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PRINCIPLES AND PRACTICE OF ASSEMBLING MACHINE TOOLS

PART I

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SECOND EDITION

CONTENTS

CHAPTER I

ELEMENTS OF ASSEMBLING OPERATIONS*

The machine shop operations usually treated in mechanical books by various authors have been almost entirely associated with machine work. Aside from this, and a factor of equal importance, is the subject of assembling. In its broadest sense, assembling may be defined as the operation of combining and adjusting the separate parts of each unit in such a manner that these units, when in combination, will properly perform a predetermined function. The operation of fitting is often included in the work of assembling; under ideal conditions, however, a distinct line of demarcation can be drawn, so that the term "fitting" will only apply to the operation of machining.

The purpose of this treatise is to show the possibilities that lie in developing methods of assembling that will ensure accuracy, economy and standardization, but before giving any concrete examples, it will be well to consider briefly the elements that directly affect the cost of assembling operations. The determination of proper methods and processes of assembling are peculiarly difficult, since the elements of human judgment and skill enter so largely into this work. It is a far more puzzling proposition than that of analyzing and determining the best method for machining any particular part. For this reason, the study of assembling work requires particular care and especially keen analysis.

Three Factors Leading to Economical Assembling

Accurate drawings, accurate machine work and the use of jigs and gages, are at the foundation of economical assembling. Without these factors, the term "manufacturing," used in its limited sense, really does not apply to the scheme of production. Much has been written on methods of dimensioning drawings and the use of limits as tending to accurate and at the same time cheap production, so that little need be said here on the subject. The system of giving all unimportant dimensions in inches and common fractions thereof, and expressing precise dimensions in thousandths of an inch, with the permissible limit of variation, is worthy of wider application. This, coupled with a thorough system of inspection, will insure that the parts function properly when assembled, besides preventing a choice of methods in machining that may entail a vast amount of work when less elaborate methods will produce a job that is good enough for the purpose. While the use of limits on drawings has been unsuccessful in many cases, the principal cause of its failure probably has been due to an injudicious selection of the maxima and minima for different classes of work.

In order to insure the accuracy of the machine work, it is absolutely

* MACHINERY, September, 1908.

necessary to provide for a thorough system of inspection in the machine departments. Some manufacturers only provide for inspection of the finished product and refuse to admit the advisability of adopting the broader plan. To state an important point which the author shall want to emphasize, we must always keep in mind not only the possibility of wasted money through excessive time in having to "fit" the parts in the assembling department due to poor machining, but *especially* the waste of valuable time in having to wait for parts to be replaced that have been spoiled in machining, the error not being discovered until ready for use. In brief, it is short-sighted to imagine for one moment that anything like economical results will be obtained in assembling unless provision for inspection after machining is made.

The great value of, and necessity for, jigs and fixtures on duplicate work and their bearing on the cost of assembling is too well recognized to need any further comment here.

Method of Investigation and Analysis

First of all, a careful analysis of the assembly drawings should be made in order to thoroughly understand the purpose of every part of a machine. This is an important consideration and will lead to the adoption of methods that will prevent undue accuracy and unnecessary expense incurred as a result. It is a mistake to accurately align and fit parts that may be said to "fit a hole in the air." The time needed for this can be more profitably spent on those parts that require accuracy and refinement. The purpose of every part should be studied; the operation necessary to produce it can then be regulated accordingly.

A matter that should receive careful attention is the question of rigidity in fits. Those of us who have "been through the mill" are painfully aware of the fact that most workmen fail to distinguish the difference in rigidity required in the fit of a lathe spindle from that necessary in the case of a shaft for operating a clutch lever. An illustration in support of this statement is afforded in the case of an automatic machine that recently came under the writer's observation. The machine in question was built by a manufacturer having a reputation for turning out very accurate work; in fact, the fits were so tight that at times certain members of the feed-stop mechanism would fail to function properly with the result that a part of the machine would be wrecked. After these members were fitted free enough, no further trouble was experienced.

Varying conditions make the determination of proper fits and adjustments in assembling work a question of experience and judgment. As a general proposition, sliding or revolving machine elements that do not affect the accuracy of the machine's product should be fitted perfectly free, so that there will be no indication of the parts working stiff. This applies especially to spring- or hand-operated mechanisms. Sometimes, however, the fact that these elements are apparently fitted or adjusted too tight can be attributed to their being out of proper alignment.

The next logical step in the study of the drawings will be to map out systematic and well-defined methods and processes of assembling so that the parts may be quickly and cheaply assembled, that they will be in proper relation to each other, and that the alignment of the various parts will be perfect within the required limits. Various ways of accomplishing the object sought will present themselves successively; unless special considerations prevent it, the process that will accomplish the object sought in the most direct manner is the one to be chosen. This consideration shows the importance of a thorough knowledge of modern methods, the facilities at command, the organization itself, and special tools and appliances.

General Requirements for Efficient Work

The drawings must always be followed. No deviations should be permitted. If any mistake is discovered or change found necessary

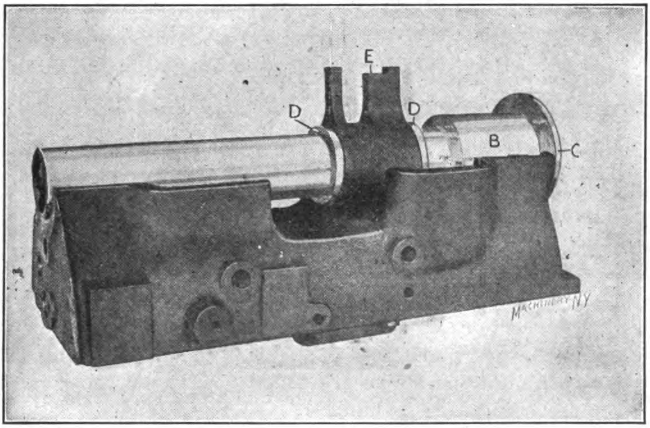

Fig. 1. Method of Gaging Clearances for Spindle Gears in a Lathe Head-stock

in the interest of economical assembling, then these corrections should be approved by responsible parties and made on the drawings. The importance of this is at once apparent. Standardization without observing this rule is impossible, and neglect of it will result in lax, inaccurate, and totally misleading methods of production. Again, in case of repairs, the new parts can be finished to the drawings with the assurance that they will fit properly. The drawings should always indicate the method of oiling a mechanism, as this matter, if left to the judgment of the assembler, may result in an inefficient system of lubrication.

If any errors are found to exist as a result of mistake in patterns or fault in casting, then these mistakes should be taken care of at once, so as to prevent a repetition on succeeding pieces. In the case of clearances this will prevent unnecessary "carving" to be done either by chipping or machining. In many instances, however, when the clearance allowed on rough castings is small and the design will not permit a change, it is unreasonable to expect avoidance of "carving."

Such cases should be anticipated before any assembling operations are commenced, and the necessary clearance made by chipping or machining so as to prevent having to take the work apart.

This principle is clearly illustrated in Fig. 1, which shows a lathe head-stock. For special reasons the clearance allowed in the head-stock casting for certain gears that run on its main spindle is very small. The gage for testing this clearance consists of a hollow arbor *B* having a locating flange *C*. Mounted on this arbor and free to turn between the collars *D* is the gage casting *E*, which has a contour 1/16 of an inch larger than that of the gears above referred to. By turning the gage it is very quickly determined whether there are any irregularities on the head-stock casting to be chipped off. The advantages of using this gage are that the irregularities can be more easily seen

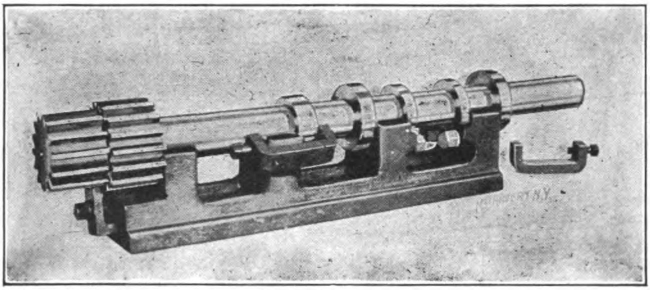

Fig. 2. Jig for Drilling Pin-holes in Collars on their Shaft to Insure Interchangeability

than by using the gears and spindle; any necessary chipping is done before the assembling operations are commenced; and the gage, being light, is quickly and easily handled.

Much profitable study can be given the question of substituting the machining process for operations that are usually performed by hand, such as chipping, filing, etc. Oil grooves should be machine cut on all pieces that can conveniently be handled on a machine; tapped holes can be tapped cheaper on a machine than by hand, except in the case of very small holes in large pieces; set-screw holes in shafts should be drilled on a drill press. The halftone, Fig. 2, illustrates the method of locating and drilling collars on a shaft in interchangeable work.

One example will suffice to show the possibilities of saving time in this direction. For many years it had been the practice of a certain machine tool builder to chamfer the threads on all split feed-screw nuts by chipping and filing. It will be understood that this is necessary in the case of split nuts so as to permit their opening and closing on the feed screw, the chamfer being at the joint. On a certain size nut it formerly took twenty minutes per pair by the hand method. The same size is now milled, using two cutters simultaneously, in one minute per pair, which includes clamping and removing the work.

It is, of course, unreasonable to expect to entirely do away with these hand operations, but in many instances to-day much of the chipping, filing and scraping could be avoided if proper attention was given to the matter. Probably the most notable example of the tendency in this direction is afforded in the manufacture of automobiles, where the hand operations consist merely in combining and adjusting the various elements.

Standardization

Standardization, as already pointed out and emphasized, is one of the "secrets" of economical assembling. It is a matter of common knowledge that interchangeable manufacturing is really economical manufacturing, and yet in many instances its fullest possibilities are not realized. There are many shops to-day that still cling to the old custom of "making every piece like itself." The practices of leaving stock for adjustment on the hubs of bevel gears, facing off the ends of

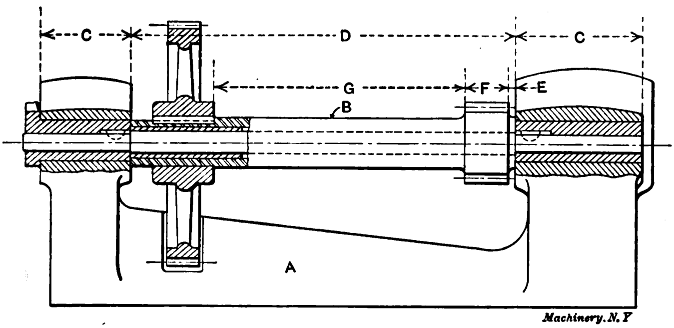

Fig. 3. Illustrating a Case where the Micrometer can be used advantageously for Length Measurements

bearings to no particular dimension, planing taper packings to fit slides that are not planed to gage and adjusting parts to fit others that are not standard, must be eliminated if economical results are expected. Some very simple form of gage, such as an inside or outside micrometer, will enable work of this character to be machined standard and made practically interchangeable at a fraction of the cost in assembling.

