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No. 82

A Dollar's Worth of Condensed Information

Locomotive Building

By RALPH E. FLANDERS

PART IV

VALVE MOTION—TOOL-ROOM PRACTICE

Price 25 Cents

CONTENTS

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NUMBER 82

LOCOMOTIVE BUILDING

By RALPH E. FLANDERS

PART IV

VALVE MOTION—TOOL-ROOM PRACTICE

CONTENTS

CHAPTER I

MAKING WALSCHAERTS VALVE GEAR*

Every mechanic really interested in mechanics, who chances to live near one of the great trunk line railroads, must have noticed a remarkable change in locomotive design which has taken place in the last four or five years. We refer to the increasing use of the Walschaerts valve gear. A locomotive equipped with this gear, as shown in Fig. 1, presents a distinctly different appearance from one furnished with the old-style Stephenson link motion, which is mounted out of sight between the frames of the engine. This difference in appearance is especially noticeable with the engine running at high speed when the lines of flashing light made by the flying steel work of the rods and links give a decidedly mazy and complicated appearance to the mechanism.

The Advantages of the Walschaerts Gear

In reality, however, the Walschaerts gear is not as complicated as the Stephenson type. The deciding factor in its adoption, as every railroad man knows, was not the matter of complication, but of dimensions. Of late years engines have grown so tremendously in size and power that it has become next to impossible to find room between the frames for eccentrics and valve movements of sufficient size and wearing area to give strength and durability for the heavy service required of them. Besides this, the large diameter of the axles of heavy locomotives requires an eccentric of correspondingly large diameter; and with this, the surface speed of the bearing of the eccentric strap on the eccentric is so great as to practically nullify the effect of any increased area which could be given to it by careful designing. These considerations led to the adoption of a form of valve gear which was located entirely outside the wheels, where no serious dimensional limitations were placed on the parts.

When it came to the actual application of the new motion to the locomotive, it was found to have further advantages. One of them lay in the fact that it is always exposed to the view, making it very easy to erect and maintain, leaving it open for the constant inspection of the engineer. Besides this, it may be easily so designed that all its movements are in straight lines, without canting or side strains, thus practically adapting it to heavy service. In the matter of steam distribution and economy, there is little to choose between the two, though the old gear may have a slight advantage.

We have referred to the Walschaerts gear as a "new" form of gear. This is true, however, only for American service. It has been used

*MACHINERY, June, 1910.

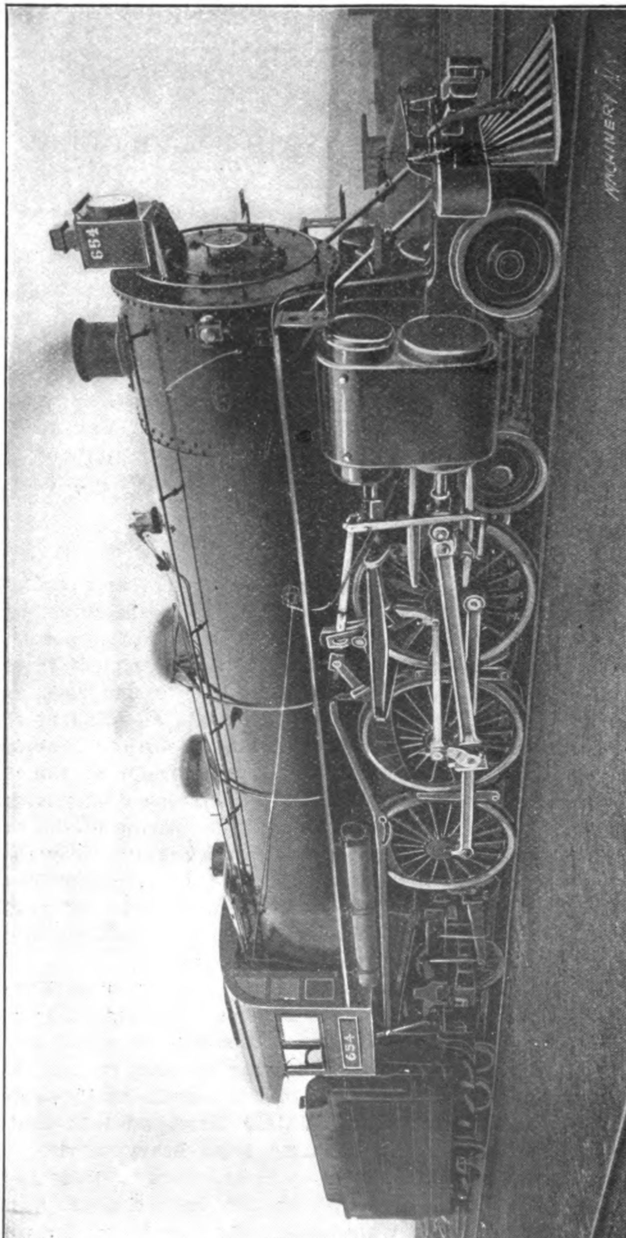

Fig. 1. Pennsylvania R. R. Pacific Type Passenger Locomotive with Form of Walschaerts Valve Gear used for Heavy Service

