but the point to be made clear is, that real material value of an invention is not realized till it is used. To have it used requires more than the inventor's vision, and more than the drawings and specifications; it must be given form and use.

A machine is a combination of the original idea with many subsequent ideas which have been added to it by continuous application. These subsequent ideas are supplied by the men who do things, who make and use the machine. These ideas do not show in the general design, but they are there in fact. They represent ideas as to proper fit of this or that part, of the advantage of easing this or that bearing at this or that place. They represent the accumulation of the ideas regarding proper tension for each adjustment, and thousands of other points that may or may not have been anticipated by the inventor, and probably could never have been known by any other process than that worked out by actual thought combined with experience in the construction and use of the invention.

After receiving this treatment, one would go forth with a knowledge that the inventor, the officers, and mayhap the foreman, taken all together, do not and cannot make a successful machine or business without this supplemental work or ideas that come from actual work of all workers.

This new kind of knowledge should not take away a man's courage; on the contrary, it gives him true sense of value of existing, "going" things. With this knowledge he can confidently and earnestly push a machine that is the product of a good organization. He will know the great value of much experience and practice of each of the many men in the organization. He will neither kill the business by half-hearted endorsement, nor increase the hazard of investment by urging this or that modification, or by this or that machine being added to the line already too great.

The invention, the organization, the proper direction of the business, are essential to success, but without that organization which is only obtained by actual, thoughtful experience of the men who do things, all the knowledge and industry of the leaders are utterly useless.

This new kind of confidence, gained by this treatment, is the kind that has the greater faith in the existing and running things than in the claims for something that has not had the development of practice. It is the confidence that knows that the right fundamental ideas and the policy of "sticking to one thing" will accomplish the best results.

This is not a doctrine of optimism that holds there is no inferior machine. The "best" implies the existence of the inferior. In nearly all lines there are many grades from the best to the worst, but the loss of faith in the relative value of a machine is most commonly due to a lack of full knowledge of the other types, and it is this kind of loss of courage, confidence, or whatever it may be, that this chapter is intended to offset.

PROGRESS SHOULD BE MADE—BUT WITH FULL KNOWLEDGE OF FACTS

New schemes or new inventions may be full of promise but cannot be realized without the various elements which include the man and his persistent industry in organizing as well as inventing—in manufacturing and selling as well as promoting.

Belief in the superiority of existing things is not a barrier to real progress; it is not a submission to the spell of environment. It is simply an appreciation of an important fact. Progress should be made subject to this fore-knowledge.

The spell of environment that should be exorcised away is not the spirit of progress—it is the group of fundamentally erroneous ideas regarding values of various methods of manufacture, general conduct of business and principles of machine design.

Here are a few of the errors:

Anything new must be good.

"Tinker & Change Machine Tool Company are bringing out a new model. It's a wonder worker." [Said company seldom make two lots alike.]

"Experience in manufacture and use of a new machine is of value, but not essential to its success."

"The talk of profit of a business should be in whispers. It is against the welfare of the workers." [As if good wages or salaries could be paid by an unprofitable enterprise.]

"The idea that specialization of the processes for producing machines is harmful to the machinist trade because it tends to simplify and make less difficult the production of certain kinds of work." [As if it were to the advantage of the machinist to be forced to work with poor implements, when in other plants, cities and countries, good tools are being furnished to each man—tools which enable each man to do the best work of which he is capable in the most favorable circumstances—methods of specialization which take the ordinary work away from the extra good workman and supply him with high-class work wholly, making his return the greatest, and making it possible to pay him good wages. As if it were possible to pay good wages when good men are required to do medium work, and all men on account of inferior tools are handicapped in their production. As if these questions of profit were not of vital interest to every worker and officer, as well as owners.]

The group of persisting erroneous ideas regarding machine design is so large and so strong that a summary would fail to serve any good purpose; therefore, no attempt will be made here to even outline these ideas, but some of these will be fully treated in some of the later chapters. It is hoped that each reader will make an effort to get back to nature in surveying the field.

LARGEST PROFIT PER DOLLAR INVESTED

One of the most satisfactory policies of management is that which tends toward getting the best return or profit per dollar of investment.

We shall not refer to the quality of the product, the design, or any other elements which affect the good name and standing of the business, for it goes without saying that no business can be maintained where these are disregarded, but the point to be brought out here is that, these things being equal, the best scheme of management for profit is one that puts the capital where it will do the most good.

The above statement is one with which all will agree, but strangely enough there has been a tendency to tie up capital in ways that actually throttle the output of the entire business.

Furthermore, this is frequently done by increasing the portion of the investment that is irrevocably tied to the existing product, thus not only reducing the earning power of each dollar invested, but also increasing the hazard by tying the capital to the present product which soon may be unsuited to the market demand.

One of the most common errors in this respect is the one that regards the reduction of the labor cost as the paramount consideration.

Reduction in labor cost has been the war cry. The labor bill has been talked about so much that it has seemed to become the whole thing.

A man who declares that the labor cost per piece is not the most important element is at once branded as an advocate of old-fashioned methods.

It is needless to give assurance that there is no intention to disregard the labor cost. The net cost per piece is a very important element, but it should neither eclipse the question of profit per dollar invested, nor the risk of the capital tied up.

What is the gain if the means for reduction of the net labor cost reduces the profit more than the saving in labor? If doing so results in an actual loss of profit, why is it done?

We can readily see that the over-hopeful managers may disregard the risk of the money invested, but we cannot see why the relative importance, or rather unimportance, of the labor cost should be so disregarded.

The machinery usually called "machine tools" determines the more or less fixed character of the plant. There is a constant change being made in its character, but the controlling spirit may be right or wrong from the economic standpoint.

It is in these changes that the scheme of management has a chance to greatly affect the earning power of the entire business.

If too large a proportion of the total available capital is tied up in the machine equipment, the business is handicapped. There is a right amount which bears a certain relation to the total required to carry on the enterprise.

With a given amount of capital for machine tool equipment, the output of the plant will be seriously throttled if the net cost of labor per piece machined is allowed to become the controlling element.

At the present time the various machine tools which are being offered for a given class of work are very unlike when compared on the basis of output per dollar of their cost.

This is no standard of measure that bars out any particular type. It seems to hit both the new and the old. For instance, it hits the automatic lathes on large work because their output in this line of work is low.

Such machines are usually installed on account of the saving, or apparent saving, in the labor cost of machining—the mistake being made by overlooking the throttling effect of using up the capital available in low-efficiency machines.

Such reduction in the total plant output makes a reduction in the profit that is frequently many times the size of the saving in labor.

The standard engine lathe is also a low-efficiency machine when measured by the foregoing standard.

It has one redeeming feature, however, that is not possessed by the automatic machines: it does not require a lot of special tools. It is an adaptable machine, while the automatic is an inadaptable, when its special tools are considered.

With the highly specialized automatic turret lathe, and the all-around utility tool, the engine lathe, both barred out, it will be seen that the net labor cost may be low or high with the low-efficiency machines. Therefore, this standard of measure should not be considered as tied to either high or low labor cost.

The practice of disregarding the profit, when considering changes in machine tool equipment, is the natural outgrowth of the separation of the mechanical and the business departments.

The changes in the equipment are usually determined by the mechanical department, and this is done with particular regard for the quality of work and the cost per piece. The relation between the profit and the net labor cost is not considered.

The cost of the product of the average plant may be divided into three nearly equal parts: the material, the labor and the burden; or, in four equal parts, if a reasonable interest charge is made for the use of the capital invested.

The material is the iron, steel and other material that enters into the construction of the machine, and it is taken in the condition in which it usually comes to the machine shop.

The burden includes all expenses and salaries necessary for the maintenance of the business.

About one-half the amount paid for labor goes to the men who run the machine tools. Therefore, the cost of machining is either one-sixth or one-eighth of the total cost.

On top of the net cost of the product there should be a profit. If it is not there, the sooner something happens the better. If it is there, then it is proportioned to the volume of the output. Therefore, both the size of the output and the labor cost should be kept in mind.

The size of the profit per unit of output is not generally known to the mechanical departments, but if it is not known, there is no reason for their being uninformed as to the importance of large output for cost of the plant.

It is needless to say that there is undoubtedly a place for the automatic turret lathe and the standard engine lathe, but we wish to emphasize that both are frequently misplaced. We all know that ultimately automatic machines will replace many or all of the hand-operated machines, and that there will be very few operations beyond the reach of the automatic machines; but in the present state of the art and crudity of design, the so-called automatics are ill-adapted to meet the economic requirements excepting on small work of manufacturing, which is generally outside of the machinery-building equipment.

The automatic has its field in the duplication of small pieces which are required in endless numbers. Either an increase in the size of the work, or a reduction of number of pieces, changes the work from automatic to hand-operated turret lathe or engine lathe. The dividing line will be more definitely understood when we have considered a few of the elements which enter into the problem.

The engine lathe is for work under 20 inches diameter, in the laboratory, the small tool room, the frontier machine shop, or small machine shop, and it is the proper machine for larger work, which it shares with the vertical boring mill.

This division of work leaves out the principal lathe work under 20 inches in diameter in the average machine-building plant.

The effect of using the automatic beyond its present field not only increases the capital tied up in machine tools for a given output, but it also ties up an extra amount of capital in stock in process of construction.

CAPITAL IN STOCK IN PROCESS OF CONSTRUCTION

The amount of capital tied up in raw material, supplies, stock in process and finished product should not be greater than that which is necessary to get the greatest output per dollar of investment.

In the machinery-building world there is no such thing as a steady, long-lived demand for any machine, hence the proposition to build a locomotive or an automobile or printing press by methods employed in watch or sewing machine manufacture, is entirely ill-timed at least.

For this reason the stock in process must not be considered insufficient if it appears to be on the hand-to-mouth plan.

The dividing line between excessive and insufficient stock must be drawn in each individual case.

Raw material should be purchased in reasonable quantities, with due regard to the price which varies with quantities, but there should always be a regard for the amount of capital used for this purpose. Any excess is that much risked unnecessarily in the business.

There should be a constant supply of material throughout the entire work. The stock in process should flow through the plant in a rapid, thin stream, but with no greater quantity than absolutely necessary to insure a steady supply for all of the workers, including the assembling and selling workers.

An excessive stock of this or that piece, or of all pieces, means that much capital idle, and it also tends to slackness of management. Frequently it is the outcome of carelessness.

A plant will run without management if given latitude in the amount of stock carried in raw material, in work in process, and in finished product. No great care need be taken in purchase of material or in putting in the shop orders. Just hurry forward the stock that "happens" to be "out," and at the same time allow the accumulation of the unneeded stock to go on unchecked.

It is no uncommon sight to see this all going on under the same management.

Immense storerooms for keeping finished stock are shown with pride, unmindful of the fact that every dollar's worth of unnecessary stock on the shelves in the stock room, every dollar's worth of unnecessary work in the plant, represents idle money and faulty management.

If this money is to be retained in the business, it should be put into changing over the system to one which will conform to the plan of putting the money where it will bring the best return.

The excessive stock in process is an outcome of blind progressiveness — the blindness that fails to see that there is as much money tied up in stock in process and in finished product as there is in the entire machinery equipment.

An adaptable equipment facilitates keeping down the amount tied up in stock in process. The modern plant should take advantage of these modern methods and machines which tend toward profitable use of capital. Such machines are highly developed and true to the controlling ideal of adaptability and largest output per dollar of investment.

PRINCIPLES OF LATHE DESIGN

CONTROL OF WORK AND TOOL

STRENGTH OF MACHINE

THE implement used in building machinery should be the best when measured by the following standard:

a. The machine should have the greatest efficiency in turning out work when measured by the output per dollar invested in the machine. *b.* It should produce the work at a reasonably low labor cost (but under no pretext should a machine be used that throttles the output or effects its savings in labor at the greater loss of profit). *c.* It should be conveniently adaptable to present and probable future needs. *d.* It should be conveniently operable. *e.* Its product should be true in shape and size. *f.* It should conveniently set for duplicate work.

The requirements should be fulfilled under the existing conditions. These conditions include the quality and quantity of work, the characteristics of workmen and present conditions of plant.

We will now consider some of the elements which are essential in a machine to bring it within the foregoing standard.

The lathe, of course, is nothing more than an implement which has evolved from the simple implements of the stone and copper age, and the early days of the present iron age. It has not reached a state of perfection in design. The evolution is still going on under the effect of changing conditions and with the aid of greater skill and knowledge of man.

The general trend of the evolution is forward towards a better implement, but some of our changes have been retrograde.

Backward steps, when recognized, have tended to make conservative people still more inert. Hence, we have today many examples of implements ranging from the good old style but obsolete machine to the one built to meet the present-day conditions.

The edge tools, such as knives and chisels, were in use before the introduction of machines. These were guided and pushed through the material by hand. Other edge tools were used in the form of the axe and the hammer-driven chisel, but we shall confine our attention to the development of the tools which were pushed with a fairly steady motion.

These tools took a longer or more continuous shaving than the axe or hammer-driven chisel, and this process of taking a continuous shaving is the one that has evolved into the turning process of the present lathe.

In its original and simplest form it is whittling or carving. The shaving taken by this process, although more continuous than the chip of axe or driven chisel, is nevertheless short compared with the possible shaving or chip of the lathe.

We speak of "chip" of the axe or lathe tool and "shaving" of a sharp knife.

Shaving, perhaps, primarily conveys the impression of a thin cutting, that is, a cutting that is thin compared with other cuttings, but it is also used to express a continuous chip or cutting regardless of its thickness in relation to other cuttings, for it is always a shaving when compared with the work from which it has been taken.

In so far as chip means a short cutting, and a shaving a comparatively continuous cutting, these terms are full of significance.

Generally speaking, all cuttings should be taken off in thick, continuous shavings, and never in short, broken or crushed chips.

Chips are the product of either intermittent action or blunt tools which crush instead of cut.

In whittling, the edge of the cutter is forced and guided through the work by hand. Generally the work is held in one hand and the knife in the other hand. The skill and strength with which the cutting edge is impelled determine the output or efficiency of the man and implement taken as a whole.

The efficiency of the whittling process is very low, because the shavings are taken intermittently and under no accurate control as to depth.

The work is reduced to correct size by continuing to remove shaving after shaving till the required size has been produced. This is necessary even in grainless material, because it is beyond the strength and skill of man to control the edge with satisfactory accuracy. Machines were devised to obtain a better control of the work and implement.

These machines made it possible to take a continuous instead of the intermittent shaving; furthermore, they controlled work and cutter so unyieldingly that the cutting edge could be forced along a path that would remove all, or nearly all, in one cut, instead of taking many cuts.

The only reason for taking more than one cut was the lack of strength of driving power or the frailness of the machine or the work, or the unsatisfactory surface left by heavy cutting.

We have reviewed the evolution of the machine for turning for the purpose of setting forth the real object of the lathe. It is another attempt to get back to first principles in order to see the subject unhampered by our knowledge of lathe design.

By the foregoing analysis we may deduce that a lathe is nothing more than a conveniently operable machine for imparting and controlling the motion of the work and tool so as to cause the tool edge to pass along a true path, cutting light or heavy chips with the least flinching or deviation from the desired path, so that the piece of work will be given the desired size and shape.

Heretofore any means for such control was considered satisfactory without much regard for the time required to produce an accurately machined piece of work, but today the time required to produce a given result is one of the chief measures of value of a lathe. It must give accurate results quickly.

Since the accuracy or quality of product, and the speed or quantity of output, are more or less interconvertible, it will be understood that the best machine is the one that gives the greatest output of satisfactory product.

The convenience of controlling the operation of the machine, including getting requisite speeds and feeds, will be considered elsewhere. We will now consider the means for obtaining the largest accurate output.

The largest output requires the kind of cutting that will remove the metal quickly — the limiting elements being the heat generated by cutting, which is more or less in proportion to the metal removed; the lack of stability of the machine for control of work and tool, and the frailness of the work.

Just as the earliest lathes were made to furnish a more exact and stronger control of the cutting edge, so each succeeding machine has been built for effecting a gain in this direction.

The accuracy of the control of the path of the tool through the metal depends on the accuracy of the machine.

The velocity with which it is capable of removing the metal with a given degree of accuracy depends on the strength of the machine, the power of its drive, and the character of the cutting edges.

In the process of whittling, only sharp edges were used because the strength of the unaided hand and arm were comparatively low. Keen tools were also used in hand-turning in the lathe, but the blunt-edge tools came into existence with the slide rest lathe.

The slide rest provided an accurate guide for the cutting tool along the rectilineal lines and gave a comparatively unflinching control of the position of the tool in the work, that is, the control was considered unflinching when compared with the control of hand turning; but as lathes continued to evolve, the demand for higher efficiency in quantity of output without a lowering of the standard of quality became imperative, and the entire lathe grew into a machine for still better control. So that the lathes of today are very much stronger than the early slide rest, and just as these lathes are better than the earlier forms so there is a difference today between these modern lathes.

The comparative control of the work and tool remains one of the real principal measures by which machines should be valued.

Although the art of lathe design is still in a crude stage, the problem for introducing improvements is not as simple as it might appear on the surface.

For instance, a lathe cannot be strengthened by merely increasing the size of its parts. These cannot be increased indefinitely any more than it is possible to strengthen a bridge by increased weight of its parts.

The stiffer control comes almost wholly by improvement in design, but, notwithstanding the crudity of the art at present, the difficulty of improving control seems to become greater each succeeding step.

In all such work we must maintain or improve quality and increase the quantity of output of product, the convenience of manipulation, and we must maintain or improve all other features that make a lathe that "pays," that is, the design must be one that will be best when measured by the economic conditions of today.

These conditions must be met both in building and using the lathe.

Regarding the stability of control, we have found all lathes lacking on the average run of work. Of course, a lathe designed for turning fly-wheels would not be lacking in strength when working on some frail shell, but such extremes should not obscure the actual conditions of the regular run of work in which the lack of control of the path of the tool edge through the metal is due mostly to the weakness of the machine.

In the use of the terms strength and weakness, in reference to tool and work control, there is no intention to imply general frailty or lightness of the machine. On the contrary, the heaviest machines for a given class of work are frequently the most unreliable, and, in many cases, they are actually the weakest.

The weakness may be due to faulty design—it may be in only one of the links that connect the work and tool—it may be a slide which is too frail to hold its gibs, or one that is provided with gibs which do not take the stress squarely, or a slide which must take its load at a disadvantage.

Great weight, and especially when coupled with great swing, in a lathe usually means a corresponding weakness not strength, and great swing always means unreliability for precise control.

Strength of control means that strength which keeps the tool following a true path, with the very slightest deviation each side of that true path. A heavy machine, or a lathe of large capacity, may be capable of taking a cut ten times larger than any cut that can be taken by a smaller machine, and yet it may be greatly inferior in control of path of tool within the fine limits of deviation.

The heavy lathe does not begin to resist the deviation of the tool from the true path till it has gone very wide of the perfect line. Nevertheless its capacity to take the bigger chips has given it the reputation of being the stronger machine.

The big machine does not possess the unflinching strength—it flinches excessively before all the slackness of its joints has been taken up by the stress, and it flinches also from no other cause than its long-distance control, due to its greater swing or perhaps faulty design.

It seems impossible to provide the necessary movements of the work and tool in relation to each other without the introduction of joints or parts which yield under stress on the average run of work.

Other features being equal, the best machines are those which give the best control of the cutting tool in the metal for a given result.

Machines made exclusively for heavy turning might have great strength of control over work and tool and yet be entirely unsuited to turning frail work in which the element of convenience of manipulation is of great importance, but for a given class of work and a given convenience of operation, the best control of the tool and work is seldom good enough. It is invariably less than it should be.

The deviation of the cutting edge from the desired path leaves its evidence on the finished product. In turning a shaft, for instance, the stress of cutting may be sufficient to spring both the lathe and the work. If either or both are sprung under the cutting stress, the depth of tool will vary with the variation in cutting stress. The amount of change of position may be less than .0001 of an inch and yet produce a marked irregular appearance of the work. If it is greater, then the size produced is unacceptable.

Usually the finished surface has an unsatisfactory appearance because the tool has fed irregularly; not that the feeding mechanism has worked intermittently but that the springing carriage has allowed the tool to alternately ride and dig.

Work produced under such conditions usually costs from two to three times as much as it should cost, because the unevenness of cut has produced a surface very much inferior to the surface which would have been produced by a regular feed of two or three times the thickness.

There are many other elements that point to the importance of good control—durability of cutting edge is one of the foremost. But when all these points have been considered we have gone no further than to discover that lathes should be measured and valued inversely as they yield or flinch in control of path of cutting edge through the metal.

Since there is no such thing as infinite stability of control, we must measure the extent of flinch or yield for a given result.

This strength of control is dependent on the margin of strength of machine above its working stresses.

REDUCTION OF STRESSES

There are two ways of increasing this margin of strength: *a*, by strengthening the machine; *b*, by reducing the stresses for a given result.

Lathes have been developed along the lines of the first scheme with more or less disregard for the second, because there seemed to be no practical way to reduce the stresses.

We have seen that lathes cannot be strengthened by the mere addition of more metal, and that the only way for improvement in this respect is to correct the design.

This may be accomplished by elimination of unnecessary features, such as unused slides and joints in the connection between the work and tool; also by obtaining the necessary motion between the tool and work by slides having best-known proportions and located in the least objectionable places.

Examples of such construction are set forth in other chapters, so that it is unnecessary to make further reference to the special forms of design by which this strengthening has been accomplished, excepting to say it is what we call a "single slide" scheme of design. This scheme has been called "single slide" in order to differentiate it from the prevailing form of tool carriage, which may properly be designated the multi-slide scheme of design.

The multi-slide scheme of design is made up by putting one slide on another; sometimes two, but oftener three sliding joints between the tool and the bed.

The stability of the single slide and the frailty and instability of the multi-slide are clearly explained on page 67.

The next step towards better control of work and tool has been taken by reducing the cutting stress for a given result.

A reduction of working stresses is equal to strengthening the machine.

It would be a great and perhaps an impossible accomplishment to double the strength of some of our modern lathes, but it does not seem so marvelous to get the same results by reduction of the cutting stresses, for that is at least conceivable.

Attempts to greatly strengthen existing machines have tended towards the use of means that have been extremely objectionable on account of greater cost, clumsiness, and lack of durability.

The importance of the reduction of the cutting stresses has been recognized, but it doubtless seemed to be something unattainable.

The cutting angle and general form of cutting edges have been varied each side of the present accepted shapes, and always with the same result of driving the experimenter back to the orthodox forms. Therefore, any suggestion to use more acute cutting edges has been considered impractical. Not that there would not be a reduction in stresses, but that acute edges have not been found durable in cutting metal.

That our orthodox cutting tools are all too blunt, and that superior results are now obtainable by the use of acute cutting edges is all clearly set forth on page 128 *et seq.* The leading characteristic of the acute edge tool is that it works with a minimum or no clearance.

Since the advent of the slide rest lathe the turning tool has had "clearance." That is, its under-face or flank has not been allowed to rub on the metal. In the process of whittling, both sides of the knife rub; the chip rubs on one side and the work on the other, but a cutting tool held in a machine — like a slide rest lathe — is not allowed to rub or ride on the work; it must take the stress of the chip on one side, and the other must stand clear on the work, only touching at the extreme edge.

The one-sided stress has led to the use of very blunt cutting edges. The present orthodox cutting angles vary from 60 to 85 degrees, and the most durable and efficient for stock reduction at high speed are approximately 70 degrees.

Since the process of turning has grown out of the whittling process, the foregoing statements of angle of cutting edges seem to indicate a devolution instead of an evolution. The retrograde step in the development of cutting edges has been more than offset by the progress in steel making and in machine design.

The subject of steel making and process of hardening for the production of enduring cutting edges is outside of our province, but cannot be passed over without reference to the great advancement that has been made through the work of Messrs. Taylor and White in the discovery of the Taylor-White process of hardening steel.

When we realize the greatness of this discovery, we shall see that it is almost without parallel in our generation in effect on costs of metal cutting.

It has doubled the output of thousands on thousands of machine tools with scarcely no outlay.

That it has also shown many tools too weak in driving power and has called for more powerful machines does not lessen its economic value to the world, for the fact still remains that all existing machines may be "speeded up" to get a very much greater output.

This is an ideal example of man's rising superior to the spell of environment, for every one *knew* that all steels should never be heated above a certain uncertain low heat called cherry red. These men discovered that phenomenal results could be attained in the treatment of certain steels by going contrary to all the practice and teaching of this enlightened age, and they acted on their knowledge. They accomplished a very great result. Others may have known as much and probably did try this process earlier — but how utterly valueless is this unused knowledge.

This digression at this point has the double object of paying tribute to the joint inventors, Mr. Fred W. Taylor and Maunsel White, and to emphasize the fact that some of our *knowledge* regarding machine design may be of the same kind that we had regarding the proper treatment of steel.

But even with the great advance in endurance of cutting edge due to the foregoing discovery, and the greater strength of machine tools which has been steadily advanced, we have still retained the blunt cutting edges, and it is all due to the departure from the fundamental principles of whittling in which the cutting edge received a fairly equal pressure on each side instead of the wholly one-sided pressure of the present metal cutting process.

Many attempts have been made to get away from this unbalanced stress, but with no good results. Our notions regarding the subject of *clearance* have been erroneous. Notwithstanding the fact that it is common knowledge that an uncleared taper tap or die — such as pipe-thread tools — cuts with not only no clearance, but with an absolute negative clearance, and that until recent years all solid taps and dies have worked without clearance, we have gone on obsessed with the spell that cutting tools must have clearance.

We have modified the design of certain parts of our machine tools with more or less freedom, and certain other parts have been left unchanged. The lathe headstock has been immovably affixed to the main bed casting, regardless of the weakness entailed by this very strong link.

The means for chasing screw threads on chucking work has been kept true to the design, which was made for cutting all kinds of long screws, unmindful of the unsuitability of this means for chuck work; and in the same way we have gone on affixing the cutting tool to the carriage, regardless of the fact that it should be free to assume any angular position required to allow its under-face to rub or ride on the work so as to eliminate the one-sided stress on cutting edge.

A cutting edge should be under absolute control of the carriage, both as to depth and thickness of cut, but it should also be free to swivel on a center line coincident with its edge.

This floating or swiveling allows the tool to work without clearance, and it prevents its acquiring the destructive "negative" clearance.

The mere statement of this fact is enough at this time. Reference to the descriptive matter on pages 130 to 141 will make clear the method of holding cutter.

The point to be borne in mind is that our orthodox cutting angles of 70 degrees are no longer necessary for this class of work.

The cutters having cutting angles varying from 55 down to 45 degrees, give a marked stress reduction.

The failure of previous attempts to work with little or no clearance has been due to the rigid mounting which has not allowed the cutter to conform to the surface of the metal from which the chip has been taken.

When a tool has been ground and set with minimum clearance, a very slight wear takes away its clearance and leaves a rubbing area of the tool in contact with the surface of the solid metal. This area is so small in comparison with the abrading stress that it quickly scores and becomes rough, and passes rapidly from a no-clearance to a negative clearance; that is, it becomes worn to an angle leaning in the opposite direction to the clearance angle, so that the edge does not remove the metal clear of the under part of the tool, hence the under face of the tool must burnish or crowd the surface of the metal back. This condition, of course, will last but a very short time at any normal cutting speed. If not arrested, it is quickly followed by worse trouble.

It is not generally known that the dulling of a tool in cutting metal is mostly due to its loss of clearance. The other changes in the top slope of the cutting edge against which the chip bears has much less or no effect on the life of the cutting edge.

When by chance or otherwise a rigidly mounted tool has been set with no clearance, it will give fairly good results for a time, providing its area of rubbing contact is sufficient to prevent scoring or abrading.

The exact angular position of the face must correspond with the angular advance of the feed. This may be approximated by ordinary means on work of small diameter and rank feed, like 1/8-inch feed on 5/8-inch or 3/4-inch, and even on finer feed, or work a trifle larger, if the feed is not positive; *i. e.*, a yielding feed like a fluid pressure or slip-motion mechanical feed, but then the slight wear of the tool face reduces the rate of advance, and the adjustment of angle to each change of diameter does not lend itself to a generally satisfactory tool.

The floating or swiveling tool makes it possible to run any desired rate of feed and on any diameter without special attention to the position for the cutter tends to assume the correct position in which it holds its face against the wall of metal from which the chip is being severed; the face it presents having ample area to withstand a reasonable amount of rubbing or riding contact without abrasion. In practice, a newly sharpened tool usually starts with either a very slight clearance or no clearance, but in either case as it wears it swings around so as never to acquire a negative clearance.

As already indicated, the no-clearance scheme makes possible the more acute cutting edges, and although excellent results have been obtained with angles from 45 down to 30 degrees, yet on account of the character of the chip produced, it has been advisable to use angles between 45 and 50 or 55 degrees for the turning tools used for turning bar work up to 3 inches diameter.

Rigidly mounted tools have lacked durability when ground at angles sharper than 65 degrees, but this refers to working the average run of tough machinery steels. The softer steels have been less destructive to these cutting edges, but there has been another barrier to reducing the working stresses by the acute tool.

The lack of durability was enough, but it would not have prevented the use of such tools on certain metals and kind of work if it was not for the troublesome chip produced. In automatic machines and even in hand-operated machines the tools are usually made blunt enough to produce a broken or crushed chip.

All beautiful ideals must stand aside in the face of the troubles incident to a snarling mass of wire-like chips that become entangled with every part of the machine.

The constant attention is more than can be given, even if the bulkiness of chips is not objectionable.

Some manufacturers of machine tools are so unmindful of the troublesome nature of such chips, that they even illustrate some favorite turning tool in a wreath of curling chips.

The early experiments with the acute tool developed the need of a chip breaker. Briefly, it consists of two obstructions placed in the path of the chip which cause the chip to be bent beyond its breaking limit.

The chips produced occupy comparatively small space, as they lie compactly in nearly flat strips seldom more than two inches long.

THE EFFECT OF QUICK RE-SET TOOLS ON THE OUTPUT

CUTTING SPEEDS

The velocity of travel of the cutting edge through the metal is called the "cutting speed."

It is usually expressed in feet per minute, and varies from 8 to 200 feet per minute in ordinary turning operations.

With all other conditions unchanged, the variation may be said to be almost directly dependent on the size of the chip, or, in other words, the change in cutting speed does not change the weight of chips removable.

Slow speeds must be run for thick and deep chips, and high speeds may be run for the light cuts, an exception to this being in bar work where the depth of the cut makes a reduction of from 25 to 75 per cent in diameter. This difference in diameter does not make a corresponding difference in cutting speed. For all such work the speed may be said to be affected by feed only.

This does not seem reasonable, but it is borne out by data obtained under the thoroughly scientific observations of Dr. Nicholson and Mr. Frederick W. Taylor.*

The unreasonableness of this relation of speeds to weight of metal may be wholly due to misconception of the real process of metal cutting.

If the metal in the chip were undisturbed, just merely severed from the parent stock, then the finer chips would truly represent more work than the coarse chips, and it would seem that a cutting tool would remove the largest quantity of metal if it were not required to cut it into such fine pieces; but we know that the metal in the chip is greatly changed by the orthodox cutting tools.

These tools are so blunt that they crush and push the metal instead of plowing or wedging it away. And since the crushing process is just as thorough in the thick chips, there may be nearly as much work done in one case as the other. The fact remains that with other conditions unchanged the cutting speed is substantially as to the quantity of metal removed where the depth of cut is slight compared with the diameter of the work.

Now let us see what are the other conditions that affect the cutting speed. These may be stated as follows:

a. The character of the work; namely, the accuracy as to size, shape and condition of surface. The quality of the metal to be cut. The quantity of pieces to be made.

* See *Lathe Design for High and Low Speeds*, by Nicholson and Smith, published by Longsman & Co., New York and London; also *Art of Cutting Metals* in the transactions of the American Society of Mechanical Engineers.

b. The quality, condition and shape of the cutting edge.

c. The quantity and quality of a liquid cooling and lubricating medium.

d. The stability of control of machine in forcing the tool undeviatingly along a path as nearly true as possible in order to minimize the edge-destroying lateral vibration that is ever present in the so-called standard machines and orthodox blunt tools.

e. The practical period of endurance of the cutting edge. This period may vary 10 or 20 minutes in rough turning with quickly renewable tools, to one or more weeks in accurate duplication of work with tools which are not conveniently renewable.

In machine tool design many of these variants may be altered.

We have shown how the stability of control may be improved by stronger machines and lesser cutting stresses.

And we will now see what determines the period of endurance and how this affects the cutting speed.

In turret lathe work, a tool should endure a sufficient length of time to allow it to complete two or more pieces in order to get the advantage of the accurate duplication for which the turret lathe is primarily designed.

The length of the period beyond this point is varied according to the time required to put a sharp tool in the place of a dull one. The degree of convenience with which this change may be made, with minimum loss of time and spoiled work, directly affects the period of endurance.

This period should not include the time required for grinding in resharpening the tool, because there should be a good supply of sharp tools constantly on hand.

The cost and time of regrinding must not be disregarded and should be comparatively low, but whether it is included in the time required to replace a dull tool with a sharp one, the fact remains that this cost in time and cost of keeping sharp cutters on hand has a bearing in determining the cutting speed. For instance, if resharpening of cutters requires a long, slow grinding operation each time and an occasional reforging, then a relatively slow speed is chosen in order to get a long period of endurance.

In resetting, the tool must be restored to the *exact* position of the former tool. The importance of the *exactness* of return should not be overlooked.

The standard engine lathe tool post provides a very convenient means for exchange of tools, but it does not put the sharp tool in the exact previous position of the tool removed.

The engine lathe tool post is satisfactory for return of tool to substantially the correct place, but this is not the fulfillment of the condition which affects the cutting speed, for it is the total time consumed in accurately replacing a new edge.

The newly set edge must be in correct position, both for production of correct diameter and shoulder position.

If this process requires the cut-and-try adjustment of both tool and feed stops, then the change is dreaded by the operator, and he will run very slow speeds just to put off as long as possible the time of change.

This not only reduces the speed and output, but on account of the inconvenience of exchange of tools the dull edge is allowed to run too long; that is, the quality of the work is not as easily kept up; for what would be considered passable in one case would not be tolerated in the other.

If a new cutting tool can be quickly substituted for the dull tool, then the period may be short. In fact, the practical and economic period is mostly determined by this one element.

For this reason a means for providing a quick change of cutters without loss of size produced is of great value, for it makes practical the use of the high cutting speeds that have relatively short periods of endurance.

If a dull cutting tool may be taken out and a sharp tool put in its place within a period of less than one minute without loss of "size," a much shorter period of duration may be chosen than when the resetting requires from 10 to 30 minutes, with more or less unsatisfactory product turned out during the "cut-and-try" method of "setting."

With the usual trouble and inconvenience of resetting tools in a turret lathe, it is customary to run speeds so slowly that a change of tools is not required oftener than once in 10 to 50 hours.

The work turned out during the resetting process is barely passable, which is worse than wholly unfit, for the "barely passable" work is generally a source of trouble.

The output of many existing machine tools is only 50 per cent of what it would be with a scheme of quick, accurate resetting of tools.

Cutter holders or tool posts now in general use seem to have been made with special regard for convenience of reclamping the tool in the *approximately* correct position, at a disregard of the total time taken in complete, accurate return, also a disregard for the damaged work turned out by the cut-and-try process of restoring edge to correct position.

This may seem to be an insignificant matter, but when we see that a little thing like a modified tool holder can take on the value of an entire machine, we realize its full significance.

Doubling the cutting speed without change of other conditions or loss of quality of work constitutes doubling the output of both man and the machine.

To obtain this result in all turning operations seems to be beyond the attainable at present, but a very ideal scheme for this purpose is shown in the turner for bar work shown on pages 128 *et seq.*

TURRET LATHE DESIGN

LATHE WORK

GENERAL SURVEY OF MEANS AND METHODS AND EFFECTS IN INDIVIDUALS AND PLANTS

THE standard engine lathe of the present day represents the highest development of the hand and power controlled slide rest machine for full range of work known as lathe work.

Originally the small screws below ½-inch diameter were turned out by the lathe, but now these small pieces are known as screw machine work, and are made almost exclusively by the various forms of automatic screw machines, and, in a sense, such pieces cannot now be considered as lathe work.

This scheme of using special machines for a certain limited range of work commenced with the smallest work, and is now encroaching on larger work each year, the present working range of such machines in some instances being as high as 48 inches in diameter.

Among the special machines the turret lathes predominate.

The turret lathes have been developed along two separate lines of design: one line has clung to the use of multi-cutter tools, having a double support, such as the box tool for screw machine work, and the more or less complicated cutter heads for chucking work. This scheme of design uses "made-up" tools in which the cutters are fitted firmly into fixed positions in the box tool for bar work and in a suitable head for chuck work, the position of the cutters being arranged so that they cut simultaneously — at least, they all finish their cut at the same time, although the cutters having the long cut start first and determine the time required for the combined cut.

The two supports for these tools being, first, the shank or base by which the tool proper is attached to the tool carriage or turret of a lathe; and, second, a support for the outer end, which takes bearing directly on the work as in the box tool back rest, or in the work or chuck or spindle nose, as in the use of boring bar cutter heads.

The second line of development has been in machines for using single cutters, under independent control of the machine, without a second support in or on the work.

Each scheme has its natural field in which it should be used and beyond which it is only used at a loss. The machine developed for the first cannot use the second method, but the machine having independent control can use either or both as the work may warrant. The dimensions, the quantity, the quality, the permanence of the demand, the time in which the work is to be executed, and the uses to which the work is to be put, all of these elements must be considered in order to determine which is the best means and method.

The advantage of box tools and multi-cutter heads is that they make a convenient means of accurate duplication and are the most suitable for automatic machines.

These tools are the best for small work below 3/4-inch diameter on bar work and below 3 inches on chuck work, but they lack of convenience of quick regrind and reset of cutters, and their lack of adjustability makes them unprofitable on larger work.

The automatic machines have an excuse for continuing to use these tools above their natural range for hand machines, for their use reduces the necessary motions and complication of the automatic.

But the excuse for their use in the hand-operated machines beyond the small work is not one that is very flattering to the machine.

They are used there because the machine is lacking in strength of independent control of the work and tool.

Within the field of lathe work these multi-cutter tools are invariably a barrier to flexibility.

The least adaptable turret lathe is the one which, on account of its frailty, is dependent on the so-called box tools or multi-cutter tools, having cutters in fixed positions, with little or no range of adjustment for diameter or shoulder lengths.

The box tools for bar work, and the multi-cutter heads for chuck work, usually have the advantage of a double support—one end supported by the turret, and the other taking bearing on the work or chuck. The double support may be advantageously used on some kinds of work, but the machine should be capable of controlling the work and tools independent of such support. The best machine is the one that gives the stiffest independent control of work and tool.

The made-up tools are the expensive kind, both in first cost and maintenance. Since the maintenance cost is so great, the box tools are run at comparatively slow speeds, particularly on the larger limits of their working range.

The box tool scheme of working has been carried to work up to 2 and 3 inches in diameter for bar work, and in chuck work the principle is exemplified in the multi-cutter heads for both inside and outside work.

The lack of adjustability of the multi-cutter tool makes it necessary to have one box tool or cutter head for nearly every piece of work. This causes endless delay in getting out new work and fills the tool room with a large stock of "back numbers" of these tools.

The attempts to make multi-cutter tools adjustable have resulted in designs too frail for accurate work. There seems to be only one good way to make a box tool or multi-cutter tool, and that gives a rigid seat on a good holder, with little or no adjustment.

These tools are distinctly screw machine tools, and should not be used for the larger work of the turret lathe. Their use on turret lathes has undoubtedly been brought about by the designer of the turret lathe thinking that the success of these tools on small work would probably be duplicated on large work, apparently forgetting that on account of the greater amount of stock to be removed by each tool on each piece on large work it is necessary to sharpen and reset cutters very often, and that the cutters of the multi-cutter heads are not suitable for frequent grinding and resetting.

Some of the other practical barriers to extending the use of multi-cutter tools to large work will be understood when we remember that the multi-cutter tool or box tool carries a number of cutters, each to perform a certain operation. Some of the cutters have longer cuts to take than others, and, since they must all travel together, the cutter having the longest cut begins first, and then the other cutters engage in their turn, the one having the shortest cut engaging last; then all the tools are cutting during the period covered by the shortest cut.

In turret lathe work the action of one tool is always more or less disturbed by the engagement of other tools. Hence the surface of the work produced by the tool having the long cut will show changes at each point which marked the engagement of other tools.

Such troubles are easily overcome in small, slender work, and sometimes in larger work, providing it is short, but there are too many difficulties encountered in extending this multi-cutter tool scheme to larger work.

The scheme of having two or more tools held in fixed relation to each other is good when it is so designed as to overcome the faults set forth.

It is making no confession to say that even the best turret control is lacking in desired accuracy. The most accurate are those designed with due regard to the importance of index control combined with slide control.

At this time we will only consider the turret's connection to its slide, including its bearings and means for locking it in each one of its working positions, leaving the subject of slide to be discussed later.

The turret should be provided with an accurate center bearing in its slide, and should be gibbed snugly down to a seat of large diameter on the slide. The seat should extend directly under the tools if possible, and the locking pin should also be directly under the working tool.

Many turret seats are too small in diameter. In many turret lathes the turret is too small, the tools overhang with no adequate support from the turret seat, and so far out beyond the locking pin that the working strains on the locking pin are from two to four times that received by the tool,—and of course the yielding of the pin is so much greater, furthermore since the pin is nearer the center of the turret, the tool springs or jumps from two to four times the distance yielded by the pin.

In such lathes the turret seat is not under the tool, the turret is seldom gibbed to its seat, and the center bearing of the turret on the slide is invariably made large for the purpose of getting a ratchet turning wheel on the lower side of the slide. A large bearing has its place in the machinery world, but it should not be used for a turret center or any other piece that must be accurately indexed with a single index locking pin.