An example is given in Fig. 3 to illustrate this point; *A* represents an engine lathe head-stock having a back-gear quill *B* running between the eccentric-shaft bearings as shown. The length *C* of the bearings and the eccentric bushings can be made to an outside micrometer, while an inside micrometer is used to measure the length *D* between the bearings, the proper allowance being made on the quill for a running fit. An ordinary scale is used to take the measurements *E*, *F* and *G*, and, if care is exercised, the gear and pinion on the quill will line up with those on the main spindle, if the same precautions are taken in the case of the spindle shoulders and gears.

The experienced man will smile at the idea of these quills having to be adjusted by the assembler, but the author recently visited a shop building small engine lathes where this practice was still in vogue.

Errors in measurements of length are far more likely to occur and cause trouble in assembling than errors in diameter. This is probably due to the fact that in the latter case instruments of precision, such as the micrometer or limit gage, are in more common use. Standard length gages are indispensable on interchangeable work, although in instances similar to that referred to in Fig. 3 scale measurements are accurate enough. The fact is that few workmen can, or really do, work nearer than 1/32 inch with a scale.

However, there are cases met with in assembling where it is not practicable to machine all the parts standard, owing to the fact that a number of conflicting elements enter into the problem, and make it advisable to leave stock for adjustment on certain pieces. A concrete example is afforded in the case of a planer reversing mechanism, which is illustrated in Fig. 4. It is obvious that the rocker *A* must swing through a certain definite arc, the amplitude being limited by the

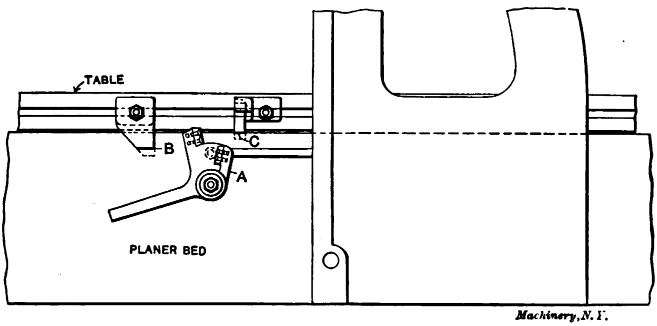

Fig. 4. Example of Work where some Fitting is left for the Assembler

movement of the belt shifter cam (not shown) and controlled by the lengths of the dogs *B* and *C*. It is at once apparent that there are a number of measurements which must be considered; a discrepancy in any one of them would make a difference in the working of the mechanism, and the easiest and quickest way to fit the dogs is to swing the rocker to one extreme position and scribe a line on the corresponding dog representing the cam face on the rocker; then repeating the operation for the other extreme position of the rocker. The dogs are then taken off and sawed close to the line, after which the surfaces are smoothed with a file and the steel members removed for the purpose of hardening.

Duplication

The duplication of parts in quantities is another step in economical manufacturing. For special reasons it may not be advisable to build the complete machine for stock, but in nearly every instance the standard parts can be assembled in lots and kept in stock ready to be placed on the bed of the machine when ordered. The advantages are many. First, a large reduction in initial cost results because of this production in quantities. This is due to the fact that the same operations can be performed on a number of pieces in succession. Again, the possibility of always having these parts on hand when wanted means quicker deliveries.

Methods and Processes of Assembling

The methods and processes of assembling will, of course, vary with the character of the work and the design of the machine, so that it is impossible to outline any comprehensive system with the thought that it could successfully be applied to all conditions alike. Indeed, a blind adherence to certain rules is liable to be a serious detriment. It is possible, however, to lay down a few fundamental principles which can safely be followed and which are adaptable to many differing conditions.

As was previously stated, the design and construction of a machine are intimately correlated, as becomes apparent when special methods needed for its construction have not been taken into account. For this reason, the designer should continually be impressed with the importance of bringing out the best possibilities of manufacture, both as to ease and cheapness of assembling, as well as machining. The tendency of modern machine design is toward the unit system of construction, in which the various units comprising the driving members, feed members, etc., are self-contained, being placed in gear-boxes and bolted to the bed of the machine. This feature enables the various units to be assembled independently and simultaneously, and is an important consideration, since the shortest possible time in which any particular machine can be assembled depends upon the number of operations that can be carried on at the same time. The most notable examples of the unit system of design are afforded in modern drilling and milling machines.

On the other hand, when the design is such that the parts are more or less interdependent, it is possible to separate or classify into groups the various members so that the unit system of assembling can be followed to a certain extent. This is especially true of interchangeable manufacturing where the necessity of adjustment is eliminated.

An important feature which should be emphasized is that, in assembling work, it is highly advisable to provide for the same sub-division of labor that exists in the modern machine department. Thus, the operations involved in assembling the units should be separated from the erecting process on the beds. In large shops these processes are carried on in different departments.

The operations involved in assembling, such as chipping, filing, scraping and fitting, are usually performed either at the vise and bench or on the floor, depending on the size or weight of the work; hence the name vise, bench and floor work.

Bench work is of a lighter nature than floor work, though it may, and often does, include the entire assembling process when the detail is small, and in case of large work many of the smaller parts are assembled at the bench and are then taken to the floor and adjusted to the other parts.

Floor work includes the erecting and assembling of heavy machines, and the machining of parts too heavy or too large to be operated on in the stationary machine tools.

In general, the sequence of operations is somewhat as follows: Work coming into the assembling department from the various sources should have all the machining operations completed, the only exceptions being in cases where it is absolutely necessary to leave stock for adjustment and where, owing to the fact that some parts are interdependent, it is not possible to carry on all the operations of machining at one time. A concrete example illustrating the latter case is shown in Fig. 5. It is obvious that it would not be practicable to bore the shaft hole *A* until the scraping operation is completed on the bed and carriage. In this particular case the support is bored in place on the bed.

The preliminary assembling operations of such parts as are interdependent consist of the chipping, scraping and aligning operations. Should chipping be necessary on parts that require scraping, then the chipping must be performed first in order to avoid having to take the work apart and to prevent the possibility of springing the pieces. Next in order are the scraping operations on such members as slides, carriages, ways on beds, spindle bearings, etc. This is to facilitate the

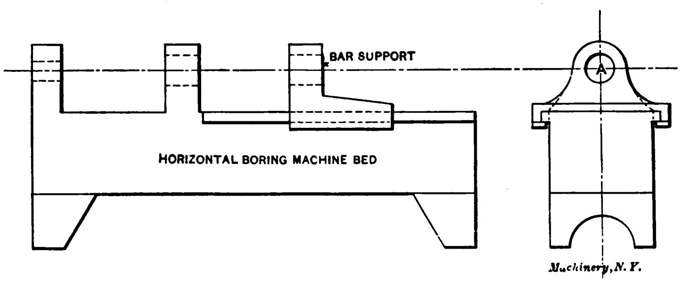

Fig. 5. A Case where some Machine Work is done after the Work is partly assembled

lining up operations. On small work, the use of special surface plates enables the pieces to be scraped and made practically interchangeable without having to try the pieces together, while on large work the element of spring in large surface plates, besides other considerations, precludes their use. Special lifting and pulling devices such as those described in Chapter III will greatly facilitate the work of scraping.

The determination of methods for quickly and easily lining up the various brackets, shafts, etc., is a matter that should receive careful thought. Whether or not jigs and fixtures are used will determine to a large extent the processes employed, although the final alignment of the brackets and bearings before the dowel pin holes are reamed, will be much the same in either case, the use of jigs saving the laying out of the screw holes. The halftone, Fig. 6, illustrates this principle and shows the method of aligning the brackets and feed-box on the head end of a turret lathe bed. Separate jigs are used for each member in drilling the clearance and tap holes and in boring the shaft bearing holes. To align the bracket members on the bed for the purpose of drilling and reaming the dowel pin holes, special arbors are used to bring the shaft bearings in the brackets and gear-box in line with corresponding bearings in the bed. With the clamping screws only tightened sufficiently to hold the various members in place, the brackets are shifted slightly to permit the arbors to be turned freely by hand, which indicates that all the bearings are in proper alignment. The clamping screws are then tightened down, and the pinning operations completed. It should be explained that the gear-box cover is in place on its base during these operations; in Fig. 6 it is shown on top of the bed for the purpose of showing the arbors more clearly.

If jigs were not used, as previously explained, the brackets and gear-box would have to be lined up and held by clamps for the purpose of marking off the screw holes in the bed. Incidentally, the method of setting the stud *C* with reference to its slot for the connection *D* is

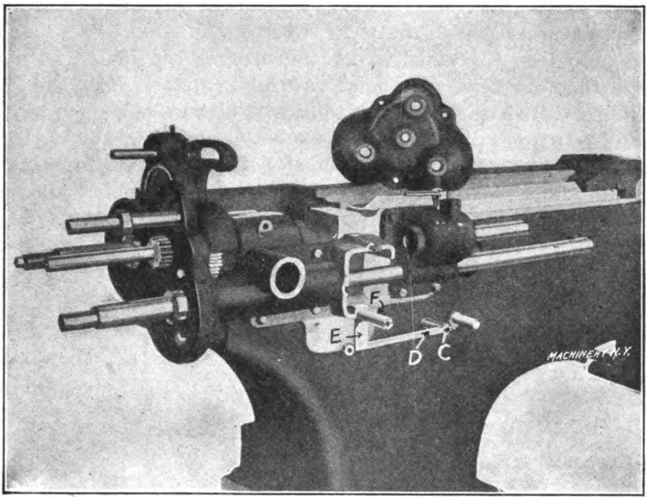

Fig. 6. Method of Aligning Bracket and Feed Box on the Head End of a Turret Lathe

shown. The sheet-iron gage *E* supports and locates the connection from the stud *F*.

In cases similar to that in Fig. 6, where it would be necessary to remove the shafts and gears in order to line up the brackets, it is advisable to perform this operation first. Otherwise, the units can be assembled complete, and then lined up on the bed.

The operation of assembling the individual units merely involves the chipping of oil grooves, hand reaming, fitting of keys, etc., and combining the various elements. Whether the units are sent to the storeroom or directly to the erectors, all operations of fitting and adjusting should be completed as far as possible. This will prevent the erectors from losing time by having to run to the vise and bench to fit the parts. Thus, in the manufacture of lathes, the head-stocks, tail-stocks, rests, aprons, etc., are assembled as complete units and are then sent to the erector to be fitted onto the lathe bed.