to a limited extent in England, but on the Continent it has been employed almost to the exclusion of any other form of valve gear ever since its invention by a Belgian, Egide Walschaerts, about 1844. Although we were so slow in adopting it in this country, its good qualities were rapidly recognized when once the start was made, as is evidenced by the fact that of 2448 locomotives ordered in this country in 1909, 1638, or about 67 per cent, were of the Walschaerts type; 30 per cent were of the Stephenson type; while the remaining 3 per cent of the total number were furnished with other designs of valve movements, some of which were of a more or less experimental nature.

Two Designs of the Walschaerts Gear

The first two illustrations show the mechanism as applied to the locomotive. Different designs are shown in the two cases, that in Fig. 1 being used for the heavy service, while that in Fig. 2 is adapted to lighter work, being applied in this case to the standard Atlantic type passenger locomotive of the Pennsylvania R. R. The main difference relates to the method of raising and lowering the radius rod in the link, the connection between the radius rod and the link block, and the support of the link.

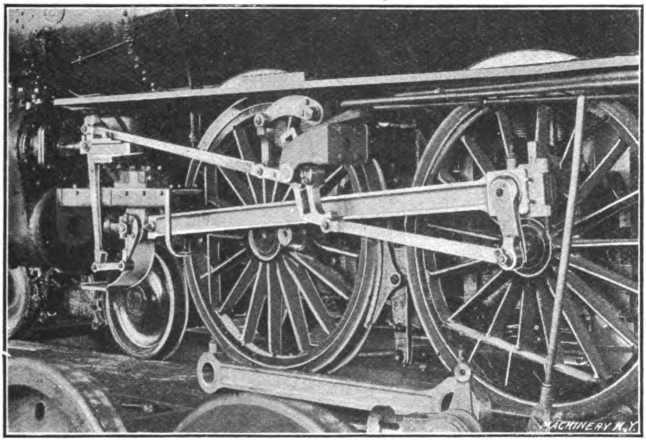

Fig. 2. Design of Walschaerts Valve Gear used on Atlantic Type Engines

In Fig. 1 the link is mounted on swinging yokes on each side, pivoted to bearings on a cast-steel frame. The radius rod is provided with an extension, which spans the link on each side inside of the yokes and is provided with a finished square shank projecting beyond the link, which bears in the pivoted block on the end of the reversing arm, by which it is raised and lowered for forward and backward running. In Fig. 2 the link is supported in trunnions or saddles at the center, and the radius rod is hung from the reversing arm on a short link.

The operations on the rod work of the valve mechanism in the Juniata shops do not differ materially, except that the work is smaller, from the method of manufacture used in making the main and side rods, described in MACHINERY'S Reference Book No. 79, "Locomotive Building, Part I, Main and Side Rods." In describing the shop operations on this valve gear, we will, therefore, confine the description to two particular parts of a special and peculiar design—namely,

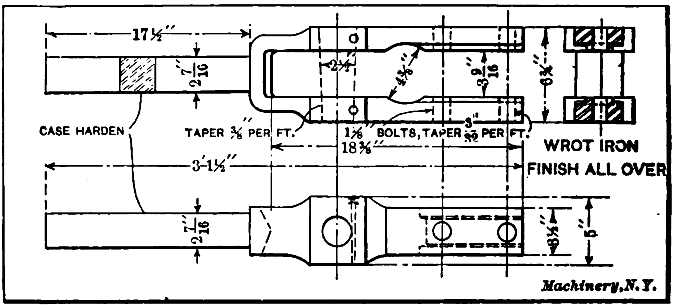

Fig. 3. Radius Rod Extension for Valve Gear shown in Fig. 1

the links for both types of valve gear, and the radius rod extension for the heavier type of locomotive shown in Fig. 1.

Roughing Out the Radius Rod Extension

A drawing of the radius rod extension is shown in Fig. 3. As may be seen, it is made from a wrought-iron forging, and is finished all

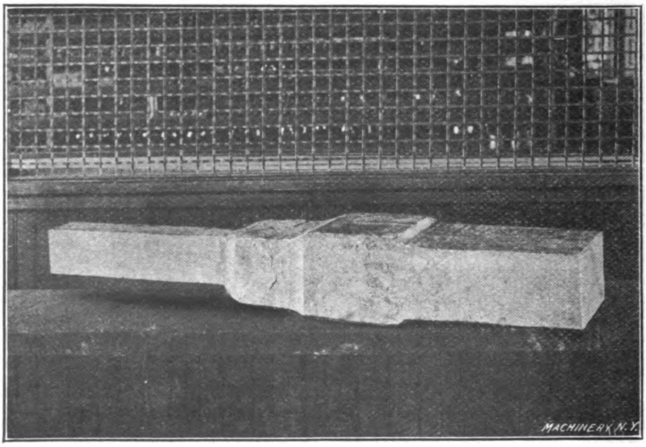

Fig. 4. Rough Forging for Radius Rod Extension

over. The square projecting shank, which bears in the pivoted block of the reversing arm is casehardened to give a durable wearing surface. This casehardening, as will be explained, introduced some difficulties in the course of manufacture. The overcoming of these difficulties gives the part its particular interest from the machinist's standpoint.