The position of the index pin should be the most favorable obtainable. It should not be required to control a cutting tool which has a leverage over it. The direct strains of cutting are all that the mechanism should be required to withstand, for be it remembered that it is this index pin on which we depend for the accurate return of each tool to its working position, and it has not only to bear the shock of arresting the turret but it must unyieldingly resist the working thrusts which would tend to change the turret position.

The machine should be built for best possible tool control, with means for using the multi-cutter tool scheme when desirable, but it should not be tied to it for all work.

The multi-cutter should not be made up in a separate head which overhangs in space; it should not be presented to the work at arm's length.

The scheme of using several cutters clamped in fixed relation should include the use of common-sense cutters. Such cutters should be mounted directly on the top of a plate-shaped turret, conveniently adjustable in relation to each other, and rigidly presented to the work by a machine which has been designed to maintain the best control of the work and tools.

It will not do to think a turret machine is like a drill press in which there is little or no chance of stiffly controlling the lateral position of the tool point. Nearly every piece of work requires some operation which calls for firm, independent control of the work and tool. Even in using box tool the cut should have the truest possible start.

This point of independent control of work and tool must be realized before it is possible to decide between the various methods and machines.

It is perfectly harmless to talk about best methods of mounting a floating reamer or screw cutting die, or even a multi-cutter tool head like the box tool, but this should not be considered as the whole question. It only relates to these individual tools. The view of the whole problem brings out the absolute necessity of firm, independent control of work and tool in order to obtain true work, and that this independent control is required by some operation on almost every piece of work.

Independent control of the work and tool means that the position of the cutter in the work is under the independent control of the machine. This control is only obtained by proper design of the entire machine, including its chuck and tools. Any weak point in the machine, any weak member, any excessive overhang, or, in fact, any indirect or bad designing constitute a weak link in the chain, and no big links in the chain will offset this weakness.

It requires the most direct designing from the work through the chuck, the spindle, the spindle bearings, the headstock, the bed, the slides, the turret and the tool holder to the very cutting edge of the tool.

Any weakness at any one of these points makes it necessary to support the tool in or on the work, or chuck, or spindle, and limits the machine to work in which accuracy of concentricity and straightness is unimportant.

A machine for turret lathe work should have the *best* control of work and tool. All machines have *some* degree of control, but there is a vast difference between the strongest and the weakest. This difference is not revealed by the scales. A heavy machine may be the weakest.

In comparing machines there has been a tendency to weigh up their good and bad points, and give them the rating of their average. Perhaps this is a good method in estimating the character of men, and in some features of machines, but when it comes to the control of the tool in relation to the work, regardless of the varying stress from light cut to heavy cut, then the machine must be rated according to its weakest point, just the same as a chain.

The turret lathe is a machine for control of tool under stress of work, and its value is not greater than its reliability in this respect.

One of these joints is the turret's connection to the saddle, which allows it to turn on the saddle to present any one of its tools, and the other joint is the slide's connection to the lathe bed by which the entire carriage is movable on the bed.

The turret's connection to the slide is for the purpose of allowing a rotary motion to the turret for presenting any one of its tools to the work. This motion is arrested by an indexing mechanism which should lock the turret in any of the working positions, with maximum precision and security.

Let us see what are the ideal conditions for a cutting tool, and then see how near the present mechanism approaches the ideal.

A cutting tool passing through metal should be under an unquivering control—its path should be as true as possible. Any lateral quivering is destructive to the cutting edge. Actual work does not destroy the cutting edge.

The tool becomes dull because there is a side motion across its edge. Actual work under ideal conditions actually sharpens a dull tool, or maintains a proper edge on a sharp tool.

The ideal control of the path of the cutting edge of a tool through metal, as in turning, is probably unattainable, but we can get much nearer to it than the general practice.

In turning, as in lathe work, it is necessary to rotate the work on an axis, and move the cutter in relation to that axis either longitudinally or laterally, or both, for length or diameter cuts.

To provide the most unyielding control of the path of the tool through the metal it is necessary to control both the work and the tool in order to maintain correct relation of these to each other.

So far as concerns the durability of the cutting edge there need be no great attempt to regulate with precision the path of the edge through the metal. It is only necessary to allow it to find its own way with the least amount of lateral control — just provide the necessary support under the edge — but we must also consider the final form of the work; this requires the precision of control of the path of the edge through the metal to insure the removal of only the superfluous stock, leaving the finished surface of the work true as to roundness, diameter and length.

To obtain this precision of control of the path of the tool edge through the rotating work, it is necessary to provide connections of maximum strength between the work and the tool, and to provide in these connections means for changing at will the relative position of the work and tool point.

This is usually accomplished by sliding joints for both the diametrical and longitudinal relations; the sliding joints called slides, carriages, tool block slides, monkey blocks, etc., must be made for convenient hand and power control, as well as rigidity and precision.

In addition to these slides there must be the rotating joint, and the means for securely holding the work to the rotating member, and for securely holding the tool to the last member of the slides; furthermore, in turret lathes, there must be the turret interposed between, which will present any one of a series of tools.

THE SUPERIORITY OF THE "SINGLE SLIDE" DESIGN

The importance of stability and reliability of an independent control of work and tool has been stated in foregoing chapters. In this chapter we will consider the relative values of the single slide and the multi-slide scheme of control.

In order to facilitate analysis we shall consider these two schemes as applied to chucking work in which there is little or no opportunity to allow the tool to be supported directly on the work.

Not that this feature is not of paramount value in the bar working machine, but since turners with back rests are used in the bar work, the value of independent control is not so apparent.

It is, in fact, as essential in bar work as in chuck work.

In both cases the value of the machine is dependent on the degree of machine (independent) control.

But it is easier to follow the stresses of the chucking machine in which the work is wholly supported by one member and the tool by another member of the machine.

In order to still further limit the subject we shall consider machines for chuck work under 20 inches in diameter.

The work includes turning and facing accurately to dimensions.

The work must be securely held by the chuck, at the same time projecting beyond the chuck jaws so that all, or nearly all, the turning can be done at one chucking.

The problem is to rotate the work at any one of a given range of speeds, and to provide a means for holding and presenting certain tools at certain predetermined positions and feeds.

The problem of rotation involves, first, a stiff and true spindle to which the work is connected by some means, usually a chuck or face plate. The work should become practically a part of the spindle, rotating truly with it.

The means for rotating the spindle should have ample power, and be so arranged that the operator can instantly obtain any desired speed while running.

The spindle and the tools should be so mounted in relation to each other that any one of the tools or groups thereof may be accurately brought into engagement with the rotating work under the most absolute control.

For the purpose of producing duplicate pieces of work there should be the most accurate system of independent stops, to which each tool or group thereof may be absolutely returned to a predetermined position.

An intermittently rotatable tool holder is the usual means for successively bringing the tools into working position. It may not be the best means, but it is one that is used by all turret machines. It is made in various forms which we need not consider separate from the entire machine. It is enough to say that some means must be employed for the successive presentation of the various tools to the work, or the work successively to the various tools.

We have then the tools carried by an intermittently rotatable tool holder, and the work carried by a rotating spindle. Now there must be provided means for feeding the tools or the work, or both, so that there is a relative motion of the working tool to the work, by which cylindrical turning, also facing, may be done.

The usual way of stating this is to say that the tools should be given cross and length feeds and adjustments, but this is misleading, for it obscures the fact that these motions are in relation to the work, not in relation to the bed of the machine.

These two motions of travel with all their adjustments and stops should be obtained by the most reliable means. There must be the strongest possible connection between the spindle bearings and the tool-carrying turret.

It will not do to have a weak joint between these two members. We must have a joint where the tool holder turns to present the tools successively, and, of course, the spindle bearing also forms a joint.

In order to get the length and diametrical travel there is usually provided a length slide and a cross slide. These joints should be so made and so located that the relative motion of the work and tool may be obtained with the minimum weakening of the connection between the work and tool.

In making an ideal sliding joint in a machine tool there should be sufficient metal in both members of the slide to unyieldingly back up the sliding surface. The two members of a sliding surface may be called the outside and inside members. The outside member embraces and surrounds the lips of the inside member, the inside form of the outside slide being a close fit to the outside form on the inside member. The fit of one member to the other is made adjustable by means of gibs. These gibs are adjusted so as to allow one member to slide on the other. In other words, the outside slide is adjusted a trifle larger than the inside slide. This difference in size constitutes a loose joint. There must be two of these loose joints; one for length and one for cross feed.

One of the greatest problems in machine tool design is to provide the necessary relative travel of work and tool without weakness.

The process of turning brings a variety of stresses which tend to vary the position of the tool to the work. These stresses in turret lathes vary from a few pounds to six or more tons, and the direction of line of force is not always exactly determinable.

The means for controlling the position of the tool in the work must be the most rigid constructions, so that there will be a minimum change in the relation of the tool to the work when the stress varies from light to heavy cut.

This control must be the most absolute, both for accuracy of the work and for the durability of the cutting edge of the tool.

The cutting edge of the tool is quickly destroyed by side stress due to quivering under cut.

The design of these two important slides should have paramount consideration.

First, as to ideal section, with faces at right angles to line of thrusts, and, second, as to proportion or shape by which both members of the slide are of the stiffest possible section.

If these members are made of ample dimensions and correct proportions, then there will be only the looseness of one member over the other that will make uncertain the position of tool point, for let it be borne in mind that the looseness of this sliding member must always be reckoned as one of the features that detract from the accuracy of the position of the tool in relation to the work.

The average operator will say that he sets the gibs up closely, taking up all the slack, and that there is no looseness in the slide. As a matter of fact, he does adjust the gibs up closely, but then the adjustment is not unyielding. The gibs are yieldingly held against inner slide by the frail outer slide.

This yielding of frail sliding members is the most disturbing kind of an uncertainty, for the tool under cut will spring away from its work in proportion to the stress, which in ordinary practice is constantly varying.

For this reason both members of the slide should be of dimensions which most unyieldingly hold their form under the varying stress.

Since the outer slide must lip over and embrace the inner slide, its section should have as nearly as may be the form of a C-clamp. A mere glance at the end view of any slide will quickly reveal its character.

The next question to be settled is, where shall these slides be located? Of course, both must be between the tool and the spindle bearings.

A question of this kind seldom gets a fair consideration because we are prone to follow precedent, notwithstanding the fact that we may be working under new conditions.

The most natural thing to do is to put both slides together in the form of a carriage like that of the good old engine lathe. But the engine lathe carriage was designed for other conditions, one of which was for the control of a tool for turning work held on centers. This required both motions for length and cross feed to be in a carriage that rode on the bed which formed the connection and base for both the head and foot center.

In the present case we have new conditions. We have a revolving tool holder which must accurately return each of its tools to a definite position with extreme nicety, and we have only chuck work to consider.

It is useless to say that the headstock of a lathe should be fixed to the bed. The problem is to keep the relation of the work and tool correct, regardless of how it is obtained.

Making the head fixed to the bed is simply strengthening one end of a clamp, while the remainder is made weaker for this gain, with a net result of reduction in strength of control.

The slides should be located each in a plane as nearly in line with the thrust of the work as possible, with due regard for dimensions for strength and durability.

In keeping the location of slides as nearly as possible to the plan of thrust, the swing of the machine must be kept as low as possible for the work under consideration.

SLIDING JOINTS — GIBBING

A very important detail that is not so commonly recognized is the means for taking up slack in slides. The ordinary gibs and gib screws are adjusted till the slide is moved with difficulty; then they are let back just enough to allow the necessary free movement for convenience in operation.

The screws and gibs in their normal adjustment are not under stress till the tool begins to work; then the slide is tilted over or cramped to the limit of the slackness of the joint, *plus the yielding of the gibs as the stress increases.*

The amount that ordinary gibbing will yield under the cutting stress adds greatly to the uncertainty of the maintenance of the position of the tool in the work, and since there is practically no limit to the extent of this yielding, there is no knowing where the tool will stand in relation to the work under heavy cut.

For this reason it is not only necessary to have slides of proper section to stiffly resist springing and buckling, but the gibs and gib screws should be of ample dimensions and under stress to take up all the slackness before the stress of work is put on; that there should be a metal-to-metal tension of the gib to its member so that it will be found firmly seated and adjusted ready to take the stress of work when the slack of slide is taken up.

These gibs should have this slack forcibly taken up by counter screws so that the slides may be adjusted to move freely, and yet with no more slackness in joint than necessary, and no yielding of the gibbing when under stress of work.

STOPS

The stops for cross travel determine the diameter produced by the tool, and the length stops determine the position of shoulder and thickness or length of the work, both of which are at times required to work with extreme accuracy.

Stops should arrest the travel positively. They should arrest the carriage at a point as nearly in line with the tool as possible — that their real office is to arrest the tool. It is not enough to arrest the lower part of the carriage when the tool is carried at the upper part, for this only tilts the carriage up an indefinite amount, allowing the tool to advance after the other part of the carriage has been arrested.

A glance at the stop mechanism of the average turret lathe will give a very good clue to the standard of designing throughout the machine.

First, see if a metal-to-metal abutment is interposed between the part of the carriage nearest the tool and a member that occupies a definite position in relation to the work. An ideal stop would take bearing against the chuck; next best would be the spindle, but since these are impractical we must go back to the bed casting. But here the stop must be rigidly clamped to and practically a part of the bed so that it stands as an unyielding abutment against which the right part of the slide is arrested.

The scheme of loose latches and triggers for disengaging feed motions lacks accuracy.

The slide should be fed with a definite pressure firmly against the positive stop, and should remain there while the work continues to turn, until the tool has had an opportunity to make a smooth shoulder which has a definite and known position. This scheme of having positive stops directly in the top of the bed for the length slide and the cross travel will be found the most reliable.

OBSERVATION *of* RUNNING MACHINES

THE NEWLY INSTALLED MACHINE

IN observing a new machine in operation, it is well to remember that the man running the machine is to be taken into consideration. A new machine which has been in operation only a few weeks may not show off to the best advantage. The operator is unused to the conditions, if not to both the machine and the work. A machine may have left the home plant in perfect health, and yet have been attacked by a long list of ailments when put in operation.

All its bearings are new. Some of its bearings may run a trifle snug; others may be free enough to run with thin oil and no grit, but in reality they may be too close to run under service, especially the strenuous service that is sometimes given a new machine.

The machine does not ride in a parlor car to save its anatomy from the hard jolts of travel. There are no double windows in its car to keep out grit and dust. It rides in a freight car, and reaches its destination covered with cinders and sand.

If the machine is dismantled and cleaned before starting, there is the chance of its being put together with its heart where its liver should be. On the other hand, if it is only half-cleaned before running, its bearings must show their ability at running with grit working through them.

If the machine lives through the grit troubles of the new bearings, it has yet to survive the shocking experiences of breaking in the new man.

"UNHANDY" MACHINES

The new man may have run a similar machine, or he may have operated some entirely different machine, in an exceedingly satisfactory manner for several years, but, nevertheless, he may find this machine "awkward."

Machines differ greatly as to the convenience with which they may be manipulated. But the machine with its levers most conveniently located for mortals to operate will seem unhandy at first, especially to one who has a set of habits that fit another machine.

The most unhandy machines are operated with apparent convenience by one who has acquired his skill through years of practice. The apparent handiness (or skill) can only come by experience, hence the real quantity of work which he can conveniently turn out cannot be determined the first month, although it may give a fair basis for estimating his output.

USE ONE TYPE ONLY IF POSSIBLE

The fact that a new machine seems unhandy is strong argument in favor of continued use of one kind of machinery, even if it has become a trifle inferior to the best. It may be difficult to decide just where to draw the line between progress and continued use of old-type machines. It certainly will not do to use methods that are too inefficient; on the other hand, this point of convenience with which men handle machines with which they are familiar must be kept constantly in mind.

Frequently there are several "makes" of a certain kind of machine, all about on the same general standing. It is no uncommon sight to see one of each kind in use in a shop because the manager wishes to know which is best.

He would have obtained the better results by using all of one kind, even of the poorest machine, and sticking to the use of that one kind till he was very sure it would pay to take the next step in the general march of progress.

The workmen will even then be handicapped if changed from one machine to another, for there is always a difference which reduces the output of a machine in a new man's hands, or the man's output if given another machine, even of the same "make." But when men must know the "ins" and "outs" of several different machines on the same class of work, there is an extra cost of work that must be paid,—and it is paid, whether it is shown up by cost cards in detail or only appears as unsatisfactory product for which the workmen or machines are unjustly blamed.

In observing automatic or semi-automatic machines in operation with the object of determining their degree of usefulness on your own work, always remember the controlling points:

The size of the work.

The number of pieces of each kind.

The frequency of changes in design of the machines into which these pieces go.

The importance of profit as well as labor cost.

Then see how many machines are running, and how many are stopped waiting for tools or work of their kind.

See how many are producing a satisfactory amount of work.

How many are turning out unfinished work,—work in which other operations are necessary, and which might have been completed in a hand machine, all in one operation.

See how many machines are *satisfactorily* run by one man.

How many machines are running at 50 per cent efficiency or stopped altogether on account of chasing the will o' the wisp of low labor cost.

See how much capital is tied up in these machines and in the extra stock of parts that is run through in order to use these machines.

In the extra special tools, new and obsolete.

In the force of tool makers employed to keep up the tools, when they should be free to build jigs, etc., for effecting greater savings elsewhere.

In the number of extra buildings necessary to carry out this scheme.

In fact, the extra capital that this scheme of automatic or semi-automatic ties up in machinery, buildings, stock, tools, in order to effect a saving in labor cost that is frequently more than offset in loss of profit.

Or, if there is only a certain amount of capital available for machine tools, buildings and stock in process, then see how much the output is throttled by use of the automatics or semi-automatics which require more floor space, more stock in process and more special tools.

Do not take your ideal figures of output per machine, for the ideal is only realized in the beginning. After that the machines are adjusted to keep going at a much reduced output, on account of change in tools or work, and because it has been found better in the long run to give the automatic machine a slower pace, to save delays incident to resetting of new tools and to prevent turning out poor work.

VIEWS FROM VARIOUS POINTS

Nearly all chucking work under 20 inches in diameter (in lengths less than 12 inches), and bar work up to 3 inches in diameter and 36 inches long, is now within the range of the various turret lathes.

The work coming within the range stated is still being turned out by various kinds of machines, from the standard engine lathe to the semi-automatic and full automatic turret machines.

The builder of the standard engine lathe thinks that the turret lathe has been used beyond its natural field, and that people will wake up some day to the advantage of the good, old, ever-ready engine lathe.

The builders of the hand-operated turret lathe feel that their particular machine should be the one in almost universal use, because it gives the most rapid production, accurately duplicates work (which the engine lathe could never do), and it is reasonably convenient for changing from one piece of work to another, and is the real machine for profit making because it turns out the largest product per dollar of first cost and at a reasonable low labor cost.

The builders of the automatic or semi-automatic show the exceedingly small cost per piece of work when machines are operated in batteries, which they hold out as offsetting the greater first cost, lack of adaptability, extra money tied up in excess stock, as well as first cost of machines. The lathe builder calls attention to the fact that the turret lathes, and particularly the automatics, are more complicated and expensive, making the first cost and maintenance of the machines greater than that of the standard lathe.

Some of the turret builders point out the great difference in cost of tools, both first cost and maintenance.

Some turret lathes have outfits of tools that are ready for almost any conceivable piece at any moment, and others are equipped with expensive, non-adjustable, or slightly adjustable, tools which must be made expressly for the work required.

Generally speaking, the engine lathe should not be used for duplicating work. The automatic and semi-automatic are for small work in very large quantities with fairly positive assurance that there will be no immediate change in design.

The hand-operated turret lathe should be used for all duplicate work where the permanency of design is not absolutely assured, and where it is highly important to get out the work quickly when it is wanted, and to give the highest output per dollar of investment.

The object of accurate duplication of the work is to insure low cost of assembling, and contribute to the reliable operation of the machine into which the product goes; hence it follows that the exact cost of production of the particular piece of work may not be the most important point.

In the usual process of turning in an engine lathe, or in turning the first piece in a turret lathe, much time is consumed in the "cut-and-try" method of adjusting the tool to the proper depth.

In the turret lathe, after the tool is adjusted to correct position and the stops are set for that position, the tool may be accurately returned to same position for the next piece of work.

The principal gain, then, of the turret lathe comes from its cutting out the loss of return of each tool to its proper position.

In the engine lathe each tool is removed from the lathe as soon as its cut is finished.

On some of the large work the cut to be taken by each tool may be so long that it is necessary to grind the tool for each cut. On such work the advocate for the engine lathe makes his reasonable claim that there is no need of a turret, and that the work is distinctly engine lathe work.

The turret lathe builder will say that the durability of a cutting edge is very much greater when securely mounted, and that the turret lathe mounting of tools is far superior to the engine lathe carriage.

ADAPTABLE EQUIPMENT

IMPORTANCE OF GETTING THE WORK OUT NOW

Frequently the real question is, how can we get results *now?*

What method, what machine, will begin at once to give us a desired quantity of accurately finished work?

The product is required in order to get our product on the market at once.

How can we get out these pieces of this new form within a given time? The time element is frequently of vital importance when it comes to production of work.

The question of getting results *now* brings out the importance of using adaptable machines.

An adaptable machine is one that can be quickly adjusted for any piece of work any time without delay of waiting for special tools, or the delay occasioned by inconvenient means of adjustment.

The engine lathe is the most adaptable, but it is generally barred out on account of the slowness of production and inability to produce duplicate work.

Business generally comes in waves; good opportunities for a time, then a business lull. In good times the demand invariably exceeds the capacity to supply. The profit is made directly in proportion to the hustling capacity and duration of the good times.

The volume of work turned out usually depends on the ability of a plant to produce the work quickly when it is wanted. This condition demands a hustling equipment. The engine lathe is not for such service, and the semi-automatic and full automatics are barred out generally on lack of adaptability as well as slow production.

Another important element in considering kind of equipment is the changing character of the work.

Progressive designing is made impossible by an equipment of machines lacking adaptability.

Progressive designing requires the get-there equipment as well as the adaptable equipment.

A sluggish plant equipped with tools lacking adaptability is of little avail.

EXTRACTS FROM "EVOLUTION"

WE know that a cutting tool will last almost indefinitely under some conditions, and under other conditions the edge seems quickly destroyed.

The destruction of the cutting edge is not wholly due to the real work of separating material; in fact, only a small amount of wear is due to the work. The greatest edge-destroying action is side motion or quivering, which in the most extreme cases may be heard and felt.

It has been generally assumed that in absence of any marked quivering, such as would be called chattering, that the tool was free from this edge-destroying action. That this is erroneous will be clearly shown later on.

Very few of the standard machine tools hold the work and tool with sufficient firmness of control to prevent this lateral trembling or quivering. Before passing this point, it should be explained that the meaning of lateral motion is that motion which is across the cutting edge of the tool, and not in the general direction of the cut.

The keen cutting edge of a knife can be quickly destroyed by scraping the surface of a stick. But the knife edge is not lost in whittling, because there is no scraping — the cutting stress is equal on each side of edge. This is just as true of a cutting tool working in metal, for the lateral motion of the metal across the edge of the tool causes a side pressure against the edge where there is no backing, and causes its wearing away, whereas, when the work is moved against the edge firmly, in its true path only, the edge is free from side thrust. For the real work of cutting, the extreme edge is braced and sustained by the backing, and has great durability.

Under correct conditions, the action of a heavy chip of steel on a properly proportioned tool occasionally wears a slight hollow just back of the edge instead of wearing away the edge. This action has been observed in the engine lathe, where it happens as a result of a balance of conditions which includes an amount of clearance of the tool that just equals the feed, and which allows the tool to steady itself by riding on the finished surface. This prevents the quivering which would otherwise have rounded the edge before the chip could have had time to make an impression elsewhere.

Experience has demonstrated that accurate control of work and tools not only adds to the durability of the tool and accuracy of the product, but this condition makes it possible to leave not only a true surface, but a smooth surface when taking a relatively large cut.

Firm control makes it possible to use sharp cutting tools; that is, tools with slight clearance and plenty of rake, the rake being principally in the direction to make easy the flow of the metal from the largest part of the chip.

We have all seen the other extreme where a blunt tool has been made to tear off metal in a powerful machine in which the finished surface looked as if the metal had been pulled out by the roots.

For the purpose of setting forth the common method of controlling both the work and the tools, it is necessary to call attention to the present scheme of work and tool carriages. In doing so it will be necessary to say some unkind things about everybody's friend, the standard engine lathe; not that it is the standard engine lathe alone that is borne in mind, for remarks regarding this machine may be readily applied to other tool mountings. We recognize that the engine lathe has been the machine from which all of the wonderful mechanism of the age has come, and although in some respects it is felt that there are other machines of higher development, there is no machine designer so near the top of the ladder at present that he has any occasion to "holler for more ladder."

From the time of the birth of the slide-rest lathe it has been customary to have the headstock rigidly affixed to or a part of the bed, and to get all of the relative motion between work and tool by mounting the cutting tool on the necessary slides. The first slide resting on the lathe bed is called the carriage. To the saddle of this carriage there is a tool-carrying slide which runs transversely to the travel of the carriage. In addition to this, it is frequently the practice to add a swiveling slide for traveling at any desired angle, which has been called the compound rest. More than one-third of the lathes used today are provided with the three slides.

A glance at the engine lathe carriage shows it to be of frail design. The guiding Vs of the bed, on which it rides and by which it is controlled, are a long distance from the point of the tool. The average carriage has four bearings on the shears. The front part of the carriage consists of a bridge which spans the distance between the two bearings on the front V. In the same way there is a bridge at the back that connects the two contacts on the back V. Now, from these bridges on the front and back Vs another bridge runs across, making the whole form in the shape of an H. This may seem an elementary description to the average lathe hand, but the object will appear later on.

There are other types of carriage saddles. The H-shape are most reliable for very light cuts; and others, although uncertain in action in all cuts, are generally better for heavy cutting.

There is no opportunity to make either the carriage or the tool mounted thereon of sufficient rigidity to withstand working strains, nor of suitable section to properly hold their gibbing, which of course serves as a means of holding each slide to the surface on which it travels.

We will assume that the bed of a standard engine lathe is all that it should be. We know that a single slide can be stiffly designed and securely gibbed to a piece having dimensions similar to the engine lathe bed; that the limitations and troubles come in when it is necessary to cut away that slide, giving clearance here and there for the swing of a pulley or a large shaft and the addition of other slides, all of which must come within certain dimensions, regardless of the effect upon the stiffness.

It is the engine lathe, with this great handicap, that is the very machine with which we have obtained our experiences and formed our opinions regarding the limitations of a cutting tool and the quality of work obtainable under the various cuts.

No conception of the performance of a tool under heavy cut in a properly proportioned machine can be obtained by the performance of a tool in the engine lathe large enough to take a similar cut. The engine lathe takes its largest cut on work about one-third of its swing, and instead of the tool being controlled by guiding surfaces close to its maximum diameter of most efficient work, these guiding surfaces are three times as far off in a direct line, and many times farther off in the line followed by the metal supporting the tool.

The extent of vibration of the tool point of lateral yielding is permitted, of course, by the stiffness of the carriage to resist the working strains at that point, and as this stiffness is inversely as the square of the distance between the sliding base and the cutting tool point, it becomes apparent that a tool working at this handicap may be forced to crowd off the metal, but while doing so the cutting edge vibrates laterally, making it necessary to use only blunt tools, which add greatly to the "pulling-out-by-the-root" process of removing the metal, and although such lathes can be forced to push off the metal, there is an absence of the cutting action that leaves a true and smooth surface. Furthermore, such lathes are very susceptible to chatter when taking light cuts such as a scraping broad tool, because a certain amount of pressure is required to take up all the slack of their parts and the spring due to long-distance control. This is not a case where the doctors disagree. Lathes are built by people who understand the work thoroughly, but they are built to supply a certain demand that calls for a standard lathe known to every machinist, and it is necessary, in offering these lathes for sale, to give swing over both shears and carriage and price.

It is apparent that the machine must be made to swing, say, 18 inches, for it is the custom to consider these dimensions in considering the price. They are, therefore, selling dimensions, and must not be reduced. Just as dolls are sold by the length, and when carried home will be found to lack the proportions of the real baby, just so lathes are sold by dimensions that would be deceptive if this were a new subject. As it is, the machinist knows that he must have an 18-inch lathe to do lathe work on a 5-inch or 6-inch shaft.

Many good results have been obtained in special forms of lathes for a given class of work that we are now to take as object lessons, and which may serve as pointers to indicate the direction of the development in machine shop evolution. In view of the foregoing, it would be safe to assume that the correct scheme is one that gets around the long-distance control and cob-house construction of slide on slide.

The machine set forth gives a control of work and tool that greatly reduces the tendency to chatter, and thereby makes possible the use of ideal tools for all cuts. Sharper tools with plenty of rake for cutting the metal may be used, also broader tools for light and heavy cuts where chattering has been the limiting element.

Chattering is caused by conditions that are fundamentally objectionable. Every boy knows that he can make a cane chatter along the sidewalk by pushing it ahead at a given angle, and that it will not chatter when dragged at same or any other angle.

The draw-cut shaper astonished many by its wonderful performances of great stock-removing feats, and although this may not be what is primarily wanted in a shaper, it may be cited as an example of the performance of a cutting tool under a pulling cut and non-chattering conditions.

In the lathe, planer, standard shaper and boring mill there seems to be good reason for using the tool mounting that is equivalent to the chattering cane. The expression, "cart before the horse," fits the case, but the plow before the horse would be a better analogy.

In order to offset the chattering tendency in machine tools of thirty years ago, a spring tool was used for finishing cuts which required a tool having plenty of rake. Under the varying strains this tool would yield in opposite direction to its frail mounting; that is, it would spring away from the work under an increased strain, while the slide rests had a tendency to tip over towards the work, which would otherwise cause the tool to "duck in." The yielding of the tool would offset the chattering tendency.

This tendency to chatter has been partly met in present-day machines by making all these slides of stiffest form possible, so that it is no longer necessary to use the old-fashioned spring tool. But the fact remains, that although we have greatly reduced the chattering, we have yet the plow before the horse and the cane ahead of the boy; that is, the tendency remains, and the conditions exist to a sufficient extent to necessitate the use of blunt tools for heavy chips, and to greatly restrict the use of broad tools for forming, taper and irregular cuts.

In order to get away from the cob-house scheme of design of slide on slide for the tool carriage, in this machine we mount the headstock on guideways running across the machine. In this scheme, of course, the head is gibbed directly to the bed, and since there are no additional slides to consider, it is possible, the same as in the case of the carriage, to adopt an ideal system of gibbing and the stiffest possible design of frame, so that here we have a slide of any desirable shape gibbed directly to the bed.

The conservative man frequently asks: How is it possible to return this head to its central position? It is only necessary for us to call attention to the fact that for years we have been turning the turret around to six different positions with a satisfactory accuracy, under conditions far more difficult to control than the present single direct slide; and to furthermore state that we not only bring this cross slide with accuracy to its central position, but by an ideal scheme of stops it is possible to bring it to as many other positions as called for by the work with the same nicety, and that these details are elsewhere described.

The machine is provided with an equipment of standard tools which it holds under absolute control, and it puts an end to the foreman's difficulties in getting out the class of work coming within its range, regardless of any changes there may be made in the design or the number of pieces to be made; and it is safely described as the "any" machine; that is, it is ready *any* hour of *any* day to make *any* piece of *any* shape and *any* quantity coming within its working dimensions, with an accuracy and efficiency never before attained.

This adaptability to all conditions not only gives a ready relief for the troubles of today, but it also makes progressive designing possible.

Many important improvements in your product can be made without delay or expense if your machines are truly ready for turning every conceivable piece.

CHANGING CHARACTER OF EQUIPMENT

We should consider a plant as a living, growing thing, ever changing for better or worse. It must not only be considered from a standpoint of present efficiency when compared with other plants, but its growth in efficiency must be keeping pace with the general progress. Slow growth, due to over-conservatism or lack of courage, may result in a serious loss of relative position; and, on the other hand, the forced growth sometimes causes a temporary discomfiture, due to failure of organization to adapt itself to the new conditions.

HOW TO KEEP A PLANT UP

Although the efficiency of the plant as a whole makes the real value, it becomes necessary to consider the elements of its equipment when we wish to find the proper places for pruning and cultivation. Each process and each machine should be compared with the best obtainable today for the particular work. This does not mean the latest, but it does mean the best for the work as it comes in this plant today and with some view of its probable nature tomorrow.

A machine may be of any age so long as it is the most efficient for the work required of it. But, just as a plant may pass from a state of value to one of no value as a plant, so an individual machine may lose its real value for a given class of work. This transition from value to no value is generally due to the particular machine having been superseded by something of much greater efficiency. This may occur one year or thirty years after it has been installed.

The process, then, of keeping a plant in permanently profitable condition requires the substitution of the efficient for the inefficient, and the natural place to begin is in that class of machinery in which the greatest difference exists between the best obtainable and that in use.

If the recent progress has been made in planing machines, and the greatest saving can be effected by changes in the planer department, then let the progressive work take place there. If, on the other hand, no great advancement has been recently made in this art, but has been in machines for lathe work, then let the old planers run, and get the saving by correcting the lathe methods.

The cost of new machinery to be put in each year cannot be stated in figures of percentage to total equipment, for it depends on the opportunities and necessities involved in the natural progress of the art. This cost at times adds no burden to the cost of running for the year, for in some instances the saving effected during the year is greater than the first cost of installation, so that the real cost for introduction of some later-day machines may be counted only as time and mental energy involved in carefully considering the problem.

If the description of this machine has made clear that it indicates the direction in which the evolution of the lathe is traveling, there is no one, from proprietor to machinist, who can afford to be indifferent to the subject.

It is not safe for us to disregard important pointers of this character; and there can be little profit or benefit accruing to anyone knowing these facts who fails to act accordingly. The foreman should strenuously advocate what he knows to be true. The superintendent's reputation suffers if he does not advise on correct lines, and the proprietor's profits, to say nothing about the depreciation of his permanent investment, will seriously suffer if he continues to use inferior machines. It is not enough to know that machines in operation were built yesterday; it must be known that they are of the correct type, for with so many machines offered for a given class of work, each machine cannot be the best; some one is better than all the others.

It is not within the scope of this chapter to answer all of the questions that will come to the mind of the man who has given this matter much serious thought and has heard claims for the old type reiterated. Each important point will be fully treated in the most fitting place. The foregoing pages present only a few of the many indications of direction of the evolution of the machine shop.

THE PERSONAL VIEW

Under this heading we wish to bring out the effect of the evolution on the interest of the individual—not as an owner, but as an earner of a salary or wage: First by stating the real value of an earning power of an individual; then by indicating its relative permanency and means for its protection and betterment.

The salary or pay received in return for services has a greater significance than a mere exchange of money for brain energy. It is an indisputable tribute to the genuine worth of the individual. This is valued by every intelligent worker regardless of his wealth, for, although tribute is sometimes falsely given in words, it is seldom falsely paid in cash.

The value of this remuneration as an evidence of real worth is not all, for it has a monetary value which should not be disregarded. On a 4 per cent interest earning basis each $100 earned per year indicates a value of $2500; hence $1000 earned per year is worth $25,000, and $2000 per year is worth $50,000 to the recipient.

This is real value, with a security in some respects better than a more easily negotiable principal which the possessor might be beguiled into exchanging for some hazardous investment. Since this earning power has this value, let us see on what basis it stands. Is it secure regardless of the possessor's indifference? Or, is it something to be guarded?

Success in management of a business or department may give a good name and a good professional standing, but it must be remembered that there may be a doubt regarding the footing of professional standing and good name of each individual in responsible position.

Today's standing is based on yesterday's action, and tomorrow's position will be the result of the decisions of today.

The correct course for today may not be very clear, but it is safe to conclude that there is no safety in standing still, for that surely results in losing one's position in the race.

One way to make or protect a good name is to be on the right side of questions relating to progressive development. No credit or good comes from weakly suggesting the adoption of this or that method, or resorting to the "I-told-you-so" attitude.

Real results come from strenuous and tireless insistence upon an action which you believe is best.

It may be that the plant will be carried along by the combined work of all without it becoming necessary for you to conspicuously push for some reform, and, as a result of such combined work, the whole scheme may for many years continue to furnish comfortable conditions for you; or, if not, perhaps some other opening may be found in some other establishment, and all this may happen without your playing the painful part of a reformer; but probably inaction now will not result in any such favorable future.

Many of the important actions may be tested without greatly jeopardizing an individual's name; for instance, a maker of a device or machine may make a claim that he can effect an important saving in the cost of your work, and stands ready to demonstrate, without cost to your company, and without placing you on record as endorsing his views—there is small chance of mistake. Let him demonstrate or fail, and let him abide by the result. It is his own proposition. You will indorse it if it is a success, but if it is not, you will not want that machine standing in your plant, for it would be there as a continual evidence of somebody's blunder.

Whatever policy you follow in the management of your own personal interests, it is safe to state that a careful consideration of each new phase of problems is absolutely necessary to enable you to hold your own, to say nothing about advancement.

The problems of machine shop management are affected by the evolution of its machinery as much, if not more, than any other element.

All new growth is not of a kind that may be of service to you; in fact, much that is new is inferior to the old.

In this book is set forth a machine built on new lines. It is one of the new things that affects machine shop values. If it is a good machine, it gives its users an advantage over others. If it is not a good machine, the advantage goes to the non-users.

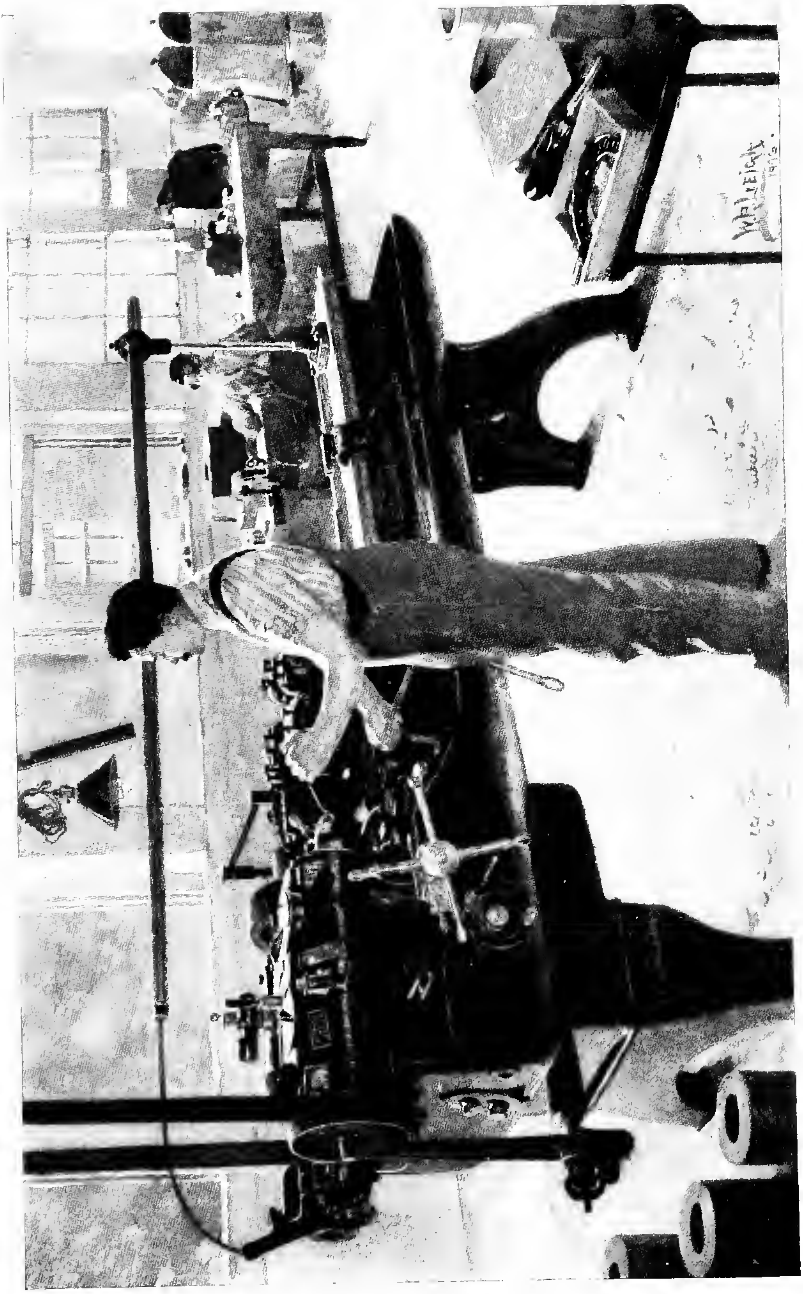
It has been on the market in its present form since March of 1904. It is an outgrowth of the original Flat Turret which held undisputed supremacy since 1891. There are thousands of both the original and the present machines in operation. The original machine was abandoned by its makers for this new type. This may only indicate that they consider the new more profitable; but even so, a machine cannot be profitable to the builder if it is not a profitable investment for the user.

In addition to your being able to see a plant exclusively devoted to its manufacture (and many of the machines may be seen in active use in other plants), you have in this problem that extra chance of proof offered by the builder to demonstrate its value on your own work, in your own plant, in the hands of your own men, without cost to you, and without your indorsement until it has there shown its value.

The foregoing pointers do not include an important element, and one that must be settled by your own decision, namely: Is this machine the best of its kind? There may be a dozen machines that would effect a saving on some of your work, but in making each move see to it that it is the best. Your own future depends on your judgment in such matters.

In this book you will find some of the important points to be kept in mind in considering such questions.

THE HARTNESS FLAT TURRET LATHE



OUR RECORD

1855—We made the first turret machine having mechanism for automatically turning the turret.

1858—We produced the present form of high turret with substantially the turret-turning mechanism now in universal use.

1870—One of the links in the chain of evolution, showing an automatic chuck.

1882—The first clutch back-geared machine.