All work on the beds and such as cannot be performed when the units are fitted, is, of course, done by the erectors. This includes the scraping of the larger pieces, the lining up operations as already explained and the final adjustments and testing of the complete machine.

The principal point to be observed on erecting work is to plan the method of combining and adjusting the various units on the bed of the machine so as to avoid having to take the work apart, due to neglect of some vital point. The practice of taking the work apart unnecessarily shows lack of forethought in planning the methods and processes of assembling and emphasizes the principle already outlined of mapping out the sequence of operations beforehand.

A very careful consideration of all these problems and a serious attempt to solve them scientifically will bring surprising results. It hardly seems necessary to argue in favor of the adoption of the methods and processes advocated, since the experienced man will at once recognize them as being the most natural to follow. Yet the lack of effort to accomplish these results in most well-run shops (to say nothing of the poorly managed) is as singular as it is prevalent. In place of haphazard, inefficient methods must be substituted those that will lead to the adoption of standards proved by experiments and experience to be efficient, and these must be adhered to without deviation.

CHAPTER II

ASSEMBLING MACHINE TOOL UNITS*

In the previous chapter some fundamental principles were laid down relative to the methods and processes employed in manufacturing, and the proposition was advanced that accurate drawings, accurate machine work and the use of jigs and gages are at the foundation of economical assembling. Interchangeability, standardization, and duplication in quantities were also discussed. The present chapter will deal with concrete examples illustrating the application of these principles in actual shop practice.

Assembling a Turret Lathe Indexing Mechanism

The turret lathe indexing mechanism shown in the line engraving Fig. 7 is presented to bring out clearly the necessity for analyzing the

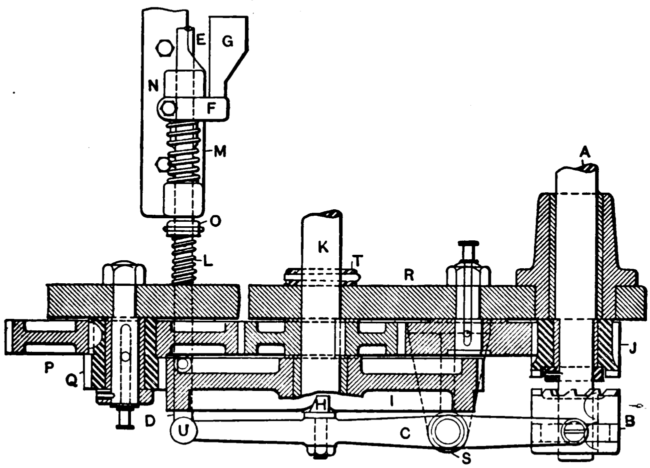

Fig. 7. Turret Lathe Indexing Mechanism to be assembled

purpose of every part of a machine in order to machine and assemble the members so that they will function properly. In operation, the driving shaft *A* is constantly revolving in a certain direction. Keyed to this shaft is the sliding clutch member *B* operated by the forked lever *C*, link *D*, rod *E* and stop *F*. The dog *G* is bolted to the turret carriage and when the carriage is run back this dog strikes the stop *F*, thus withdrawing the indexing pin *H* from its slot in the index gear *I* and engaging the driven clutch member *J*. This starts the train of gears that revolves the turret by means of the worm shaft *K*, the worm-gear being bolted to the turret. An automatic knockout (not

* Machinery, October, 1909.

shown) stops the power traverse of the carriage the moment clutch *J* is engaged.

The turret continues to revolve until the carriage is run forward by throwing in the rapid power traverse mechanism which allows the indexing pin *H* to enter the slot in the index gear, and the turret stops revolving by virtue of the springs disengaging the clutch member *B*. The ratio of the back-gears is such that the index gear makes one revolution for each station on the turret. Spring *L* is for releasing the clutch and spring *M* keeps the stop *F* in position when the bracket *N* is moved along the bed in its T-slot. It is obvious that the springs should be as light as possible in order to avoid unnecessary wear on the indexing pin and face of the index gear and also to prevent a heavy pound when in operation, but the springs must have sufficient power to always bring the index pin to the bottom of its slot in the index gear.

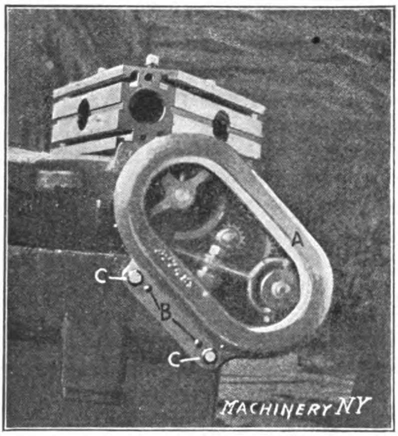

Fig. 8. Assembled Turret Lathe Indexing Mechanism shown in Detail in Fig. 7

The length of the springs, their stiffness, and the position of the collar *O* on the rod are determined in the beginning by experiment, and when found to be correct, their dimensions are marked on the drawing so as to provide for standardization. To permit the use of light springs, it is absolutely essential that the clutch-operating members be fitted perfectly free so that the mechanism will index properly. The function of these members requires no rigidity in fit and the looseness desired is provided for by limits on the detail drawings, so that when the work, properly inspected, comes to the assembler, no special fitting is required. As a general rule such parts receive little or no oil when the machine is in the hands of the operator, and if the parts are naturally stiff, trouble will arise. It must not be inferred that the writer is advocating such looseness in fits as to indicate poor workmanship, but many similar mechanisms have failed to work properly because of being too stiff, which shows lack of judgment and experience on the part of the assembler. The trouble in some cases, however, was due to the parts not being in proper alignment.

Before starting to describe any of the assembling operations, it will be well to bear in mind that while the description necessarily gives the operations in sequence, it is probable that in actual practice a number of different operations will be carried on at the same time, depending on the number of men working on the job. The gear plate and its cover, the latter being shown at *A*, Fig. 8, come to the assemblers with all the holes jig drilled and reamed except the taper dowel pin holes *B*. All the oil grooves are machine cut except those for the worm-shaft in the gear plate and cover.

Assuming that the turret lathe beds are in process, the operations of assembling the mechanism complete will include bench and vise work and also floor work, since some of the members are interdependent with others on the lathe bed. The bench work consists of assembling the three independent groups, *viz.*, the back gear members *P* and *Q*, Fig. 7; the fork lever members, including the sliding clutch *B*; and the operating rod bracket members *D*, *E*, *F*, *M*, *N*, and *O*.

The floor work consists of lining up the gear plate *R* on the lathe bed and assembling the entire mechanism. The operation of lining up is accomplished by means of two special arbors, one of which fits the worm-shaft bearings in the turret carriage, and the other the holes in the operating rod bracket *N*, the arbors being long enough to pass through corresponding holes in the gear plate. The arbors are placed in position, with the turret carriage and operating rod bracket moved as close to the gear plate as possible, the latter now being bolted to the lathe bed. For obvious reasons the lining up is done with special reference to the operating rod and worm-shaft holes, since the adjacent bearing on the bed for the driving shaft *A* is some four feet away from that on the gear plate. Alignment of the driving shaft is tested by surface gage measurements taken from the top and side of the V on the bed, a few thousandths "off" being permissible.

Referring to Fig. 8, the bolt holes *C* have 1/32 inch clearance in the gear plate to allow it to be shifted slightly, and when properly set, the taper dowel pin holes are drilled in the bed by means of a pneumatic drill, then hand reamed, and the taper pins driven in place. The subsequent operations consist of assembling the shafts, studs and gears in their places, the process being so simple that no explanation is necessary. Next, the operating rod bracket members are put in place, and then, after setting the index gear, the fork lever bracket *S* (Fig. 7), with its members already assembled, is bolted on and the connection with the link *D* made by inserting its pin.

Setting the index gear is accomplished in the following manner: The worm-shaft is set so that one-quarter of its total amount of back-lash is on the driving side, *i. e.*, if a line is placed on the periphery of collar *T*, and the total amount of back-lash in the worm between its bearings in the turret carriage allows the line on this collar to travel ½ inch, then the worm-shaft is turned so that the line on collar *T* moves back ⅛ inch from the side towards which the shaft revolves when in operation. Now, with the fork lever members in place, excepting the pin *U*, the index gear is set so that when the indexing pin *H* is in position in its slot, the pin *U* will enter freely in its holes by virtue of their being in line.

The setting of the index gear to accomplish this is done by keeping the teeth of the index gear in mesh with its pinion and changing the teeth in the large back-gear *P* in relation to those in its driving gear. Smaller adjustment of the index gear is obtained in this manner than by changing its teeth in relation to the teeth on the pinion *Q*, which fact is due to the ratio of the gears. Bolting on the cover is the final operation.

Assembling an Engine Lathe Apron

The engine lathe apron illustrated in the line engraving Fig. 9 is presented to show how machine tool units of this character are assembled on a manufacturing basis. Lathe makers, as a rule, build their lathe parts such as head-stocks, tail-stocks, rests and aprons in large lots so as to take advantage of the economy to be gained from carrying on the same operations on a large number of similar pieces in succession, both in machining and assembling; this has already been referred to.

It will be observed that the various shaft members are entirely independent of each other as far as their separate assembling is concerned,

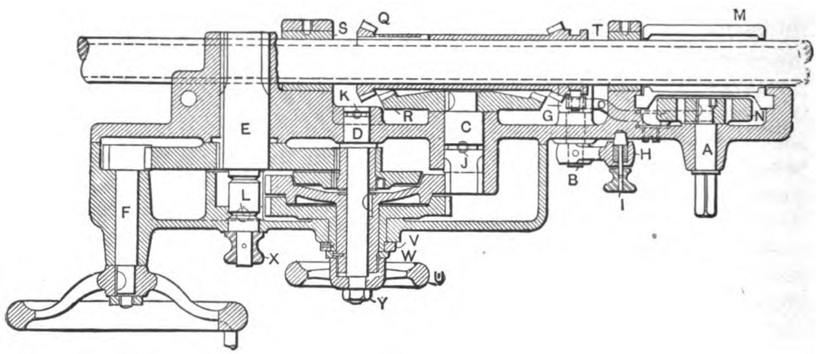

Fig. 9. Engine Lathe Apron to be assembled

so that it is highly advisable to group these units to permit their being assembled at the bench as opportunity offers, which in most cases is while the aprons and covers are being bored and drilled. There are six distinct groups consisting, respectively, of the shafts *A* to *F* and their members. The assembling of these groups at the bench merely involves ordinary vise work so that little explanation is necessary. It will be well to state here that when these parts are machined, particular attention is paid to the inspection of the length over shoulders, so that when the groups are assembled and put in place in the apron and cover, no occasion will arise for any fitting or adjusting.