The rough forging from which the piece is made is shown in Fig. 4. The illustration shows that the ends of this forging have been trimmed to size in the cold saw to practically the required length for the finished piece. Fig. 5 shows this forging roughed out all over. The various cuts shown have been taken in the slotting machine and the shaper. On the shank, which is to be casehardened, the rough stock

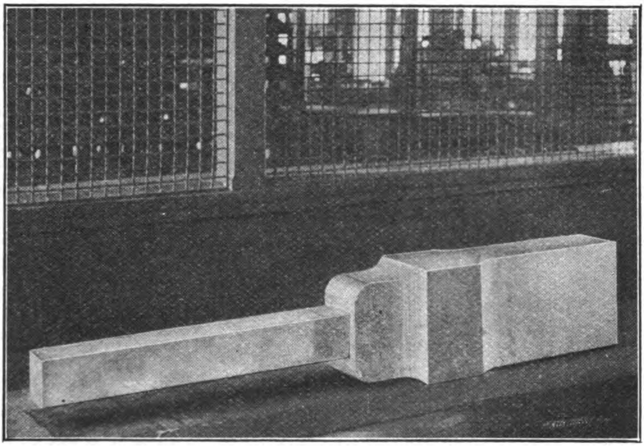

Fig. 5. Forging Roughed all over and Shank Finished

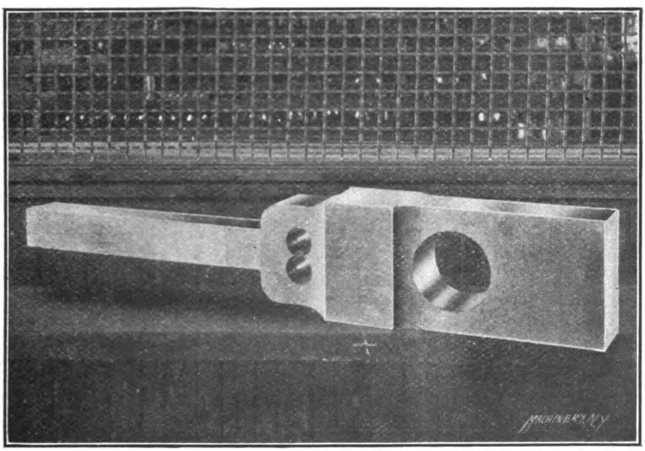

Fig. 6. Radius Rod Extension Drilled for Slotting

was in the first place necked out close to the connection with the body of the forging, the cuts being taken crosswise of the work on the four sides, on the slotter. The forging was then taken to the shaper and the square was finished down to size. This, of course, is the obvious method of procedure.

The holes have next to be drilled for slotting out the interior of the blank to form the two arms which encircle the link. The machining of these holes is performed on a heavy drill press; or, as in the case shown at the left of Fig. 7, on a regular rod boring machine, using only one of the spindles, leaving the other free for other work. The larger hole is first drilled out, and then it is bored with a bar carrying a double-edged blade, as shown in the engraving. After these boring and drilling operations, the work has arrived at the stage shown in Fig. 6.

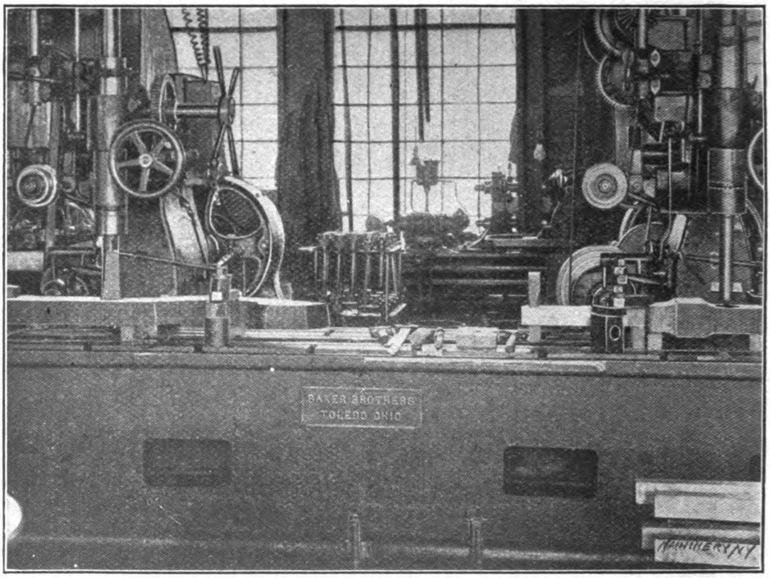

Fig. 7. Drilling Radius Rod Extension and Walschaerts Links

The forging is now taken to the slotting machine, where (see Fig. 8) it is mounted on parallels, so as to hold it firmly and accurately to the table of the machine. A square-nosed tool is used for cutting out the block of stock between the holes. The C-clamp, which is shown tightened in place on the forging, prevents the two sides of the newly formed opening from separating under the pressure of the cut. The state of the work at the end of this operation is shown in Fig. 9.