1886—The same in more symmetrical form.

1890—The first revolving roller feed.

1891—The first Flat Turret Lathe.

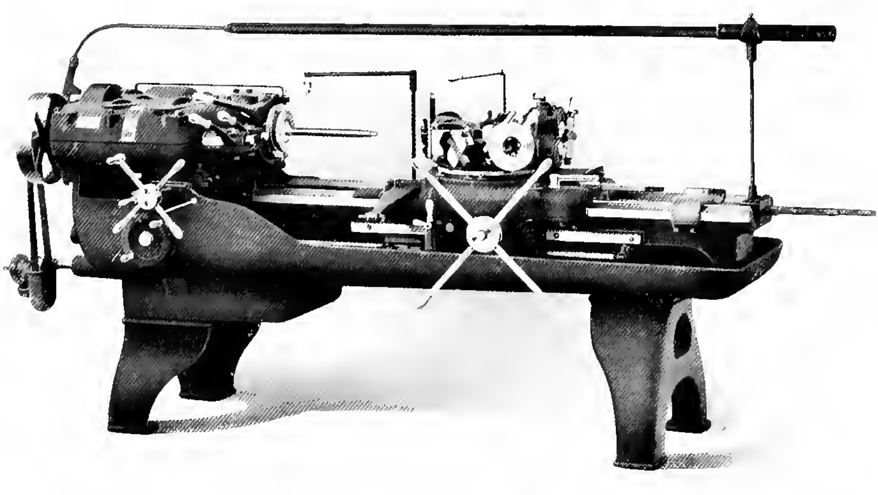
1891—The first quick-opening turner.

1896—Equipped with the lead controlling screw-cutting die.

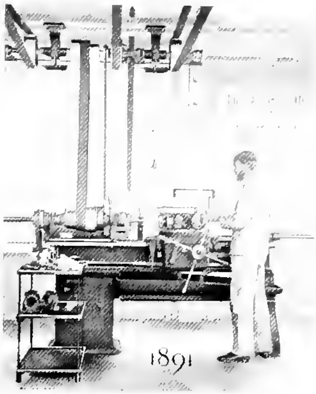
1904—The first Flat Turret Lathe with cross sliding head.

1906—Equipped with the turret chasing tool.

1909—Equipped with chip-breaking turner.



INTRODUCTORY



This section contains description of the Flat Turret Lathe brought up-to-date — to include full information regarding chip-breaking turner and other new features.

In order to avoid an abstract and wearisome description, frequent reference has been made to other machine tools, but throughout the whole it is hoped there will be found a spirit of fairness and an exactness of utterance.

Our aim has been to avoid the discourtesy of making extravagant or superficial statements to those who are seeking information of a definite character.

Since the introduction of the Flat Turret Lathe in 1891, it has had a steadily increasing sale and a corresponding development.

For many years our entire plant has been exclusively devoted to the manufacture of this lathe and its equipment of tools, and we have enjoyed the reputation of being the only machine tool builder making only one machine, and that in only one size.

We now offer the machine in two sizes for both bar and chucking work. An important change in its appearance was made in 1904 when the new cross sliding head was introduced, but the lathe was the same old machine taking on an outward shape that conformed to the natural growth and development.

OUR METHOD OF SELLING

We sell only to the user, and have no other agents or offices than those given on page 99 for the various countries named.

In the United States and Great Britain we have our own traveling representatives, whose time is wholly devoted to the Flat Turret Lathe.

A personal inspection of your work by a specialist thoroughly versed in this branch of lathe work may be had within one or two days by wiring us, provided your plant is located in the British Isles or in the manufacturing States bordering on or east of the Mississippi and north of North Carolina and Tennessee.

Since we have our representatives in this field, you are placed under no obligations to us by making a request for such an inspection and report or proposition.

There can be no uncertainty about price, for we quote a fixed price only, and anyone may know our prices.

We make free deliveries to nearly all points, and send without charge an operator to instruct your workmen in the use of the machine, thus relieving you of all responsibility, except that you agree to accept and pay for the machine and equipment if we fulfill our agreement.

The Flat Turret Lathe is made by no other maker in America. There are over 5000 now running; therefore, there is no uncertainty about this being *the* machine. It is either called the Hartness Flat Turret or the Jones & Lamson Flat Turret. The present machine is protected by many patents in America, England, Germany and other countries.

Jones & Lamson Machine Company

Springfield, Vermont, U. S. A., and 97, Queen Victoria Street, London, England

BRIEF OUTLINE OF HARTNESS FLAT TURRET LATHE WITH CROSS SLIDING HEADSTOCK

Machine tool designers have constantly before them the problem of getting greatest convenience of manipulation and working range combined with an unflinching control of the work and tools.

The firmness of control comes first and should be as nearly ideal as it is possible to obtain; after that, any extension of working range is not objectionable—on the contrary, it is highly desirable, to meet the ever-changing conditions of the work on which machine tools are used.

The Flat Turret Lathe development has been kept true to the high ideal of firmness of control regardless of alluring advantages of great working range that might have been obtained by a departure from what was known to be the best scheme of unflinching control.

For a dozen years this machine was restricted to work below two inches in diameter, and although occasionally used with special tools for chuck work its distinctive and undisputed domain was under two inches.

During that time there was an important class of work known as chuck work, which was either retained by the engine lathe or by a lathe having some of the features of both the engine lathe and the turret lathe.

These engine-lathe-turret-lathes either used a turret mounted on an engine lathe carriage or were provided with an auxiliary engine lathe carriage on which was mounted a small revolving tool holder; the object being to get the advantage of combined cross and length motions and feeds. All such schemes, however, sacrificed firmness of control for working range and convenience, and all resorted to the use of a double slide tool support in some of its many forms.

The inherent weaknesses of the double slide tool support as used in the engine lathe, brass lathe and other machine tools is fully set forth in the more complete story which precedes the catalog section of this book, so that here it is only necessary to say that accurate work is obtained from such machines only at the expense of eternal vigilance of the lathe hand; for such machines are unreliable both in control of the tool in operation and in the return of the tool to its former position for the purpose of doing duplicate work.

The cross sliding head marks an important step in lathe design, for it extends the domain of the turret lathe over an important field of work without resorting to the use of the unreliable double slide tool carriage or any other scheme that would weaken the firm control that has been the Flat Turret Lathe's leading characteristic.

Now, the second point in the Flat Turret Lathe's characteristics is that it requires no special tools; its tools are of the adaptable kind — not special — just standard and always ready for any kind of work. In extending the field of operation its original convenience of adjustment to various kinds of work and the convenience of manipulation have been maintained.

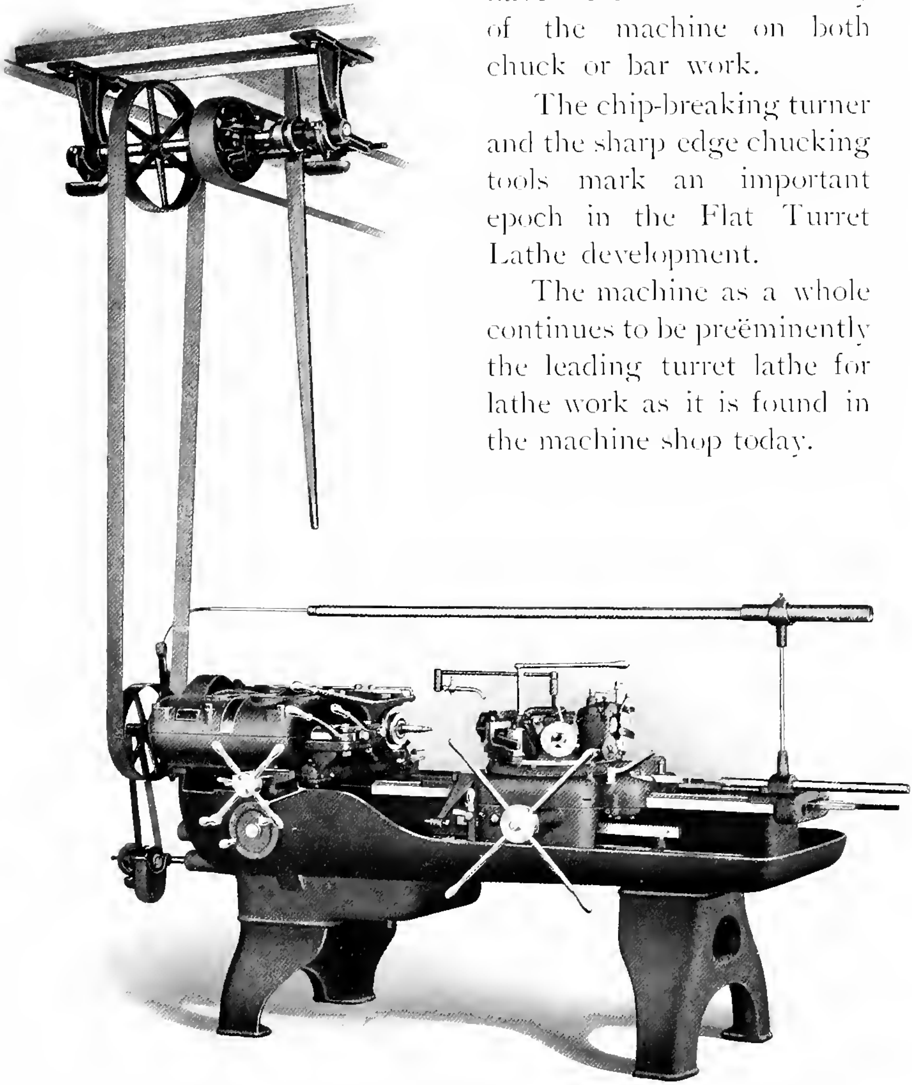
The directness of design as exemplified in the flat turret and cross sliding head features is to be found in the thousand-and-one other features of this machine, any one of which will well repay a careful consideration — for instance, just as we furnished the first and are now furnishing the only screw cutting die in which its cutting lead is not a matter of chance, just so we have pushed forward the art of cutting screw threads of relatively large diameter and short length by a turret chasing tool.

Following our introduction of this novel means of cutting quickly a true screw thread on chuck work, we now present the next important development in the chip-breaking turner for bar work and a modification in the chucking outfit of tools which use sharp-edged quick-change cutters, which have evolved out of our experiment leading to the production of the new turner.

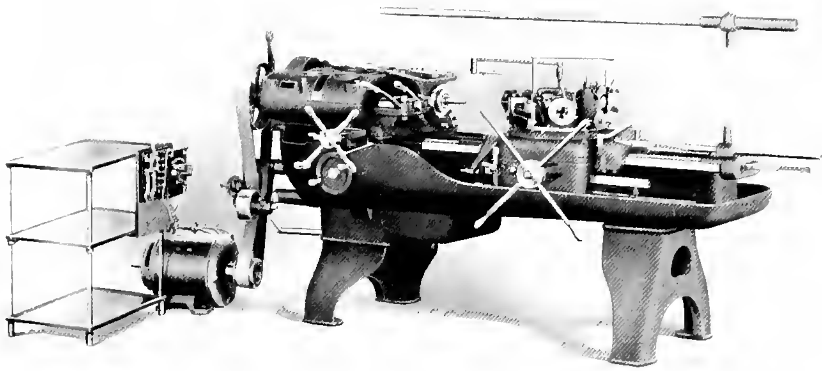
These sharp edge tools have increased the efficiency of the machine on both chuck or bar work.

The chip-breaking turner and the sharp edge chucking tools mark an important epoch in the Flat Turret Lathe development.

The machine as a whole continues to be preëminently the leading turret lathe for lathe work as it is found in the machine shop today.



2 x 24-inch Flat Turret Lathe with Cross Sliding Head, Equipped for Bar Work (Countershaft Drive)



2 x 24 inch Flat Turret Lathe, with Cross Sliding Head, Equipped for Bar Work (Motor Drive)

The Hartness Flat Turret Lathe with cross sliding head is made in two sizes, and may be furnished with an equipment of tools for either bar work or chuck work, or a double equipment for both bar and chuck work.

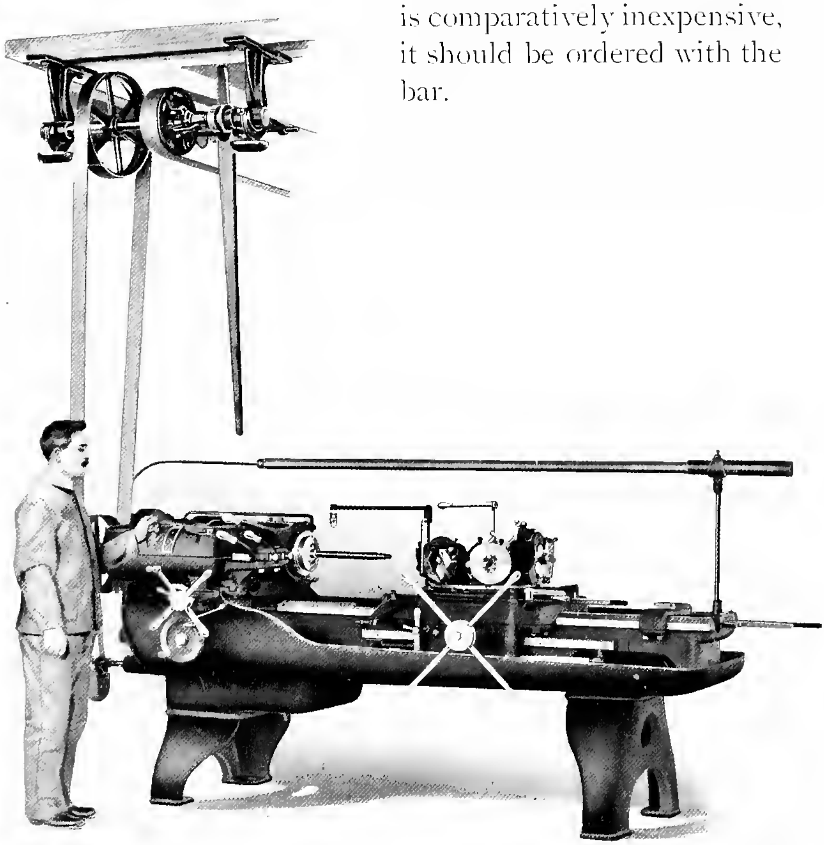
The smaller machine, shown above and on preceding page, is called the 2 x 24-inch, and when equipped with the automatic die outfit of tools it turns nearly every conceivable shape under dimension of $2\frac{1}{4}$ inches diameter and 24 inches of length. The hole through the spindle is now made $2\frac{3}{8}$ inches. For various details of working range and outfit for bar work, see pages 110 to 160. Itemized outfit, pages 204 and 205.

This machine, equipped for chuck work, is described on pages 161 to 203. See also pages 116 to 120.

The machine may be ordered with either the chucking or bar outfit, and supplied later with the other outfit, if for any reason the machine should be changed from bar to chuck work or *vice versa*. Since the chucking outfit is comparatively inexpensive, it is frequently ordered with the bar outfit of one or more machines of a lot, so that at least one machine may be used on short notice for chuck work.

The machine shown on this and opposite page is the 3 x 36-inch size. It is shown in these three views arranged to handle full bars of stock up to 3 inches in diameter, turning pieces up to 36 inches in length, of the class of work shown on the following pages. It may also be equipped for chuck work up to 14 inches in diameter, and is illustrated and described as a chucking machine on pages 161 to 203. Itemized outfits on pages 206 and 207. This machine may be ordered with either the chucking or bar-working outfit of tools, and supplied later with the other outfit.

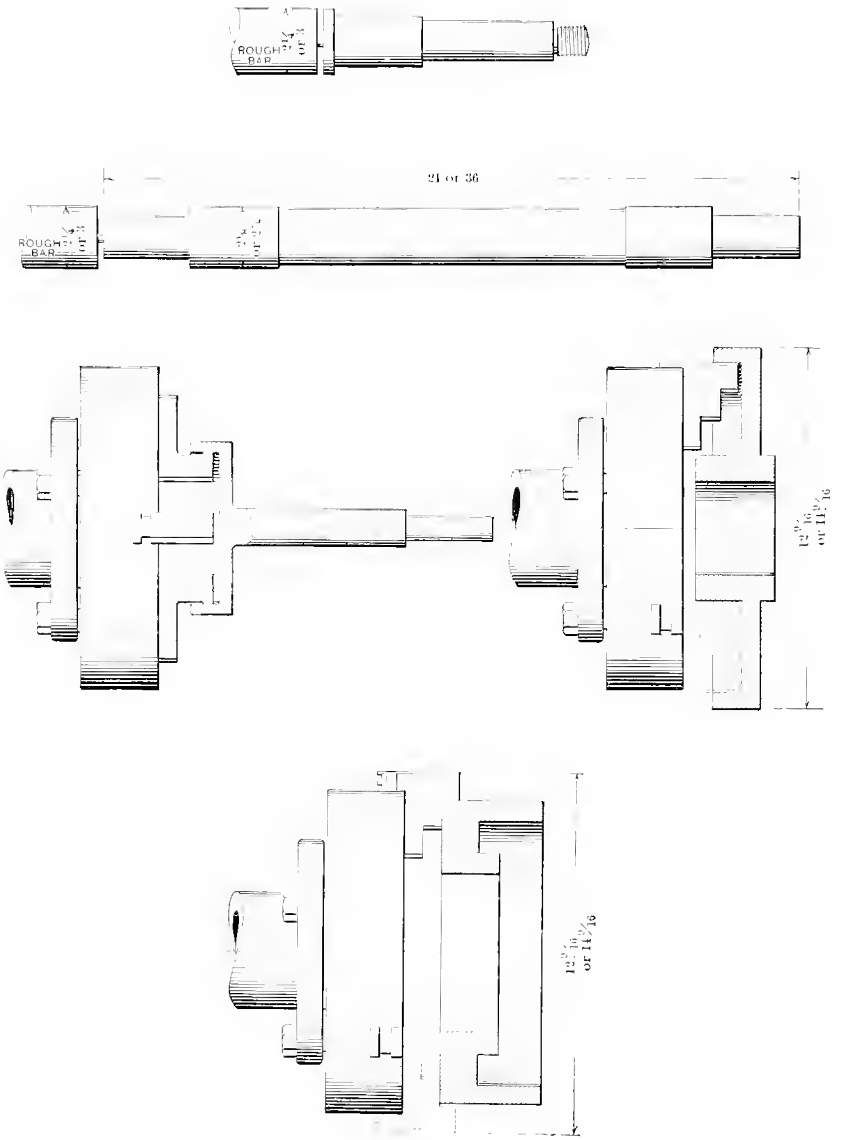
Since the chucking outfit is comparatively inexpensive, it should be ordered with the bar.



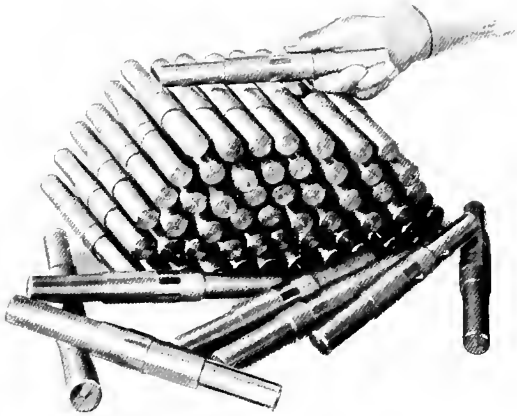
3 x 36-inch Flat Turret Lathe with Cross Sliding Head, Equipped for Bar Work

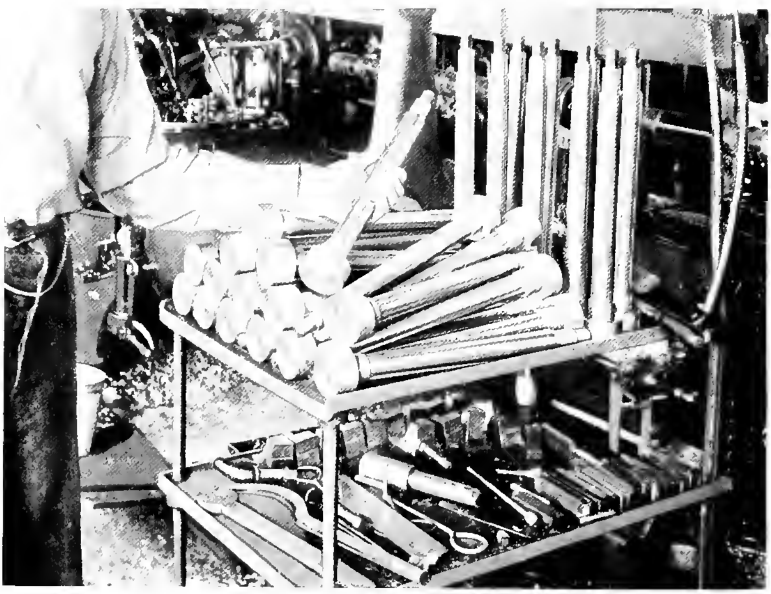
Missing Page

Missing Page

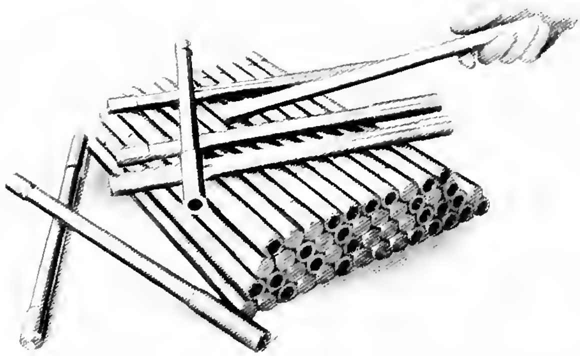


Examples indicating working range and character of work covered by both machines. (For chucking range and thread chasing, see pages 161 to 203)





Bar Work. (Pieces made from long bar of stock)



Bar Work. (Pieces made from long bar of stock)

MULTI-STOP AND DOUBLE TURNERS

Fig. 1 illustrates the advantage of the *double stop* for each position of the turret, and the multi-adjustment of each turner. This piece has six finished diameters and six shoulders, and is turned by only two turners, which, of course, occupy only two positions on the turret. This not only leaves the remaining positions free for other tools, but it saves the operator the time and energy required to run the turret slide back each time.

All this is obtained without complication, and without introducing any features that are annoying when not in use.

In addition to the double stop for each of the six positions of the turret, we have an extra stop, consisting of a pin which may be dropped into any one of the six

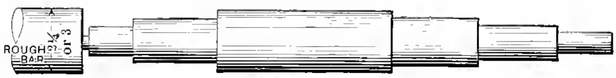


Fig. 1

holes at the rear of turret slide. This makes it possible to borrow five extra stops for any one of the tools, and gives to this tool seven length or shoulder stops, and leaves one stop for each of the remaining tools.

The illustrations, Figs. 2 and 3, give examples of what one tool can do in this machine on chuck work, when we take advantage of the seven length stops and the seven shoulder stops of the cross-feed head.

Of course, in general practice three or four stops for one tool are all that will be needed, but since the modern cutting steels have greater durability, there is nothing lost by giving each tool all the work it can do.

Outer face and all shoulders and diameters accurately finished to independent stops by one tool. When roughing and finishing cuts are required, the roughing tool can be set near enough to use the same stops that are

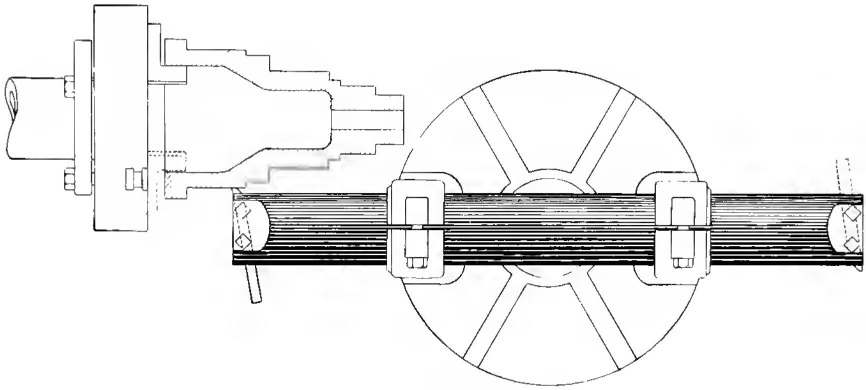


Fig. 2

accurately set for the finishing tool. When an extra tool is used to give a roughing cut it is set as indicated by dotted lines in Figs. 2 and 3.

We find it difficult to illustrate all of the classes of work that can be turned out by this machine, but a little thought will suggest many forms that may be readily handled in bar and chucking work, both steel and iron, on account of the many provisions for bringing both turret and cross slide up to fixed stops, either by power feed or by hand.

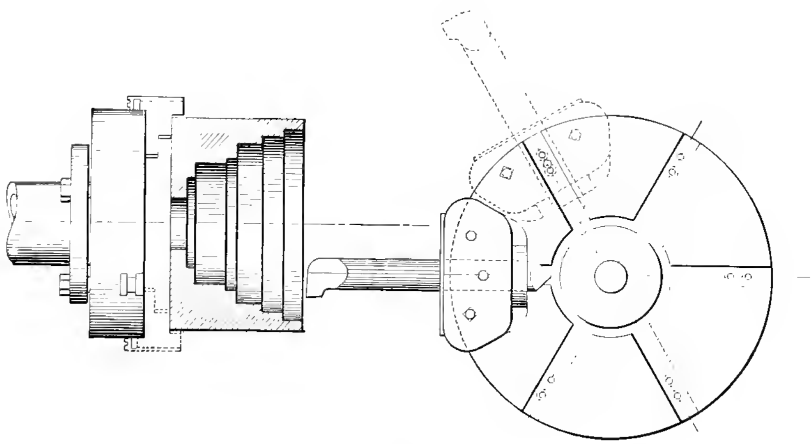


Fig. 3

TURRET DESCRIPTION

The turret is a flat circular plate; it is mounted on a low carriage containing controlling mechanism. The connections of the turret to the carriage, and the carriage to the lathe bed, are the most direct and rigid, affording absolute control of the cutting tools. The turret is accurately surfaced to its seat on the carriage by scraping, and securely held down on that seat by an annular gib. In the same manner the carriage is fitted to the Vs of the bed; the gibs pass under the outside edge of the bed.

The index pin is located directly under the working tool and so close to it that there can be no lost motion between the tool and the locking pin. The turret is turned automatically to each position the instant the tool clears the work on its backward travel, and it is so arranged that by raising and lowering trip screws near the center of the turret, it may be turned to three, four or five of the six places without making any other stops.

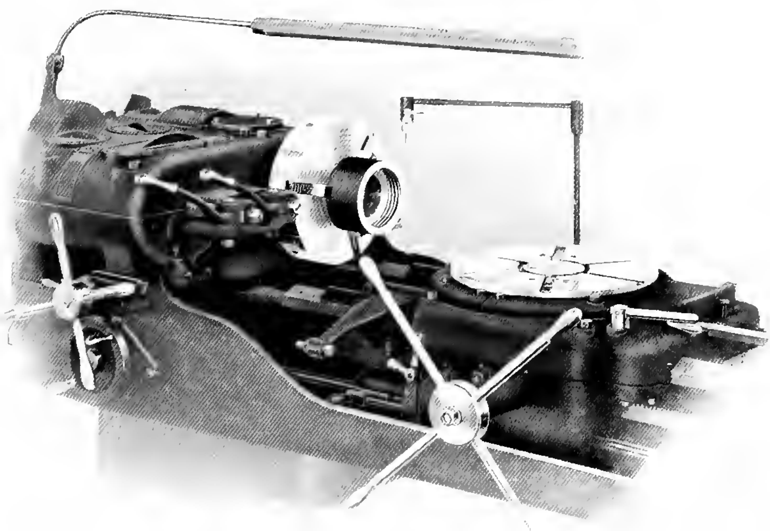
A simple, accurate stop mechanism for the turret slide provides twelve independently adjustable stops, two for each of the six positions of the turret, or any other division required by the operator.

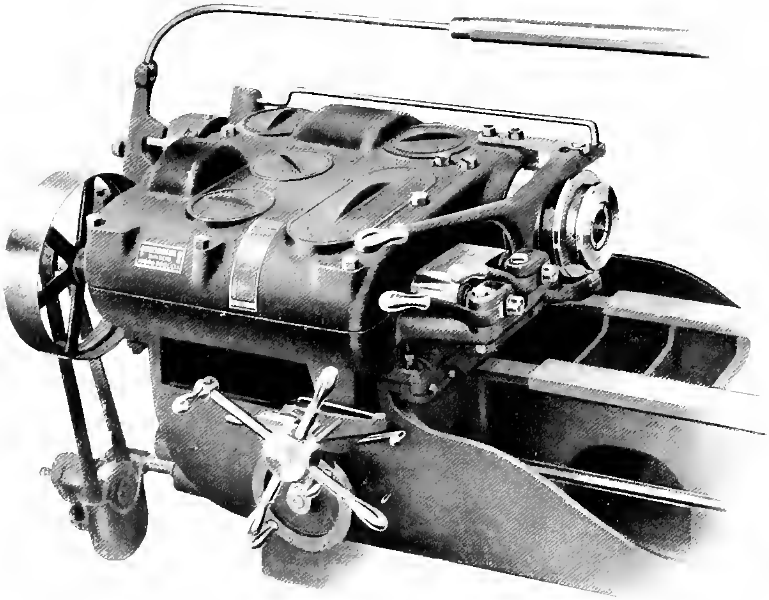
The *feeding mechanism* for the turret slide and the cross-feeding head receives its power through a speed-varying device which is under the convenient control of the hand wheel at head end of bed. One revolution of this wheel gives the full range of feeds, from drilling feed of 100-per-inch to coarse turning feed of 10-per-inch, and every intermediate feed.

A spring torc weighing device on the feed rod gives the pulling power of this feed mechanism a known value. This device yields at a certain predetermined pressure.

In operation the carriage is fed forward until it reaches one of the stops, against which it is held by this pressure till disengaged by the operator. Arresting the feed without releasing the carriage gives the tool a chance to accurately face the shoulder, leaving a smooth surface instead of the ragged face left when carriage is released under full cut.

It has been the practice heretofore to arrange the positive stop a thirty-second of an inch beyond the knock-off for the feed, and in the usual operation of a machine of this kind the feed knocks off, and then the turret slide, released, jumps back, and the tool digs in, cutting a slight groove just back of the shoulder. When on work requiring exact shoulder distances or smoothly-finished shoulders, the operator brings the slide against the positive stop, holding it there with as nearly as possible uniform pressure until the turner has surely faced its full length. In the present machine the turret is always fed against the positive stop and held there with a uniform pressure, insuring the most accurate results for shoulder length.





CROSS SLIDING HEAD

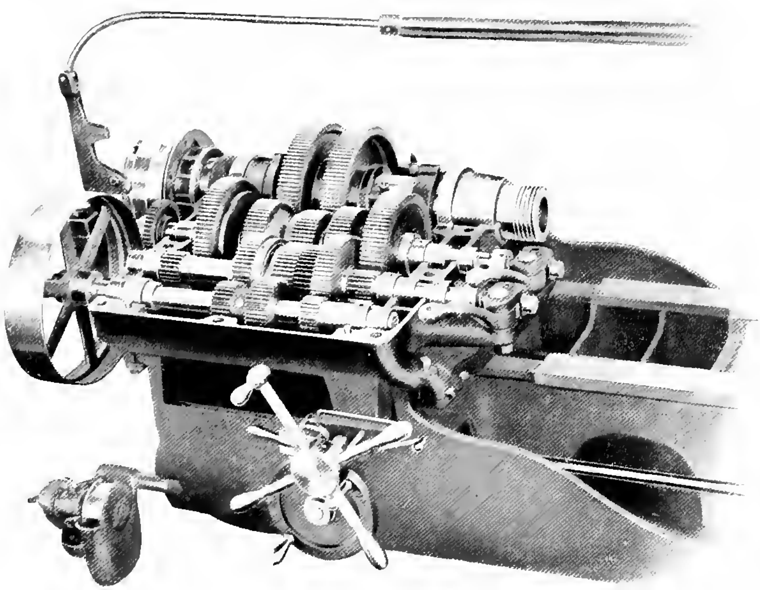
The distinctive feature of the original Flat Turret Lathe was the flat, plate-shaped tool holder from which the lathe took its name. The original work-holding headstock possessed many distinctive features, such as the automatic chuck and roller feed, but it contained the now nearly obsolete cone pulley drive and back gear scheme. In the present machine we have combined an ideal scheme of speed regulation with many other desirable features.

The cross-feeding feature of the head grew out of our desire to get the best form of self-contained speed variator. After trying several combinations and positions, we found it best to arrange all the shafting and gearing in a horizontal plane, so that the lower half of these running parts could be *submerged in oil* to insure perfect lubrication.

This determined the adoption of a shallow pan-shaped frame for the headstock, into which were placed all the clutches and bearings, including main spindle bearings. The natural form of bed for holding this headstock made the way open to give the headstock a cross travel, which we had long realized was a most desirable feature, as shown by our earlier patents.

A most fortunate combination was the result. We not only obtained a most compact and symmetrical machine, but in one machine we succeeded in getting practically all of the features made desirable by present-day conditions.

The sliding headstock is securely gibbed to guide-ways running across the machine, thus giving the work-carrying spindle a cross feed relative to the turret, or, in



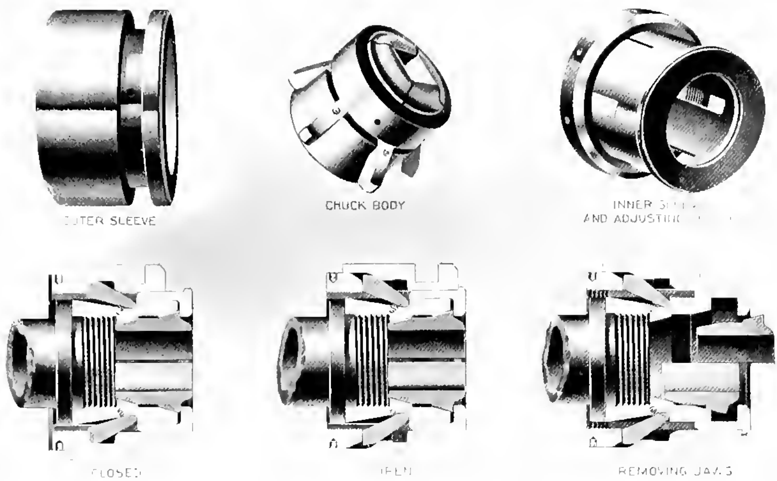
other words, providing a cross feed for each tool. The value of this feature is not only for chuck work, but for many other kinds of work.

The single drive receives power at a constant speed and in one direction, and all of the changes for variation and direction of speed are obtained by clutches and gears between the power-receiving shaft and the spindle.

Since the pulley receiving the power is driven at a constant speed, it may be belted to *countershaft* above or to a constant-speed electric *motor*. No controller is necessary, only a starting box, and since we do not vary the motor speed, it is not necessary to provide a motor four times the nominal size to compensate for loss of power due to reduced speed. Since we use belt connection, any kind of motor may be used, thus avoiding the delay incident to getting a given type of motor.

The *new high-speed* steels tax the running bearings of a machine to their limit, and to meet this we have used bronze bearings for the driving shafts, and all of these bearings get a continual shower of oil when running, for they are enclosed in the chamber formed by the shallow pan-shaped headstock and its lid.

The cross sliding head is provided with *ten stops* carried in a revolving holder, which is turned at will by the operator. These stops positively arrest the travel of the head. The power feed mechanism feeds the head till it reaches one of these stops and then holds it there against the stop till released by hand. The feeding pressure which is exerted against the stop is always the same. In order to get the same uniformity when the head is moved against the stop by hand there is provided a sensitive indicator which shows the operator when he has exerted sufficient force.



AUTOMATIC CHUCK FOR BAR WORK

The automatic chuck and roller feed handle the rough bars of round, square, octagon, hexagon and flat stock, presenting a new length and gripping it while the machine is running.

The automatic chuck is one of the essential features of the machine in its equipment for turning work from full lengths of bars. Its strong and unyielding grip gives a rigid presentation of the work, which is of paramount importance. The jaws are of unbreakable form and may be readily made for any size or shape of material within the spindle's capacity. All sizes, from 2$\frac{1}{4}$-inch down to $\frac{1}{2}$-inch in the 2 x 24-inch machine, and from 3-inch down to 1-inch in the 3 x 36-inch machine, and any of the above-mentioned shapes, may be held by the jaws furnished in automatic die outfits of tools.

Special attention is called to the superior construction of this chuck for handling rough bars of stock.

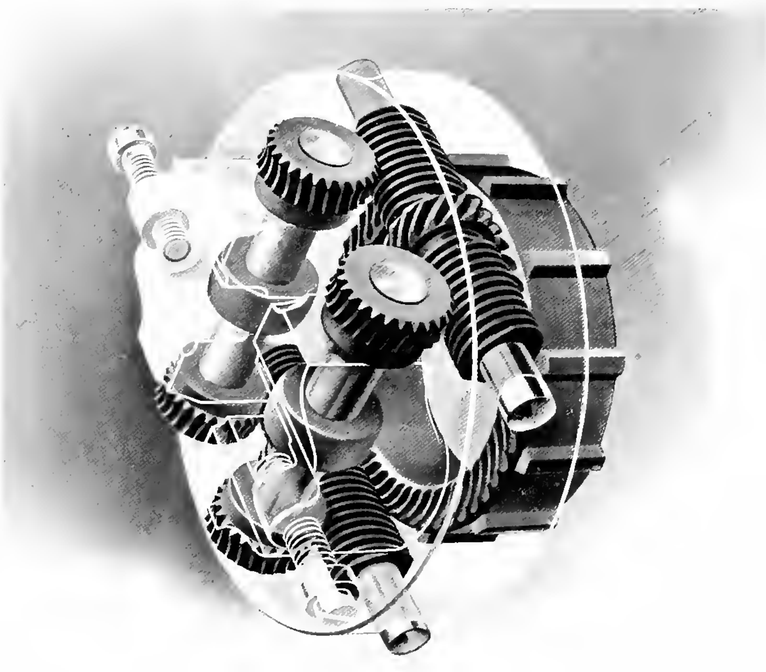
This chuck is used in connection with the roller feed, which is described on the following page.

ROLLER FEED FOR BAR WORK

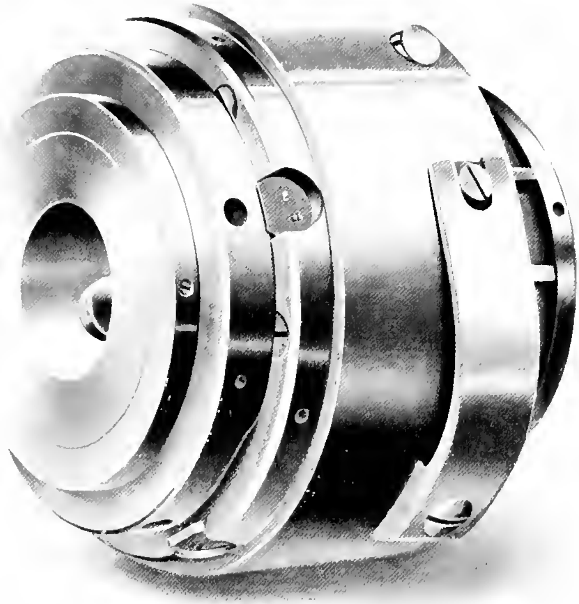
The roller feed is used in connection with the automatic chuck for the purpose of feeding the bar of work through the chuck while the lathe is running. This of course is only in operation when the chuck is open and is solely for the purpose of presenting a new length of work.

The lever that opens the chuck also actuates the plunger that starts the feeding motion of the rolls.

The roller feed shell is securely affixed to the end of the spindle and of course revolves with the spindle and the work. The outer end of the roller feed is provided with scroll chuck for holding the bar of stock in central position in the spindle.



Roller Feed



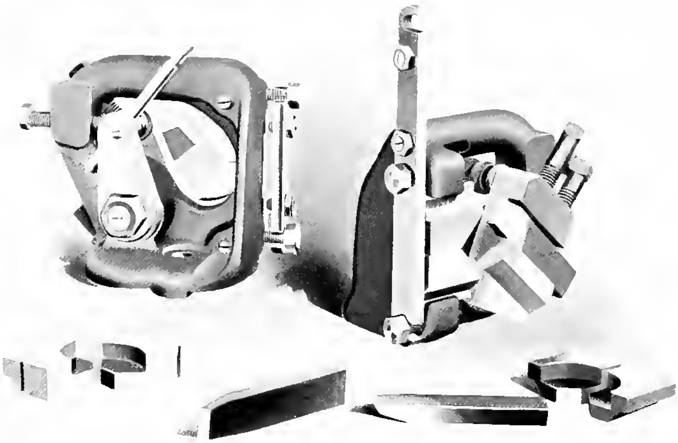
Roller Feed

The rolls are held in roll carriers which provide a bearing on each side of the rolls.

The driving gears are double, there being a worm gear on each end of each roll shaft; these, in turn, are driven by four worms, the mounting being so arranged that the work is equalized between each member.

The roller feed is the outgrowth of the original revolving roller feed which we introduced in 1889; the present scheme of gearing has been in continuous use since 1890; the only changes have been those resulting from long use and natural evolution.

This is not only the original but it is the only one that has been continuously manufactured for any considerable number of years.



Turner B

TURNING TOOLS

One turner of this kind in each outfit D for bar work. Turner B has the full working range of the machine and may be used on sizes down to 3/8-inch or less. The roller back rest and chip-breaking turners do not go below 5/8-inch.

Turner B is not a high-speed turner for it has no anti-friction back rest; it is, however, a desirable addition to the outfit on account of its general adaptability for unusual conditions.

It is provided with a double adjustment for both the cutter and back rest, but it has lost none of its original convenience and simplicity, and may now be used for turning only one diameter without any inconvenience from extra adjustments.