The method of testing shoulders on the friction gear shaft members, group *D*, in Fig. 9, is clearly shown at the right in Fig. 10; *A* represents a surface plate having a hole to receive the bearing end of the shaft. The double friction gear *B* when in its place in the apron has a lateral movement of 1/16 inch, the movement being controlled by the hand-wheel *C*. The dimension *D*, when all the friction surfaces are tight, being known, it is tested with a surface gage as indicated. The dimensions *E* and *F* are tested with ordinary length gages. A running fit is allowed on all shoulders, while the lengths of the bearings in the apron and cover are made standard.

At the left in Fig. 10 is shown a jig for locating the levers *G* and *H* (Fig. 9) at the proper angle on their shaft while drilling and reaming the taper pin holes. This operation is done on a sensitive drill press to permit machine reaming. The jig is shown standing on end for the purpose of illustration, and its being used for two different sizes of levers accounts for the extra locating pins.

Referring now to Fig. 11, the method of testing the lead-screw nuts *M*, cam *N*, safety lever *O*, trunion lever *G* and the bevel gears *Q* and *R* is clearly indicated, the reference letters corresponding to those in Fig. 9. At *D* is shown a testing fixture in the form of an apron casting which is bored and reamed in the apron jig and is provided with supports at the back for holding it in the position shown. A short arbor representing the lead-screw is placed in the bearings *S* and *J* and holds the double bevel pinion *Q* (not in place in the engraving) in position.

It will be observed that the function of the safety lever is to prevent the double bevel pinion and the lead-screw nuts from accidentally

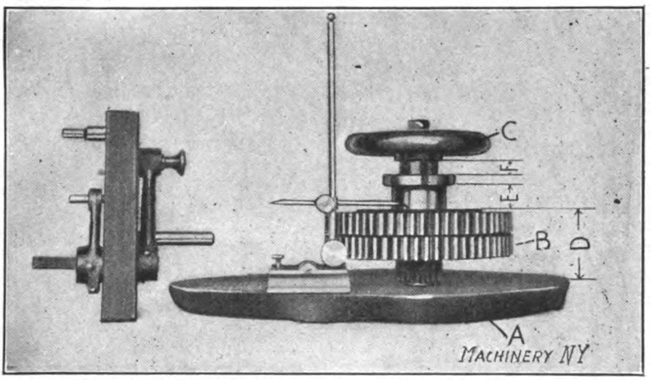

Fig. 10. Special Devices used in Assembling the Lathe Apron shown in Fig. 9

becoming engaged at the same time, which would cause a breakage. Special milling fixtures are provided for milling the ends of the safety lever and the slot in cam *N* and lever *G*.

A babbitting jig is provided for the lead-screw nuts so that it is not necessary to babbitt them in place on a threaded arbor. This has the advantage of making the nuts interchangeable, besides avoiding the necessity for carrying hot babbitt any distance through the shop. The cam pin holes in the nuts are jig drilled. If any of the members fail to function properly, the faulty member is, of course, replaced.

All the drilling, boring, and machine reaming on the aprons and covers is completed in the drilling department except the holes for the oil pipe (not shown), spring pin *I*, and set-screws *J* and *K* (Fig. 9). Small holes such as these can be drilled cheaper with an air drill, due to the fact that the oil holes are comparatively short and are on an angle, while the spring pin hole *I* cannot be drilled until some of the assembling operations are completed.

When the aprons and covers are received in the assembling department, they are placed on special trestles for convenience in assembling. The castings are now painted, all of the chipping and cleaning having been done in the foundry. The next operation consists in drilling the oil holes and the holes for the set-screws *J* and *K*. Jigs for drilling the latter are shown at *A* and *B* in Fig. 11. Jig *C* drills the spring pin hole *L* in the apron cover, which is machine drilled. The holes are at right angles to the top of the cover and the jigs are easily set up, as is evident by referring to Fig. 12 which shows jig *B* in position on the apron. It will be observed that these jigs permit the groove in the shafts to be cut standard size and the shafts made interchangeable.

After chipping the oil grooves and tapping the screw holes, the covers are bolted on for the purpose of hand reaming all shaft holes to standard size. The covers are then removed and the aprons laid face down for the purpose of fitting the lead-screw nuts *M* (Figs. 9 and 11). The nuts, babbitting jig and guiding ways in the apron being ma-

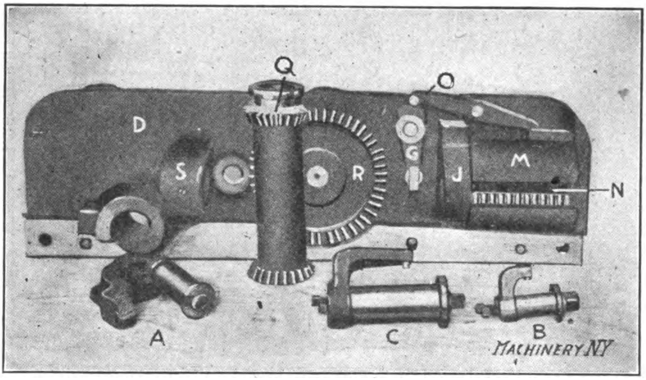

Fig. 11. Testing Fixture for Parts of Lathe Apron

chined to gage, it is only necessary to smooth the surfaces on the nuts and apron to make the nuts slide freely.

When all of the members shown in Fig. 11 fitting the back of the apron have been fitted and tested at the bench, they are put in place in the aprons. In performing this operation the corresponding pieces are placed in each apron in succession. With the lead-screw nuts closed by means of the cam, a special tap, mounted on an arbor fitting the lead-screw bearings, is run through the nuts to clean out the threads.

The aprons are now turned face up for the purpose of fitting the oil pipes and drilling the holes for the spring pin *I* (Fig. 9). There are three holes to be drilled in the apron for this pin to enter, one for the central position of lever *H* which operates the double bevel pinion, and one for each extreme position. A special center punch which fits the hole in lever *H* is used to lay out these. The central position is determined by the safety lever fitting into the notch in lever *G*; while the bevel pinion mounted on an arbor and alternately brought into mesh with the bevel gear, determines the extreme positions. After the holes are drilled by means of a pneumatic drill, a reamer is substituted for the center punch in lever *H* and the holes reamed taper to fit the spring pin *I*. A collar on the reamer acts as a depth gage. It would, of course, be possible to drill these holes in the jig that drills and bores the aprons, but this is hardly deemed advisable as there are a number of elements that must be taken into consideration, an error in any one of which would prevent the bevel gears from meshing prop-

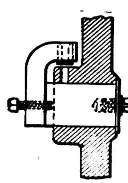

Fig. 12. Jig for Set-screw Holes

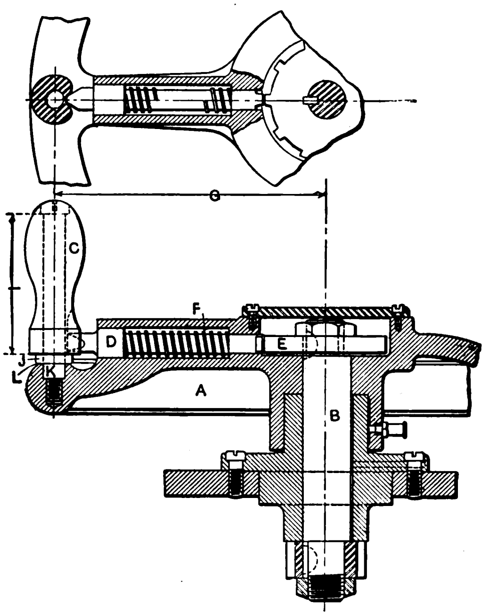

Fig. 13. Example of Device Difficult to assemble if Parts are not made in Jigs insuring Interchangeability

erly. Placing the spring pins *I* in position completes the work on the feed reversing mechanism.

The rack pinions *E* and gears are now put in place, then the friction gear shafts *D* and their members, except the hand-wheel *U* and collars *V* and *W*. After driving in the studs for the intermediate cross-feed gears (not shown because of the sectional view), the aprons are ready to receive the covers.

The work on the covers consists in placing the hand-wheel pinions and hand-wheel members in position and fitting the rack pinion spring pin members, after which the covers are bolted onto the aprons. The rack pinion knob *X* is now put on, and then the collars *V* and *W* are fastened onto the friction gears as shown in the line engraving Fig. 9. Screwing on the hand-wheel *U* and nut *Y* completes the apron, and it is ready to be sent to the store room.

Assembling an Automatically-releasing Hand-wheel Mechanism

Unless jigs and gages are used in the machining process, the peculiar conditions encountered in assembling a mechanism such as shown in the line engraving Fig. 13 would call for a high degree of skill on the part of the assembler besides involving excessive cost. The half-tones Figs. 14 and 15 illustrate a set of jigs and gages for producing this mechanism, which enables the assembling to be done without any filing or fitting, the object being to illustrate that *interchangeable* manufacture is really *economical* manufacture.

It will be seen that the function of the device is to automatically engage the hand-wheel *A* with, and disengage it from its shaft *B*, the action being as follows: Turning the hand-wheel in either direction by means of the handle *C*, so that the latter does not rotate in the hand, engages the pawl *D* with the ratchet *E* which is keyed to the shaft *B*; on releasing the handle, spring *F* disengages the pawl.

The requirements are that the handle and pawl must work perfectly free so that no effort to grip the handle hard will be necessary; the

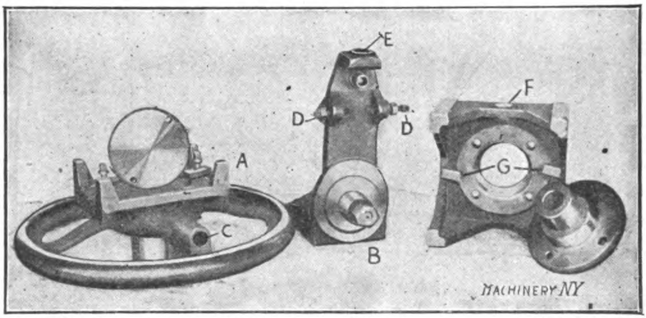

Fig. 14. Jigs for Drilling Parts of Device shown in Fig. 13

axis of the handle and pawl must intersect so that each cam face will work equally well; when the pawl is fully engaged with the ratchet, the handle end of the pawl must still be on the cam face of the handle; the contour of the cam, length of the pawl, diameter of ratchet and center distance *G* must be within close limits. Referring to Fig. 14, *A* is a jig for drilling the hand-wheel cover and its screw holes in the hand-wheel. The jig is shown in position for drilling the latter, being located in the counterbore of the hand-wheel. Resting on top of the jig is the hand-wheel cover which fits into the recess shown and is held by the two straps and bolts. The hand-wheel and its cover are, of course, drilled separately.