Casehardening the Shanks of the Radius Rod Extension

It has been found advisable to caseharden the shank at this point in the procedure. The advantage of doing it at this time lies in the fact that the remainder of the work is not yet finished to its final dimensions and the two sides are still tied together by the mass of material left between them at the outer end. Thus the distortion which is sure to take place in work of this kind in hardening, takes place at a time when it does no harm, as the finishing cuts will be taken with reference to the finished and casehardened surfaces of the shank, with which they will, therefore, be true and accurate. If the opening between the two sides were completely cut out, as shown

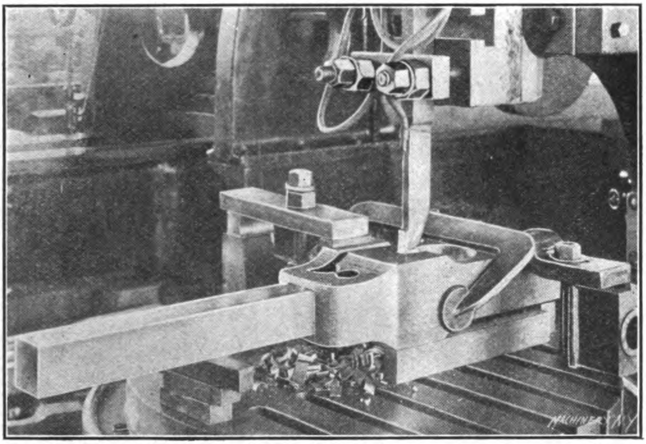

Fig. 8. Working out the Slot in the Slotting Machine

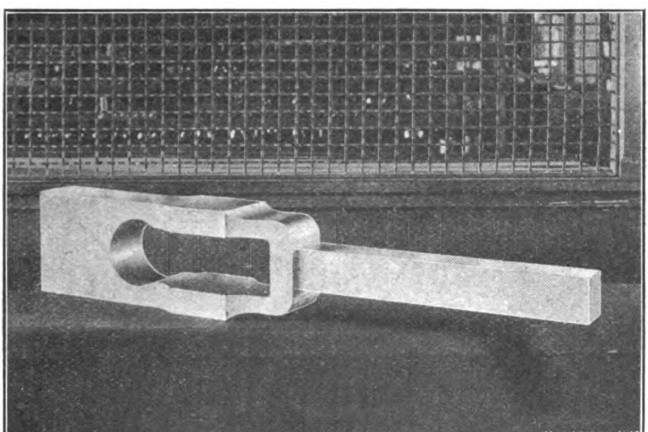

Fig. 9. Work with Center Slotted out ready for Casehardening

in Fig. 3, before this hardening operation, they would almost certainly be sprung out of parallel with each other, or out of line with the casehardened portion.

Fig. 10 shows the casehardening furnace and two pieces of work ready for heating. The furnace is fired with oil, and supplied by a blast from the regular blower service of the forge shop. Provision is made, however, for an independent blast for keeping up the fire