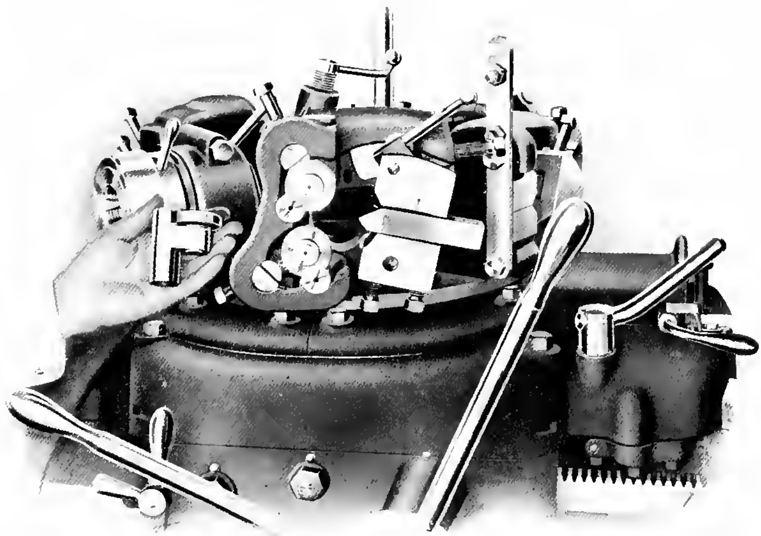
We retain our means for quickly withdrawing the cutter and back rest so that the turner can pass over a large diameter.

The cutter is rough 1-inch by ½-inch high-speed steel, is held in the pivoted tool block of forged steel, which in turn is accurately fitted to the hollow frame.

The adjustment of the cutter is effected by two screws arranged side-by-side. These screws take bearing against cams on cam-shaft, which is controlled by a handle similar to that used in a machinist's bench vise. These cams are diametrically opposite, so that either may be brought into action by a half turn of the handle.

The back rests are controlled by a double latch in order to obtain the double adjustment.

The hollow frame serves as a conduit for the oil which enters the base of the frame through the turret. The oblong opening in the frame over the cutting tool delivers a large, slowly-moving stream of oil directly on the cutting edge.



Roller Turner, Model H

ROLLER TURNER

The roller turner is provided with roller back rest instead of the V back rest used in the regular turner.

One of these turners is furnished with each machine equipped with outfit for bar work (outfit D).

It has two independent adjustments for turning two sizes.

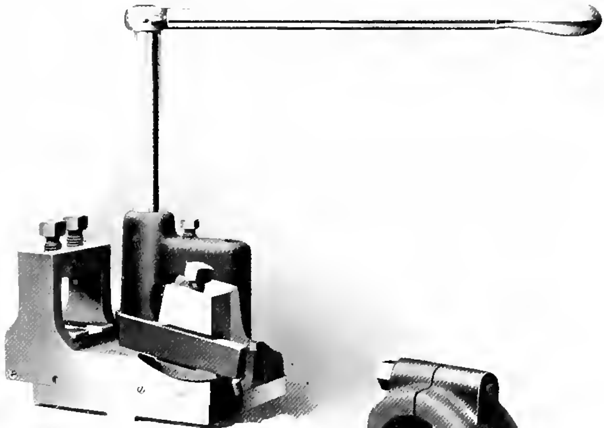
It may be quickly opened to pass over a large diameter and instantly closed to either of the two sizes for which it has been set.

The rolls may be set to precede or follow the cutter.

It turns either to or from the chuck.

Its rolls run on straight headless pins hardened and ground. These pins are held by a rocker insuring an axis in parallelism with work.

All adjustments are conveniently made and are the most direct and unyielding in resistance of working strains.



Cross Slide

Tool Holder

CROSS SLIDE AND TOOL HOLDER

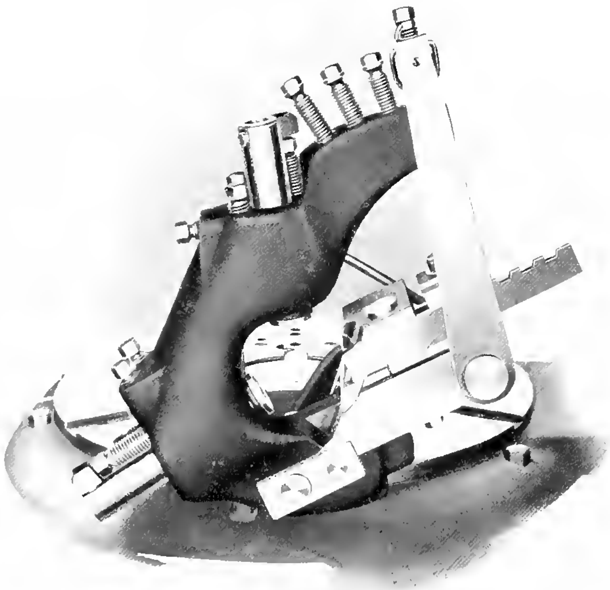
The turret cross slide is made very compact. The sliding tool block is closely fitted and gibbed to the base, which is bolted securely to the turret. A long lever and a small pinion furnish means for feeding the cross slide tools. The sliding surface is so close to the work that its slight necessary amount of looseness is never greater at the tool point.

This slide is used as a cut-off, also for holding broad tool, especially when the latter is to be used near the outer end of a long and slender piece. For such broad tool work on a slender shaft a supporting bushing is fitted to the hole in upright.

The tool holder furnishes convenient means for holding drill chucks, reamers, taps, etc.

Characteristic Chips (about double size). Chips at the left made by diamond point tool having 70 degrees cutting angle. Chips at the right made by no-clearance tool, 45 degrees cutting angle

Illustrating the work of the chip breaking turner. The six groups of short chips were produced by the chip breaking turner. The fine, curling chips were not run through the breaker



Front View of Turner

CHIP BREAKING TURNER

The chip breaking turner marks a departure from the beaten paths of turner design. Briefly, its new features are:

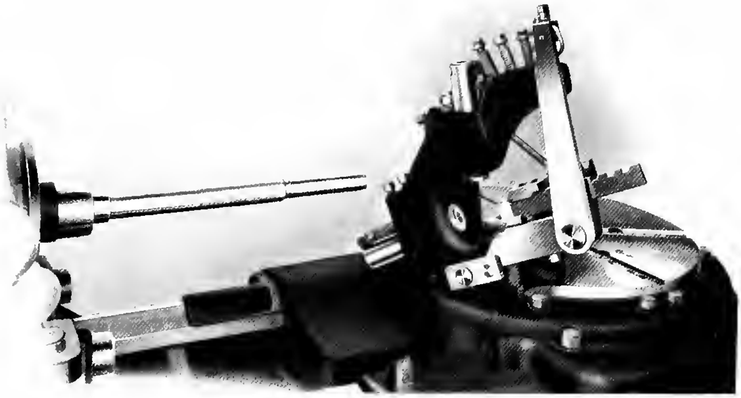
A round-bottomed cutter that swivels so as to get the ideal position of the extreme edge in the metal.

This cutter can be adjusted to cut without clearance or an exceedingly small angle of clearance.

The cutter has an acute edge of 50 degrees instead of the standard 70 degrees.

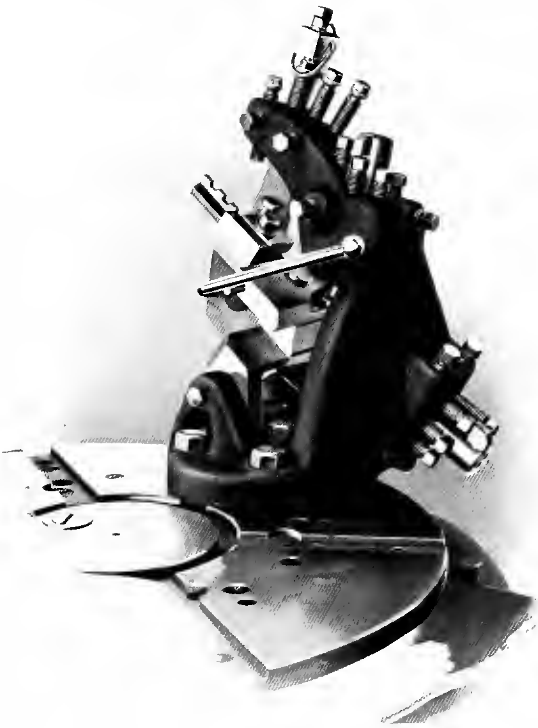
The cutter requires very little grinding to sharpen its edge.

A dull cutter can be quickly and accurately replaced by a sharp one.



Turner adjusted to large diameter of work

Turner adjusted to small diameter of work



Back view from back of machine (turner)

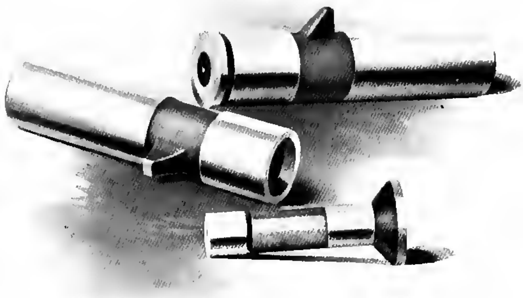
Adjustments are provided by which the turner may be set to turn four different diameters on each piece of work.

In other words, it is equivalent to four turners without occupying four turret positions.

A compensator provides a means for offsetting slight wear of tool point and slight difference in size produced by putting in a newly sharpened cutter.

Directly back of the cutting edge is a chip breaker.

The rolls in roller backs take a flat face contact on work instead of the usual periphery or wheel-like bearing. These end thrust rolls present a most unyielding support for the work.



Back Rests

Each of these features has an important effect on the quality and quantity of output, but perhaps the sharp-edge cutter — one that can cut without clearance — is of greatest interest.

Heretofore all turning and planing tools have been given clearance. Notwithstanding the steady advance along all other lines of design there has been no change in the real position of the extreme edge of a cutting tool in the metal.

All tools have been tipped up so as to scrape off the chip. This position of the cutting edge in the metal has been considered necessary. The angle at which the under-face stands away from the work from which the chip is scraped is called "clearance angle." It has varied from 15 down to 3 or 4 degrees, with the average practice of about 8 or 10 degrees.

All shapes of tool noses from the round nose to the sharp-cornered side tool have been made, yet in all these tools the real working condition of the edge in the metal has not been changed. The tool has always taken its stress wholly one-sided. The chip has borne on one side of the edge, and the edge has had no support or corresponding pressure from the other side; therefore it has had to be made of sufficient lateral strength to withstand this one-sided stress.

This has made it necessary to abandon thin edges or acute edges such as would be naturally chosen for cutting.

In designing the present turner, an effort was made to "get back to nature" by considering the stresses and conditions at the extreme edge.

This attempt resulted in the following conclusions:

The blunt edge tools of standard practice (70 degrees cutting angle) should only be used for turning cast-iron and for rough-turning steel.

For turret lathe bar work the best results can be obtained by a tool having a real cutting or wedge shape edge — one that actually cuts and plows the chip away from the stock.

The wedge-like cutting edge should be allowed to act like a wedge; that is, to ride on the surface of the metal from which the chip was being lifted and wedged away.

By allowing the under-face of the edge to ride on the surface of the work, it is supported directly under the chip stress. Thus the cutting edge is relieved of the one-sided stress to which it is subjected when set in the orthodox "clearance" or scraping position.

In other words, the consideration of the conditions of the cutting edge in the metal led to the conclusion that, for the work under consideration, the time-honored practice of giving a tool clearance and a blunt scraping edge was not the best.

The first experiments obtained astonishing results with tools down to 30 degrees of cutting angle, but the chips were so troublesome that it nearly led to abandoning the whole scheme.

It is true that in exceptional cases the cutting angles of tools for steels have ranged all the way from 45 to 60 degrees for extremely soft steel, and from 60 to 90 degrees for medium and tough steels, and for brass work in unstable lathes from 90 to 110 degrees, but the tendency of the standard practice has been to drift back to an acute angle of at least 70 degrees for nearly all purposes.

One of the barriers to the use of the more acute angles has been the troublesome nature of the tough chips produced, and the other has been the lack of durability of the cutting edge.

Both of these barriers have been removed by the present design.

The tough chips have been broken into short pieces, and the new position of the cutting edge in the metal has rendered it more durable.

TROUBLESOME CHIPS

The lathe hand dislikes a stringy, curling mass of chips almost as much as he dreads the perpetual menace of the fire-balls thrown off by blunt tools at high speeds.

The curling, continuous chips are sometimes used to illustrate the ideal cutting condition, but they make just one impression on the lathe hand who has encountered them at the high cutting speed.

The illustration of a turner or a lathe with one or two beautiful curls of chip arranged in wreath or scroll may be pleasing to the artist's eye, but it is a reminder of trouble to the lathe hand.

A picture of the same turner or machine under the one mile's length of beautiful chips (which would be produced in one or two hours' time at 100 or 50 feet per minute), would not be so pretty, but it would be truer to life.

THE "SHARPEDGE" CUTTER

The chip-breaking turner uses a cutter having an acute edge. It is a knife-like blade that is always ground to certain fixed angles. No special talent or special facilities are required for grinding it, but it should always be ground to directions found on pages 235 to 237 to insure the best results both as to speed and quick change of cutters.

A machine-formed cutter has been adopted in preference to the rough steel cutter of other turners — the object being to get the advantage of quick reset and least grinding.

Heretofore the machine-formed cutters have only been used in inadaptable holders and were run at slow speeds to save trouble of renewal.

The rough bar steel cutter, which is so dear to the hearts of most of us, requires much grinding for sharpening, and it cannot be quickly reset with the precision necessary for satisfactory duplication.

THE SWIVEL MOUNTING

The present cutter has a round bottom which allows it to swing around a few degrees so as to allow its underface to ride flatly against the face of the work, and to gradually change its angular position to compensate for an unequal wearing away of the face of the tool. This swinging does not materially change the location of the extreme edge, for the cutter swings on a center line that follows nearly the line of the edge. Therefore, the depth of the cut and the advance of the edge in cutting are both under absolute control, while the cutter is more or less free to swing to any angle that may be necessary to insure an ideal position of the extreme edge in the metal.

The tool has been called a no-clearance tool, but it would perhaps be more fitting to call it a no-negative-clearance. It will cut without clearance, with its face rubbing flatly against the shoulder from which the chip is being taken, or it may be set to cut with extremely slight clearance.

The tendency of the cutter is to swing into the no-clearance position, but the stress of cut usually holds it in its seat wherever it happens to stand in beginning the cut. But if there is an excessive rubbing contact on the so-called clearance face, the tool swings slightly to relieve this stress.

This allowing the cutting edge to take bearing on each side of its face — which in reality is the condition when it is cutting with extremely slight clearance or no-clearance — has made it possible to use more acute cutting edges than heretofore, for it has greatly reduced or wholly balanced the one-sided stress of the orthodox tool, and it has wholly eliminated the quivering incident to forming the chips under the usual intermittent flow.

CHIP BREAKING

Probably the use of sharp edges for very soft steels would have been more general if it had not been for the already-mentioned troublesome nature of the chips.

Long, curling and wirelike chips are a torment to the average man. The sharp cutter of the chip-breaking turner produces a very tough chip, but the chip passes directly into a diverter or controller that breaks it into short pieces.

The chip produced is a flat or slightly curved chip which occupies very little space.

Thus the two barriers to the use of a sharp tool have been removed. The thin edge has been made durable by allowing it to ride on the metal from which it is cutting the chip, thus eliminating the destructive one-sided pressure and lateral quivering, and the tough chip is no longer troublesome because it is now broken into short lengths.

LEAST GRINDING AND NO FORGING

The cutter used in this turner requires no reforging, and since it is comparatively slender it requires very little grinding for maintaining its edge. The shape of its cutting end is always ground the same, with the exception that the top slope may be varied from 55 down to 45 degrees of cutting angle, but for best results on average work with 50-degree top slope.

QUICK RESETTING

The cutter is always set in its holder against a locating stop, so that a dull tool may be quickly and accurately replaced by a sharp tool, with minimum effect on the size produced. The locating stop makes the new tool take the position of the preceding cutter with a very slight error.

A compensator is provided to quickly and nicely offset any slight error.

MULTI-SIZE ADJUSTMENTS

One of the distinctive characteristics of all of the Flat Turret Lathe turners is their multi-adjustment, by which each turner can be used for more than one size. Previous types (Nos. *B* and *H*) are provided with adjustment that may be set for producing two sizes, while the present turner may be used for four different sizes.

It is therefore almost a turret in itself. The extra adjustments are of such simple nature that they add no expense to the first cost and are not in the way if not required by the work. The advantage, however, of the quadruple size turning turner will be readily recognized.

The compensator previously mentioned is a valuable adjunct to the multi-size producing scheme, for it is obvious that a slight wear of the tool point, as well as a failure to accurately return the sharp tool to the previous position of a dull tool, would necessitate the readjustment of the four adjusting screws in the absence of this auxiliary adjustment.

The importance of quick resetting, minimum grind and no forging will be realized when we remember that we run a cutting tool as fast as we can consistently with the time lost in exchanging and sharpening cutters and in restoring a new tool in the exact position of an old one without loss of size.

The quick reset to exact position, therefore, becomes the means for making higher cutting speeds practical in actual work.

It does not increase the cutting speed for a stunt performance on one piece of work, but it does increase the actual running speed and output.

BACK RESTS

The back rests are also unique — they present nearly a flat face to the work instead of the usual wheel peripheral contact of former roller back rest.

The face rolls and holders present a strong resistance to the cutting stresses, and are practically unyielding in this respect; and, last but not least, they lend themselves admirably to the multi-size adjusting features.

SUMMARY AND DISTINCTIVE CLAIMS

THE CUTTER

A cutter that is wedge shape, and not blunt.

It cuts and does not crush, crowd, or scrape the metal away.

Its sharp edge is durable because it is not subjected to one-sided stress.

It works with a minimum or no clearance.

Its riding contact prevents lateral quivering.

It cannot acquire a negative clearance.

It can be quickly reset.

It requires the least grinding and no forging.

Sharp edge, with durability, and without troublesome chips.

THE CHIPS

Flat chips that lie compactly in small space.

No curling, snarling bunch of stringy chips.

No fire-balls of hot chunks of crushed metal being shot out in all directions, to the continual menace of the lathe hand.

All chips are deposited in one place, and lie flatly in position dropped.

Each turner is a veritable turret in itself, for it may be used to turn four different cuts one after the other without turning the turret, each of the four sizes having independent adjustments, which may be adjusted without disturbing the others.

In addition to the independent adjustments, there is an auxiliary adjustment which may be used to compensate for the slight wear of the tool point, or to offset the slight change in size by inserting a new tool.

The compensator restores the tool point position so that the main independent adjustment need not be disturbed after being once adjusted to a piece of work.

Quick resetting scheme provides for a quick and accurate return of tool to position, greatly reducing the interval of idleness of machine due to exchanging a dull cutter for a sharp one, and greatly increasing the practical cutting speeds; not the stunt performance, but the actual running speed and actual output.

The disc roller back rests provide the most unyielding support and a convenient means for the quadruple adjustment.

The multi-adjustment may be used for four different sizes on one piece of work; or, if the character of the work requires only one or two diameters produced by this turner, the other adjustments may be used for special or repair jobs. In other cases, where one machine is kept running on two or three different pieces, the adjustments may be left undisturbed till required again. It is a distinctly adaptable as well as the most reliable size producing turner.

The chip-breaking turner is offered with the feeling that it represents another one of those moves by which we have kept the Flat Turret Lathe preëminently the leader.

This turner may be used on any old or new Flat Turret Lathe.

The multi-adjustments of the turners combined with the extra turret slide stops, greatly increase the working range and convenience, and reduce the total turret travel.

Oil or cutting solution flows through the turret and turner frames, thus doing away with the troublesome oil pipes. The liquid flows directly on the tool point without attention.

THE AUTOMATIC CHUCK

The automatic chuck grips square, round or hexagon bars of rough or smooth stock, and the roller feed works equally well on all shapes.

THE LATHE

The Flat Turret Lathe has the advantage of the development that comes from specialization.

Over 5500 of these lathes have been built, the first 2500 being with fixed heads and for bar work exclusively.

The last 3000 have had cross sliding heads, and have been used both for bar and chucking work.

It is the only lathe having a cross sliding head. All others must resort to mounting the turret on two slides in order to get the same movements; hence,

It is the only turret lathe having length and cross feeds for each tool without resorting to the double slide turret support.

The only turret lathe built on the single slide principle.

The single slide principle gives the most accurate, powerful and convenient control of work and tools.

The single slide control makes it possible to accurately control each tool; first, as to its exact position in the metal while cutting; second, as to length of the cut to insure correct shoulder length as well as diameter; and third, for the most precise return of each tool for accurate duplication.

(Multi-slide does not give an unyielding control of work and tool. It does not furnish a means by which diameters or shoulder lengths can be accurately duplicated. Its stop mechanism does not accurately arrest or locate the tool in relation to the work. It only arrests a remote corner of a frail slide or pile of slides. Therefore, the greatest value of the machine *as a machine* is not realized by the multi-slide, but it is attained by the single slide scheme of design.)

The precision of the stop mechanism is due to the scheme by which the slide is always fed firmly against a positive stop with an accurately measured pressure. This insures accurate shoulder lengths. The stops are located relatively near the line of thrust, and not at some remote position which in arresting the slide throws it around, causing the tool to change its position in the work.

The flat turret gives the most natural tool support, both from point of security and convenience in grouping.

Combined with the cross sliding head, it makes possible the use of the simplest tools for chuck work. These tools are simply clamped to the top of the turret or to convenient holders mounted thereon. But in all cases, the tools are so held that they overhang their support only the extent required by the work.

There is no intermediate cross slide on the bed over which all of the tools must project in order to reach the work.

MULTI-ADJUSTMENTS FOR EACH POSITION AND TOOL

On account of the dozen turret slide stops and the ten cross slide stops any one of the chucking tools may be used for producing a number of diameters.

MULTI-STOPS

The turret slide is provided with twelve stops which may be used in any desired order. They may all be controlled by the turret, or a few of them may be operated by hand, thus making it possible to use two for each position of the turret, these being automatically selected by the turret and auxiliary lever; or one for each position, leaving the other stops to be used as desired, even to using seven for one position and one each for the other five positions. There are ten stops for cross sliding head under control of the operator.

SCREW CUTTING

Screw cutting for bar work is done by the only lead controlling die.

Screw cutting for chuck work is done by the only turret chasing tool.

The turret chasing tool accurately and quickly cuts a thread that is absolutely true with the other cuts taken at same holding.

SPEED CONTROL

By combinations of friction clutches and ratchets the whole nine changes are obtained by only two levers.

Each lever controls two friction clutches. When both are out of engagement a ratchet picks up the motion and carries it along. Hence three speeds are actually under control of each lever, the slowest of the three being the ratchet which engages when the friction clutches are free.

Gears, clutches and bearings for the spindle and its drive are encased in a shallow, pan-shaped head, with lower edges of gears immersed in oil to insure perfect lubrication.

ECONOMIC SUMMARY AND CLAIMS

It is the machine to use in building machinery for profit.

Consider these points and determine on what scheme of management your moves will be made.

The cost of machining your work probably stands at one-half the shop's labor cost, and your labor cost stands at one-third the total cost of your finished product, when sold, accepted, paid for. Thus your machining, such as lathe work, planing and milling work, amounts to one-sixth the total cost.

You wish to get out the largest output per dollar invested in your business. The output is limited to your capacity for machining your parts.

Here are some cardinal points which we consider good:

Put your capital where it will do the most good in getting out work when it is wanted.

Don't extend the use of machines which lack adaptability. Machines which lack adaptability make it necessary to run the work through the plant in excessively large lots. This ties up money where it is useless. Such machines are usually run on excessive lots or are standing idle awaiting new tools.

On the other hand, do not increase your old style lathes when you can handle the work with turret machines.

The output of new (old style) lathes is very low per dollar of investment and very high per dollar of labor cost per piece. Such lathes cannot duplicate work; hence, their product causes endless trouble when it reaches the setting-up or assembling department.

Don't tie up too much of your capital in low-efficiency machines.

Don't try turret attachments on an engine lathe. They are weak and unreliable makeshifts. The standard lathe is not adapted for use of turret tool-holder.

The most popular automatics are not "adaptable," and do not give good output per dollar of investment.

The song of exceedingly low labor cost includes no reference to the lot of obsolete tools in tool room, which were made for other work; nor the excessive size of lots that are run through just because the machines cannot be changed over from one kind to another; nor reference to the money tied up in excessive stock of finished pieces in stock room that must wait six or more months before use; nor the fact that a change in line of work leaves a lot of these parts a dead loss on your hands; nor the fact that their scheme of duplication does not always duplicate, on account of use of overhanging tools; nor the excessive cost of assembling, entailed by work that is not true.

Remember that your profit is madê by getting out the work when it is wanted, and as it is wanted.

That your capacity for machining the parts determines your total capacity.

That if you tie up your capital in machine tools which cannot get out the product quickly, you have cut down your capacity to get out work under pressure of good business.

Remember, too, that your profit or dividend per dollar of investment is very low, or minus, if your equipment is low in efficiency.

Your capacity to get out the work, and especially your capacity to get out an extra amount of work, is what makes your profit.

Buy more Flat Turret Lathes, for they give you the largest output per dollar of investment; also a low cost of work and an accurate duplication.

In buying turret machinery remember that any machine that requires a lot of special tools for your work will require a lot more when there is a slight change in your work. Such machines cannot be changed from one kind of work to another without weeks and sometimes months of delay or previous notice.

The expensive tools which you buy with such machines will be obsolete in a short time—if you doubt it, go into your own or some other plant where such machines have been used a few years and see the obsolete tools.

If the "just as good" turret machine is said to possess a standard set of tools, look sharp as to the character of those tools; they are weak and unreliable under stress or they are very inconvenient in adjustment, or both.

You will be told that we use many machines of this or that "make" in our own works.

It may be economy for us to use many and yet very wasteful for you to do so, for we are lathe-work specialists, and must know how the various lathes perform under every-day conditions.

Regarding the use of many different kinds of machines, we think it is very bad practice to use more kinds of machines than necessary. Our reason for doing so does not fit other builders.

If one kind gives satisfactory results as to output per dollar of cost of the lathe and low cost of work, with accurate duplication, then stick to that one kind even if it is not our machine, or the best, providing it "gets there."

The introduction of many kinds of lathes into a plant causes endless and needless expense. It is hard enough to break men into running one kind, without having several kinds.

The loss due to failure of men to understand the machines is greater than appears at first glance.

Of course, if your present equipment is not right, or if you have a variety of machines, with no desire to increase the kind in use, then strike out and get the best, but don't decide till you have carefully considered the facts herein set forth. It is a fairly unbiassed story of the turret lathe, and it describes the present Flat Turret Lathe, which is the result of many years of continuous application of our entire plant and energies to this one machine. The first Flat Turret Lathe was shipped in '91. It soon became our sole product.

Our present guess is that this machine will be kept a leader for many years to come.

In considering "tuning" up your plant by correcting your lathe methods, bear in mind that the Jones & Lamson Machine Company is a company of lathe-work specialists.

The Flat Turret Lathe has the lead in cost-reducing duplication of work and large output per dollar of cost.

Just now the air is reverberating with the wild note of the low labor cost enthusiast—who would have manufacturers throttle their output by putting their capital for machine tools in low-output machines.

What good can come from a system that would reduce the cost of machining per piece, 99.9 per cent, if said reduction were obtained by machines of such low efficiency that the available capital for machine tools would not get out one-tenth the required work? These are extravagant figures to illustrate the point.

The output of your plant when business is good determines your profit. Your output cannot be larger than your capacity to machine your work — in fact, the capacity to machine the work usually determines the output.

Is your business to be throttled by the use of low-output machines, or do you want to get out the work when it is wanted?

To offset the profit in good times we have the idleness of capital in dull times. This loss is enough when the capital is in high-efficiency machines.

Don't be deceived by the song of the enthusiast, of saving last fraction of cent of labor cost. He usually does it by expensive, short-lived, frail, inadaptable tools which become obsolete with change of work. His machines when in use a few months average to be found idle too much of the time. Go through your own or other plants with this thought in mind.

If you have reached the point where you are convinced that the kind of machine you want is the "adaptable" turret lathe, hand operated, because you want to get out any piece any time, and get it out in large or small lots—(yet you are bewildered by the claims made for the "just as good" machines)—let us give you a few pointers which will make it possible for you to settle the question in your own mind, without the unsettling advice of our friends the enemy.

If you cannot see a sample of each machine running (and by the way, the other machines are hard to find), then take the cut of each machine—see how readily you can pick out the original machine — the one that was designed on the natural lines, and then see the other that was compelled to take the next best way.

The original accomplishes its ends by the simplest and most direct means.

It has the fewest levers; it uses the most substantial tools with the least overhang of work or tools; it has business lines, and not fussy accumulation of parts; it is not built on the frail "slide upon slide" scheme of design; its stops are where they will most accurately arrest the cutting tool — not at the lowermost corner of carriage apron.

The Flat Turret Lathe has had the benefit of not only the first choice of means to the ends desired, but also a thousand and one minor but important developments of detail that come only by continuous application and exclusive devotion to just one thing, by the entire force and organization of a company.

Don't forget the importance of each workman in our plant knowing by experience how to make the best machine.

It is faintly rumored that our gentle friends the enemy on the other side of the Atlantic have murmured overmuch regarding the fundamental principles in machine design, particularly that which declares that a machine designed for two kinds cannot be as good as one built for one kind, regardless of the other; that the machine built to cover both is probably weak on both.

Our record for the seventeen years proves we agree with this general principle, but let us see how it fits present conditions, and let us see how our machine as either a bar-working or a chuck-working machine compares with other machines, which are alleged to have been built expressly for each class.

Before considering our machine let us call attention to the fact that our friends the enemy (on the other side of the Atlantic, remember) make a great variety of machines, and it is barely possible that our concentration on one machine may make that one machine better for each of two classes of work than it would be possible for us or these friends to cover these two classes by independent machines, providing our energies were simultaneously being dissipated over a long list of other machines.

The aforesaid murmuring is aimed at our machine which is built with cross sliding head because it is offered for either bar or chuck work, or both bar and chuck work. But facts are facts. It was originally designed exclusively for bar work and has been developed as a machine for bar work from the very first.

It was the original and only turret machine for bar work up to twenty-four inches long, and has from the first been known as the 2 x 24 Flat Turret Lathe.

It has enjoyed a constant growth since the year of 1891, and it was the outgrowth of the original automatically turning capstan, or turret head screw machines of which this company was the first builder in America, and probably in the world. The first machines were built by us in 1855.

The present machine was originally designed, and for thirteen years was made and sold, for bar work only.

The development in every detail for such work was just what would be expected when we say that we devoted our entire energies and plant to this one machine which, during the first thirteen years, was made in one size only.

In 1904 we brought out our cross sliding head, which made a slight change in the outward appearance of the original machine, but it still possessed all of the original features for good.

We knew that the sliding head was not necessary on all kinds of bar work, but we also knew that bar work merges into chuck work in such a way that it is not objectionable, to say the least, to have an opportunity to give each tool the benefit of the slide which the head affords.

No one will deny the supremacy of our lathe as a bar working machine. They only say the cross sliding head is unnecessary expense on a bar machine—but we will explain the expense quickly after we have stated that everyone admits the cross sliding head the correct principle and makes the best machine for chuck work. Hence we get indorsed on both bar and chuck work— only criticised for making a machine with cross sliding head, in that it is an unnecessary expense, and which the buyer must pay for.

Well, let us see about this expense:

Here is an outside confession: we are by record and by habit of thought believers and practicers of the extreme art of manufacturing one thing. Our record shows that we were the only American, and probably the only lathe-building company in the world, that built for many years only one machine, and that in only one size. We did that because we could make more money doing so. That is a confession, isn't it? Well, incidentally we were able to produce a better machine both in design and workmanship than our friends the enemy, who have generally been a long way behind us, just simply because they continue to squander their energies over a long line of machinery.

Now, we believe that sticking to one thing gets the best results for both manufacturer and buyer. It was that which had something to do with our deciding to make our machine with same head for both purposes. The manufacturer of many machines can't appreciate our attitude. We believed, and still believe, that we can manufacture all machines alike cheaper than we could leave off a few dollars' worth of parts for this or that order. Then a shorter way of saying the same thing, or of proving it, is that there is no machine on the market that comes anywhere near our machine for value or output per dollar of cost. In other words, our machine is actually the cheapest, notwithstanding the talk about the needless expense of the cross sliding head on the bar machine.

A Group of Hartness Automatic Dies

DIE-CUT SCREW THREADS

In the original development of the turret lathe for accurate lathe work, the greatest obstacle to our progress was the means then employed for cutting and measuring screws.

Die-cut threads were never correct in lead, and seldom of good shape. Lathe-cut or chased threads were found to have an error in lead averaging $\frac{1}{32}$ of an inch in 12 inches when cut by new lathes, and much greater error when produced by old lathes. On account of errors in lead and shape, neither the die nor lathe-cut screws could be measured.

The so-called screw gage used would tell how a screw would "feel" in a hole of the same length as the gage, but would never tell how it fitted.

The die which is the subject of the following description has a lead error of less than $\frac{1}{64}$ in 18 inches; it produces a shape of thread accurate beyond measure, making it possible for the first time to measure screw threads by the use of the ordinary micrometer, ring or snap gage. The introduction of this die in 1894 marked a most important step in the advancement of accurate machine construction. A full explanation of the present form follows, making very clear how such results are obtained.

GENERAL DESCRIPTION

The Hartness automatic die, shown on preceding page, is made in four sizes, viz., No. 1, for cutting screw threads from $\frac{3}{32}$ inch to $\frac{1}{2}$ inch in diameter; No. 4, for screw threads from $\frac{1}{4}$ inch to $1\frac{1}{4}$ inches in diameter; No. 6, for screw threads from $\frac{3}{4}$ inch to 2 inches in diameter; and No. 9 for screw threads from $1\frac{3}{4}$ to 3 inches diameter.

Right or left-hand chasers are supplied as required for cutting United States Standard, Whitworth Standard, V, Acme and pipe threads; also, the various fine threads in customary use. It was designed expressly for the Flat Turret Lathe, but may be used in any of the existing screw machines or turret lathes by change of shank.

It opens automatically when the travel of its holder or shank is retarded.

The cam for controlling the chasers takes bearing directly over and very close to the cutting strains, hence there is no chance for the chaser to get away from its work by canting or tipping. This insures straight work, which is seldom obtained from other automatic dies. The connection between the shank and the body of the die is a double universal joint, allowing the die to assume any position required by the work. This connection remains perfectly flexible under the greatest torsional strain of cutting, and provides a compensation for the slight but important change of alignment that takes place in all turret machines as soon as a die begins to cut.

The latch pin which holds the cam in close adjustment is provided with two latch surfaces, one for a roughing cut and the other for a finishing cut. Turning the latch half way around changes it from one to the other without disturbing the principal adjustment for size. With this feature smooth screw threads can be cut when the lead is very coarse. It is seldom used on standard threads below 1 inch in diameter.

Every part of the die is made either from open-hearth or tool steel, the lathe work being done exclusively on the Flat Turret Lathe, and all other operations by special machinery. It is perfectly interchangeable throughout.

LEAD CONTROLLING FEATURE

The process of forming the chaser teeth is such that the front or working teeth have an ideal cutting clearance, while the back teeth have no clearance, but, instead, take bearing on the work a trifle back of the face of the chaser, forming substantially a lead nut which rides on the thread produced by the front teeth, thus governing the lead of the screw.

These chaser teeth are formed by special milling machines provided with means for recording to a nicety all angles and positions of approach of work to cutters, so that an absolute knowledge of the clearance and contact of each tooth is possessed. Each chaser is milled separately, insuring a perfect interchangeability.

The milling cutters used are 2½ inches in diameter, regardless of the size of the screw to be cut by the chasers. These cutters are formed in backing-off lathes and possess an ideal clearance. When in use the faces of their cutting teeth are ground frequently, thus maintaining the correct degree of rake and a keen cutting edge; they take a clean cut without any of the burnishing or rubbing action which always accompanies the hobbing or tapping of dies. The importance of this feature is appreciated after the dies have returned from the hardening process. Since the metal in the chaser teeth has been undisturbed by the cutting process, and only the extreme edge hardened, leaving the soft back very near the edge, no appreciable change of form takes place. In the process of hardening other dies the compressed or burnished metal—which has

Hartness Automatic Die No. 4 and its parts been squeezed into shape by the hobbing or tapping action —is quick to assume a more natural position, and this results in a distorted die. Our method does not depend on the accuracy of the lead screw of a lathe in which hobs, taps and mills for producing dies are made, neither is it affected by the change in hardening such tools.

All other methods have at least the errors of two hardenings and one lead screw. We correct in the milling machine all errors excepting the final hardening

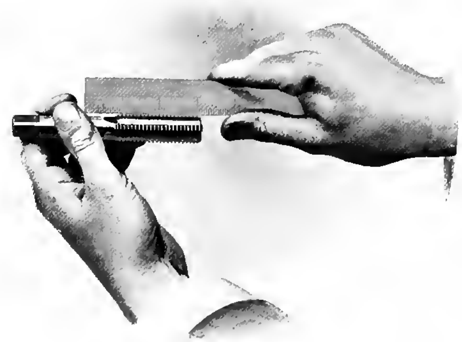
of the chaser, which takes place under such ideal conditions that we cut a practically perfect screw.

The error in lead is less than $\frac{1}{64}$ in 18 inches in screws of standard pitch, and, when cutting threads of fine pitches, a proportionate accuracy of lead is maintained.

To obtain a full appreciation of the comparative minuteness of this error it is only necessary to measure with a good scale the lead of the best taps on the market, the lead screws of engine lathes, and the screws cut by other dies, any of which will show errors from four to ten times as great. In view of these facts, we consider our die practically perfect in its lead-controlling features.

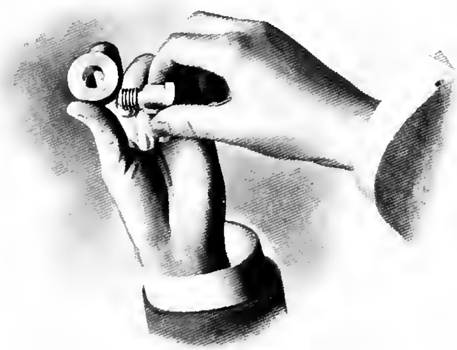
GENERAL DIRECTIONS FOR USING

If the lead of the work produced does not correspond to the nut into which it is fitted, do not condemn the



die, but measure the lead of both the work and the taps with a scale, providing you can get both in length of 4 or 6 inches. It is practically impossible to make taps

that will lead accurately on account of varying results in hardening. This element of uncertainty is eliminated in this die, as explained in the preceding pages. The error in lead of taps is usually so great that it is plainly visible on 1 or 1½ inches of length. A scale placed on tops of teeth will show at the even inches the error, and at the 1½-inch graduations if the pitch is an even number to the inch. Fifty per cent of the taps now in use should be discarded. When you order new taps ask the maker to select taps of good lead, and, if necessary, pay an extra price for getting the cream. It will be worth it if you

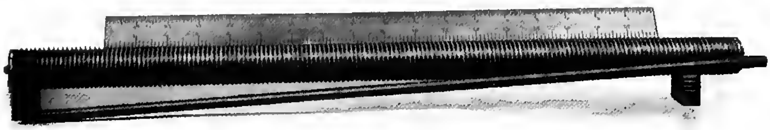


want good work. Measure the diameter of the taps and see that there are no burrs or fins in bottom of thread to spoil shape of thread in the work.

The so-called thread gages, in the form of a circular nut, though nicely finished and hardened pieces of steel with an internal thread, are very misleading.

All that has been said in the foregoing regarding the impossibility of making correct lead dies is equally true of these gages. Furthermore, such gages wear in directions for which an adjustment cannot be made. A more unreliable gage could hardly be invented.

The three distinct dimensions of a screw thread should be measured separately. The shape and lead should be measured when the die is made; in other words, the die should cut a correct shape and lead; then the third dimension, the diameter, should be measured when the die commences on a lot of screws, and occasionally thereafter. The thread may be measured by the ordinary micrometer, snap or ring gage, taking the diameter at the top of the thread.



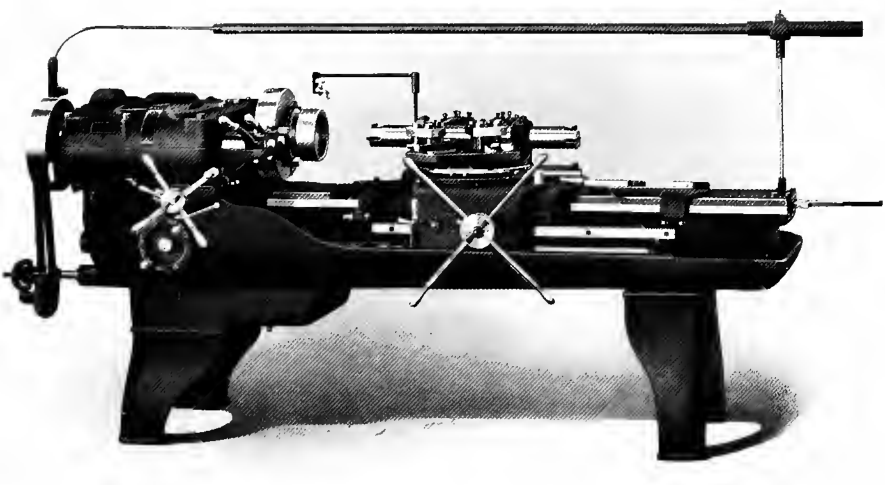
As the die becomes badly worn, the lead should be measured occasionally. This can be done by cutting a thread 6 or 12 inches long and measuring it with a good scale, remembering that all scales may "look alike" and yet not be the same in length; hence, get a good scale.