At *B*, in the same figure, is shown a jig for drilling the handle stud hole and the pawl hole *C*. The hand-wheel is located on a stud through its bore, and clamped to the jig by passing a bolt through the stud, this bolt being provided with a split washer on the end. To bring the pawl hole central with its hub, two set-screws are provided at *D* which hold the hand-wheel in position while being drilled by clamping against the sides of the spokes. The jig is fastened on the edge of the drill press table, so that the table does not interfere with the wheel. The vertical hole, with the drill guided by bushing *E*, is now drilled and reamed in all the hand-wheels, this hole being the pawl hole. For drilling and reaming the small diameter, a long bushing is used in the large diameter of the hole, to guide the tools. When this hole is drilled, the jig is then clamped to the side of the box table and the hole for the handle stud is drilled in all the wheels.

The jig shown at *F* in the same engraving is for drilling the shaft bearing which is seen to the right. The hub on the bearing fits into the jig, the straps *G* holding the work in place. Both this jig and the one at *A* are provided with complete sets of clearance and tap bushings so as to permit their being used on a multiple spindle drilling machine.

In Fig. 15 will be seen a set of gages for testing the component parts of the mechanism shown in Fig. 13. Gage *A* is for testing the length of the pawl which is shown in position in the gage. The ends of the pawl are milled with forming cutters. At *B* is shown a gage

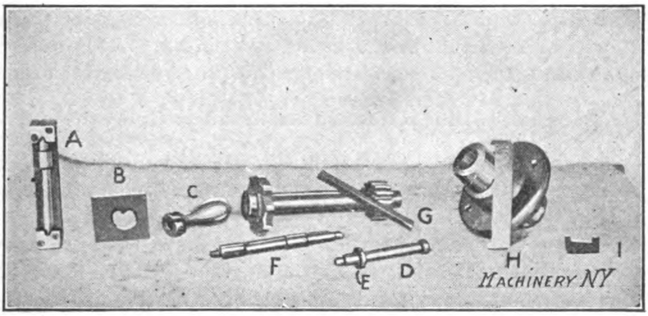

Fig. 15. Gages for Testing the Parts of the Device shown in Fig. 13

for testing the cam surface on the handle *C*. This cam is also milled with a forming cutter and when milled to the proper depth will just pass through the gage. The gage *D* is used to test the handle for length *I* (Fig. 13), the collar *J*, the depth of counterbore *K*. This gage represents a standard handle stud except that it is provided with a groove to fit the U-shaped collar *E* which is of the same diameter and thickness as the collar *J* in Fig. 13. To test the handle, the gage is inserted into the hole and the U-collar slipped into the groove; the collar *J* is tested for thickness by fitting it to the groove in the gage; to test the depth of the counterbore *K*, the gage is screwed into the hand-wheel and the collar *E* tried as before.

The tool shown at *F* is the counterbore used in connection with jig *B*, Fig. 14, for finishing the counterbore *K* and surface *L* in Fig. 13. At *G*, Fig. 15, is a length gage for the shoulders on the hand-wheel shaft against which the gage is seen resting. In the same engraving, *H* is a gage for testing the length through the bearing hole, while to the extreme right at *I* is shown a length gage for the hand-wheel shaft hole.

It will be observed that all of these gages, with one exception, that of the cam gage *B*, are length gages. Their use was found imperative for interchangeable work. This is due to the fact that errors in length are far more likely to occur and cause trouble in assembling than errors in diameter. All of the essential measurements of diameter on the component parts of the mechanism shown in Fig. 13, *i. e.*, the running and driving fits, are tested with ordinary limit and plug gages, while the threaded members are tested with male and female thread gages.

In assembling the mechanism, the pawl, its spring, and the handle members are first assembled. After fitting the Woodruff keys and the shaft members, the ratchet wheel is removed for the purpose of assembling the bearing and hand-wheel. The ratchet wheel is then replaced and the nut screwed down tightly with a socket wrench, the shaft being held from turning by engaging the pawl. Fastening on the cover and screwing in the oil cup finish the assembling operations. There is no adjusting or fitting to be done since the proper allowance for all fits are provided for on the detail drawings and the accuracy of the machine work is insured by a thorough system of inspection. Thus it will be seen that the work of assembling in this case merely consists in combining the separate elements in their logical order.

Summary of Principles of Assembling Operations

Summarizing the principles referred to in the previous discussion, we may state the following rules as being the main points to be considered in assembling work.

1. To secure economical results we must have accurate drawings, accurate machine work, and use jigs and gages.

2. The use of limits on detail drawings is valuable especially when supplemented with a thorough system of inspection.

3. Inspection, both in the machine and assembling departments, is absolutely necessary.

4. Before assembling any part of a machine, its function should be thoroughly understood in order to have the parts work properly and to avoid any unnecessary refinement.

5. Study carefully the question of rigidity in fits.

6. Plan quick and efficient methods of lining up.

7. Always follow the drawings. In no case should deviations be permitted.

8. Anticipate any extra chipping for clearance that may be necessary, and so avoid having to take the work apart.

9. Analyze the elements carefully, and see if it will not pay to substitute the machining process on pieces that are sometimes fitted by hand.

10. Standardization is one of the cardinal principles of economical assembling. Therefore, do not leave stock for adjustment when the pieces can be machined to standard size.

11. Provide for the duplication of parts in quantities so as to take

advantage of the saving to be gained from performing the same operation on a number of pieces in succession.

12. Separate the assembling operations for any particular job so as to provide for a subdivision of labor.

13. Follow the unit system of assembling in order to permit a large number of workmen to be employed on a job.

14. The operations involved in assembling the units should be separated from the erecting process.

15. All chipping should be done before the parts are scraped.

16. Where it would be necessary to take the work apart to line up the brackets or bearings, perform the lining-up operation first.

17. Plan methods and processes so that the work can be assembled with the least amount of handling

18. Provide ample handling facilities.

19. Make the laborious operations in scraping as easy as possible by providing efficient pulling devices.

20. Before sending the units to store or to the erectors, see that the operations are completed as far as possible.

CHAPTER III

LABOR-SAVING DEVICES FOR SCRAPING OPERATIONS *

There are a number of elements entering into the cost of scraping operations, other than that of scraping proper, which are always of sufficient importance to merit the closest consideration. In fact, very often it is the lack of attention to these other factors that accounts for much lost time. This is particularly the case in such laborious operations as "straightening out." This operation consists in moving the sliding machine member with the packing set up tightly, over the fixed member, in order to find the bearing on the packing, and finally to feel the "high spots." It is obvious that the packing must be adjusted to make the sliding member pull hard, otherwise it would be impossible to detect any variation in pressure due to inequalities in the machining.

Even on comparatively light work this pulling and pushing, if done directly by hand, involves more labor than is required in the actual operation of scraping. In work of this character, where brawn and muscle are prime requisites, we are dealing with the human elements which may cause a slowing up of production. The principal point to be observed is that a workman has a certain amount of physical endurance, and if the greater part of his energy is concentrated on the productive operation of scraping, a material increase in production will result; because of this fact, it becomes of extreme importance that means be provided for making the task of pulling easier.

The classifications of work determining the selection of a proper type of pulling device are:

(*a*) Planer slides, lathe rest slides and work of a similar character; these are usually pulled directly by hand. For this work a rack and pinion operated by a ratchet wrench is the most convenient type of pulling device; the tight and loose places in the work being easily detected.

(*b*) Boring mill rams, shaper rams, milling machine tables and similar work, which is comparatively short and too heavy to be pulled by a ratchet wrench. The type of device suitable for this class of work is a rack and pinion operated by power. The pinion being driven through a frictional device, the slipping of the driven friction member indicates the "high spots" in the work.

(*c*) Planer cross-rails, lathe beds and work having large dimensions, and where the pull required is long. For this class of work the pulling device takes the form of a power-driven wire rope drum. A tension indicator interposed between the work and the wire rope indicates any variation in pulling force required to move the work.

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* MACHINERY, April, 1909.

Pulling Devices Consisting of Rack and Pinion Operated by Ratchet Wrench

Concrete examples of the conditions stated in class (*a*) are illustrated in Figs. 16, 19 and 20. Fig. 16 shows the application to a planer slide and swivel, of a rack and pinion operated by a ratchet wrench. In this case, the clamping bolt hole *A* in the swivel is made use of as a bearing for the pinion. A lug is cast on the slide at *B* to provide a

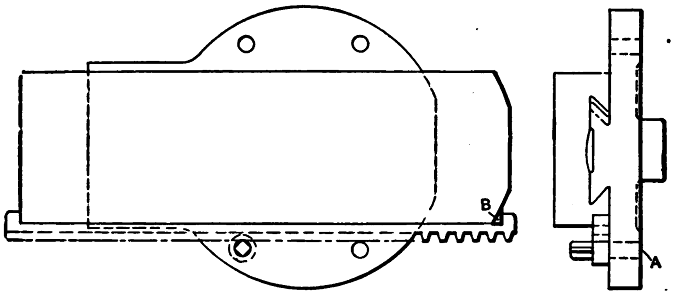

Fig. 16. Device for Pulling Planer Slide Back and Forth

square seat for the projection on the rack. The rack is a loose fit endwise on the slide and is easily removed.

When the design of the swivel is such that the clamping bolt hole *A* is too near the slide to be used as a bearing for the pinion, the device shown in Fig. 17 is substituted. The pins *C* fit into the holes in the swivel and hold the device from moving. The surface *D* supports the rack and keeps it in place when the slide is in the extreme positions. The lugs *E*, indicated by the dotted lines, show how the device can be

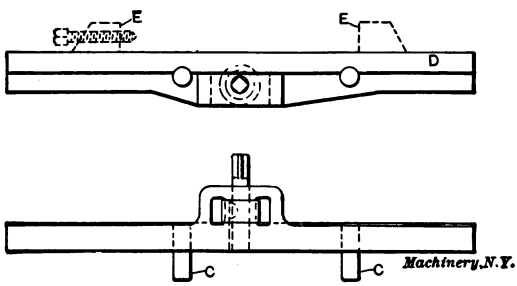

Fig. 17. Support for Rack and Pinion

attached to a swivel in which the clamping bolt holes *A* (Fig. 16) are not available for supporting the device.