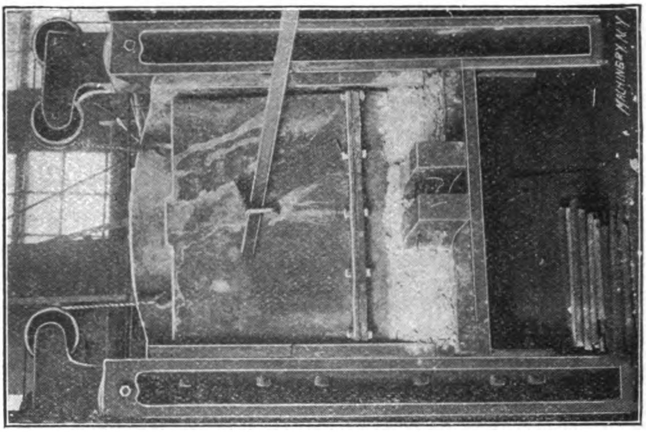

Fig. 12. Casehardening Furnace ready for the Heating

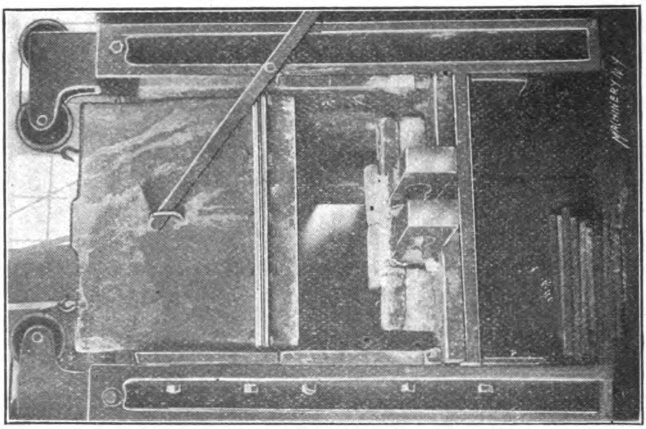

Fig. 11. Work Placed in Furnace ready for Casehardening

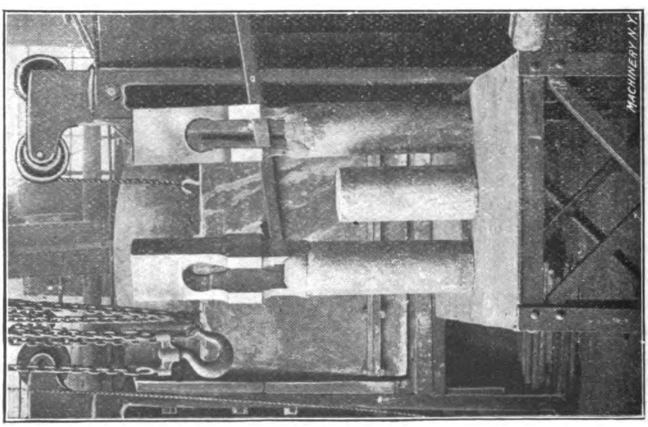

Fig. 10. Work and Test Piece Packed for Hardening

during the night or at times when the regular forge service is not in operation. This independent service is furnished by a small blower fan, which is itself operated by impingement on its blades of a jet of air from the high-pressure shop service line, used for the pneumatic hammers, riveters, etc. This latter is kept continually under pressure, day and night, so it is available any hour of the twenty-four, making it possible to use the furnace at any time or for any length of time.

As may be seen in Fig. 10, only that portion of the work which is to be hardened is packed. This is inserted in a section of wrought iron pipe, filled with the casehardening material, composed of 11 pounds of prussiate of potash, 30 pounds of sal-soda, 20 pounds of coarse salt and 6 bushels of powdered charcoal (hickory-wood charcoal preferred), thoroughly mixed with 30 quarts of water. The pipe is luted with

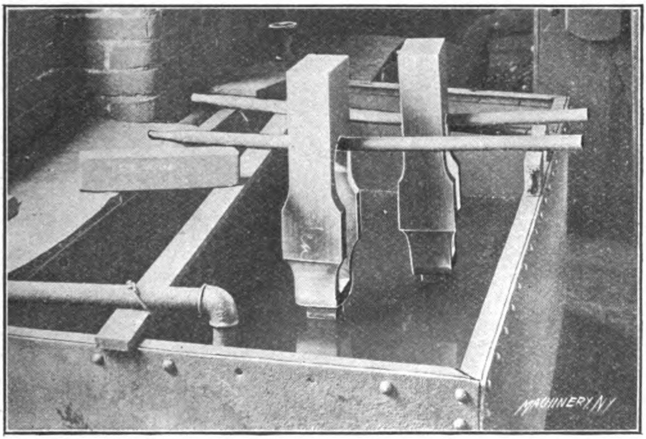

Fig. 13. Cooling the Casehardened Shank of the Work.

fire-clay at each end to retain the carbonizing material and exclude the air. The work is placed in the furnace as shown in Figs. 11 and 12. The part that is not to be made hard is left projecting outside the furnace door. A wall of fire-brick and clay is built up to close the space between the lower edge of the door and the bottom of the furnace opening. After soaking for, say, fourteen hours, more or less, the work is removed from the furnace and from its packing, and plunged into a tank of water as shown in Fig. 13, being suspended there until cool.

Test Pieces for Casehardening

Fig. 13 also shows a square block of hammered iron marked "Test piece." The use of this test piece gives an idea of the precautions which the Pennsylvania officials have found it wise to adopt to make sure that all the material and treatment given to the vital parts of their locomotives, are up to the standard required of them. This test piece is forged at the same time and from the same material as the radius rod extensions. It is machined to the same dimensions as the square shank of the extension which is to be casehardened. It is packed in a similar wrought-iron casing, as shown between the two pieces of work in Fig. 10, and is placed in the casehardening furnace next to the work itself, remaining there for the same time and subjected to the same degree of heat. It is then cooled and hardened in the same manner. It is evident, then, that the condition of the test

Fig. 14. Broken Test Pieces for Showing Condition of the Work.