The various forms of screw lead-measuring devices may be used with economy of time and material, but such gages should be handled with special care and occasionally compared by the foregoing method.

FLAT TURRET CHUCKING LATHE

JUST as the original Flat Turret Lathe was equipped with an outfit of conveniently adjustable tools for bar work, so now, with the present machine, we have provided a universal outfit of tools for chuck work.

The many illustrations of chucking tools and conditions under which they work will carry conviction that we have not fallen short of our established record, to use only the most practical and efficient tools, held under the most rigid control, and in



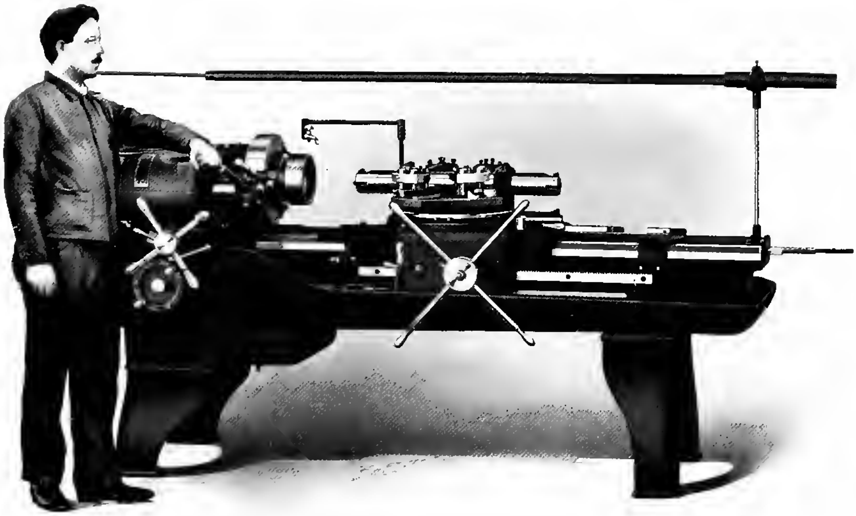
The Flat Turret Lathe at work, showing the convenience of control and the stability of tool support conveniently adjustable holders. When we say chuck work, we do not mean merely the process of boring a rough hole in a piece of work to be reamed elsewhere, and after that to have the piece pushed on an arbor and turned in some other machine, but we mean finishing the work shown by our accompanying sketches, in which every possible cut is taken that can be taken, and still leave means for holding the piece.

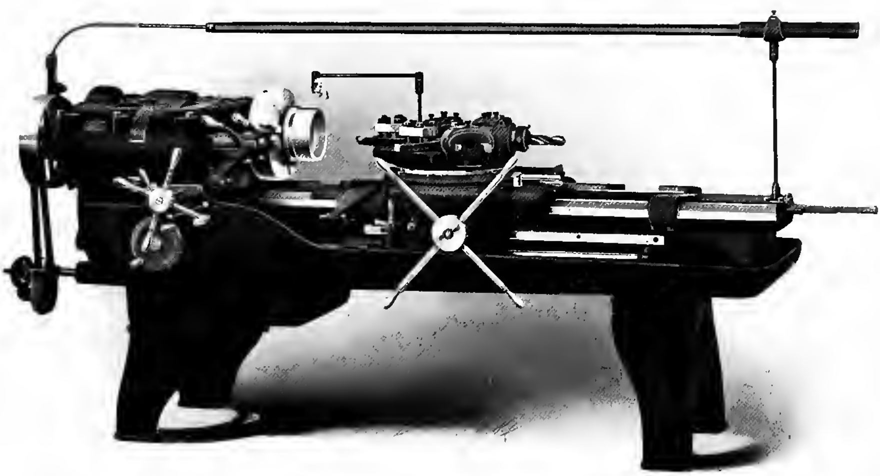
Just as in the past we restricted our working dimensions to a 2-inch spindle hole, so now in this machine we restrict our chucking swing to 12 and 14 inches; but in doing so we furnish a machine that cannot be equaled by any other machine.

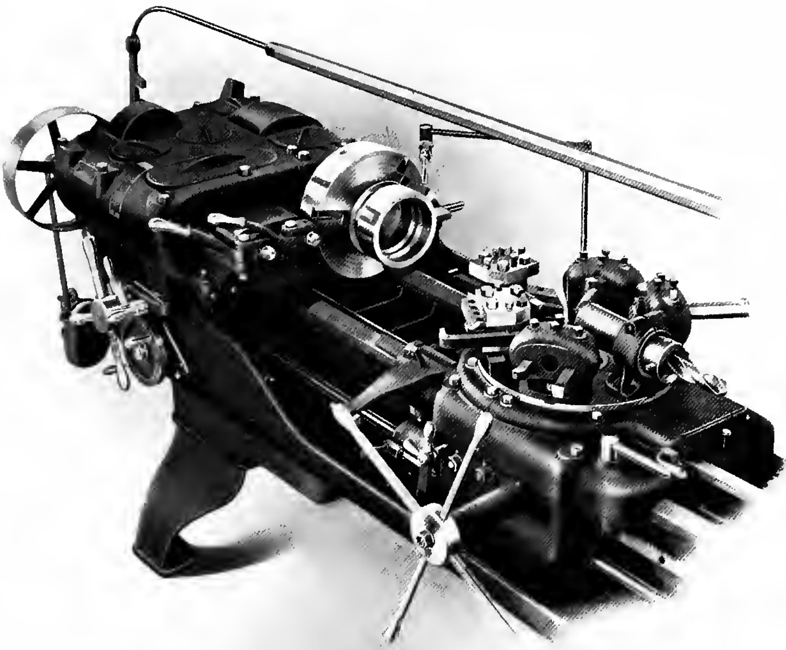
The simplicity of our entire scheme makes it possible to retain for our entire range of work our claim made for the original machine, viz., we can make one piece quicker than it is possible to make it in an engine lathe, and if two pieces or more are required, our system of stops makes a convenient and quick means for accurate duplication.

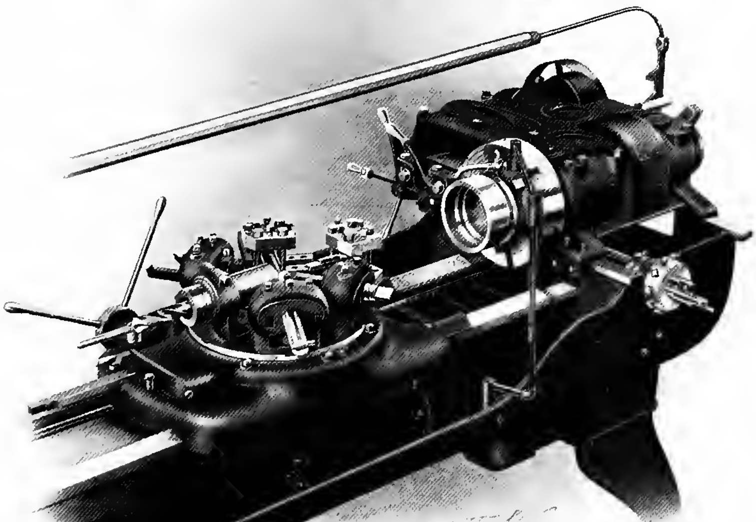
The ten stops for the cross-feed head, combined with the dozen stops for the turret, and the turning and boring tools, all of the simplest and stiffest construction, make this machine ready to begin work as soon as it is supplied with the driving power. It is not only ready to begin work on the work for which it may have been purchased, but it is supplied with a set of tools that will take care of any similar piece any hour or any day in the future; and, notwithstanding this universality, adaptability and efficiency, our tools and work are brought together under the most rigid control and under ideal conditions never before attained in a lathe.

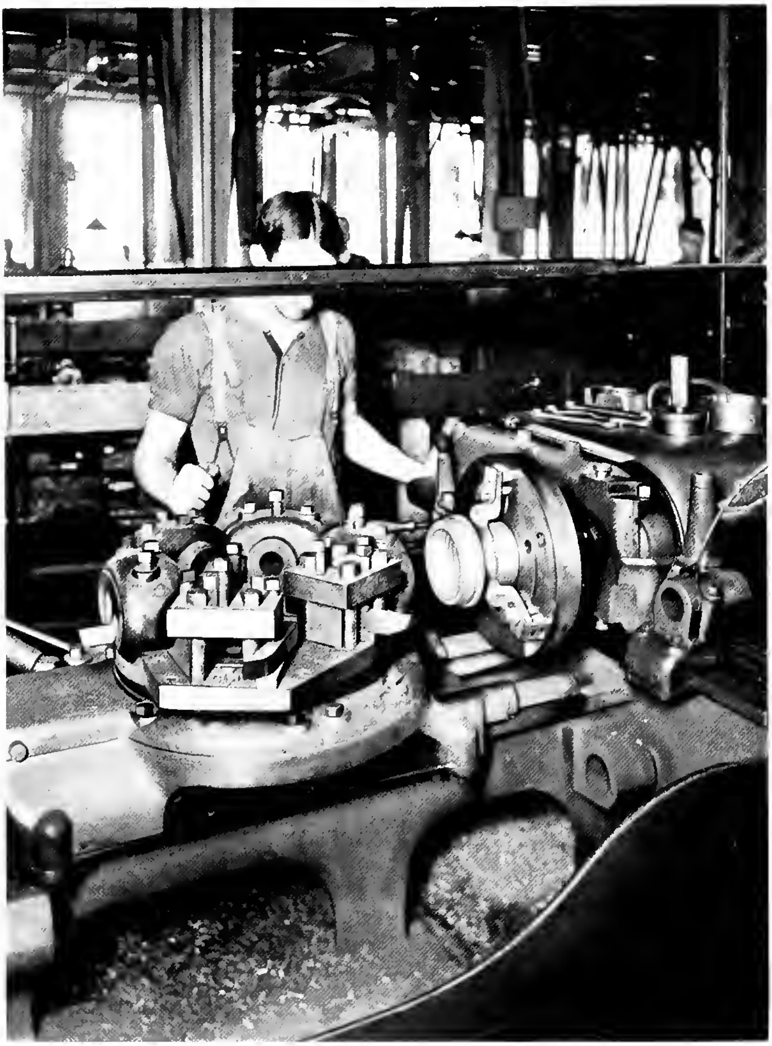
All the shears and running surfaces are protected from the dust of cast-iron, so that the machine may be used for either steel work in which oil is used, or for cast-iron chucking.





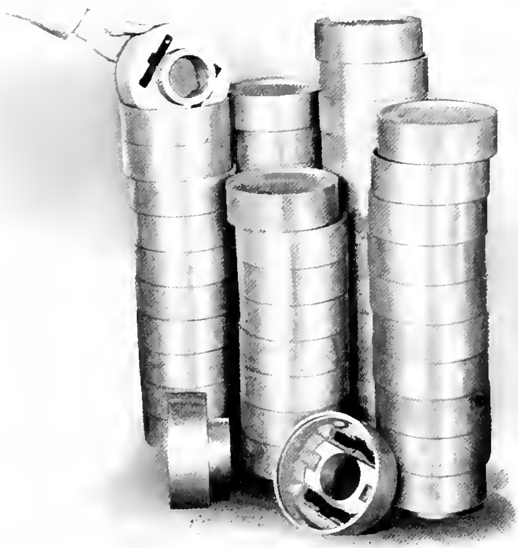


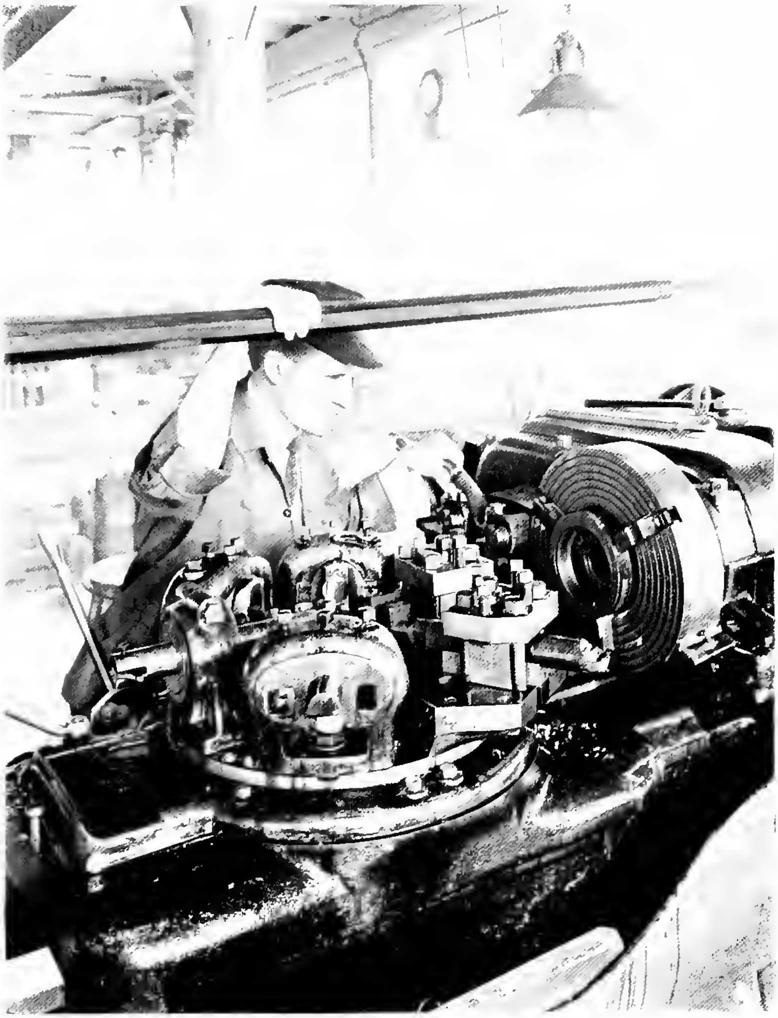




Showing simple arrangement of tools for producing parts of cone friction clutches, broad tools being used for short taper surfaces. This also shows one method of accurately chucking for second operation—a central plug being used for centering the piece.

Samples of work for which the machine shown on opposite page is adjusted





The examples of chuck work, shown on pages 166 to 203, inclusive, indicate the working range of our machine with its standard equipment of tools. With the exception of the chasing attachment, all of the work shown may be accurately and quickly produced with our chucking outfit, and only an occasional extra arbor, or part, that will be readily apparent by looking over the cuts.

AUTOMATIC SCREW CHASING TOOL

The automatic turret chasing tool is for cutting screw threads on chuck work.

It cuts screws of any diameter from 11½ down to 2¼ inches in diameter for internal screws, and about 1 inch for external threads, and any length under 4 inches.

It consists of a compact tool which is rigidly bolted to the top of the turret.

This tool contains a 2-inch sliding cutter bar and a small lead screw with automatic devices for engaging and disengaging the nut. There is also a small rod which furnishes a rotary connection between main spindle of lathe and the lead screw.

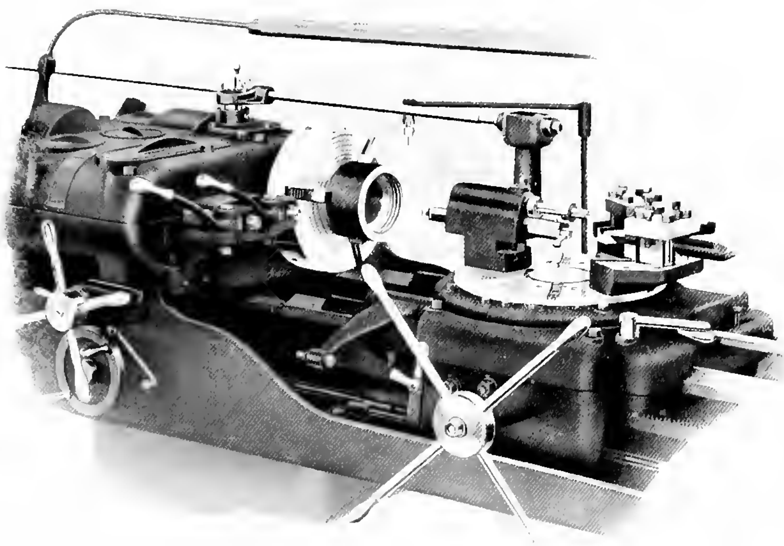
In use the cutter bar carries the cutter or chaser back and forth over the work automatically, while the operator's only duty is to regulate depth of cut by feeding cross sliding head the requisite distance each trip of the tool.

This chasing tool greatly extends the working range of the turret lathe, for it is now possible to include that class of chuck work which was formerly retained by the lathe on account of its having a screw thread.

Much of this work has been distinctly turret lathe work, but on account of the turret lathe having no accurate means of completing all operations, including the screw threading, it has been necessary to have all the work done on the engine lathe.

But now, with this feature, the chuck work with screw threads may have the advantage of the most rapid and accurate scheme of screw cutting, combined with the unflinching tool control and other features for accurate duplication, that may be found in this turret lathe.

An extra lead screw, with nut, is required for each lead, but one set will cut any diameter and either right or left-hand screws.

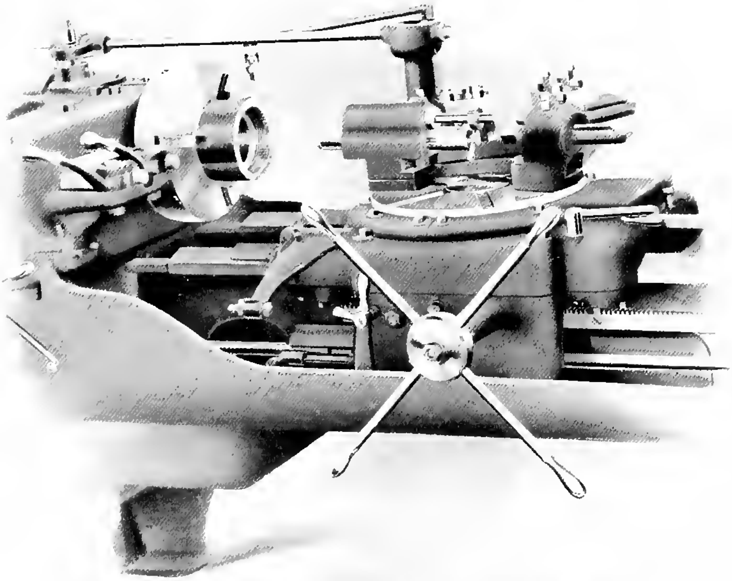


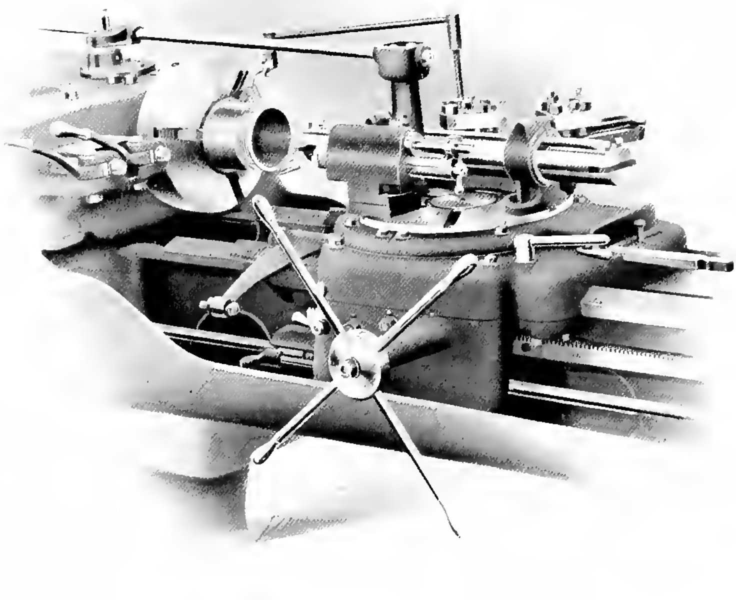
The above cut shows the chasing tool in working operation (some of the other tools have been removed to give a fuller view).

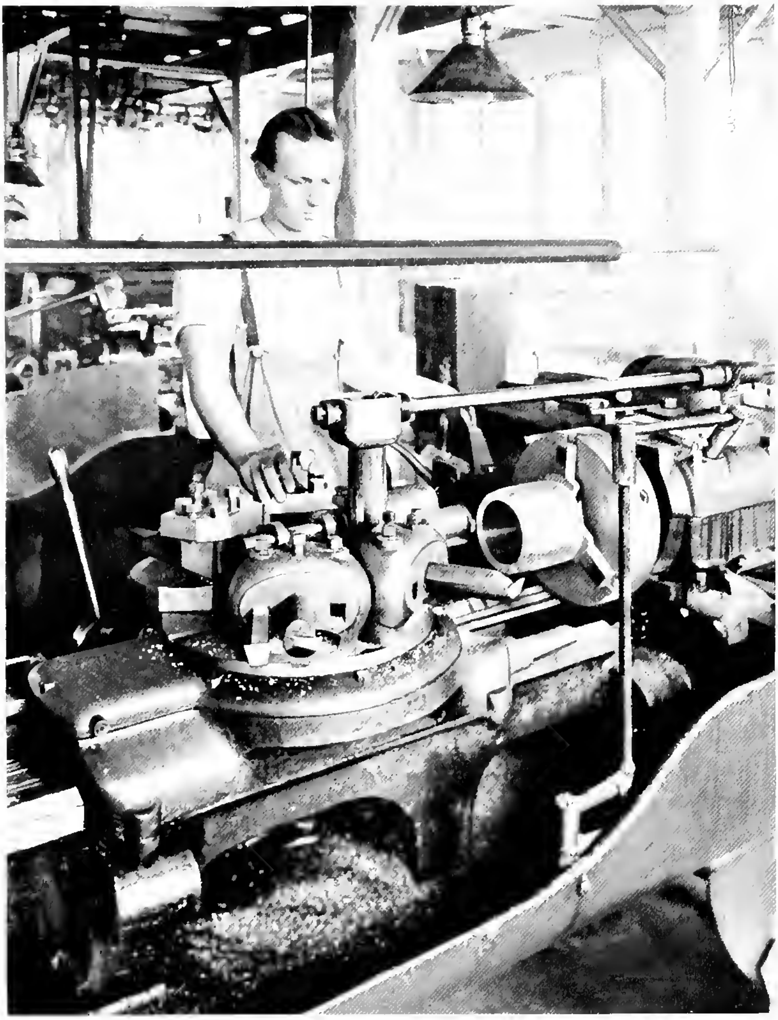
The main casting may be bolted square for parallel screws, or at any angle for taper screws. A removable key fits slot in turret top for holding tool in position for parallel threads.

A chaser-shaped cutter having several cutting teeth is furnished for U. S., V, and Whitworth threads, but we recommend the use of single-point cutters for square and Acme standards; also for all threads that must run full close to a shoulder.

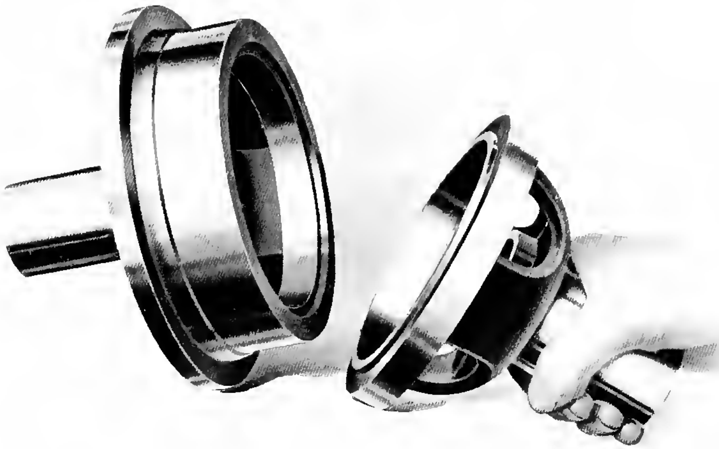
The great advantage of this attachment is in its producing a screw thread which is known to be absolutely true with the other cuts that have been taken at same setting, and, notwithstanding its rapid operation, its accuracy exceeds the product of the average engine lathe.



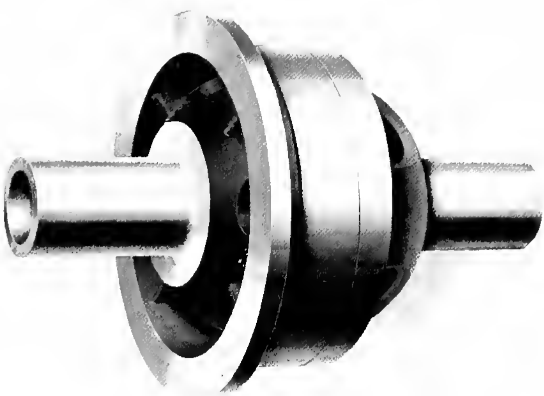




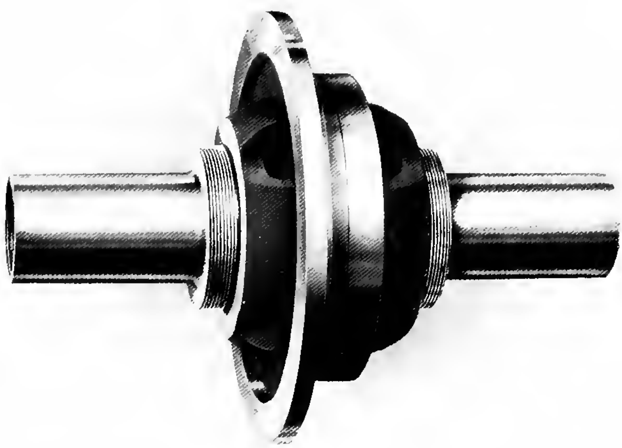
These three views of the chasing tool show its use for three different kinds of work. In the top picture on opposite page it is cutting an inside screw thread and the lower cut illustrates the tool in position for chasing an outside thread.



Samples of Chuck Work



Samples of Chuck Work

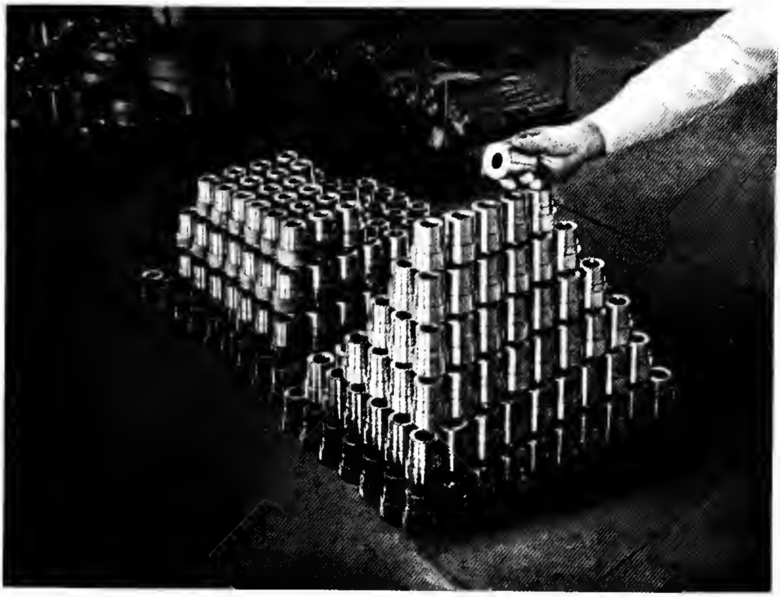


Samples of Chuck Work

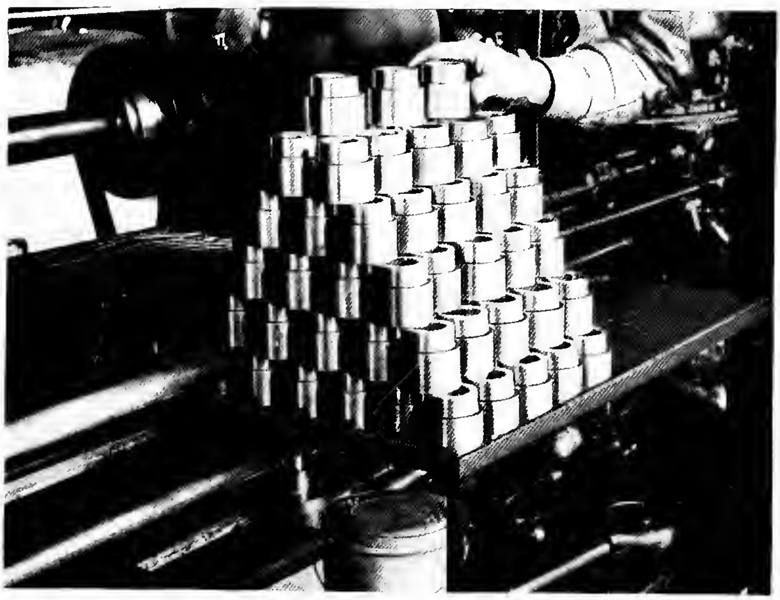
Samples of Chuck Work

Samples of Chuck Work

Samples of Bar Work

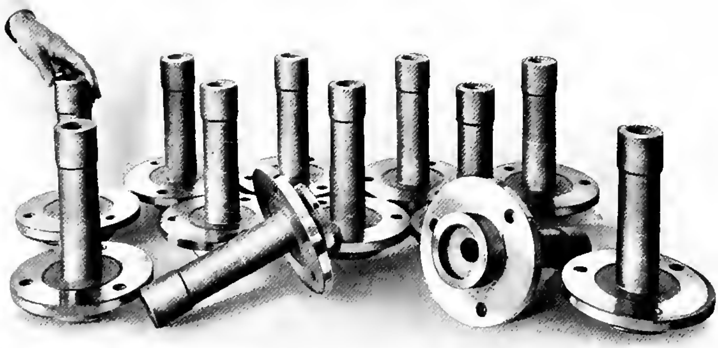


Samples of Bar Work



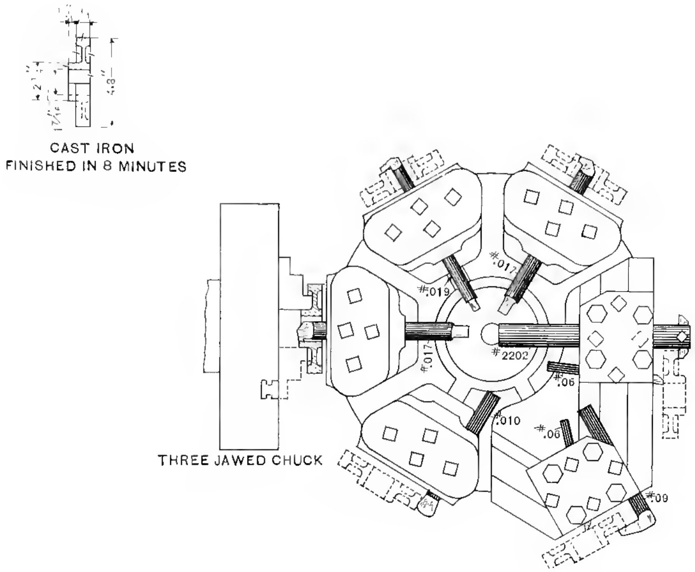
Samples of Bar or Chuck Work

Samples of Chuck Work

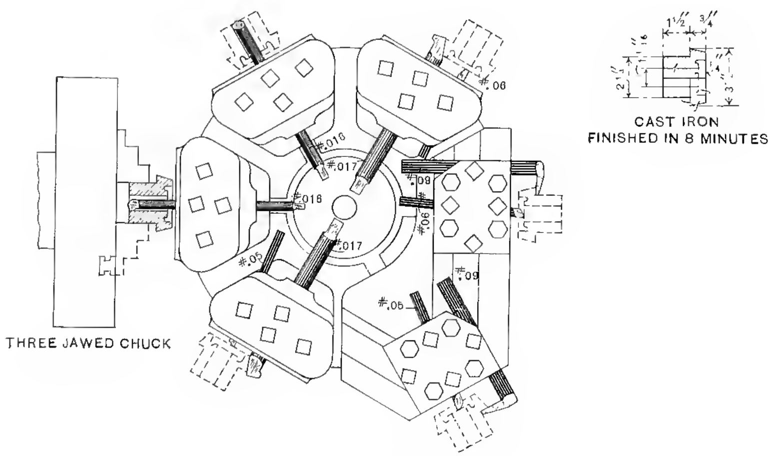


Missing Page

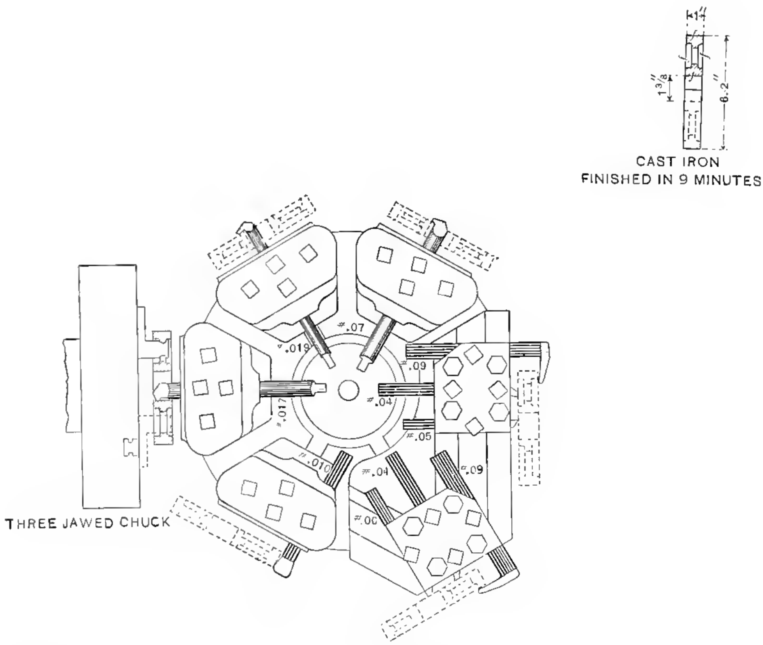
Missing Page



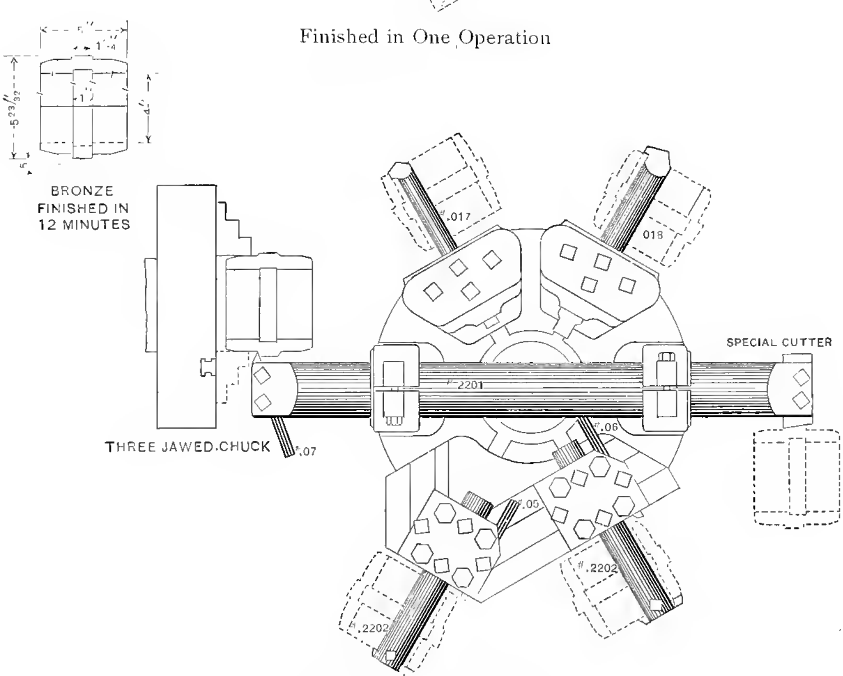
Finished in One Operation



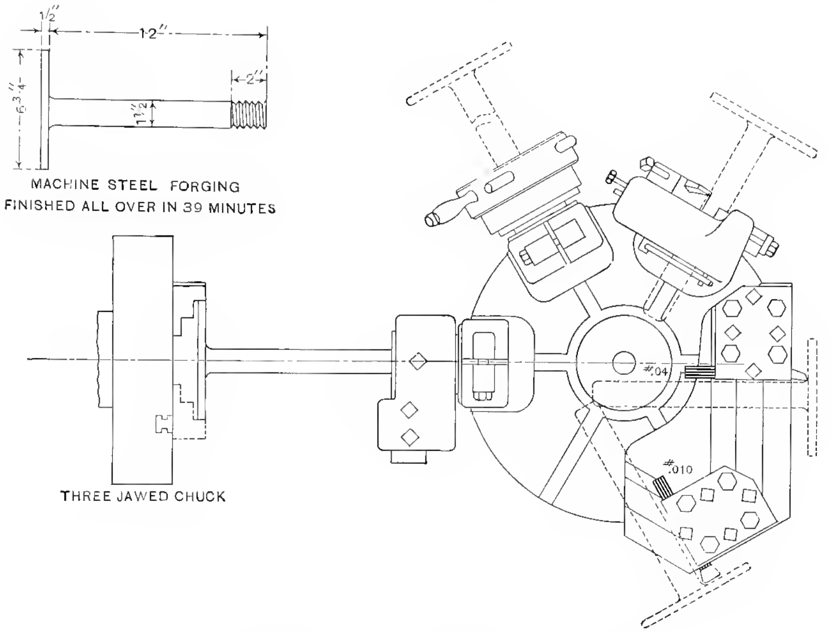
Finished in One Operation



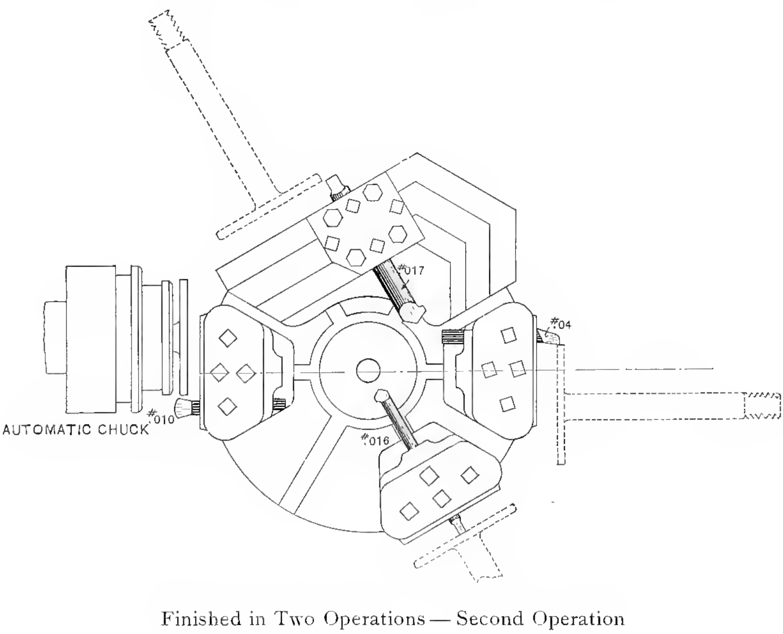
Finished in One Operation



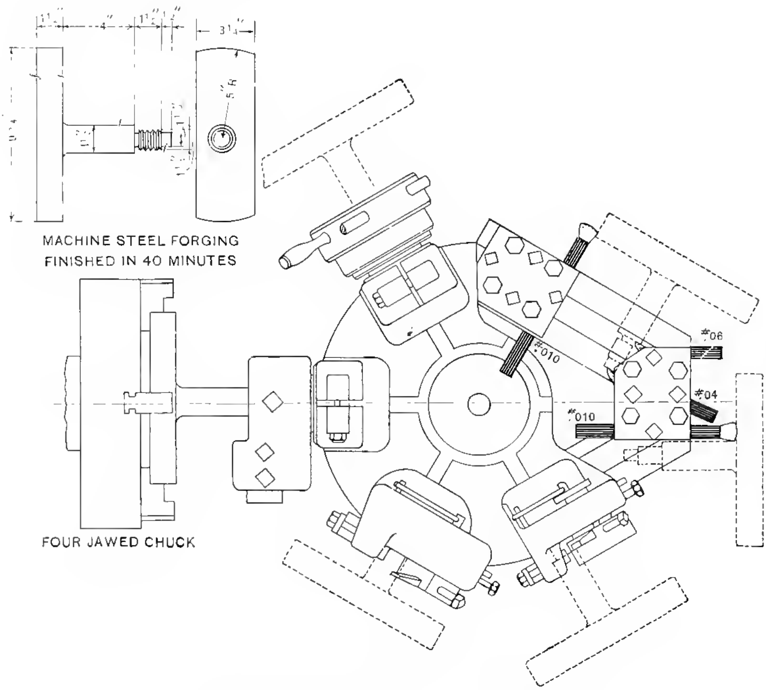
Finished in One Operation



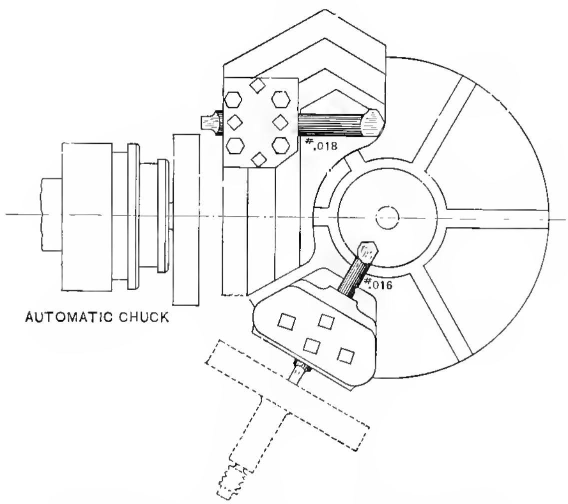
Finished in Two Operations — First Operation