The special bench represented in Fig. 18, while not strictly a pulling device, is shown because it is very useful for holding slides and swivels and work of a similar character, during the operations of pulling and scraping. The top half of the bench, shown tilted, is for holding the swivel on an angle, the object being to easily keep the slide against the fitting angle of the swivel while finding the bearing before the packing is fitted. When the packing is being fitted, and during the operation of "straightening out," this swinging top *A* is kept level. The magnetic chuck *B* provides a very convenient means for holding the packing while it is being scraped. A drawer *C* is for keeping the scrapers, oil-stone, etc. The bench is made of wood and iron and bound at the corners.

Fig. 19 clearly indicates the method of attaching a rack and pinion to a lathe rest and shoe. The rack *A* is bolted to the rest by means of the T-slots. The pinion bearing casting *B* extends across the top of the shoe and is clamped by two bolts in the circular T-slot. The rack

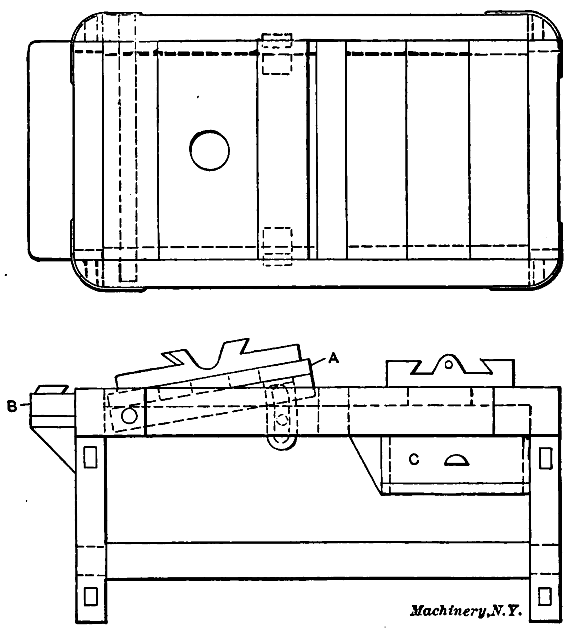

Fig. 18. Bench for Holding Slides and Swivels

is quickly made parallel with the ways of the rest by placing the shoe, with the pinion clamped to it, in one extreme position and clamping the adjacent end of the rack in proper mesh with the pinion; then repeating the operation with the shoe in the other extreme position.

The method of attaching a rack and pinion to a small planer cross-rail and saddle is shown in Fig. 20; it is practicable to apply this method for pulling the saddles of cross-rails up to sizes of 48 inches. Referring to the illustration, the rack rests on the rough inside surface of the cross-rail, and is held in position by a screw, studs and nuts as indicated. The adjustment of the pinion into proper mesh with the rack is accomplished by making the pinion bearing *A* in the form of an eccentric bushing fitting into the hole in the saddle. The eccentric bushing is clamped by the strap *B* and bolts *C*.

Power-operated Rack and Pinion Pulling Devices

The principles embodied in the design of the pulling machine illustrated in Fig. 21 are adaptable to the work mentioned in class (*b*). This machine is made for pulling boring mill rams; the simplicity of the design is immediately apparent from a study of the three views

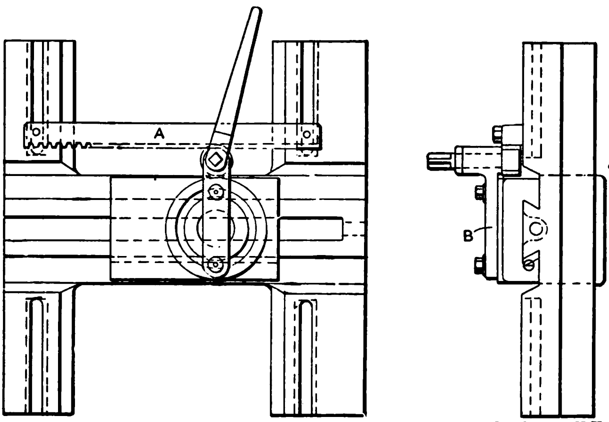

Fig. 19. Method of Attaching Rack and Pinion to a Lathe Rest

shown in the engraving. The top and end views show a right-hand ram and swivel in position on the table of the machine. This table is supported on three legs to avoid any tendency to "wind," and the design is adapted to hold either right- or left-hand swivels.

The machine illustrated is belt-driven, although a motor drive could be easily substituted. The mechanism for driving the pinion *A*, which

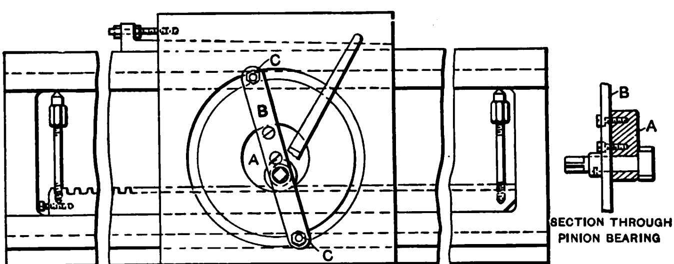

Fig. 20. Rack and Pinion for Pulling a Planer Saddle

meshes with the teeth of the ram, is clearly shown in the side view. Referring to the sectional view of the friction pulley, the driving member is the flanged pulley casting *B*, having solid web. This member is a running fit on the shaft *C* and friction disks *D*. The friction disks are the driven members, and are keyed to the shaft *C*. Between these disks and the pulley casting are two leather washers *E*. The amount of friction required is adjusted by means of the split nut *F*,

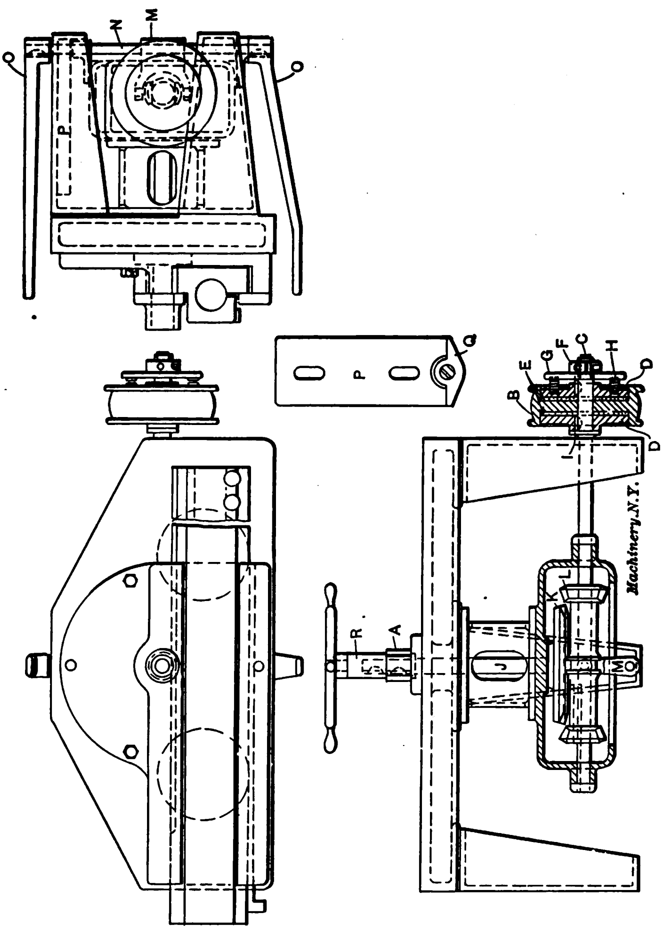

Fig. 21. Machine for Imparting Motion to Boring Mill Rams while Scraping

which moves the spring disk member *G* (keyed to the shaft) and compresses the twelve springs *H*. This regulates the pressure on the friction disks, leather washers, and pulley; the thrust is taken by the nut *F* and collar *I* on the shaft.

The leather washers are prepared by being soaked in oil for 24 hours. This preparation, together with the action of the springs, provides a very uniform and positive slippage of the driven members when the load is excessive.

A motion in either direction is imparted to the pinion shaft *J* by the bevel gear *K* and the double bevel pinion *L*. The bevel pinion is operated by the yoke *M*, shaft *N* and operating levers *O*. The detail sketch of the weight *P* shows its action on the double rocker arm *Q*, which is pinned to the lever shaft *N*. It is obvious that this device keeps the double bevel pinion in a central position when the hand levers are not being operated. The hand-wheel sleeve *R* is a sliding fit on the pinion shaft and its key.

In operation, the swivel is centered by its hole fitting the hub cast on the table, and clamped by bolts as indicated. When the packing and gibs are being fitted, the hand-wheel is left off the machine, and the ram only moved back and forth for a short distance near the center of its travel. After the operation of "straightening out" the ram is completed, the hand-wheel is used to pull the ram by hand

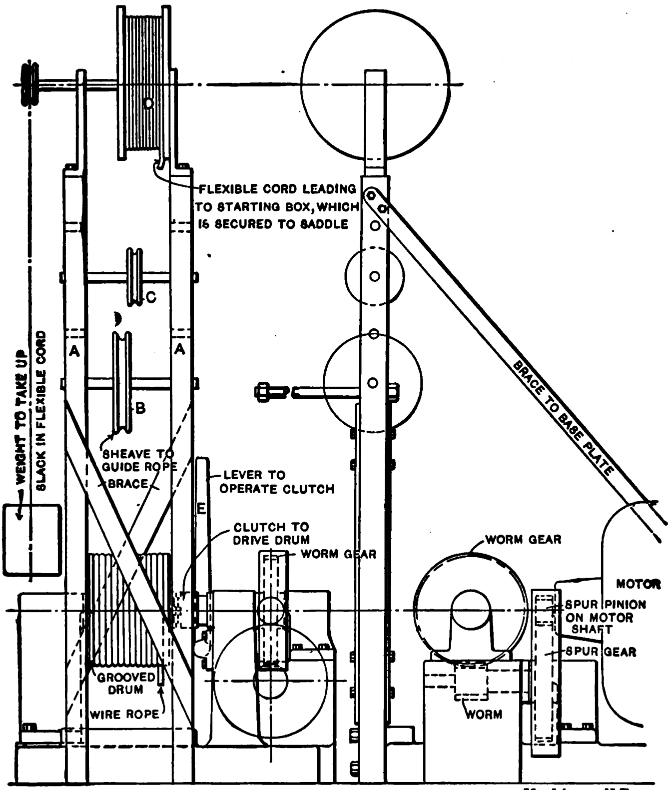

Fig. 22. Pulling Device for Large Planer Saddles

(once or twice) to make sure the ram pulls evenly from end to end of its travel. The friction is adjusted so it will just pull the ram when the packing and gibs are set to a rather tight running fit. The "high spots" in the ram are indicated by the friction slipping. The machine is geared to move the ram at about the rate of 15 feet per minute. A modification of this machine is adaptable for pulling any work of comparatively short dimensions, by coupling the sliding work member to a rack supported in suitable guides and driven by a mechanism similar to that shown in Fig. 21.