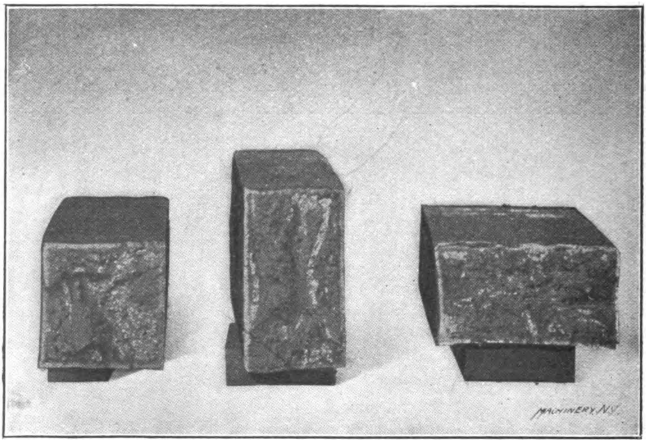

Fig. 15. End View of the Test Pieces showing Depth of Hardened Portion and Character of Fracture

piece should give an accurate index of the condition of the work itself, so far as the hardening operation is concerned.

The test piece, thus prepared, is now taken to a press and broken, in order that the condition of the interior may be noted. Figs. 14 and 15 show various examples of these broken test pieces. The examination shows the condition of the metal, the texture of the fiber, and the depth of the casehardening. One-half of each test piece is thrown away. The other half is retained, marked with the date of hardening and the class and construction number of the engine on which the casehardened parts are to be used. These are kept two years, until it is proved that the work is giving good service, and it is certain that no trouble is to be expected from it. It is held by the shop as a sort of guarantee of the good work done in the heat treatment.

Such precautions would hardly be necessary or advisable in any other kind of work, but there are many cases in locomotive practice where the extra expense and trouble is worth while. A defect in a

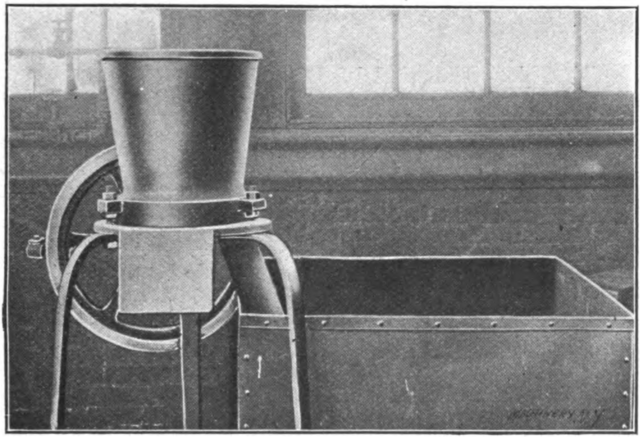

Fig. 16. Charcoal Crusher Built on the Bone Mill Principle

locomotive is a serious matter. It may mean nothing worse than the delay of thousands of tons of valuable freight, or it may mean the loss of human life and serious damage to the prestige of a great railway system. Good steel properly treated is absolutely essential for the vital parts of a locomotive, and every precaution is taken to insure reliability.

It was mentioned that ground charcoal is one of the ingredients used in casehardening. Fig. 16 shows the mill used here for grinding the charcoal. It had formerly been broken by workmen with hammers, in much the same primitive fashion that ice is pounded for the ice-cream freezer in the ordinary American home. The foreman discarded this primitive process, however, and bethought himself of a bone grinding mill used on a chicken ranch in his neighborhood, which he proceeded to copy. His copy is made of a few simple castings, and consists essentially of a hopper, as shown, having projections on the inside, alternating with similar projections on a revolving cone. The inner surface of the conical hopper and revolving cone taper toward each other, and as the charcoal passes through the revolving teeth into this narrowing space, it is crushed finer and finer until it drops through a spout into the box. The fineness can be regulated by raising and lowering the hopper by means of the adjusting nuts on the studs by which it is supported. This crusher is operated by an air motor.

Finishing Operations on the Radius Rod Extension

Fig. 17 shows the completed radius rod and extension assembled. The remaining machining operations have been performed, as required by Fig. 3, finishing out the slot between the two sides of the fork, and machining them for the tongue and groove joint of the radius rod head. These tongues are made with a taper, as shown, so that they bear on the sides only. When the bolts are tightened down to form the joint, assurance is given of a firm grip with no possibility of play or backlash.