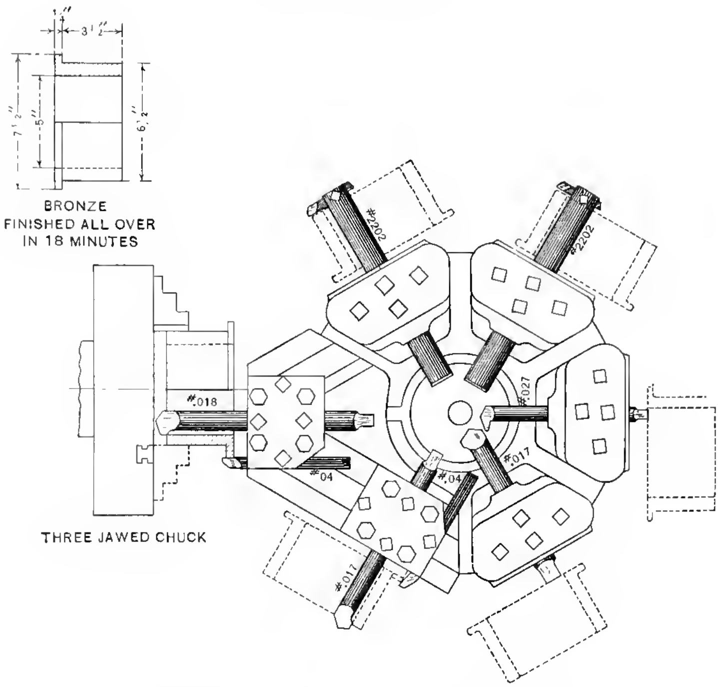
Finished in Two Operations — Second Operation



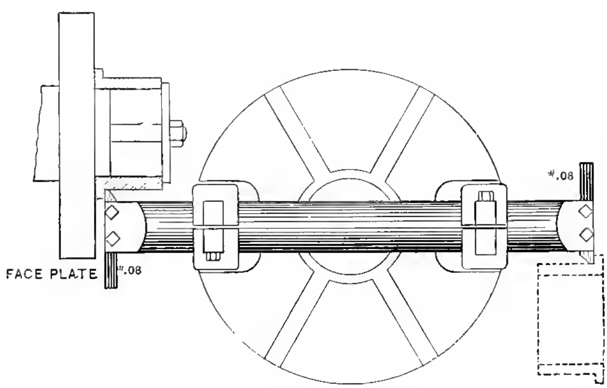
Finished in Two Operations — First Operation



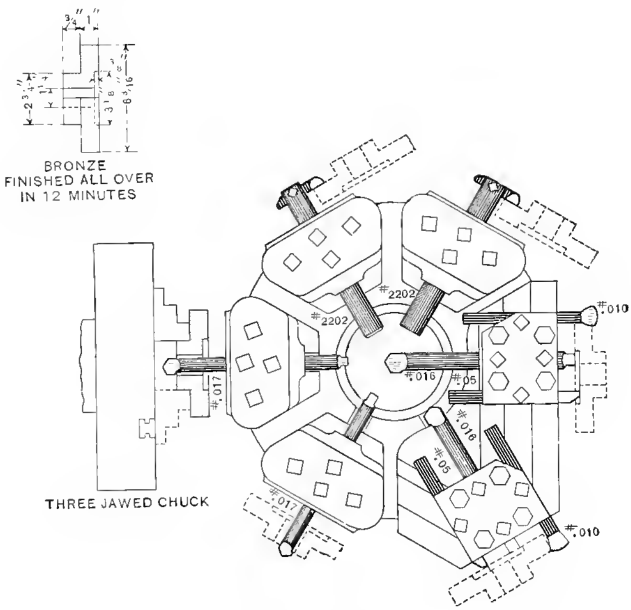
Finished in Two Operations — Second Operation



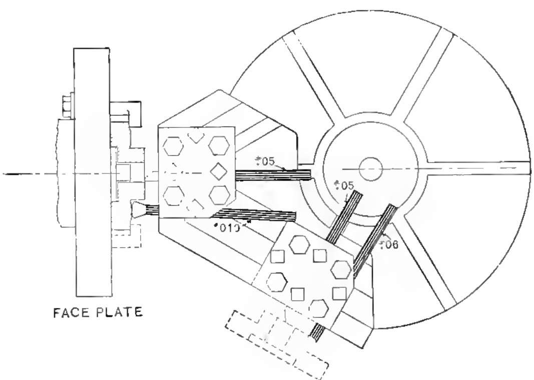
Finished in Two Operations — First Operation



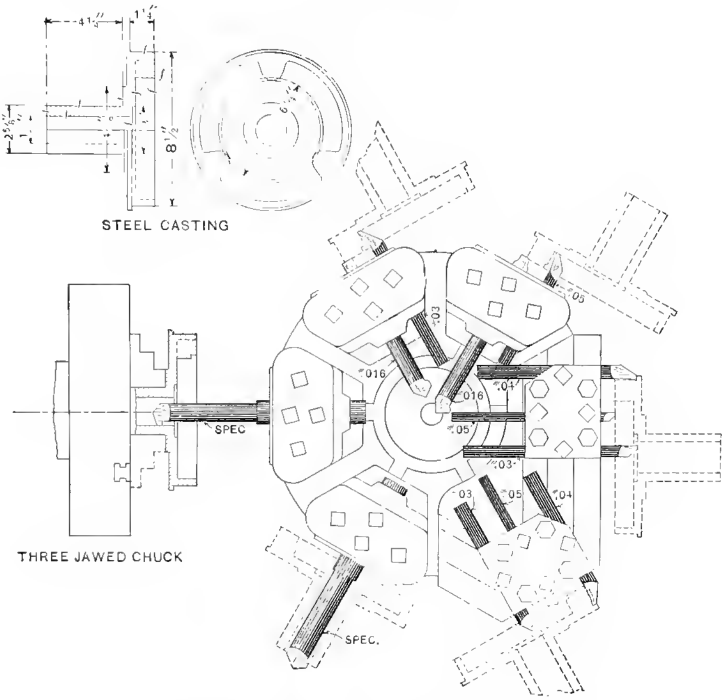
Finished in Two Operations — Second Operation



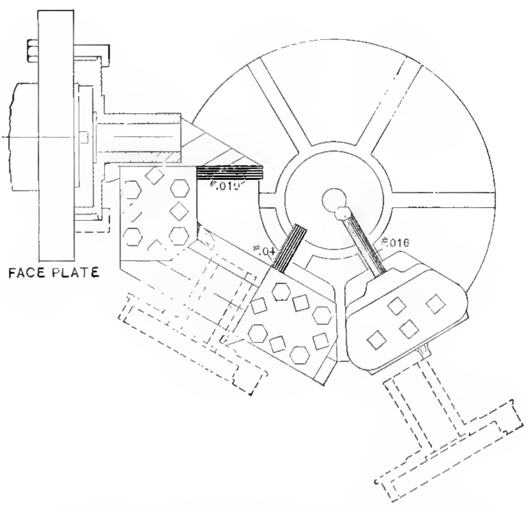
Finished in Two Operations — First Operation



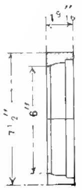
Finished in Two Operations — Second Operation



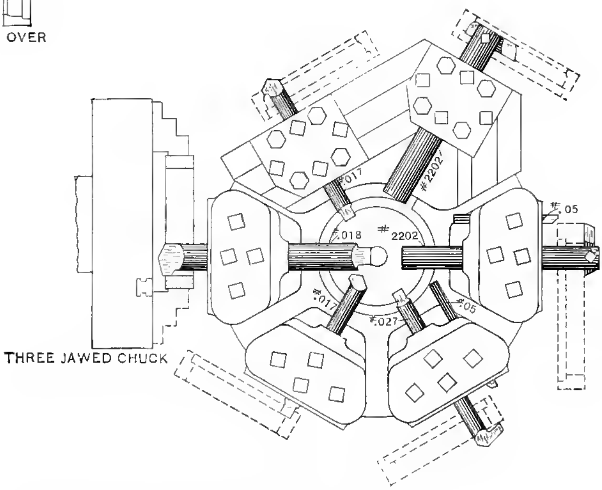
Finished in Two Operations — First Operation



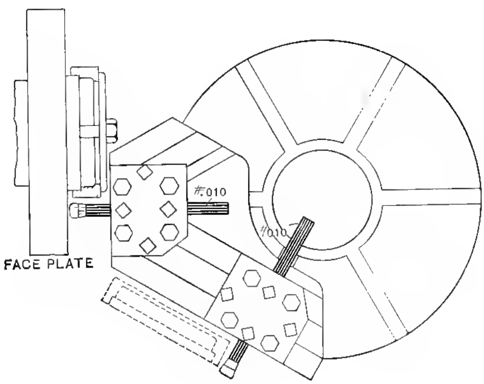
Finished in Two Operations — Second Operation



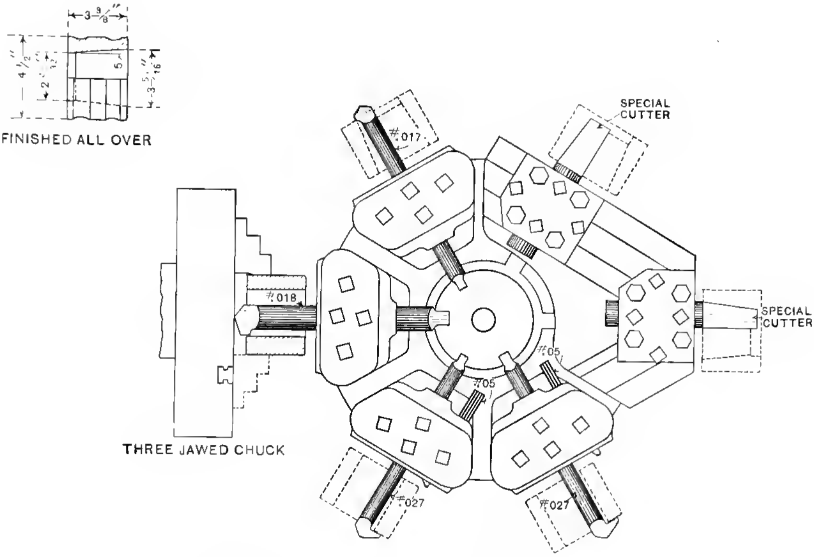
FINISHED ALL OVER



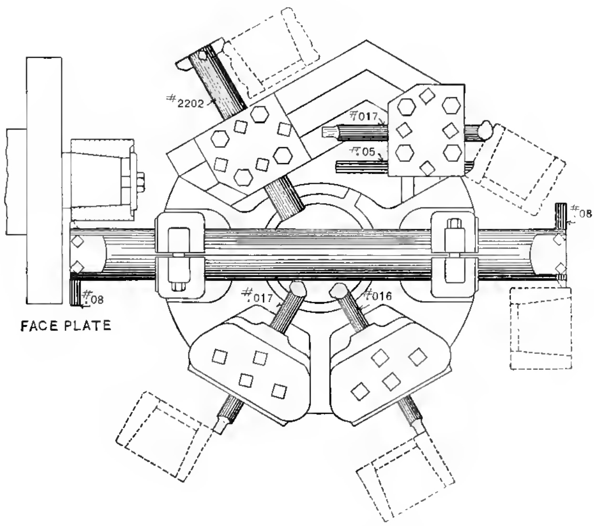
Finished in Two Operations — First Operation



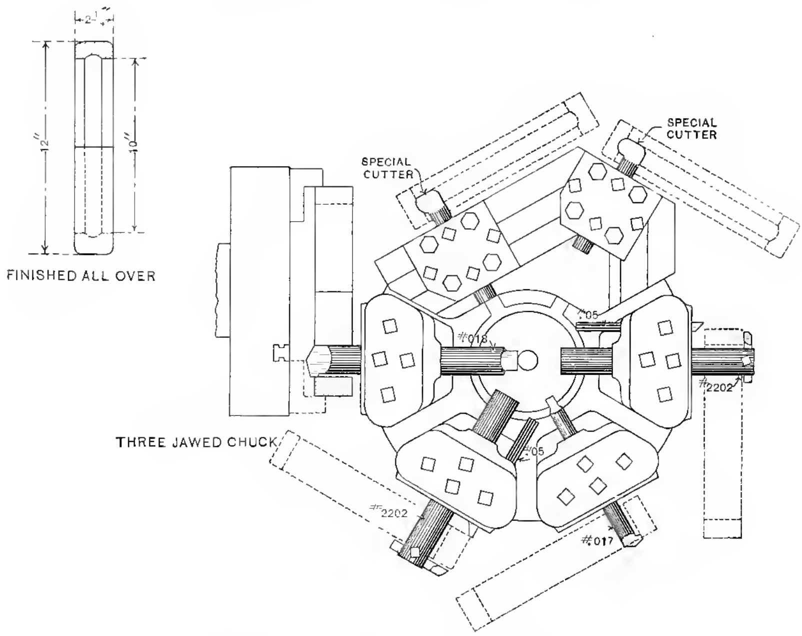
Finished in Two Operations — Second Operation



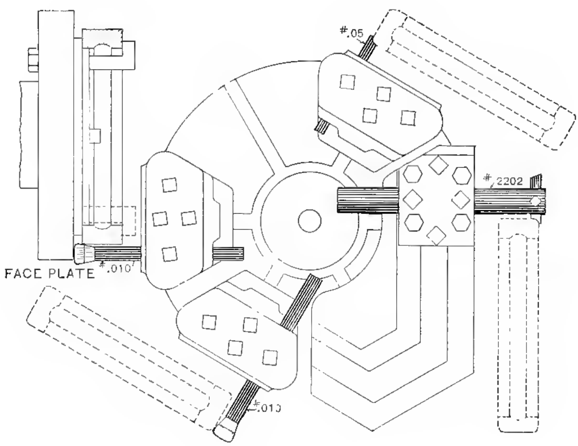
Finished in Two Operations — First Operation



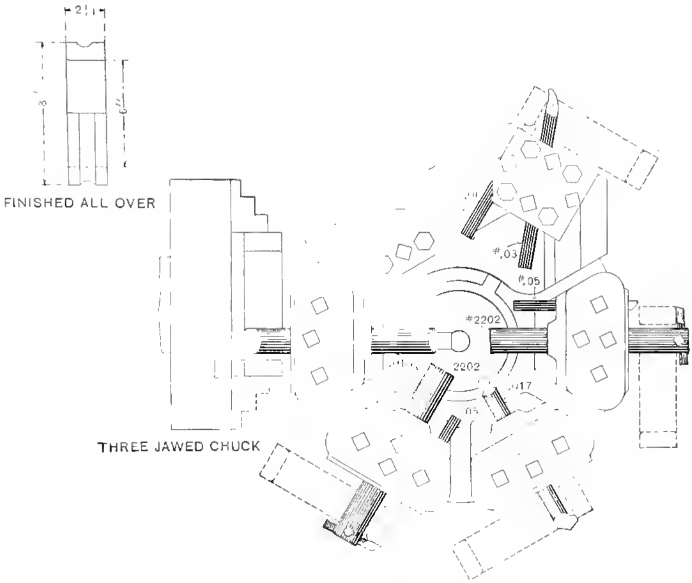
Finished in Two Operations — Second Operation



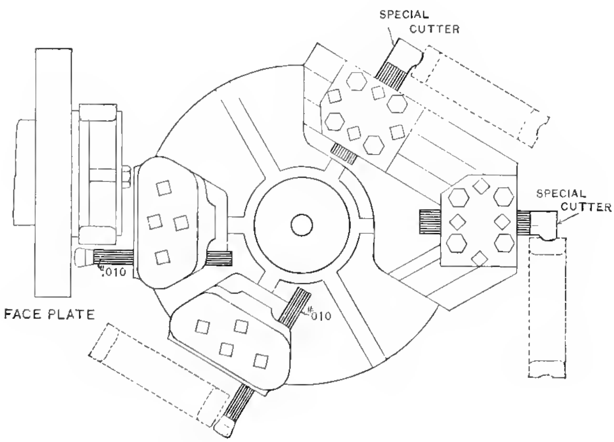
Finished in Two Operations — First Operation



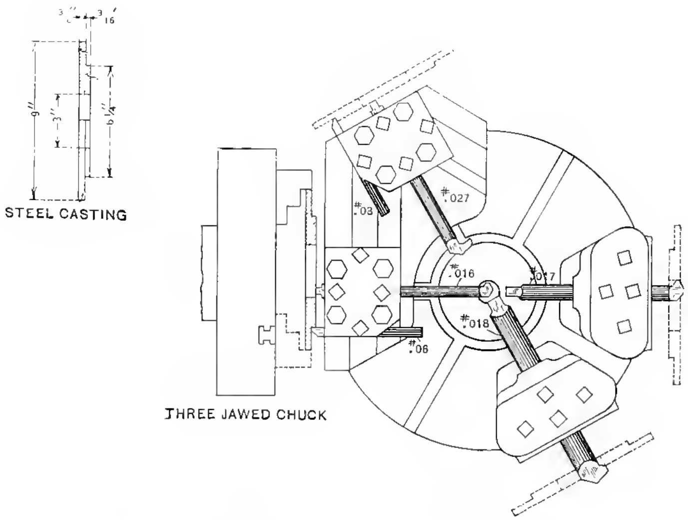
Finished in Two Operations — Second Operation



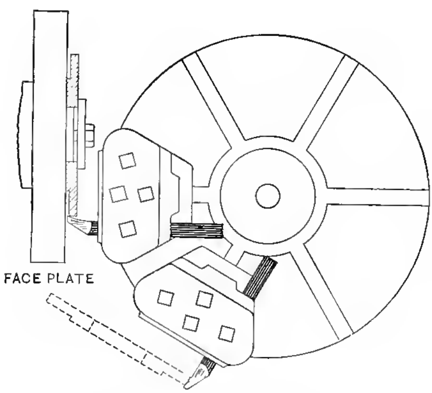
Finished in Two Operations — First Operation



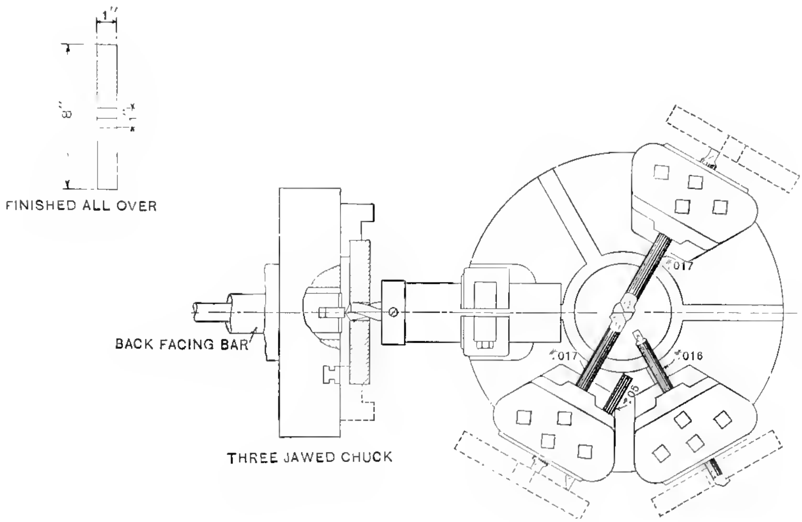
Finished in Two Operations — Second Operation



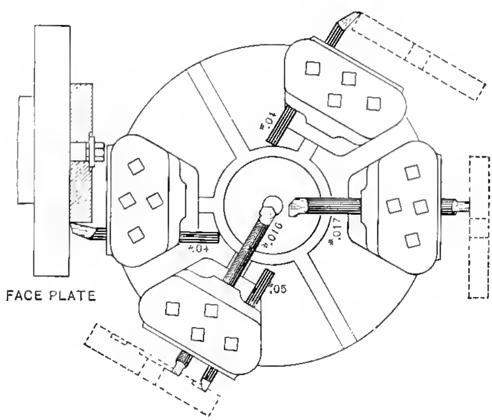
Finished in Two Operations — First Operation



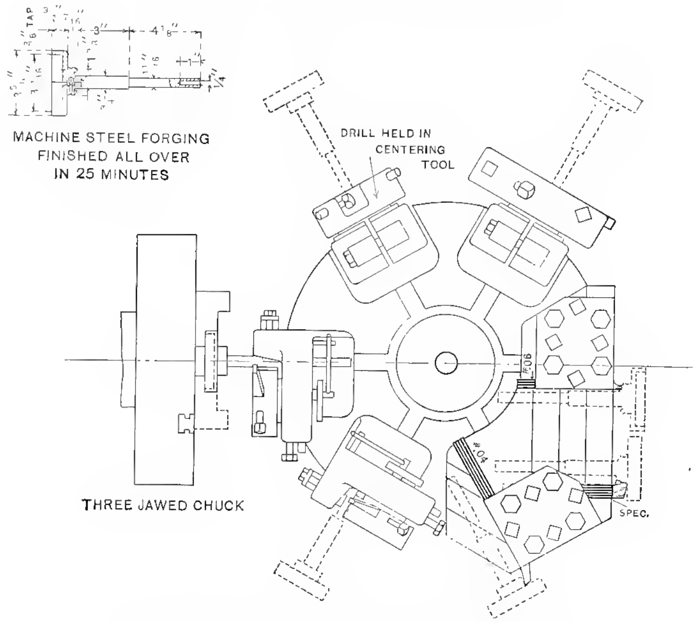
Finished in Two Operations — Second Operation



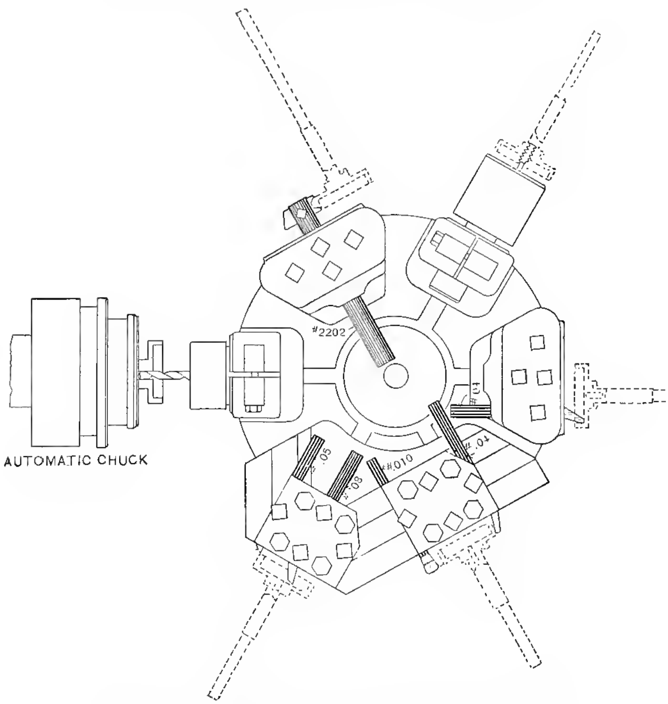
Finished in Two Operations — First Operation



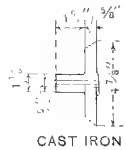
Finished in Two Operations — Second Operation

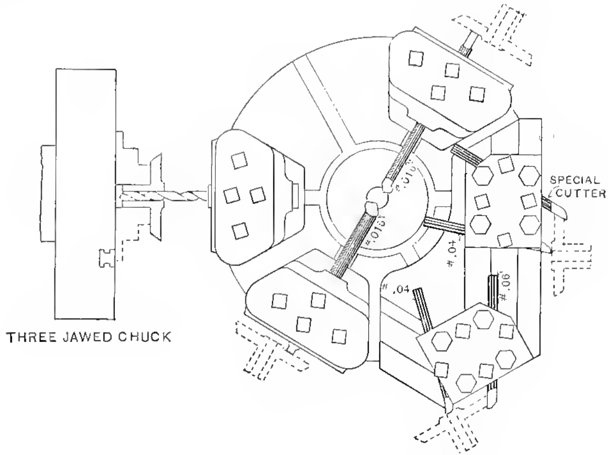


Finished in Two Operations — First Operation

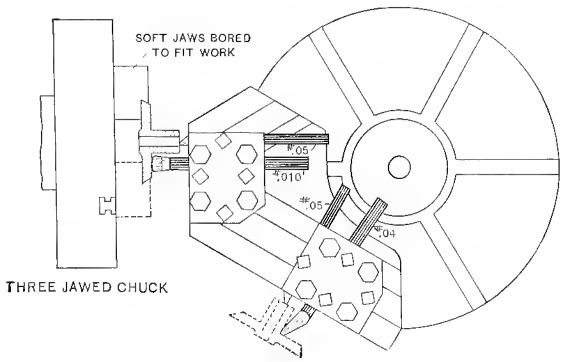


Finished in Two Operations — Second Operation

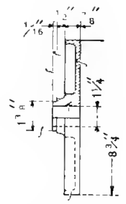




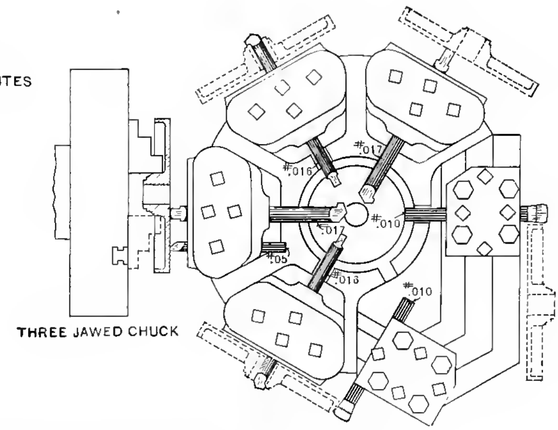
Finished in Two Operations — First Operation



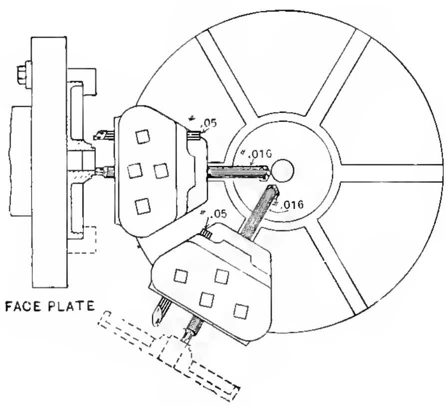
Finished in Two Operations — Second Operation



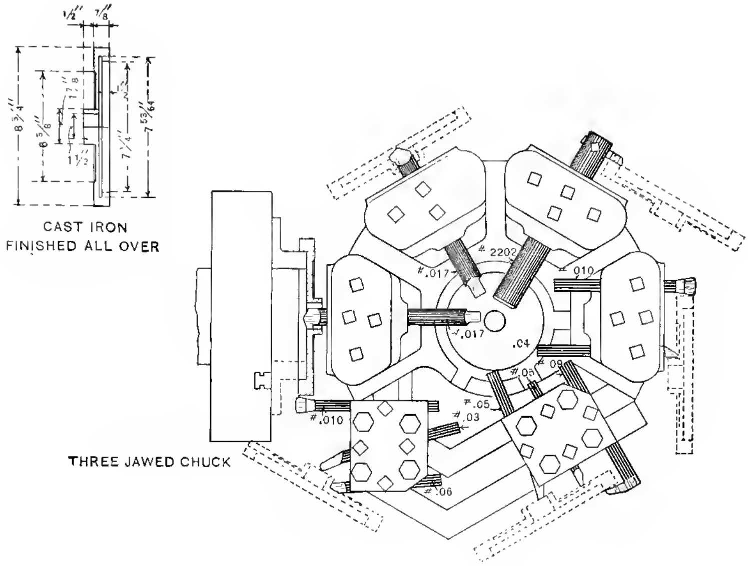
CAST IRON
FINISHED IN 15 MINUTES



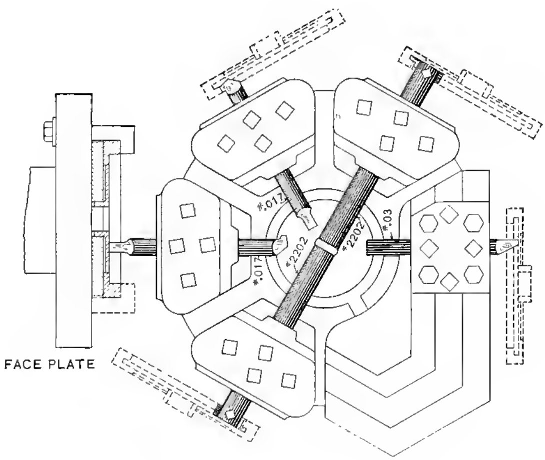
Finished in Two Operations — First Operation



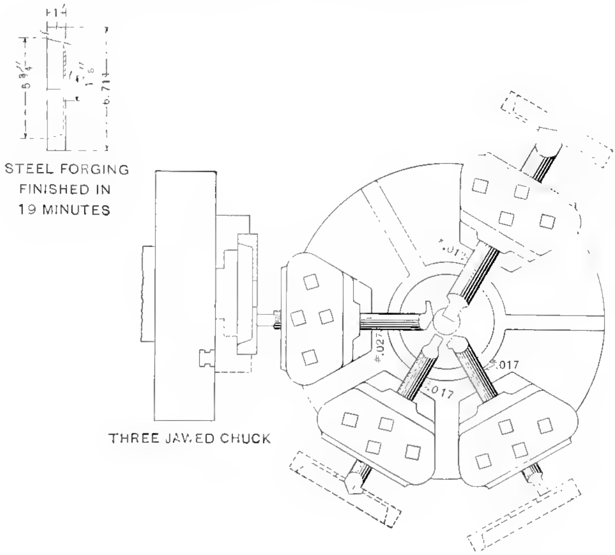
Finished in Two Operations — Second Operation



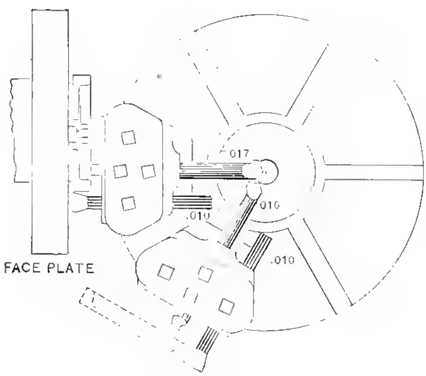
Finished in Two Operations — First Operation



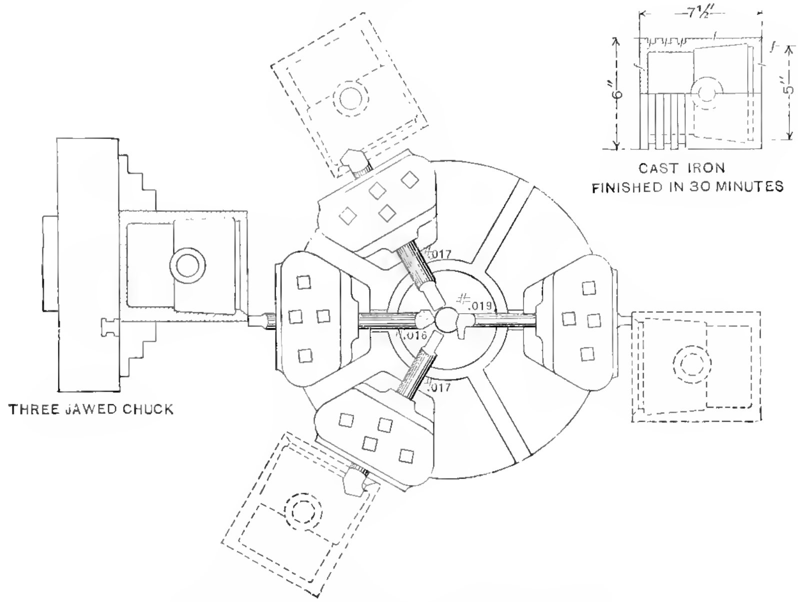
Finished in Two Operations — Second Operation



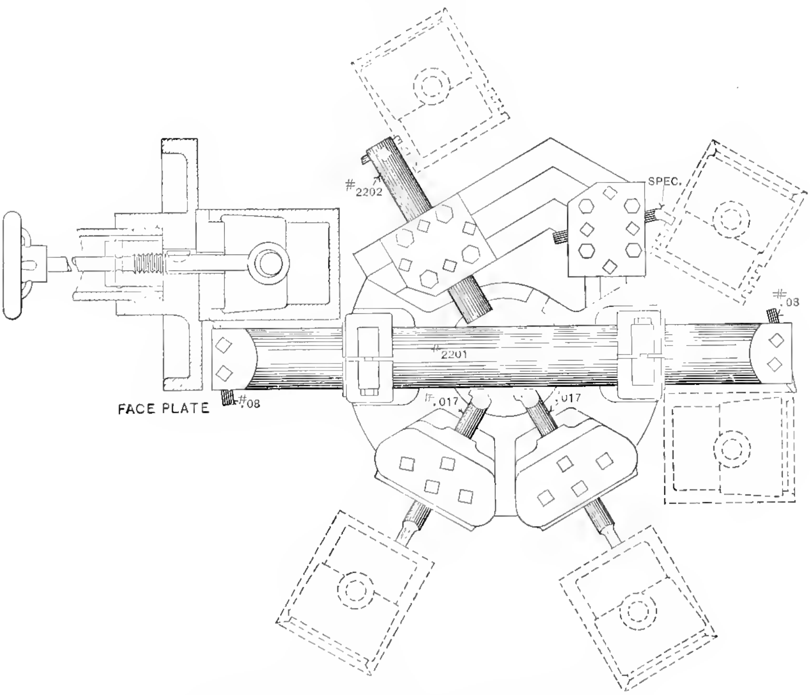
Finished in Two Operations — First Operation



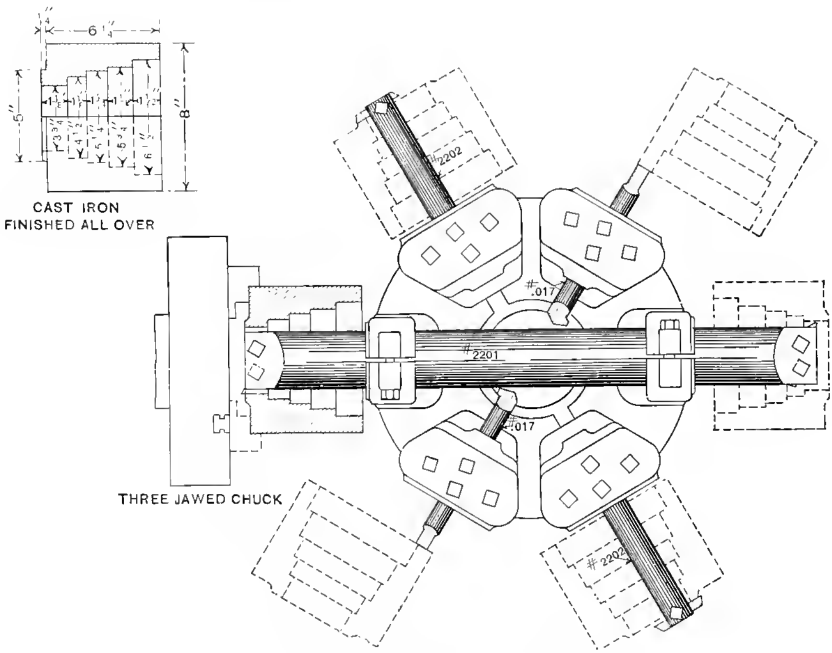
Finished in Two Operations — Second Operation



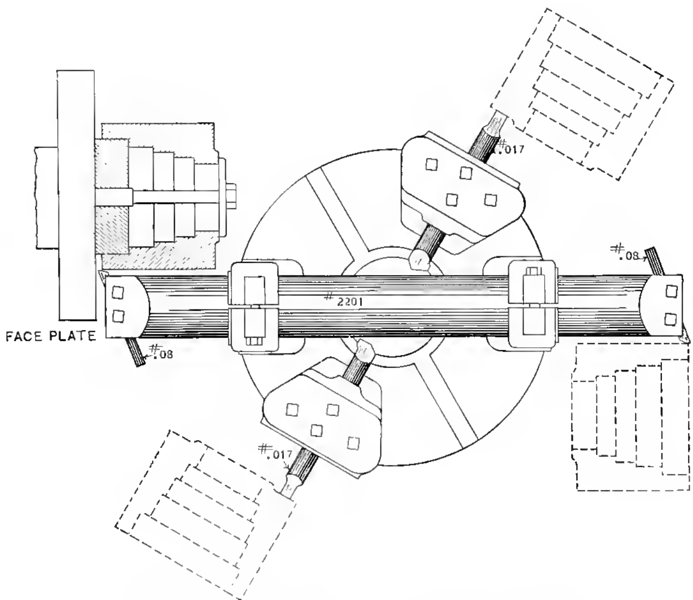
Finished in Two Operations — First Operation



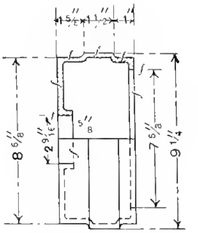
Finished in Two Operations — Second Operation



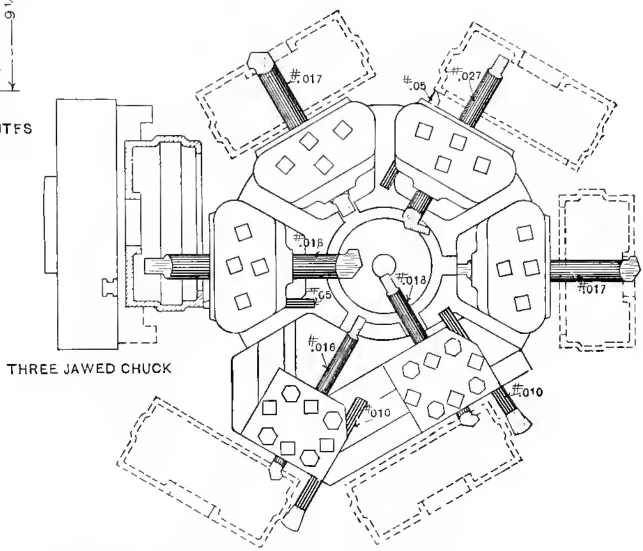
Finished in Two Operations — First Operation



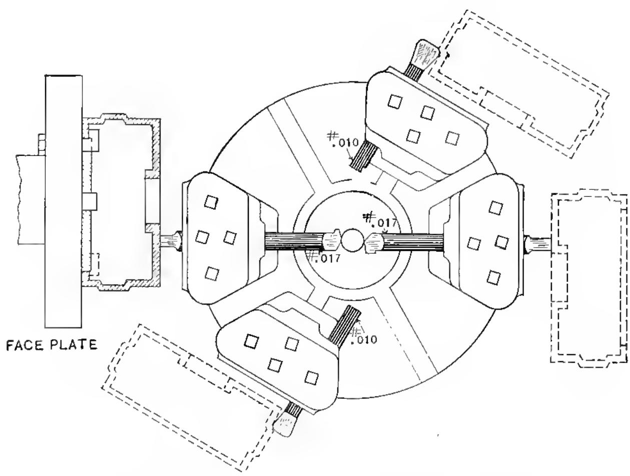
Finished in Two Operations — Second Operation



CAST IRON
FINISHED IN 24 MINUTES



Finished in Two Operations—First Operation



Finished in Two Operations—Second Operation

DETAILS OF OUTFIT OF TOOLS FOR BAR WORK UP TO 2¼-INCH BAR

The Machine One 2 x 24-inch Flat Turret Lathe, cross-feed head, single drive, four tool holders, three stock supports, oil pump and piping, friction countershaft, cast-iron table for holding tools, etc., and suitable wrenches.

Parts for Handling the Bar of Stock Automatic chuck and roller feed. Fifteen sets of jaws for chuck, holding all sizes from ½ inch to 2¼ inches in diameter, inclusive.

Turning Tools One chip breaking turner (Model K) with four independent adjustments for each back rest and cutter. One double size turning roller back rest turner (Model H) and one Model B turner without roller rests — all adjustable to sizes from 2¼ inches down. One cross slide for holding cutting-off and forming tools. One pointing tool, one centering tool, one drill chuck.

Screw Thread Cutting One 1¼-inch automatic (opening) die, with 15 sets of chasers for cutting all U. S. S. threads ⅜ inch to 1¼ inches in diameter, inclusive, by sixteenths.

All the above may be briefly described as 2 x 24-inch Flat Turret Lathe, with the automatic die outfit (outfit D).

DETAILS OF 2 X 24-INCH FLAT TURRET LATHE WITH CHUCKING OUTFIT FOR WORK UP TO 12 INCHES DIAMETER

The Machine One 2 x 24 by 12-inch swing Flat Turret Lathe, cross-feed head, single drive, four tool holders, oil pump and piping, friction countershaft, cast-iron table for holding tools, etc., and suitable wrenches.

Chucking Tools One 12-inch face plate, with hook bolts and clamp blocks. One 12-inch 3-jawed scroll chuck with two sets 3-step jaws for in and outside gripping, one set long-necked jaws for inside gripping, and one set soft blank jaws that may be turned to fit any special form.

Four tool blocks.
One combination tool plate with clamp blocks.
One dozen outside turning cutters.
Seven inside boring and turning cutters.
Two 1½-inch round boring bars with four cutters.
One 3$\frac{7}{16}$-inch round boring bar.
Two square cutter bars with two cutters.
One extension drill support, with four sockets for standard taper shanks.

All the above may be briefly described as the 2 x 24-inch Flat Turret Lathe, with chucking outfit (outfit C).

For chuck work requiring chased threads the turret chasing tool should be added to chucking outfit. It should have one set of lead screw, nut and cutter for each pitch.

DOUBLE OUTFIT FOR BAR AND CHUCK WORK: FOR BAR WORK UP TO 2¼ INCHES DIAMETER AND 24 INCHES IN LENGTH AND CHUCK WORK UP TO THE 12-INCH SWING CAPACITY

The Machine One 2 x 24-inch Flat Turret Lathe, cross-feed head, single drive, four tool holders, three stock supports, oil pump and piping, friction countershaft, cast-iron table for holding tools, etc., and suitable wrenches.