Power-driven Wire-rope Drum Type of Pulling Devices

The type of pulling machine illustrated in Fig. 22 is particularly well adapted to the work mentioned in class (*c*). The general features of the machine comprise a heavy cast-iron base carrying the motor, wire rope drum and driving mechanism. Bolted to the base are two upright steel bars *A*, which are made rigid by the braces as indicated. These bars support the wire rope idler sheaves *B* and *C* and the electric conductor cord drum D. The holes in the bars *A* are for carrying the wire rope sheaves at a height to suit the work, it being desirable to have the rope attached to the gage, measuring the pull, as nearly level as possible.

It will be seen that the machine is self-contained as far as the application of power is concerned. The spur pinion on the motor shaft meshes with the gear on the worm shaft. Between the bearings for this shaft is the worm; this worm drives a worm-gear on a cross-

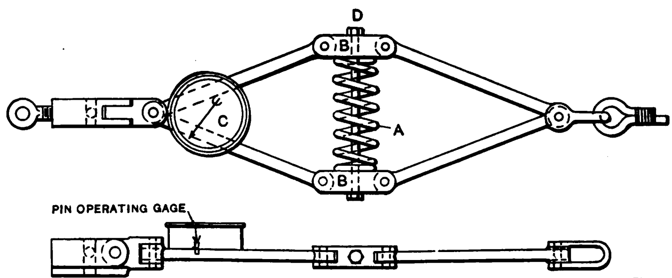

Fig. 23. Indicating Mechanism for Pulling Device

shaft. On the cross-shaft are also a sliding clutch and wire rope drum. This drum has clutch teeth cast on one end and is driven by the sliding clutch. The lever *E* is for operating the sliding clutch. The advantage of this clutch is to facilitate the attaching of the wire rope with its tension indicator to the work.

The tension indicator illustrated in Fig. 23 and used in connection with the pulling machine just described, is essentially a double toggle joint. A force pulling on the wore rope, with the indicator attached to the work, compresses the spring *A* between the two short links *B*. The amount of compression is indicated by the index hand on the dial of the gage *C*. The function of the stud *D* is to limit the outward travel of the lever arms and thus reduce their movement by keeping the spring under a slight compression when there is no load, *i. e.*, there is no movement of the lever arms until the pull is sufficient to move the work. This avoids the tendency of the gage to jump or vibrate.

The construction of the gage is clearly indicated in Fig. 24. The body of the gage is pivoted to the lever arm *A* by the screw *B*. A stud *C* screwed into the lever arm *D* passes through a slot in the body of the gage. A shoulder on this stud and the screw *B* keep the gage in place. The link *E* connects the stud *C* with the sector *F*. The teeth on this sector mesh with the pinion on the index hand shaft. There is no stop pin at zero for the index hand, the return to zero being controlled by the stud *D*, Fig. 23.

Referring now to Fig. 23, it is evident that since the relative movement of any two levers of the toggle joint is not in direct proportion to the amount of tension applied to the device, compensation should

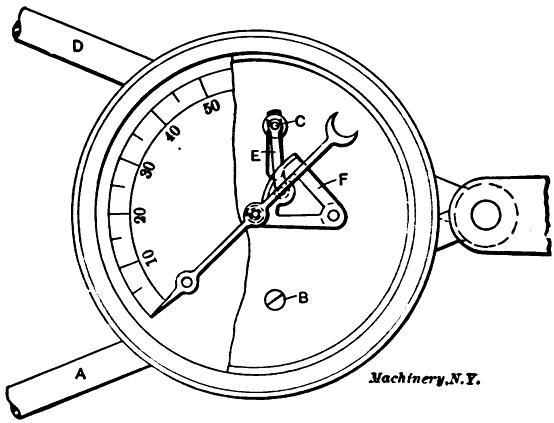

Fig. 24. Detail of Gage shown in Fig 23

be made in the dial graduations. This refinement is not necessary, however, as the requirements simply are that the gage indicate *variations* in tension and not the *amount* of variation measured in any definite quantity.

Fig. 25 shows the pulling machine and tension indicator in position for pulling a planer cross-rail saddle. The cross-rail is shown lying

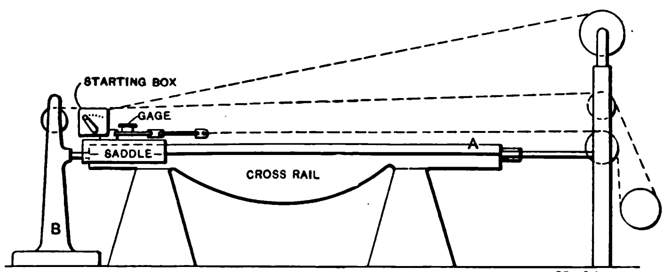

Fig. 25. Pulling Machine, Fig. 22, and Tension Indicator, Fig. 23, in Position for Moving a Planer Saddle along the Cross-rail

face up on suitable iron parallels. This is the position for fitting the packings and "straightening out" the angle. When the surface *A* is being scraped, the cross-rail is turned right-side up. In this case the idler sheave shafts are moved up in their supports so as to keep the wire ropes level. The pulling machine is not fastened to the floor; its weight and the braces keep it in position. The same conditions exist in the case of the idler pulley stand *B*.

The wire rope for pulling the saddle back to the starting point is fastened to the eye-hook shown in Fig. 23. The swivel block of the indicator is bolted to the T-slot in the saddle. When the saddle is pulled backwards, the packing is left loose.

The starting box and reversing switch for the motor are on a board which is fastened to the saddle. The weight and cord attached to the sheave on the drum shaft, Fig. 22, take up the slack in the electric cable as the saddle moves forward. The rate of traverse is about 10 feet per minute.

In operation, the saddle is moved for a short distance near the center of the cross-rail to fit the packings. During the operation of "straightening out" the cross-rail, the saddle is brought to the position shown in Fig. 25, the packing is adjusted and the operator starts the motor. By watching the gage, the operator marks on the cross-rail with a piece of chalk the tight places. When the surfaces being tested are parallel with those that have previously been sur-

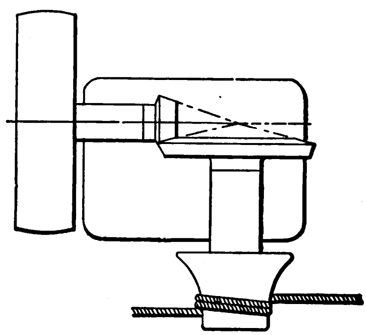

Fig. 26. Winch Superseded by Pulling Machines in Figs. 21 and 22

faced with a straight-edge, the index hand on the gage will remain fixed from end to end of the cross-rail. The packings are, of course, tightened one at a time.

The engraving, Fig. 26, represents a power-driven winch that was superseded by the pulling machines described in this chapter. The advantages possessed by the latter types are at once apparent; they are time and labor savers. The principal point to be gained by their employment, however, is the fact that far more accurate results are obtained.

It will be observed that the gage shown in detail in Fig. 24 consists of parts from a standard pressure gage. The reason for using this was a special one in this case.

When the pulling machine shown in Fig. 26 was designed, a hydraulic tension indicator, illustrated in Fig. 27, was made. The general principles of this indicator are immediately apparent from a study of the line engraving.

Although the piston was grooved, and the cylinder and piston ground to insure their being a good fit, trouble was experienced from the oil leaking past the piston. Provision was made for returning the oil to the front of the piston by opening the valve *A* and pushing the piston-rod back. The principal cause of its failure, however, was the fact that the gage was too sluggish in its action. The sliding members to which the indicator was attached, had to travel quite some distance before the gage indicated the actual tension.

The indicator above referred to was then designed by the writer, using parts from the pressure gage. This type proved to be very simple and efficient.

Application of Lifting Devices to Assembling Work*

The operation of scraping the sliding or revolving machine elements to a fit, necessitates their being lifted and turned over a number of times. When the pieces are too heavy to be lifted by hand, the im-

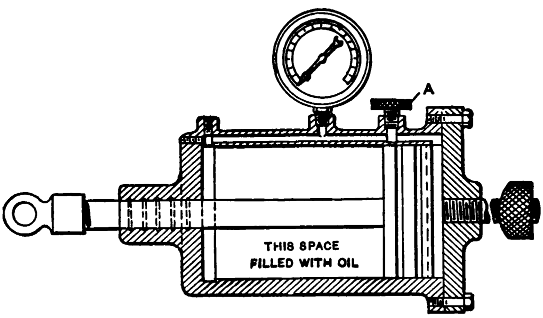

Fig. 27. Tension Indicator which proved a Failure

portance of providing efficient lifting devices is much greater than is usually apparent. Very frequently the time consumed by the scraper hands in trying the pieces together to find the bearing, and in waiting for the crane, exceeds, by quite an appreciable percentage, the actual length of time consumed in the operation of scraping.

In many instances a properly designed lifting device is far superior to a chain or rope for handling the work, and in cases where a device can be designed to eliminate the use of both a chain and crane, a large saving in time can reasonably be expected.

Requirements Placed on an Efficient Lifting Device

The main points to be considered in the design of an efficient lifting device are stated in the following rules:

1. The device must be safe and simple.
2. It must admit of being quickly attached to the piece to be handled
3. Avoid the necessity of detaching the device when trying the pieces together.
4. In case the work has to be turned over to scrape the surface, bal-

* MACHINERY, February, 1909.

ance the piece so that it will swivel easily and yet hang in a position to slide or lower onto the fixed member.

5. Make the device adjustable to allow for the varying center of gravity in similar pieces of work.

6. If possible, clamp the device to the work by making use of holes already in the work.

7. Admit of close adjustment for height.

8. When possible, handle the work without the use of a chain or crane.

Examples of Lifting Devices for Assembling Work

The accompanying engravings illustrate a number of lifting devices, and suggest their application to a variety of work. The function of

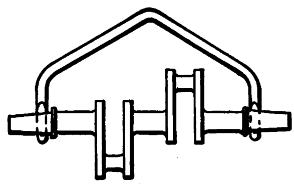

Fig. 28. Machine Steel Sling for Lifting Crank-shafts

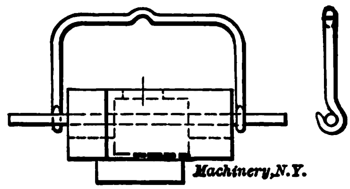

Fig. 29. Device for Lifting Turrets

the device illustrated in Fig. 28 is clearly indicated in the engraving. The device is made of round machine steel bent to the shape shown. Fig. 29 represents another application of a similar device for lifting turrets. The device is attached to the turret by means of a round bar passing through the holes in the turret. The ends of this bar are left long to serve as handles for revolving the turret on its carriage to

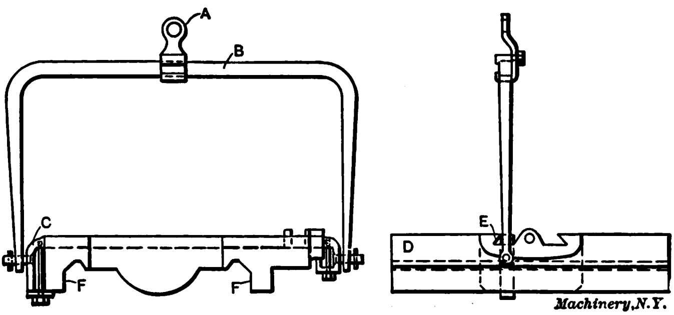

Fig. 30. Sling for Lifting Lathe Carriages, which is equipped with an Adjustable Crane-hook Eye

find the bearing. A device of this character covers the fundamental principles laid down in rules 1, 2, 3, and 4.