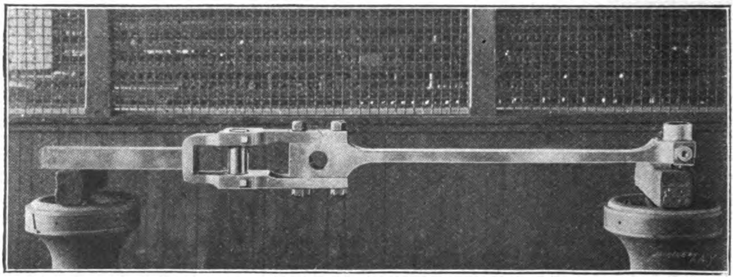

Fig. 17. Radius Rod Extension with Slotting Complete—Assembled with Radius Rod

Another point should be noticed in Fig. 3, which is a regular practice in locomotive construction, but one with which many machine-tool machinists are unfamiliar. This practice is the use of taper bolts. The two bolts shown, which hold the joint, are of 1⅛ inch normal diameter, but they are tapered on the body of the bolt 3/32 inch per foot. This is the standard practice for all important bolts used throughout the whole locomotive. After the holes are drilled, the taper reamer is run through them to such a depth that, when the bolts are screwed home, they will draw in to a tight fit in the holes, and come solidly against the head. Each bolt thus serves as a well-fitted dowel, in addition to its duty of drawing the parts together. When the work is properly made, the joint thus formed is of a superior character.

Roughing Out the Link

A general drawing of the link used for the heavy form of Walschaerts gear is shown in Fig. 18. As was explained in connection with Fig. 1, this is of the kind in which the link is supported by yokes which are attached to it at each end of the slot, and are provided with central pivots mounted in stationary bearings in the side frames. The two jaws of the radius rod span the link inside of the yokes in a way that will be understood by comparing Figs. 1, 17 and 18. The

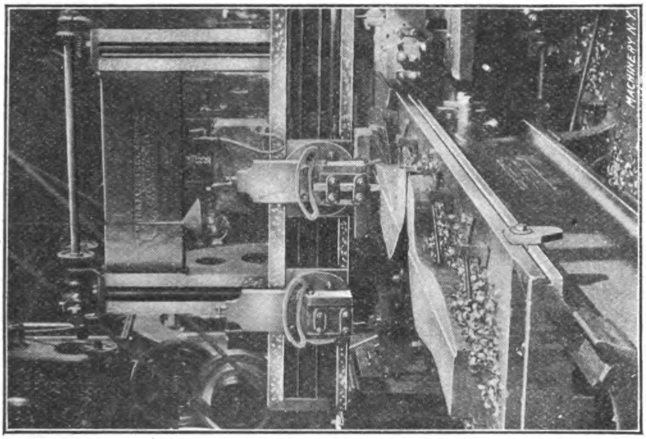

Fig. 19. Planing the Forging for Links

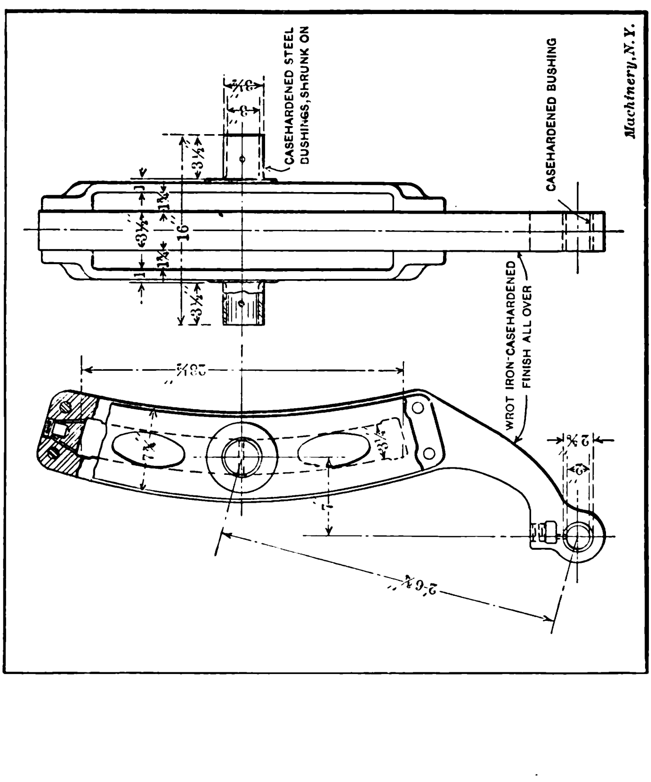

Fig. 18. Link and Mounting used for Heavy Type of Walschaerts Gear

method of manufacture to be described applies in general to the light form of link shown in Fig. 2 as well as to the heavier type.