Parts for Handling the Bar of Stock Automatic chuck and roller feed. Fifteen sets of jaws for chuck, holding all sizes from ½ inch to 2¼ inches in diameter, inclusive.

Turning Tools One chip breaking turner (Model K) with four independent adjustments for each back rest and cutter. One double size turning roller back rest turner (Model H) and one Model B turner without roller rests—all adjustable to sizes from 2¼ inches down. One cross slide for holding cutting-off and forming tools. One pointing tool, one centering tool, one drill chuck.

Screw Thread Cutting One 1¼-inch automatic (opening) die, with 15 sets of chasers for cutting all U. S. S. threads ⅜ inch to 1¼ inches in diameter, inclusive, by sixteenths.

Chucking Tools One 12-inch face plate, with hook bolts and clamp blocks. One 12-inch 3-jawed scroll chuck with two sets 3-step jaws for in and outside gripping, one set long-necked jaws for inside gripping, and one set soft blank jaws that may be turned to fit any special form.

Four tool blocks.
One combination tool plate with clamp blocks.
One dozen outside turning cutters.
Seven inside boring and turning cutters.
Two 1½-inch round boring bars with four cutters.
One $3\frac{7}{16}$-inch round cutter bar for turning and boring.
Two square cutter bars with two cutters.
One extension drill support with four sockets for standard taper shanks.

All the above may be briefly described as 2 x 24-inch Flat Turret Lathe, with automatic die and chucking outfits (outfits D and C).

For chuck work requiring chased threads, the turret chasing tool should be added to the chucking outfit. It should have one set of lead screw, nut and cutter for each pitch.

DETAILS OF OUTFIT OF TOOLS FOR BAR WORK HANDLING FULL LENGTH BARS UP TO 3 INCHES DIAMETER—TURNING ALL DIAMETERS UP TO 3 INCHES AND THREADING UP TO 2 INCHES DIAMETER

The Machine One 3 x 36-inch Flat Turret Lathe, cross-feed head, single drive, four tool holders, three stock supports, oil pump and piping, friction countershaft, cast-iron table for holding tools, etc., and suitable wrenches.

Parts for Handling the Bar of Stock Automatic chuck and roller feed. Seventeen sets of jaws for chuck, holding all sizes from 1 inch to 3 inches in diameter, inclusive.

Turning Tools One chip breaking turner (Model K) with four independent adjustments for each back rest and cutter. One double size turning roller back rest turner (Model H) and one Model B turner without roller rests—all adjustable to sizes from 3 inches down. One cross slide for holding cutting-off and forming tools. One pointing tool, one centering tool, one drill chuck.

Screw Thread Cutting One 2-inch automatic (opening) die, with 9 sets of chasers for cutting all U. S. S. threads 1 inch to 2 inches in diameter, inclusive, by eighths.

All the above may be briefly described as 3 x 36-inch Flat Turret Lathe, with the automatic die outfit (outfit D).

DETAILS OF 3 X 36-INCH FLAT TURRET LATHE CHUCKING OUTFIT FOR WORK UP TO 14 INCHES DIAMETER

The Machine One 3 x 36 by 14-inch swing Flat Turret Lathe, cross-feed head, single drive, four tool holders, oil pump and piping, friction countershaft, cast-iron table for holding tools, etc., and suitable wrenches.

Chucking Tools One 14-inch face plate, with hook bolts and clamp blocks. One 14-inch 3-jawed scroll chuck with two sets 3-step jaws for in and outside gripping, one set long-necked jaws for inside gripping, and one set soft blank jaws that may be turned to fit any special form.

Four tool blocks.
One combination tool plate with clamp blocks.
One dozen outside turning cutters.
Seven inside boring and turning cutters.
Two 1½-inch round boring bars with four cutters.
One $3\frac{7}{16}$-inch round boring bar.
Two square cutter bars with two cutters.
One extension drill support, with four sockets for standard taper shanks.

All the above may be briefly described as the 3 x 36-inch Flat Turret Lathe, with chucking outfit (outfit C).

For chuck work requiring chased threads the turret chasing tool should be added to chucking outfit. It should have one set of lead screw, nut and cutter for each pitch.

DOUBLE OUTFIT FOR BAR WORK UP TO 3 INCHES DIAMETER AND 36 INCHES IN LENGTH AND CHUCK WORK UP TO 14-INCH SWING CAPACITY

The Machine One 3 x 36-inch Flat Turret Lathe, cross-feed head, single drive, four tool holders, three stock supports, oil pump and piping, friction countershaft, cast-iron table for holding tools, etc., and suitable wrenches.

Parts for Handling the Bar of Stock Automatic chuck and roller feed. Seventeen sets of jaws for chuck, holding all sizes from 1 inch to 3 inches in diameter, inclusive.

Turning Tools One chip breaking turner (Model K) with four independent adjustments for each back rest and cutter. One double size turning roller back rest turner (Model H) and one Model B turner without roller rests—all adjustable to sizes from 3 inches down. One cross slide for holding cutting-off and forming tools. One pointing tool, one centering tool, one drill chuck.

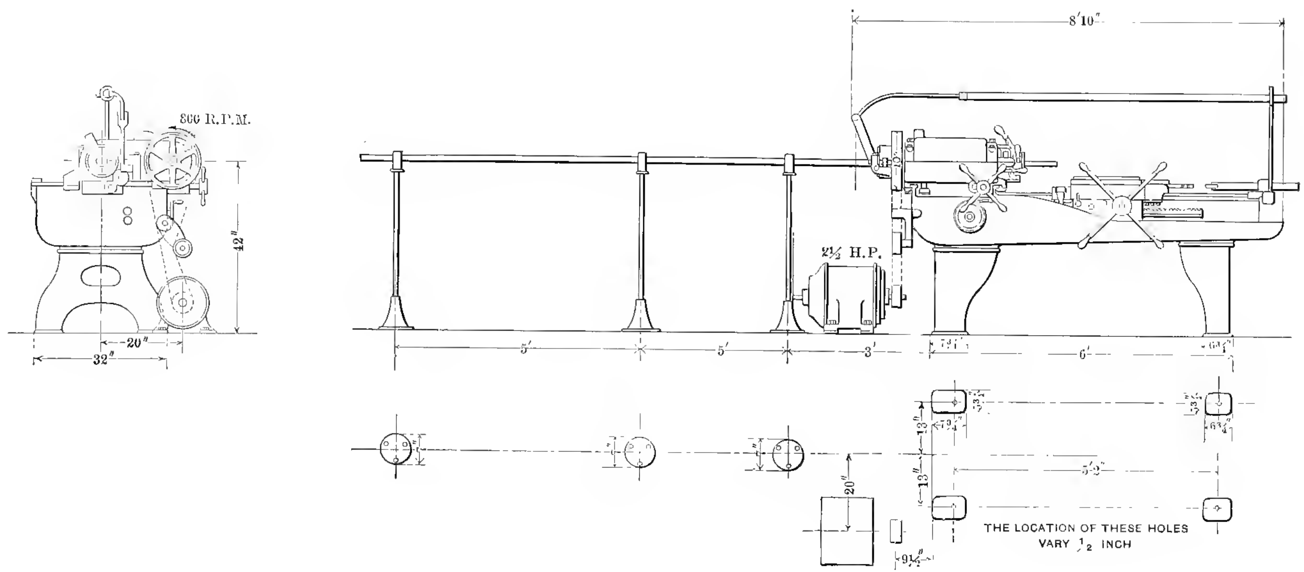
Screw Thread Cutting One 2-inch automatic (opening) die, with 9 sets of chasers for cutting all U. S. S. threads 1 inch to 2 inches in diameter, inclusive, by eighths.

Chucking Tools One 14-inch face plate, with hook bolts and clamp blocks. One 14-inch 3-jawed scroll chuck with two sets 3-step jaws for in and outside gripping, one set long-necked jaws for inside gripping, and one set soft blank jaws that may be turned to fit any special form.

Four tool blocks.
One combination tool plate with clamp blocks.
One dozen outside turning cutters.
Seven inside boring and turning cutters.
Two $1\frac{1}{2}$-inch round boring bars with four cutters.
One $3\frac{7}{16}$-inch round cutter bar for turning and boring.
Two square cutter bars with two cutters.
One extension drill support with four sockets for standard taper shanks.

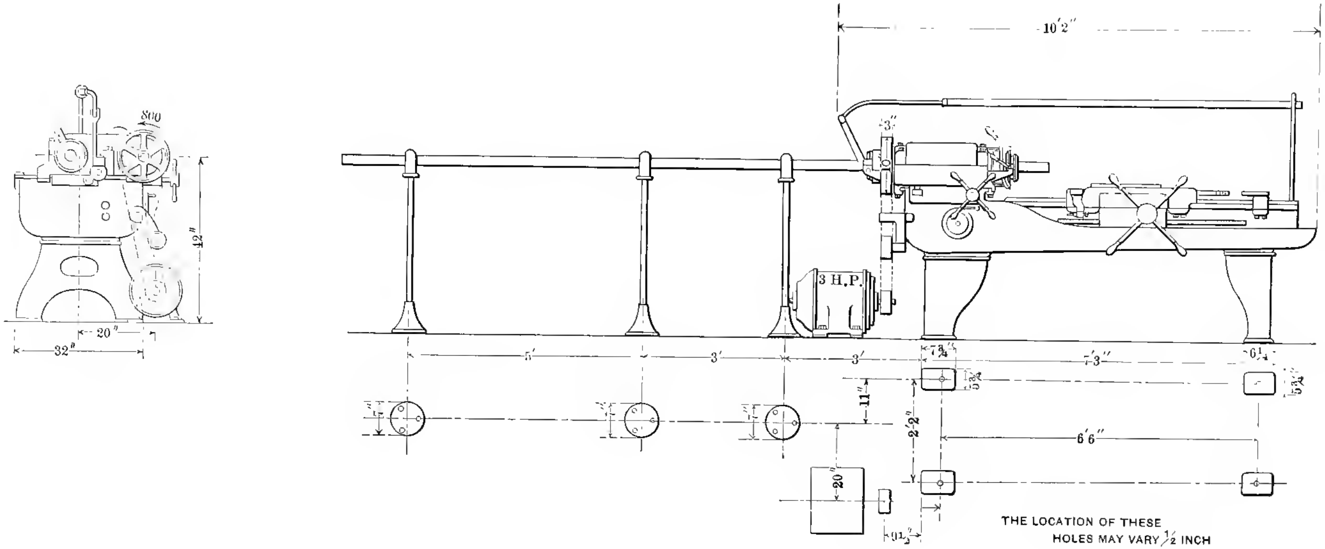
All the above may be briefly described as 3 x 36-inch Flat Turret Lathe, with automatic die and chucking outfits (outfits D and C).

For chuck work requiring chased threads, the turret chasing tool should be added to the chucking outfit. It should have one set of lead screw, nut and cutter for each pitch.



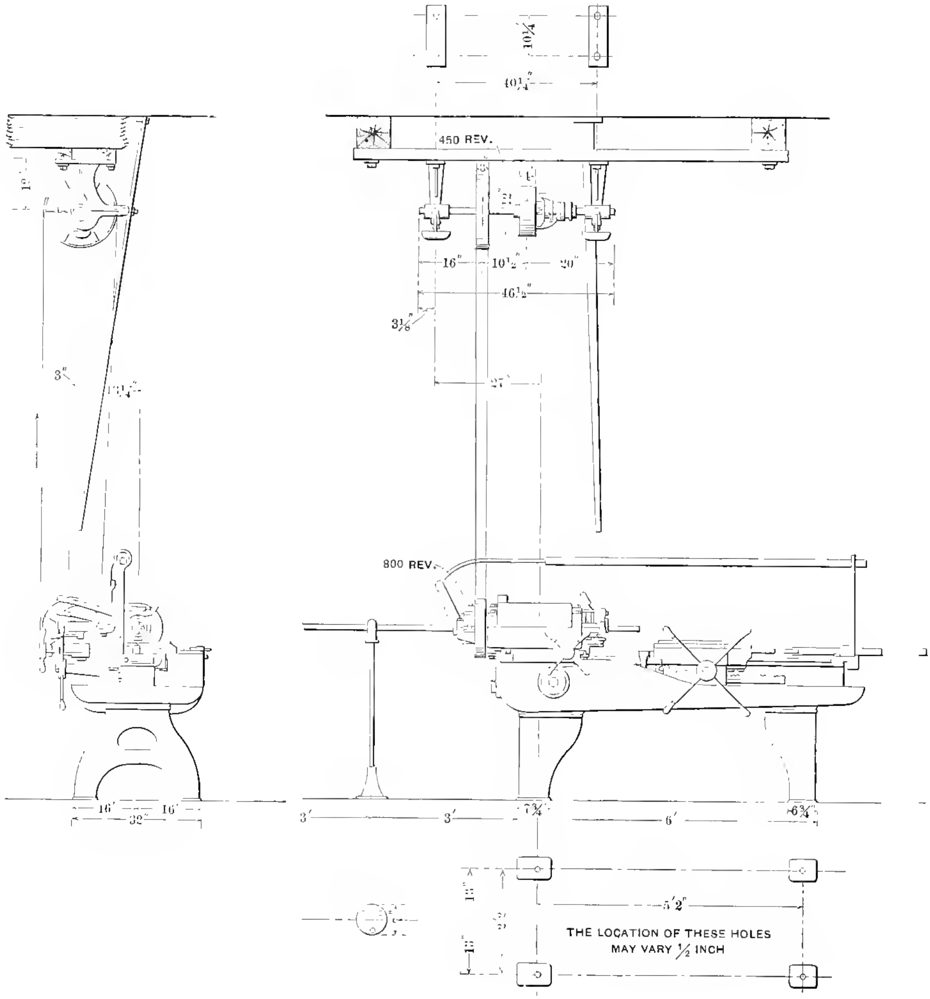
2 x 24-inch with Electric Motor

The motor is bolted to floor and an idler pulley running on slack side of belt compensates for the change in center distance as the sliding head travels. The starting box may be attached to the face of the machine or to the iron work table which accompanies each machine having the chucking or bar outfit. Any constant-speed motor may be used. No variation in speed is required in the motor, neither is it necessary to reverse the motor, for all such changes are obtained by mechanism in the head. See page 212 for self-contained motor drive.



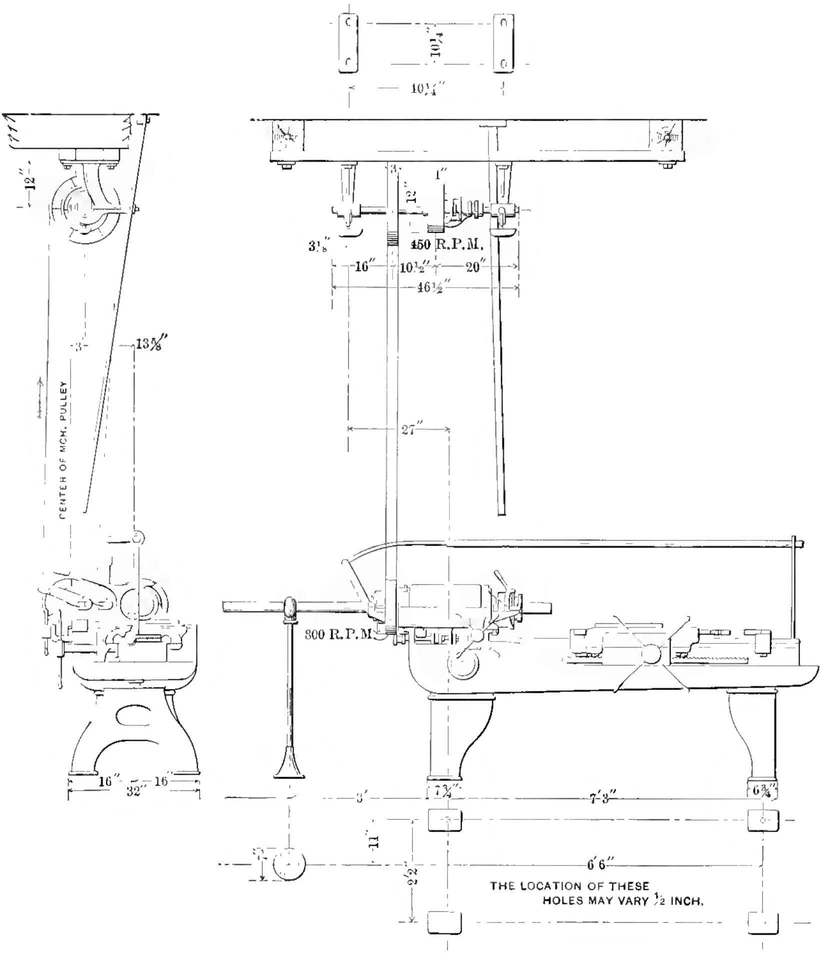
3 x 36-inch With Electric Motor

Electric drive is shown on this and opposite page. The starting box may be attached to the face of the machine or to the iron work table which accompanies each machine having the chucking or bar outfit. Any constant-speed motor may be used. No variation in speed is required in the motor, neither is it necessary to reverse the motor, for all such changes are obtained by mechanism in the head The motor is bolted to the floor and an idler pulley running on slack side of belt compensates for the change in center distance as the sliding head travels See page 212 for self-contained motor drive.



Plan for Setting up 2 x 24-inch Flat Turret Lathe with Countershaft

Three stock supports are furnished and should be located as shown in cut on page 208



Plan for Setting up 3 x 36-inch Flat Turret Lathe with Countershaft

Three stock supports are furnished and should be located as shown in cut on page 209

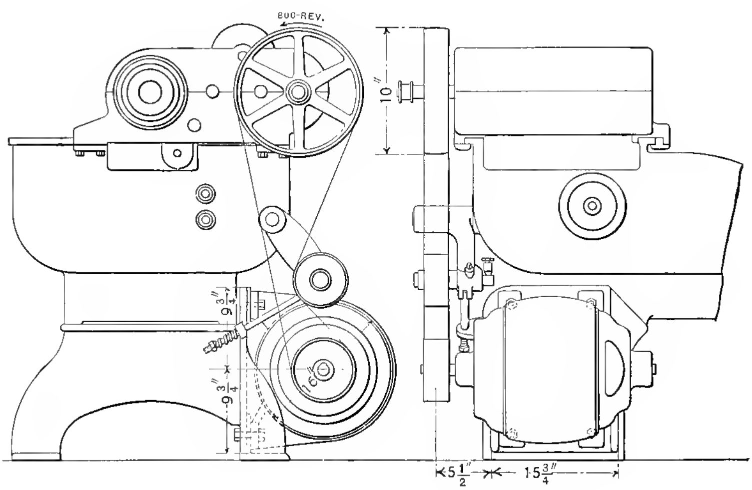
SPECIAL ELECTRIC DRIVE WITH MOTOR ATTACHED TO MACHINE

The regular machine is driven by an electric motor as shown on pages 208 and 209.

This special electric drive is intended to meet the demand for motor attached to machine.

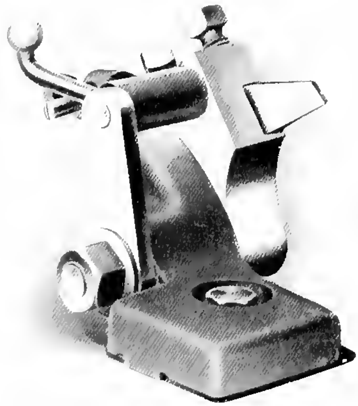
This scheme of drive requires a special leg having a face to which the motor may be bolted; otherwise the machine is the same as regular.

We are prepared to furnish motor or to furnish machine with special leg of the dimension given below, to which the purchaser may attach motor. The latter method generally is saving in time. It is only necessary to see that the motor selected will go in the space provided on leg. This is only furnished on special order clearly stating that motor leg is preferred.



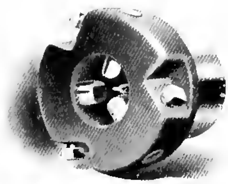
SPECIAL FEATURES

The open-side turner is occasionally used for special work, having short cut of over $2\frac{1}{4}$ and under 3 inches in the 2 x 24-inch lathe, and over 3 and under 4 inches in the 3 x 36-inch machines. Only recommended for taking light cuts.



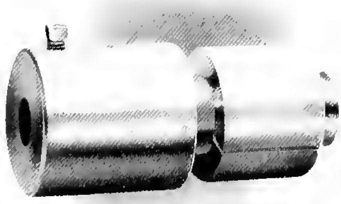
Open-side Turner

Herewith is shown the centering tool, for drilling centers in work for grinding or other purposes. By careful adjustment of two of the back rests just a little nearer the center than the third rest absolutely true centering can be done.

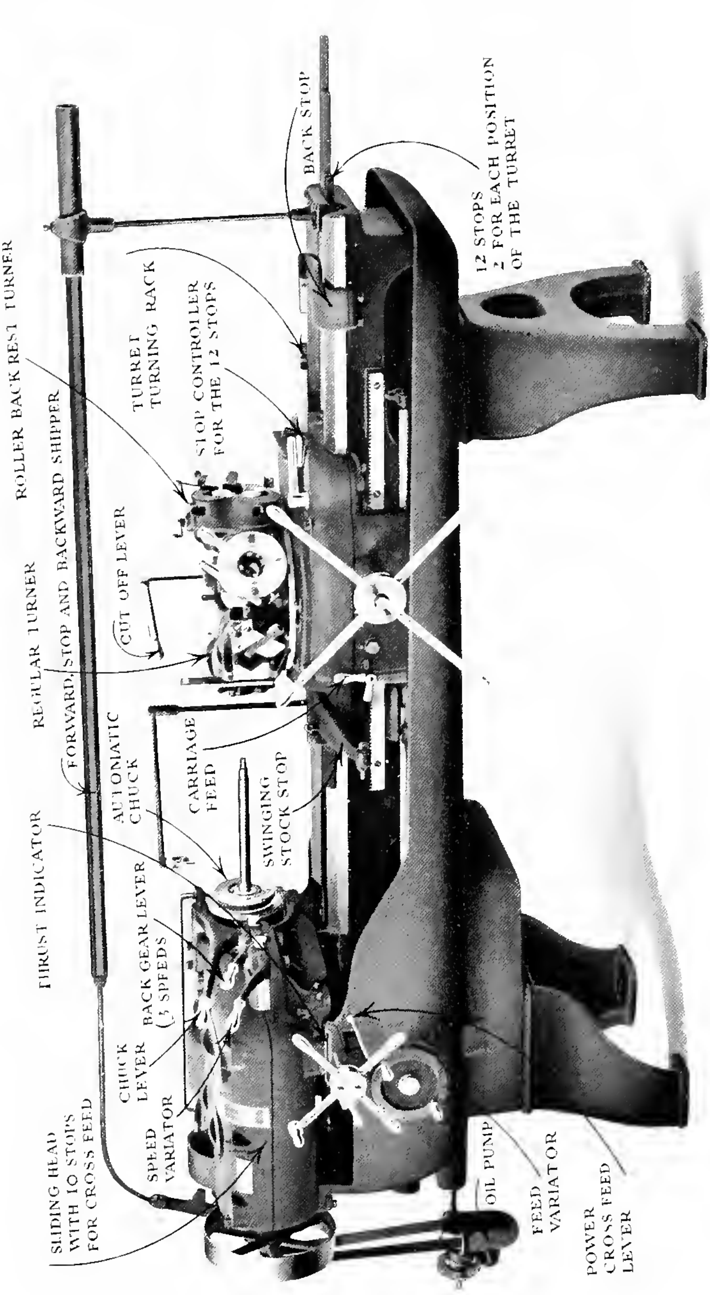


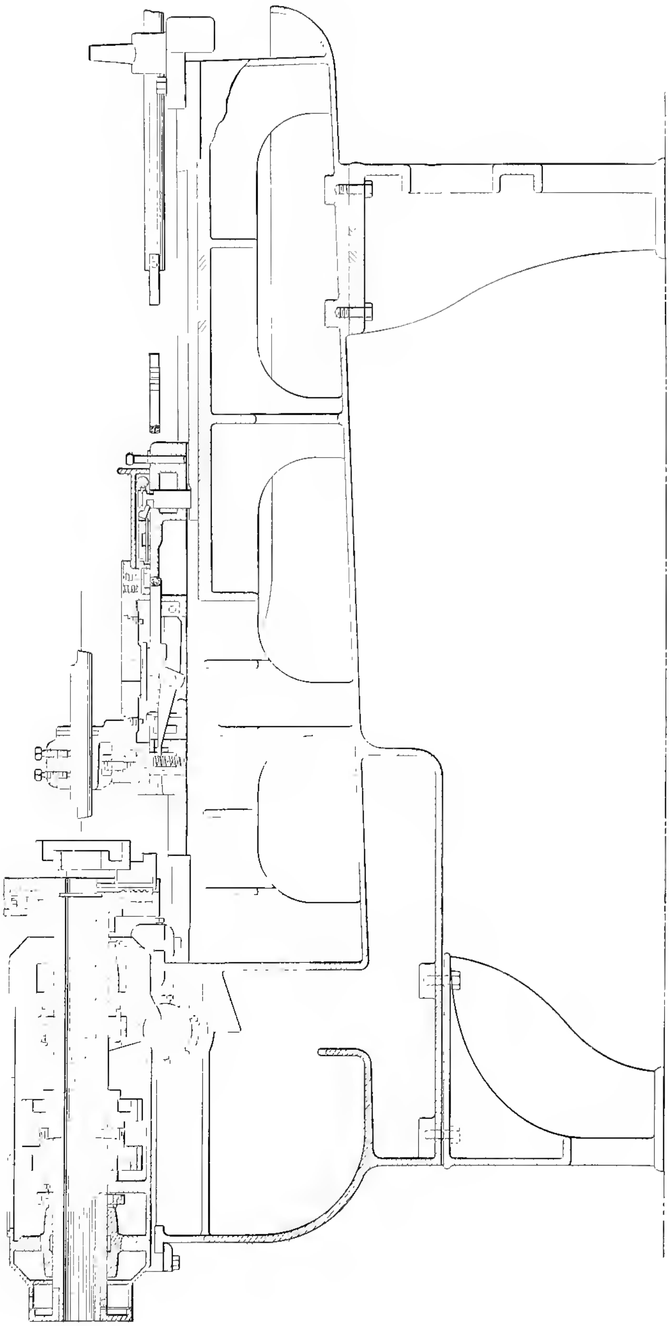
Centering Tool

The clutch tap holder is used for holding a tap against turning until it has tapped to a desired depth, at which point the carriage is stopped, causing the clutches to pull apart and allowing the tap to rotate with the work until spindle is reversed for screwing it out.



Clutch Tap Holder


ROLLER BACK REST TURNER
FORWARD, STOP AND BACKWARD SHIPPER
TURRET TURNING RACK
STOP CONTROLLER FOR THE 12 STOPS
BACK STOP
12 STOPS 2 FOR EACH POSITION OF THE TURRET
CUT OFF LEVER
REGULAR TURNER
AUTOMATIC CHUCK
CARRIAGE FEED
SWINGING STOCK STOP
THRUST INDICATOR
BACK GEAR LEVER (3 SPEEDS)
CHUCK LEVER
SPEED VARIATOR
SLIDING HEAD WITH 10 STOPS FOR CROSS FEED
OIL PUMP
FEED VARIATOR
POWER CROSS FEED LEVER



2 x 24-inch Flat Turret Lathe with Cross-feed Head — Vertical Section

DIRECTIONS

"SETTING UP" AND OPERATING

BOLT the machine to the floor before putting on the belt. Do not adjust the position of the machine to the running of the belt. Set the machine true with the countershaft or main line by dropping down a plumb bob from each end of the shaft. Since plumb bobs are not in the kit of every machinist, an inch nut or any weight on the end of a string thrown over the shaft will answer.

The countershaft should line up perfectly with the shaft from which the power is received, and it should be perfectly level. It should be well oiled before starting and examined after it has run fifteen minutes to see if any of the bearings are warm.

After the machine has been set parallel with the counter the lag screws should be put through the legs into the floor, but should not be screwed down until after the machine is leveled. As the bed rests on three points and is flexibly connected to one pair of legs, the leveling of the machine is not done in the usual way. When the level is placed across the Vs of the lathe bed and is found to be a little high on one side, drive the wedges under the edge of the leg at head end. Do not try to change it by wedging up under the back leg, for it is not connected to the bed by the usual means, but only serves as a pivotal support. Wedging under this leg will only raise or lower this end of the machine. Care should, however, be taken to have this leg stand on a fairly level spot. Now place the level on one of the Vs lengthwise and wedge up carefully until both ends of the machine are equal in height.

Locate the stock supports as indicated in the drawings and adjust them for height by placing a bar of stock in the machine and slowly revolving it.

If the countershaft clutch slips, screw up the two small nuts at the rim of friction and slightly turn each the same amount. The speed should be exactly 800 revolutions per minute. If this speed is not as prescribed, the table of sizes of work for which the various speeds are intended will be of no value. This table is furnished for ready reference in a suitable frame with each machine.

Do not put your belts on too tight at first. It is much easier to lace the belt two or three times while it is stretching than it is to get a new bearing running smoothly after it has been roughened up by the belts being too tight. All new bearings should be frequently oiled and run with care.

LUBRICATION OIL IN HEADSTOCK. Put five gallons of lubricating oil in the case of the sliding head. The lightest or thinnest oil is the best. There is an overflow hole drilled at the proper level in the back of the head case. The oil should always be kept up to this level — if the oil is allowed to get too low there is sure to be trouble.

COOLING SOLUTION OR LARD-OIL. If the machine is to be used in working steel, the reservoir in pan should be filled with either good No. 1 lard-oil or a mixture of lard-oil with borax and water — about 10 or 11 gallons are required.

The change from the carbon to the so-called high speed steels has effected the problem of cutting solution.

Lard-oil is undoubtedly the best and only cutting oil for tools made of carbon tool steel, and perhaps for all tools taking a broad cut, like a forming tool, but there is much evidence of the superiority of a borax solution made of one pound of borax to seven gallons of hot water mixed with one gallon of lard-oil.

The quantity of borax should be the least that will make the water and oil mix.

This quantity varies with different waters (hard or soft) and unfortunately with different lard (?) oils, depending on the proportion of lard-oil to the adulterant and the quality of the adulterant. But a safe mixture in the usual circumstances may be made in accordance with the above formula.

A convenient amount may be mixed in a 50-gallon barrel which will take 7 pounds of borax with water heated to 100 or 110 degrees.

The borax is better than sal soda, which has heretofore been used for making a cutting solution known as soda water.

The objection to an excess of either borax, or sal soda, is that it cuts away the lubricant from the sliding surfaces, and causes an excessive wearing away of the sliding surfaces between the turret and the saddle, and the saddle and bed.

If borax water is used instead of clear lard-oil, provision should be made for a daily supply of a good quantity of oil (preferably lard-oil) to the turret seat and carriage slide; otherwise, these surfaces will rapidly wear down.

Lard-oil is preferred for lubricating the turret and carriage-slides, because the oil on the slides is washed away and becomes mixed with the cutting solution, and the increase of percentage of lard-oil in the cutting solution improves the quality of the solution, whereas other oils have the adverse effect.

Borax water and soda water compounds both have a common characteristic which seems to cause a wearing away of the clearance-face of the tool. This face of a worn tool looks as if it had been lapped; that is, a tool loses its clearance quicker with soda or borax water than with lard-oil straight, and a tool refuses to cut because its under-face has been worn to a slightly negative clearance, whereas the tool dulled by cutting with lard-oil has a crumbled edge which has grown into a negative clearance.

The cooling qualities of borax water are very much greater than that of lard-oil.

It is, of course, much cheaper than straight lard-oil, for the quantity of oil and borax per gallon is relatively inexpensive.

To Start the Machine on Bar Work, begin on some very simple work. Suppose the diameter of the head is $1\frac{13}{16}$ and the body $1\frac{1}{4}$ inches, that the total length is 6 inches, and that the piece must be finished all over. Get a bar of $1\frac{7}{8}$-inch stock. See that it is fairly straight and free from short kinks and that there is no burr of any size on either end. If the bar has been cut off in the shear the burr should be hammered down. The large adjusting collar under the sleeve should be screwed back to open the chuck and forward to close it. Now remove the bushing from the spindle, for this is only used for smaller bars than 1 inch, and would not admit the $1\frac{7}{8}$-inch bar. It is necessary to let back the rolls in the roller feed in order to remove this bushing. After this is done push the bar through the stock supports into the spindle and through the chuck until the end projects about $\frac{3}{4}$-inch beyond the face of the chuck. Adjust the jaws at the back of the roller feed till they are about $\frac{1}{32}$-inch loose on the stock. Adjust the chuck till it requires much force to thrust the chuck lever to the left. The rolls of the roller feed should be set down against the bar till each spring is raised a trifle.

Now, the next thing is to determine the speed to be run. This can be done by the use of the table or by experience. Turn the turret around until the cross slide comes in working position, set the cut-off tool, and trim off the rough end of the bar. Before turning to the next place set the stop. See directions for adjusting the stops on page 223. No. 1 is the stop for the cross slide. Next move the "back stop" up close and clamp it. Run the turret back against it till it turns to the next position; next loosen the back stop again and push it back till the end of the swinging "stock stop" measures a distance equal to the length of the work, which is 6 inches, plus the width of the cut-off tool, which we will call $\frac{3}{16}$-inch. That is, the stock stop should be swung up into place, and the turret should push the back stop until the length between the end of the bar in the chuck and the end of the stock stop is equal to $6\frac{3}{16}$ inches; then clamp the back stop firmly.

Now open the chuck and hold the lever to the right until the roller feed pushes the bar out against the stop, then forcibly close the chuck. Turn the turret to turner. Now use the turner carefully and without the back rest till the cutter is adjusted to size. This must be done on the first piece by use of calipers or any other gauge; take off about $\frac{1}{8}$-inch chip each time while roughing, and allow it to run on about $\frac{3}{4}$-inch. After the end has been reduced to $1\frac{1}{4}$ inches, adjust the back rest, have it follow the tool and bear on the $1\frac{1}{4}$-inch size, then throw in the feed by the lever on the front of the apron near the pilot wheel. Let this cut run up the required distance and adjust the feed stop for this tool.

Before running back withdraw the tool by pulling the small cam lever towards you. Run back the turret until it brings the next tool into position, and adjust this tool for turning the head of the piece; the head may be turned without the use of the back rest.

Now the end of the piece may be shaped by the pointing tool held in one of the tool holders. The screw cutting comes next. Directions for using the automatic die will be found on pages 244 to 247. The next operation is rounding the head, which may be done by an offset tool in the back tool post of cross slide, or it may be done by putting a crowning tool in place of the cut-off tool and then having the cut-off tool work from the back post of cross slide. By using the former instead of the latter an additional tool may be set in the back post for shaving the under-side of the head. This, however, is not often necessary. Then cut the piece from the bar and proceed to run off the required number.

If but one piece is desired it is not necessary to set any of the stops. These stops were set only for the benefit of more rapid production of the other pieces wanted. In starting the turner on a piece of this proportion do not throw in the feed until the edge of the back rest is started on the work; it should be fed thus far by hand. The fine feed should be used with a chip of this kind, but if the tool is beveled slightly the medium feed can be used.

IF THE BAR IS CROOKED and the end runs out too much to true up, the piece may be partly severed from the bar — enough to weaken it so that it can be bent to run true.

THE JAWS MAY BE USED ON WORK A TRIFLE LARGER, but never on smaller diameters than are marked on the jaws. For instance, the 1 7/8-inch jaws will hold 1 15/16, but will not hold 1 13/16. The latter size must be held by the 1 3/4-inch jaws.

Hexagon Stock is held by the same jaws that hold round and square by removing one of the jaws and inserting spacers that will hold the jaws in place for taking bearing on three sides of the stock. Round stock may be held in the jaws as arranged for holding hexagon or square, but if it is a trifle oval in section, an arrangement of jaws for hexagon is better.

The Chuck should be wiped clean every time the jaws are changed, and should be kept well oiled. To remove the chuck from the spindle of the 3-inch machine it should be gripped on a short piece of 2-inch stock to which a lathe dog is fastened. By the use of a lever placed between the tail of the dog and the bar of stock, the chuck may be readily loosened. This also serves as a good means of screwing the chuck firmly against the collar when putting it on again.

The chuck body of the 2-inch machine is part of the spindle and cannot be removed.

The Roller Feed should be kept as clean as possible and well oiled. The bar of stock should be wiped free from grit and dirt before the bar is placed in the machine.

The Turret Stops and How to Adjust Them. There are twelve feed stops for the turret, two for each position of the turret. These stops are numbered A1 and B1 for No. 1 turret position, and A2 and B2 for No. 2 turret position, and so on up to 6. The lever marked stop controller is arranged to lift out of position all of the A stops or all of the B stops, or both the A and B stops. When only one stop is required for each position of the turret, the stop controller is set to keep either the A or the B stops out of position, allowing the others to do the work.

If more than two stops are required for any one position, then the extra stop pin at the back of the turret slide may be dropped into any one of the other five holes, thus borrowing one or more of the B stops not required by the other tools. This extra stop scheme makes it possible to give one of the tools seven stops, if desired, and still leave one stop for each of the other five tools.

Each of the twelve stop bars is held in place while setting by the set screw directly over it, but these set screws should not be set down hard or depended upon for holding against the carriage feed. The stop binder at the side clamps all of the stops together, and should be set hard.

The notched edge of the stops should be up when the stop is to arrest the forward motion of the carriage, and down when stop is to arrest motion of carriage traveling away from the chuck.

The back stop serves two purposes: first, it forms an abutment for the rack that turns the turret; and, second, it determines the backward travel of the turret, and thus locates the stock stop which is attached to the turret carriage. The back stop should be set with reference to the desired position of the stock stop, against which the bar of work strikes when a new length of work is being pushed out of the chuck. Care in setting the back stop will leave very little to be done in adjusting the screw at the end of the stock stop.

Turners B and H. The adjustments for the turning tools and for the back rests are provided with binder screws to prevent their moving after being once set. These screws are set up with a screw-driver from the back of the turner. For all kinds of work set the tool so that the part of it that does the finishing is just a trifle ahead of the back rest. The tool should be so adjusted that the part that does the finishing will come exactly to the center of the bar when the tool holder is swung in. The two cams are diametrically opposite and side by side. The lever for turning the cams is like a machinist's vise handle. When one end is up one of the cams engages one of the adjusting screws, and when the other end of the handle is up the other cam is brought against the other adjusting screw.

The Cutting Tool Used in the Turners B and H should be ground so as to leave a square shoulder. This form of cutting edge, with plenty of rake, or top slope, is the best for this service, although it is not the form of tool for work on which the back rests cannot be used.

It is the best for producing true work because the cutting pressure which is to hold it into its chip is mostly end pressure on the work, and not radial — that is, no very great pressure is required to hold it into the proper depth to produce the desired diameter, hence a slight variation in depth of chip due to eccentricity of stock has little or no tendency to spring the work away from the tool. For this reason this tool may be depended upon for true work in taking long cuts, even when the stock runs a trifle crooked.

The Cross Slide is arranged with stops for the front and back tools. The upright which supports the pinion shaft is bored out to receive bushings for supporting the work against the forming tool when it is necessary to use a broad tool near the end of a slender piece of work.

Never Use a Drill that is Longer than is absolutely necessary. If the depth of the hole is to be great in proportion to its diameter, a short, stiff starting drill should be used to start a true hole. Never drill beyond the piece that is to be cut off, for after the piece has been cut off and the bar run out to make another, it will be found that the end does not run exactly as it did when it was drilled into, and consequently the hole runs out. In some cases, where the mouth of the hole is to be larger, it does not make any difference, because the larger drill will true the hole, but generally it makes trouble that is difficult to overcome without the waste of stock.

THE STOCK-STOP SCREW must be lengthened out when drills are used, and the length of the extension should be equal to the length of the longest drill used.

CHIP BREAKING TURNER

HOW TO SET TOOL. In putting in a newly ground cutter, push it firmly against stop pin and then tighten inner clamp by nut on under-side of cutter holder.

The tension on the clamp should be comparatively light. The clamp should be firmly held, but no tighter than can be conveniently set by the very short wrench by hand.

The outer clamp serves to hold the cutter endwise as well as sidewise. This outer clamp is made slidable on the cutter holder so that the pin in it may drop into one of the notches in the top of the cutter for the purpose of holding the tool endwise against the stop pin and to resist the outward stress of cutting.

This outer clamp should be pressed inward as it is being gripped by its binding screw. This holds the pin firmly against the inner side of the notch in the top of the tool so that it is ready to resist any tendency of the work to push the tool outward.

The outward thrust is not as great with this kind of a cutter as with the round nose or blunt edge tools in common use, but it should be firmly and unyieldingly resisted.

The clamp for this purpose is fitted to a rail to which it is gripped by the binding stress, so that although it is free to move when the screw is loose, it becomes fixed endwise when clamped.

The tension of both of these clamps may be varied to suit conditions, but for general practice the tool should be clamped with sufficient firmness to a little more than equal the stress of cutting. The cutting stress alone presses the tool very firmly in its seat, and the additional stress of the clamp only makes for stability of lateral control of the edge without undue restriction on the oscillatory freedom under actual working stress.