The device shown in Fig. 30 is for handling a lathe carriage, and illustrates an application of rule 5. It will be observed that the eye *A* can be adjusted along the frame *B*. This is to balance the carriage and allow for the varying center of gravity in different carriages. The method of clamping the swivel bar *C* to the carriage is clearly indicated. The carriage is balanced lengthways so that the end *D* will be raised first, the object being to prevent the swivel bar *C* from slipping away from the angle *E* of the carriage. In some designs the sides of the carriage *F* are a close fit on the lathe bed. In this case the carriage may bind when being lifted off the bed, and if a power crane is used there is danger of springing the carriage. The safety device shown in Fig. 31 overcomes this difficulty, and is so simple that little explanation is needed. The device is suspended from the crane hook by the link *G*. The hook *H* is for attaching the carriage

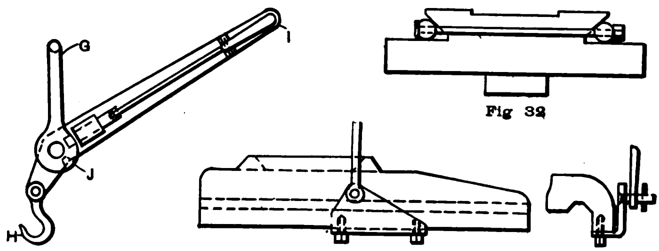

Fig. 31 Fig. 33

Fig. 31. Crane Attachment, for ascertaining whether a Piece being lifted from its Seat binds. Fig. 32. Device for lifting a Swivel by Hand. Fig. 33. Method of attaching a Lifting Device to a Turret Carriage

by the device shown in Fig. 30. When lifting the carriage off its bed most of the weight is taken by the crane; the lever *I* is then pulled down until the spring pin enters the hole *J*, when the carriage is clear of the bed. The operation is reversed for lowering. By this

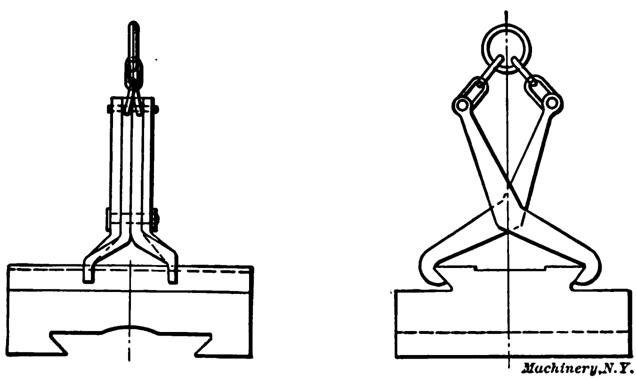

Fig. 34. Gravity Tongs for Handling Work such as Illustrated

method any tendency of the carriage to bind is quickly felt, and the danger above referred to is avoided.

Fig. 32 illustrates a method of lifting a swivel by hand. Two round machine steel bars, about 12 inches longer than the swivel, are laid one in each angle and bolted together as indicated. The projecting ends serve as handles to lift the swivel. In case the swivel is lifted by a crane, a sling chain is passed around the handles to lift the swivel from its shoe; it is easily turned over by making a hitch to one of the bars.

The method of attaching a lifting device to a turret carriage is clearly indicated in Fig. 33. The point mentioned in rule 6 is observed in its design, and the holes already filled in the turret carriage for the gibs are made use of for clamping the swivel plates.

The gravity tongs shown in Fig. 34 are very efficient for handling

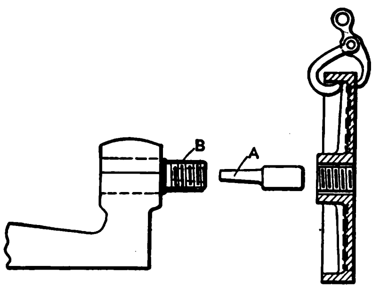

Fig. 35. Appliances which Facilitate placing the Face-plate on the Lathe Spindle

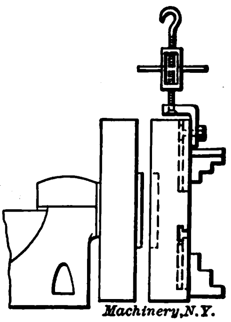

Fig. 36. Crane Attachment for Lifting Turret Lathe Chucks

work of the character represented. They are so simple that no description is necessary.

For lifting a lathe face-plate for the purpose of screwing it onto the spindle, the method shown in Fig. 35 is very convenient and enables the work to be done quickly. The face-plate is lifted by the gravity

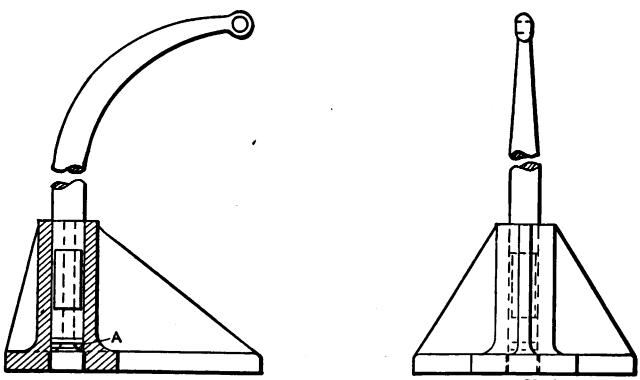

Fig. 37. Small Individual Crane provided with Ball Thrust Bearing

tongs. The taper shank of the pin *A* fits into the spindle *B*, and the straight end is an easy fit in the hole of the face-plate. When the pin is lightly driven into the spindle hole, it supports the face-plate after it is released by the tongs. Being thus centered and free to revolve, the face-plate is easily screwed onto the spindle. Especially where head-stocks are built in lots, this method of screwing on the face-plates will save considerable time.

The function of the device shown in Fig. 36 is clearly indicated in the engraving. The device is an application of rule 7, and is for lifting turret lathe chucks when attaching them to the chuck gear. The T-slot in the chuck is made use of to clamp the device. The turnbuckle,

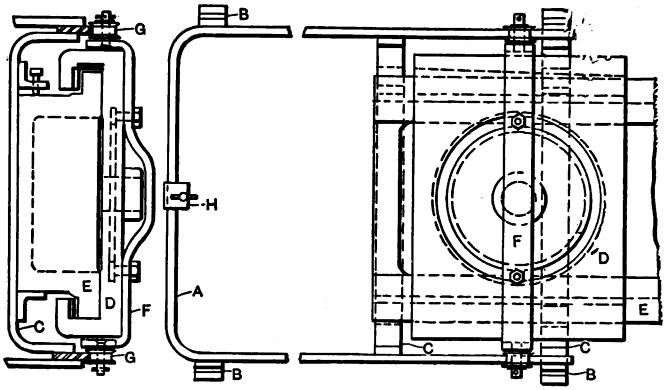

Fig. 38. Device used when fitting a Saddle to a Cross-rail

with its right- and left-hand threads, provides an easy adjustment for height so as to center the chuck with the gear.

In shops where the crane facilities are limited, the jib crane shown in Fig. 37, which is used in connection with an air hoist or chain fall, will be found very useful. With this outfit there is no excuse for not being "on the job." The ball thrust bearing *A* allows the arm to be

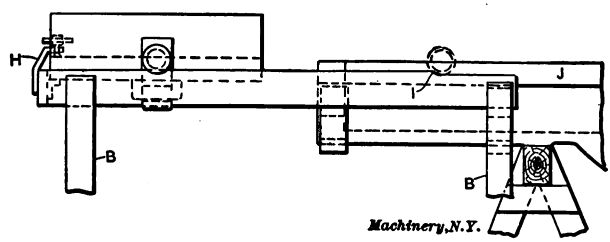

Fig. 39. Elevation of Device used when fitting a Saddle to a Cross-rail, which enables the Former to be removed from the Latter and scraped, without the Use of a Crane

swung easily when under load. The base can be clamped to a lathe bed, cross-rail, or any solid foundation, and the device used in connection with the lifting devices previously referred to.

Fig. 38 shows two views of a device designed by the writer, for fitting a saddle onto a boring mill or planer cross-rail. Rule 8 is observed. The object of the device is to provide a means for holding the saddle in a position to scrape, turn it over, and slide it onto or off of the cross-rail, without the use of a crane. Referring to the illustration, the frame *A* has four legs *B*, and is fastened to the cross-rail by the braces *C*. This frame serves the purpose of a track to guide and support the saddle *D* when it is off the cross-rail *E*. The saddle is carried by the strap *F* and rollers *G*, and when in position to be scraped, is held by the clamp *H*. By referring to the elevation shown in Fig. 39, of a similar device, it will be observed that the frame at *I* is cam-shaped. The object of this curve in the track is to keep the saddle from touching the end of the cross-rail while being slid on or off, making the operation easy and preventing a false bearing being made on the saddle, as would be the case if the saddle had to drag over the end of the cross-rail. Fig. 39 represents the end of a boring mill cross-rail lying on horses, in position to have the saddle fitted. In practice the edge *J* of the cross-rail would be elevated slightly so as to easily keep the saddle in contact with this edge when it is being slid along.

When using a power crane, and lifter similar to the one shown in Fig. 30, for doing the work just described, trouble was experienced in obtaining the proper adjustment for height so that the saddle would slide easily onto or off the cross-rail. This was to be expected, as the variation in height had to be within a limit of say ¼ inch, an adjustment not easily obtained with a power crane. The main advantage to be gained, however, by using the device illustrated in Fig. 38 was in not having to wait for the crane. A similar device could easily be made for handling lathe carriages when fitting them to the bed.

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