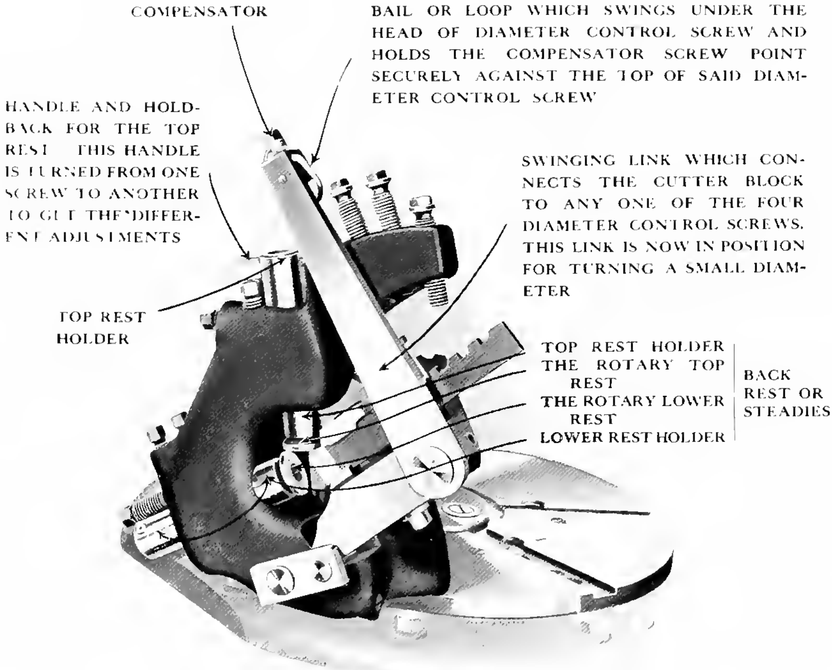
The tool should be set with slight clearance when sharp — the oscillatory motion being simply to allow it to swing away from the shoulder of the cut when its edge has worn to the no-clearance condition and is tending toward the negative clearance.

The screw marked "Clearance Control" may be adjusted while running. Do not set the screw up hard. If you wish the tool to work with no clearance, you may adjust it up slowly after the cut has been started. If you adjust it too fast you will get a chip that will be of uneven thickness; that is, the tool will alternately "ride" and "dig."

There is a nice position for ideal running which may be reached by adjustment, but the better way is to allow the tool to have the extremely slight clearance which its holder naturally gives it, and then let it run till by wear it has lost this clearance and has commenced its proper function by preventing a "Negative" clearance.

Adjustment of Cutting Tool. The diameter produced by the cutting tool is controlled by the adjusting screws marked "Diameter Adjustments."

There are four of these screws — one for each diameter to be produced.

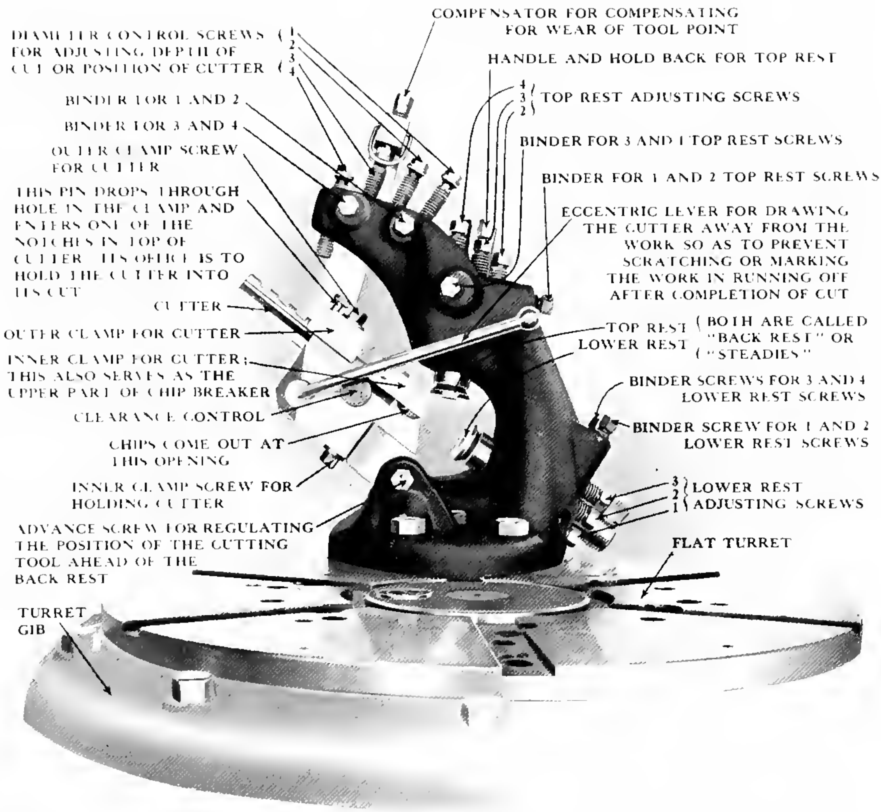


Chip Breaking Turner

In general practice, the turner may be set for only one or two diameters, but if the work needs more cuts than can be taken by the other turret tools, then two or more of these adjustments may be brought into service.

The connecting arm or link is swung from one screw to another as required by the work.

An auxiliary adjustment is provided to compensate for wearing away of the tool point, or change of position

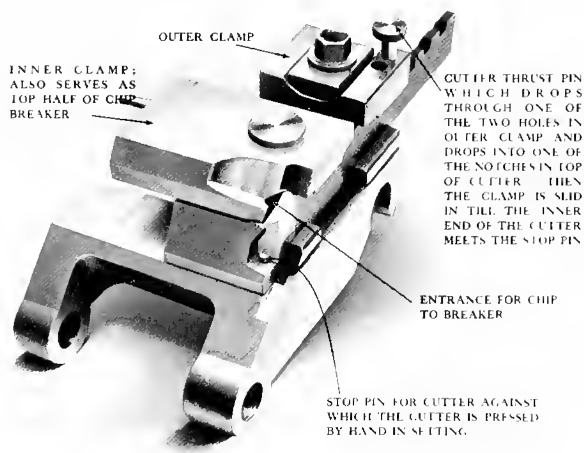


Back View of Turner

of tool point, due to putting in a sharp tool. This adjusting screw is called the compensator, for it furnishes a means for offsetting this slight change.

The compensator is provided with a pointer that should be moved over from time to time as the tool wears, or as required by the position of a new cutter.

The compensator thus becomes a very convenient means for offsetting changes that would otherwise affect all of the adjustments. Its proper use, combined with care in grinding cutter, with point always exactly $\frac{1}{16}$-inch high, makes possible the quick resetting; this makes it practical to running higher cutting speeds than would be practical if the resetting required the usual amount of time and entailed the usual amount of poor or bad work.



Cutter Block Complete with Both Caps in Place

THE ADVANCE ADJUSTMENT FOR CUTTER. The cutter should be adjusted to stand a very slight distance in advance of the back rests.

The screw marked "Advance Control" should be adjusted so as to hold the tool only as far ahead of the back rest as necessary.

A good way to effect this adjustment is to gradually let the screw back till the back rests are exceedingly close to the shoulder.

The importance of maintaining the extremely slight advance of cutter ahead of back rests is to get the straight work which comes from this method.

If the work runs rope-like or in bunches, or is extremely crooked, look to this point of cutter advance. The correct adjustment of this screw should cure both ropey and bunchy work, and almost all cases of crooked work.

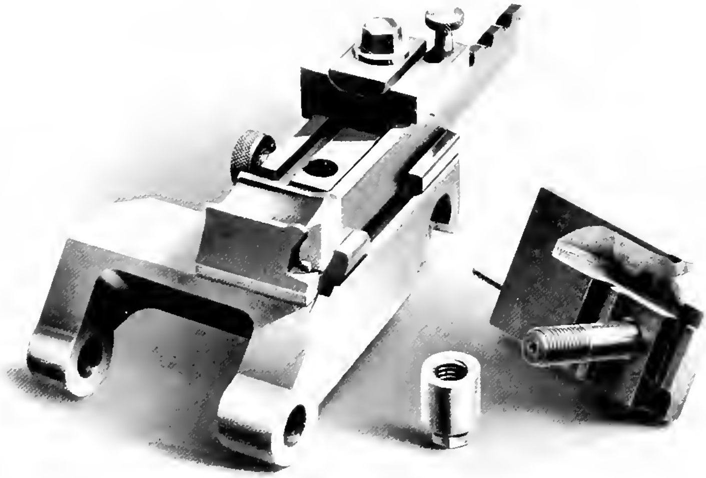
Of course, crooked work may be due to change in metal due to removal of the outer stresses, but it is more often due to faulty adjustment of back rests or to a careless start made by banging the cutter into its work at the beginning of the cut without allowing it to get a true surface turned for its back rests.

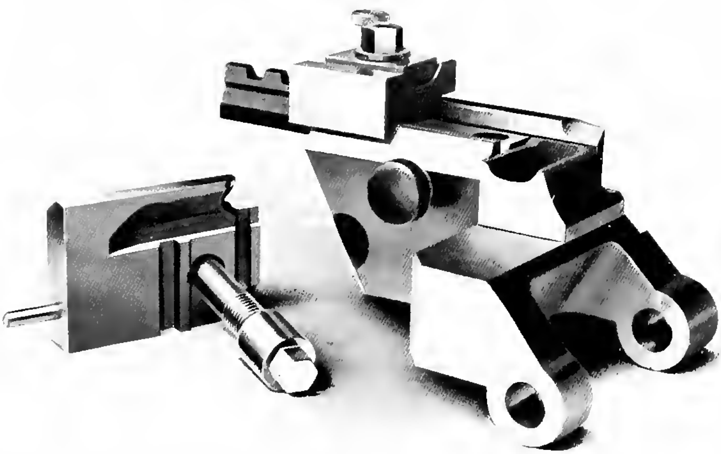
The "Advance Control" screw also furnishes a means for setting the tool to follow the back rests when in turning long, slender work it is desirable to have the back rests precede and take bearing on a surface to which the new cut must run true.

This is not often necessary, but when a long piece of slender work runs out a trifle it is frequently desirable to run with the back rests ahead of the tool in order to make the new cut run concentric with the previously-produced surface.

This requirement is brought about when it is necessary to turn the end of a long, slender piece of drawn stock a long distance from the chuck. In all such work the back rests should precede the cutter just far enough to get its full flat contact, which is about $\frac{5}{16}$-inch ahead of edge.

The one point to remember, the regulating of the advance control screw, is to keep the back rest opposite the cutting stress as nearly as may be. For it will be readily seen that the work will spring away from the tool more under a heavy cut than a light cut, providing the back rests are not directly opposite the stress.





Cutter Block with Top of Chip Breaker Removed

In turning rough bars there is always more or less difference in the depth of cut on opposite side of bar, due to the bar running "out."

With the back rest too far away from the position directly opposite the cutting stress, every time the heavy side comes to the tool, the bar springs away, due to the slight bending of the bar, and the canting around of all the yieldable members of the machine. Therefore see to it that the relation of the back rest to the cutter is always properly adjusted by the advance control screw.

The Tension of the Back Rests against the work depends on the cutting stress. If the back rests are not properly adjusted, the work may run tapering.

For instance, in taking a cut 1½ inches in diameter, and say 8 inches long, if the outer end is found to be larger than the part near the chuck, then it is safe to assume that the back rests have not been set up hard enough. On the other hand, if the work is larger at the chuck, the reverse may be true.

The back rests should be adjusted for tension on a true diameter produced near the chuck. Of course, there are instances where this is impossible, but always remember that the tension should be equal to the stress of the cut—this will give the top rest a little greater tension than the lower rest.

The adjustment of the back rests is effected by the screws arranged around each back rest holder.

All adjustment screws are provided with binder screws. In some instances one binder screw clamps two of the adjusting screws. Reference to illustration on page 229 will clearly show the function of each screw and binder.

The cutter holder is seated into the main frame by a knuckle joint, and it is held firmly in this seat by a pin and binder plate on front of the turner.

The eccentric pin has a slotted head that makes it appear like a cheese-head screw, but this will not deceive anyone who has once known its function.

The eccentric pin may be turned by a screw-driver till it firmly seats the knuckle of the tool holder into its socket in the frame.

The binder screw for this eccentric pin is under the tool holder in the main casting, and faces the operator when the turner is in working position on the turret.

The binder plate may be removed by releasing the binder screw and by pulling out the eccentric pin.

Eccentric Pin. This pin is under the control of the eccentric lever at the back of the cutter holder.

The connecting arm or link is connected to the cutter holder by an eccentric pin in order to provide a means for preventing the cutter scratching the work in running off after having completed its cut.

The stream of oil or borax water flows through the hollow frame of the turner and emerges from a rectangular slot directly over the cutting edge.

THE "SHARPEDGE" CUTTER

How to Grind. The best results for quality and quantity of work can only be obtained by care in grinding the cutter.

The cutter should be ground to the gage with a reasonable degree of precision.

The important dimensions are shown in the illustrations on page 237.

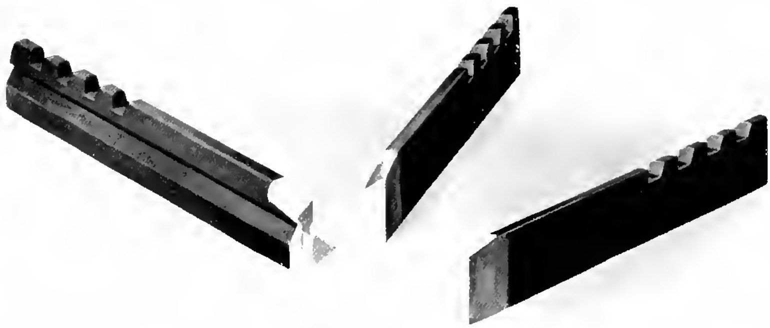
The height of the nose of the tool should always be the same in order to get the advantage of a quick resetting of the cutter. This height should be $1\frac{3}{8}$-inch for all new lathes. If the center of the spindle is not exactly three or four inches above the top face of the turret, then the height of the tool nose may be made that much more or less.

But always remember it should always be the same for all the cutters used in the lathe. It will be a very old lathe that will require any departure from the $1\frac{3}{8}$-inch height of tool point.

If all tools are ground accurately in this respect, there will be very little delay in exchanging tools for the purpose of getting a sharp tool quickly substituted for a dull tool.

Always grind the cutting edge from the $1\frac{3}{8}$-inch up to the top edge of the tool, making the cutting edge $\frac{5}{8}$-inch long.

The object of keeping the edge slanting down toward the point is to reduce the end grinding which is necessary to carry the edge back far enough to restore the edge. If this front slope is made less than 18 degrees it only increases the amount of end grinding; and of course a steeper angle, say of 20 degrees, will reduce the amount of grinding. The only objection to the steep angle is that it makes the cutting edge too short for cuts that are deeper than $\frac{1}{2}$-inch.



The end of the tool should be exactly square with the bottom and the front face. The corner may be rounded a trifle with a hard oil-stone, and in extreme cases may be given some drag, but beware of the troubles of a faulty drag—a very slight change makes a vast difference in surface of work. The square corner, or the one nearest to square, turns the nearest to straight, providing back rests are set close to shoulder.

The sharpness of the edge should not be neglected. The angle should be 50 degrees. It may be as much less as the material will work satisfactorily, but it should not be more than 55 degrees.

The form of the chip breaker makes it necessary to grind the top slope of the tool within certain limits. These may be roughly stated as lying between 45 and 55 degrees.

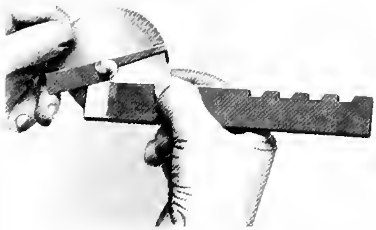
Grinding Gage — Full Size

If the grinding gage should be mislaid, the following illustrations will serve as a guide to grinding. The use of the square and bevel protractor will not be necessary to one accustomed to grinding.

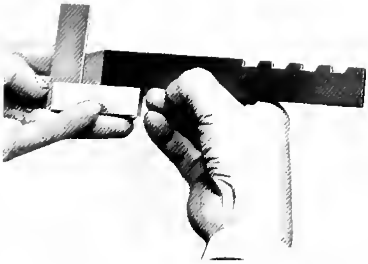
The "Sharpedge" Cutter

This measurement should be $\frac{1}{16}$-inch

The cutting angle should be 50 degrees, never more than 55 degrees and never less than 45 degrees



Front slope should be about 18 degrees. It may be more, but never less



Grind the nose square to bottom and face

If the tool is too blunt the chip will curl up and pass over the breaker, and if the tool is too sharp, say below 45 degrees, a stringy chip may cause trouble by going between the cutter and the chip breaker.

FEEDS AND SPEEDS

Meaning of "Feed." The rate of advance or traverse of the tool to each revolution of the work is expressed in parts of an inch.

For instance, 100 feed means that the tool advances $\frac{1}{100}$-inch per revolution of the work, and that the chip consequently is metal that was that thickness before it was severed from the work.

Likewise, 20 feed indicates that the rate of travel has been $\frac{1}{20}$-inch per revolution, or 20 revolutions required to carry the tool one inch.

The demand for accurate work tends toward the use of the finer feeds, and the demand for rapid output tends a trifle toward coarse feeds.

The feed should always be coarse enough to take a steady cut; feeds finer than 80 or 90 in lathes of 12 or more inches of swing frequently give an unsatisfactory surface due to the chip being too light to maintain a steadying effect.

When the feed is too light, as in feeds, say of 100, in such lathes, the work has a surface which is produced by the mixture of scratches and burnished rings, for the tool point has alternately rubbed by riding and scratched by digging in. Therefore, the feed for all purposes should be heavy enough to get a continuous and steady cut. In the work under consideration, this is a feed between 60 and 80 per inch.

The product is nearer straight and true from the finer feeds, providing the excessively fine feeds are not used.

The demand for rapid production generally makes it necessary to go to coarser feeds, and when the quality of the work will be satisfactory, then feeds may be used from 20 to 40 to advantage.

But remember through it all that after the feed has been selected the speed must be run up as high as the tool will stand.

The endurance of the turning tool should be at least two hours in the present machine. Forming tools or screw cutting dies must be run at much slower speeds.

MEANING OF "CUTTING SPEEDS." Cutting speed means the speed at which cutting edge passes through the metal. It is expressed in feet per minute.

In lathe work, the cutting speed may be determined by use of a Warner cut-meter or similar instrument, or by the use of a speed table which is usually furnished with each lathe.

In absence of these, the speed may be calculated by multiplying the circumference of the work by the number of revolutions per minute, and divide by 12 to get it into feet. The circumference should be taken at the largest diameter of the cut for all work. In exact experiments the mean diameter is taken, but for turret lathe work the largest diameter gives the best means of comparison, for the depth of cut does not call for a reduction in speed, particularly on work below 3 inches in diameter where a cut, say of ½-inch deep, reduces the 2-inch to 1-inch diameter, would give a cutting speed which would be very high if the mean diameter of 1½ inches was taken as a basis of determining the correct cutting speed.

Furthermore, the cutters wear most at the part of the bar that travels the faster; the point of the tool generally holds out the longest.

The point of the tool wears off faster in cast-iron work than in steel, and of course it also is at a disadvantage on the larger work, say above 3 and 4 inches in diameter. On the larger work the depth of cut is seldom sufficient to greatly reduce the cutting speed at the point.

The scale on both cast-iron and steel has an important effect, but it frequently is offset by other elements which make useless the attempts to make a direct comparison of cutting speed with and without scale.

One of these elements in the turret lathe is the fact that in taking the first cut (which encounters the scale) the work is cold, whereas in taking the next cut the work is warm to begin with.

The temperature of the work makes a material difference to the heat which must be carried off by the tool. Therefore, the cutting speed may safely be calculated from the speed of the largest diameter of the cut.

THE EFFECT OF RATE OF FEED ON RATE OF SPEED. The cutting speed is generally stated to be directly affected by the size of the chip, but this does not apply to the average work under consideration.

In the work of the Flat Turret Lathe the cutting speed is generally affected by the feed only—and not by the depth of the cut—but the feed must surely be considered, and occasionally the depth.

If 50 feet per minute is the fastest cutting speed at which a tool will stand satisfactorily at 30 feed, then the same tool will run 100 feet per minute at 60 feed per inch.

The speed should be up to a high standard, and always above 50 feet per minute, and with present steels speeds of from 50 to 150 are practical on average machinery steel.

The exact statement of cutting speeds is impractical on account of the rapid progress that is being made in the art of making high-speed steels; but there is one safe rule, and that is, to run each tool up to its best performance, and if that is too low, according to the latest information, see to it that you get the best steel.

Do not let your product or your personal record be kept down by a poor piece of steel. Cutting tools are cheap and good reputations and output are valuable; hence it is well to know that you are getting there at the proper speed.

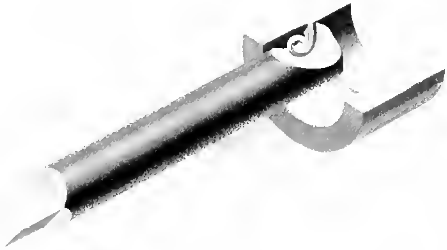
Many a careful man has become a marked man in his superior's eyes just because he thought the cutting tool could not stand a higher speed. His experience may have fully warranted his conclusion, but he got his experience with some "out-of-date" steel or a poorly hardened or poor piece of later steel.

When personal records are so easily injured, when output is so easily increased, it behooves every man to give heed to the subject of speed and feeds.

CHUCKING OPERATIONS

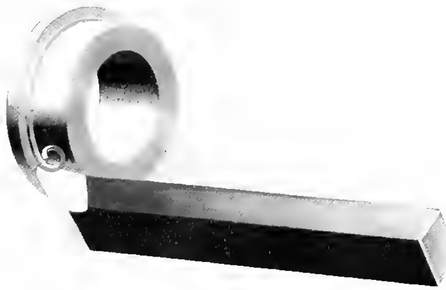
The Cutting Tools for Chucking Operations, whether turning or boring, should have their rake or top slope sharp to the heaviest part of the chip. For instance, if a tool is to be used for facing a hub of a gear, the part that begins to cut first should be a sharp angle, so that the heaviest part of the chip should flow easily away, while that part of the tool that leaves its mark on the finished face should take a shearing cut or angular shaping cut, which leaves the smooth surface.

Perhaps there is no more important point to be borne in mind by anyone wishing to know how to make the machine do its best work, than the cutting angles of the tools. In a general way everyone knows that a tool should have the least amount of clearance and the greatest amount of rake consistent with the wear of the tool, but the man who makes the best record is the one who puts it into practice.



Boring Tool

The next point is that no tool should be allowed to project beyond its holder or support more than is absolutely necessary. After having ground and set the tool properly, see that it has a chip or feed coarse enough to keep it from losing its edge in making thin chips— you have made the tool not only remove the metal, but cut it into fine chips having no special value. Even weak lathes generally do better work with a medium feed than a fine feed. It is not uncommon to see a very fine feed being used in trying to turn an extra true piece of work, with the only result that the tool does not leave an even surface. It alternately rides and "digs in" with a fine feed, when an even, steady cut would have been obtained by a medium feed.



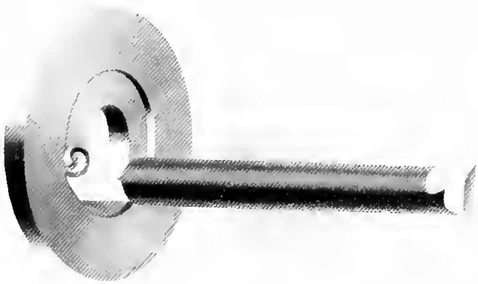
Cornering Tool

Back Facing Tool

Chattering frequently occurs because the chip is not large enough to hold all the slack of springing parts. The cure for chattering is frequently more, not less, feed. Of course, chattering may be caused by a cut that is just heavy enough to balance the weight of the work and spindle, and then the slight necessary looseness of spindle bearings gives the chance for chattering. An old-fashioned remedy for this is to turn the tool upside down to get the pressure down on the work.

Chattering is destructive of the sharp edge of the tool, and should not be tolerated.

Facing cuts may be taken by the tools with round shanks, for these can be turned so as to give the desired rake for free cutting. In facing, make sure to take



Facing Tool

advantage of the convenient means of changing the speed, for a very important reduction in time of operation as well as the durability of the tool may be effected by keeping the correct cutting speed by shifting the lever once or more times as the tool is cutting. The failure to change the speed in this way involves the selection of an average speed which is too fast at one part of the cut and

Turning Tool

too slow at the other extreme. The fast cutting destroys the edge and makes a net loss of time when the grinding and resetting are included, and of course the slow cutting is also a needless loss which does not get a corresponding durability of cutter edge.

THE AUTOMATIC DIE

PUTTING CHASERS INTO THE DIE. One set of chasers may be removed and another put into place by simply withdrawing the two knurled thumb-screws which are located in approximately opposite positions on the cam holder. After these screws have been withdrawn about one-quarter of an inch the cam holder may be removed.

In changing the chasers always see that the chaser grooves in the die are wiped out clean; also that the interior of the cam holder and cam are free from chips and dirt. Place the chasers in the respective grooves in the die body by making the numbers on the chasers correspond to those on the body; then slide them towards the center till they meet. Now put on the cam holder, and, after having pushed it as far back as possible with the chasers in this position, push each of the chasers out against the cam surface; this will allow the cam holder to go back the full extent. Now see that the screws in the cam holder enter the holes in the spring collar.

To Close and Adjust Size. To close the die, pull the handle with the thumb pressing gently on the latch pin. Before adjusting the die for size see that the latch pin is in its notch and that the O. K. is uppermost; then turn the adjusting screw till the lines on the cam and chaser come together. This gives only an approximate adjustment; the micrometer or thread gage should be tried on the work. A binder screw will be found to prevent accidental turning of the adjusting screw.

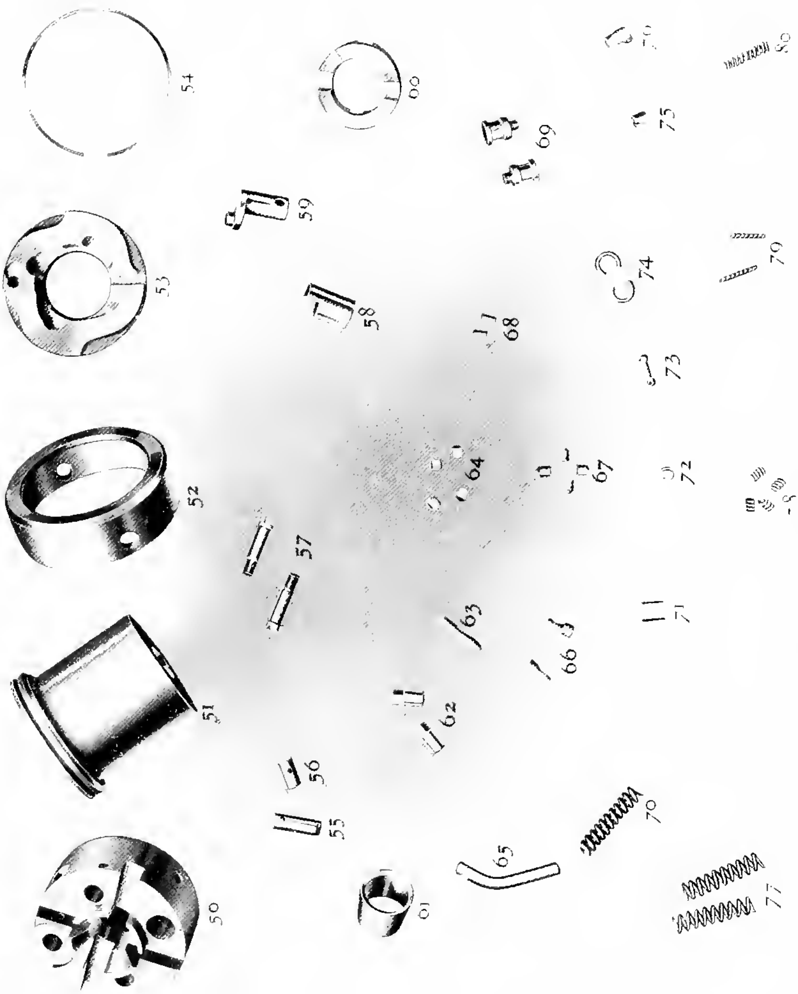
Adjusting Cutting Length. Now the die is ready to cut its thread, but it is yet necessary to adjust the stop which will determine the length of the thread. The stop which arrests the motion of the carriage is the one which determines the length of the thread, for when the die is cutting it is only necessary to retard the travel of its holder to cause it to fly open. If the thread is to be cut close to the shoulder the stop must be so adjusted as to avoid all possibility of the chasers screwing against the shoulder. It is not safe to allow the chasers to get closer to the shoulder than $\frac{1}{32}$-inch. The die head travels forward $\frac{3}{16}$-inch before opening after the carriage has been arrested.

Roughing and Finishing Cuts. One cut is sufficient for all U. S. S. threads under 1 inch in diameter, under ordinary conditions, but to obtain best results on larger dimensions, extra coarse pitch or very rough material, two cuts are necessary. The latch pin is made reversible for this purpose. It may be readily turned from one position to the other after it has been pulled out. The letters O. K. should be uppermost when the finishing cut is taken. The work should never be allowed to run backwards in the die.

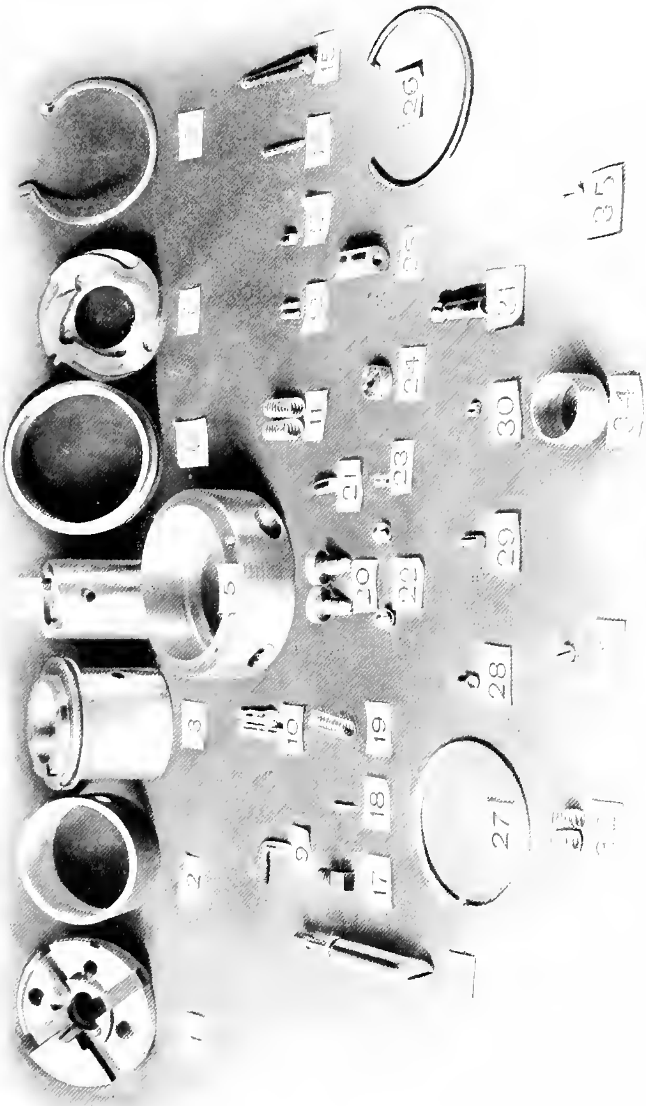
Cutting Speeds for Screw Cutting. Do not run your work too fast. If the pitch is extra coarse or the work warm from previous operations, the speed of threading should be proportionately slower. Better half-speed than a trifle too fast. Do not turn the part to be threaded under size, for the line of travel of the die is governed at the top of the thread, without which the die is inclined to travel crooked or to *wabble*.

To Resharpen the dies grinding must be done very sparingly. Grind the least possible amount off the face; do the principal grinding in the throat of the die. This, of course, carries back the cutting edge into the die so far that it is impossible to cut close to a large shoulder. If the work requires cutting close to a small shoulder the chasers may be ground back enough to admit that shoulder. Some grinding must be done on the face of the die, as it wears back to the last threads, but it should be done with great care. In grinding the throat do not follow the curved lines of the teeth in order to obtain the correct clearance, for the teeth were produced by a mill 2½ inches in diameter; following this shape would give too much clearance. Don't change the angle of chamfer; it is better to be guided by the wearing of the die. See that each chaser is ground an equal amount, either by gage or by bringing the teeth only to a cutting edge.

ORDERING PARTS. The chaser and all other parts of the dies are made by special machinery, and are perfectly interchangeable; any one of the standard chasers may be duplicated from stock, and special chasers on short notice, providing you give in your order all the letters and numbers appearing on the chaser. Chasers may be sent by mail. When ordering other repair parts please use list number of piece given on pages 248 and 249 and always state size of die head. The head which has capacity for threads up to 3 inches diameter is called No. 9; the 2-inch capacity, No. 6; the 1¼-inch capacity, No. 4; and the ½-inch capacity, No. 1.



Parts of Automatic Die No. 1



Parts of Automatic Die Nos. 3 and 6

TABLE OF SPEEDS FOR 2 x 24-INCH FLAT TURRET LATHES

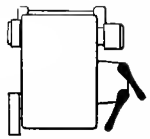
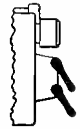
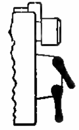
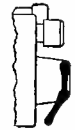
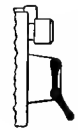
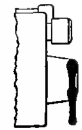
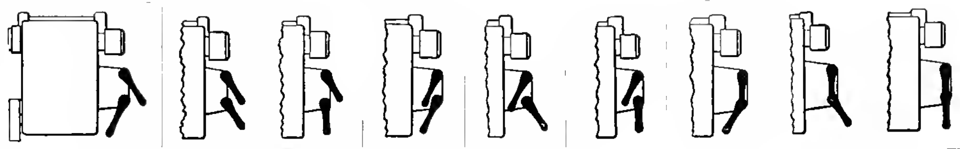
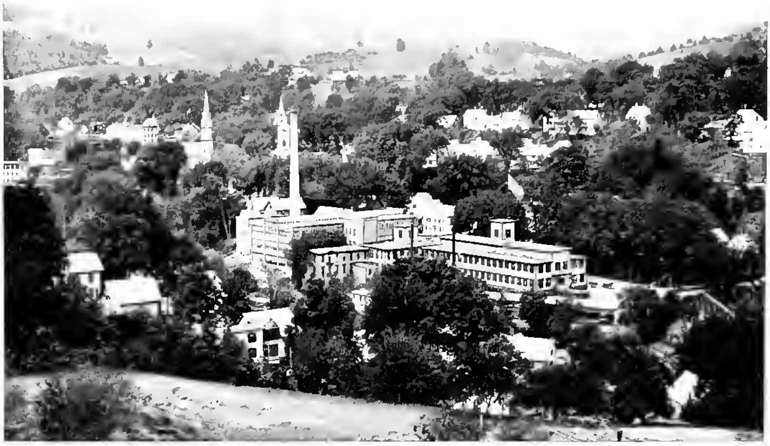
Diagrams Showing Clutch Lever Positions (Speed of Driving Pulley 800 Revolutions per Minute)											Feet per Minute
Spindle Speeds—(Approximate Revolutions per Minute)		380	240	160	120	74	50	43	27	18	
Screw Thread Cutting				1/4	5/16	1/2	3/4	7/8	1 7/16	2 1/8	10
			1/4	3/8	1/2	3/4	1 3/16	1 5/16	2 1/8	3 3/16	15
Turning Speeds for Carbon Steel		3/16	5/16	1/2	5/8	1	1 9/16	1 3/4	2 13/16	4 1/4	20
		1/4	3/8	5/8	13/16	1 5/16	1 15/16	2 3/16	3 1/2	5 5/16	25
		5/16	1/2	3/4	1	1 9/16	2 5/16	2 11/16	4 1/4	6 3/8	30
		3/8	9/16	13/16	1 1/8	1 13/16	2 3/4	3 1/8	4 15/16	7 7/16	35
		3/8	5/8	1	1 3/16	2 1/16	3 1/8	3 9/16	5 11/16	8 1/2	40
Turning Speeds for High-speed Steel		3/8	5/8	1	1 5/16	2 1/16	3 1/8	3 9/16	5 11/16	8 1/2	40
		7/16	3/4	1 1/16	1 7/16	2 5/16	3 1/2	4	6 3/8	9 9/16	45
		1/2	13/16	1 3/16	1 5/8	2 9/16	3 7/8	4 7/16	7 1/16	10 5/8	50
		5/8	1	1 7/16	1 15/16	3 1/8	4 11/16	5 5/16	8 1/2	12 11/16	60
		13/16	1 1/4	1 15/16	2 9/16	4 1/8	6 1/4	7 1/8	11 5/16		80
		1	1 5/8	2 3/8	3 1/4	5 3/16	7 13/16	8 7/8	14 1/8		100
		1 1/4	2	3	4 1/16	6 7/16	9 3/4	11 1/8			125
	Feeds per Inch	Time Required to Travel One Inch									
Turning Feeds	10	.03	.04	.06	.08	.14	.20	.23	.37	.56	
	15	.04	.06	.09	.13	.20	.31	.35	.56	.83	
	20	.05	.08	.13	.17	.27	.41	.47	.74	1.1	
	30	.08	.13	.19	.25	.41	.61	.70	1.1	1.7	
	45	.12	.19	.28	.38	.61	.92	1.0	1.7	2.5	
	60	.16	.25	.38	.51	.81	1.2	1.4	2.2	3.3	
	70	.18	.29	.44	.59	.95	1.4	1.6	2.6	3.9	
Drilling Feeds	80	.21	.33	.50	.68	1.1	1.6	1.9	3.0	4.4	
	100	.26	.42	.63	.85	1.4	2.0	2.3	3.7	5.6	

TABLE OF SPEEDS FOR 3 x 36-INCH FLAT TURRET LATHES



Diagrams Showing Clutch Lever Positions (Speed of Driving Pulley 800 Revolutions per Minute)	Feeds per Inch										Feet per Minute
Spindle Speeds—(Approximate Revolutions per Minute)		284	180	118	88	55	36	32	20	13	
Screw Thread Cutting				5/16	7/16	11/16	1 1/16	1 1/8	1 15/16	2 15/16	10
			5/16	1/2	5/8	1 1/16	1 5/8	1 13/16	2 7/8	4 3/8	15
Turning Speeds for Carbon Steel		1/4	7/16	5/8	7/8	1 3/8	2 1/8	2 3/8	3 13/16	5 7/8	20
		5/16	1/2	13/16	1 1/16	1 3/4	2 5/8	3	4 3/4	7 3/8	25
		3/8	5/8	1	1 5/8	2 1/16	3 3/16	3 5/8	5 3/4	8 13/16	30
		7/16	3/4	1 1/4	1 1/2	2 7/16	3 11/16	4 3/16	6 11/16	10 5/16	35
		9/16	7/8	1 7/16	1 3/4	2 3/4	4 1/4	4 3/4	7 5/8	11 3/4	40
Turning Speeds for High-speed Steel		9/16	7/8	1 5/16	1 3/4	2 3/4	4 1/4	4 3/4	7 5/8	11 3/4	40
		5/8	15/16	1 7/16	1 15/16	3 1/8	4 13/16	5 3/8	8 5/8	13 1/4	45
		11/16	1 1/16	1 5/8	2 3/16	3 1/2	5 5/16	6	9 9/16	14 11/16	50
		13/16	1 1/4	1 15/16	2 5/8	4 3/16	6 3/8	7 3/16	11 7/16	17 5/8	60
		1 1/16	1 11/16	2 5/8	3 1/2	5 9/16	8 1/2	9 9/16	15 1/4		80
		1 3/8	2 1/8	3 1/4	4 3/8	6 15/16	10 5/8	11 [illegible]/16			100
		1 11/16	2 11/16	4 1/16	5 7/16	8 11/16	13 1/4	14 15/16			125
	Feeds per Inch	Time Required to Travel One Inch									
Turning Feeds	10	.04	.06	.08	.11	.18	.28	.31	.50	.77	
	15	.05	.08	.13	.17	.27	.42	.47	.75	1.2	
	20	.07	.11	.17	.23	.36	.56	.63	1.0	1.5	
	30	.11	.17	.25	.34	.55	.83	.94	1.5	2.3	
	45	.16	.25	.38	.51	.82	1.2	1.4	2.3	3.5	
	60	.21	.33	.51	.68	1.1	1.7	1.9	3.0	4.6	
	70	.25	.39	.59	.80	1.3	1.9	2.2	3.5	5.4	
Drilling Feeds	80	.28	.44	.68	.91	1.5	2.2	2.5	4.0	6.2	
	100	.35	.56	.85	1.1	1.8	2.8	3.1	5.0	7.7	



View of Our Upper Plant and Springfield Village

Lower Plant where Machines are Assembled

TRAVELING DIRECTIONS FOR VISITORS

Our plants are open to all.

Springfield, Vermont, the home of the Flat Turret Lathe, is located near the Connecticut River just north of Bellows Falls. It is reached by a modern freight and passenger electric railway which connects with the Connecticut River Division of the Boston & Maine Railroad at Charlestown, New Hampshire.

The electric railway cars meet all trains, including the midnight, and take the travelers directly to the office and works of the Jones & Lamson Machine Company, which is located on the electric line three minutes' walk from the terminus.

The Adnabrown Hotel, at the end of the railway, is, of course, ready to receive guests at any hour.

Travelers from Boston come via the Fitchburg Division of the Boston & Maine Railroad through to Bellows Falls, at which junction they change cars to the Connecticut River Division for an eight-mile ride north to Charlestown, where an electric car will be found awaiting the train.

Visitors from New York come to Springfield, Massachusetts, over the New Haven Road, and change there to the Connecticut River trains, which run north through the beautiful Connecticut Valley to Charlestown, New Hampshire. In the summer season White Mountain trains run without change from New York through Charlestown.

The trip takes six to eight hours from New York, and from four to four and one-half hours from Boston.

Travelers from the West, if coming via the New York Central Railroad, generally continue to Springfield, Massachusetts, over the Boston & Albany Division or take the Fitchburg Railroad through the Hoosick Tunnel to Greenfield, Massachusetts, the junction with the Connecticut River Railroad.