The first operation is the simple one of machining the sides of the rough forging from which the link is made. This is done in the planer with the usual holding devices as shown in Fig. 19. In Fig. 20 these forgings, which have been finished on each side to the required thickness, are laid out on horses, for marking off with a templet. The further one has the templet clamped to it as shown. From this the outline of the finished piece is scribed, together with the outline of the curved slot for the link block. The location of the pivot for the return crank rod is also indicated, as well as that of the four holes for holding on the yokes. This is an example of

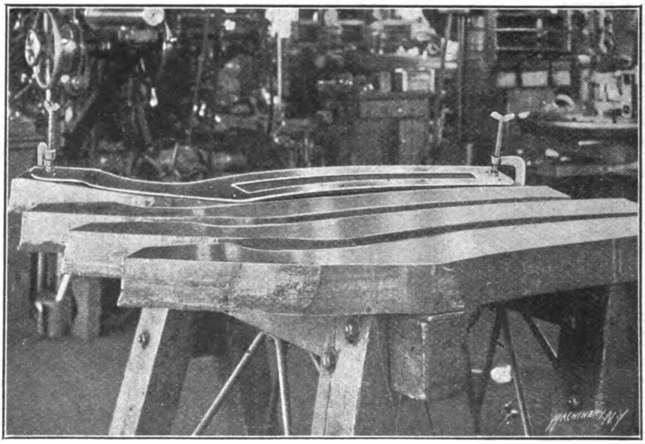

Fig. 20. Laying out the Links with Sheet-iron Templet

standard practice in this shop, where the use of an inexpensive templet saves a great deal of time in laying out work, and gives assurance of proper location of the various machining cuts.

The slot has next to be worked out. As indicated in Fig. 7, the forgings are first drilled through at the ends and in the middle of the slot, one end of the rod boring machine being conveniently employed for the purpose when not otherwise engaged. The links are then taken to the slotting machine, where the stock is roughly worked out by a parting tool as shown in Fig. 21. Two forgings are operated on at a time, with the holes lined up with each other. The parting tool is fed from one hole to the other on each side, removing thin slices of metal from the interior of the slot, and leaving it in condition for finishing to size.

Finishing the Slot of the Link

This finishing operation is performed on a link planing attachment of the usual construction, shown in use in Fig. 22. It would not be necessary to explain this device to railroad men, but for non-railroad readers the accompanying sketch, Fig. 23, will explain the principle.

The link, shown at *A*, is mounted on a table *B* with T-slots on the top, which swivels about pin *C* fast in the base *D*. The swiveling of this table is governed by a stud *E* having a roller engaging a swivel guide *F*, clamped to the under side of the ram, or traveling head of the shaper. By setting the guide *F* to the proper angle, it so swivels the work about pivot *C* that the tool *G* will cut to a line closely approximating the true arc of a circle.

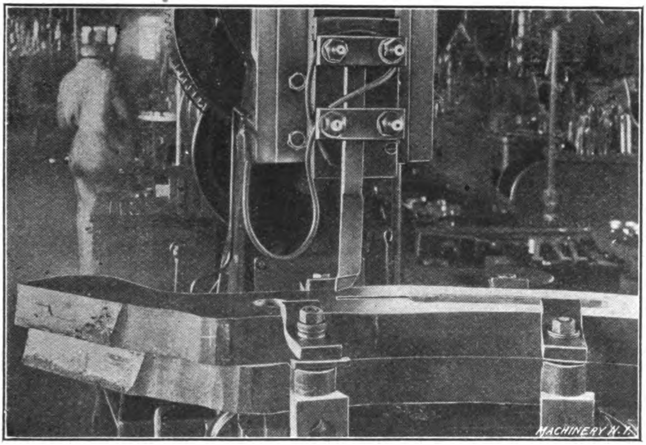

Fig. 21. Slotting the Links Two at a Time after Drilling as in Fig. 7

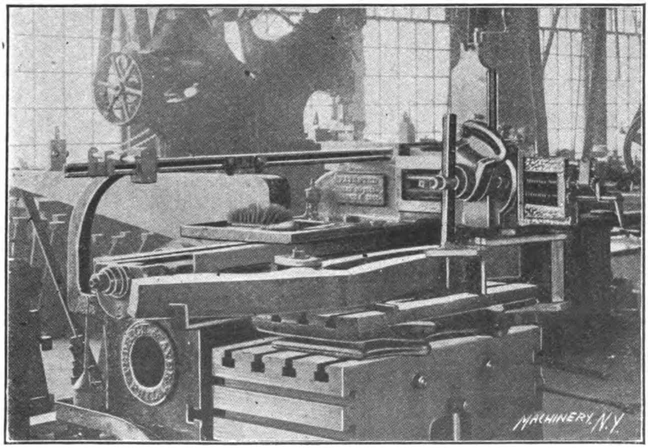

Fig. 22. Planing the Slots in the Links with Link Planing Attachment

The diagram Fig. 23 shows the mechanism as applied to the planer rather than to the open-side shaper, inasmuch as it shows guide *F* and tool-point *G* stationary, while the work *A* and work-table *B* are moving backward and forward. The principle is, of course, the same as in Fig. 22, except that here the work-table *B* (Fig. 23) is stationary and the guide *F* reciprocates with tool *G*, swiveling table *B* and work *A* about stationary pivot *C*. It should be noted that whenever the tool is changed in this attachment for any reason, it must always be set up again with dimension *X* (the distance from the tool-point to the center of the swivel of guide *F*) always the same. If this distance is altered, the radius and position of the arc are changed.

Inasmuch as the surfaces of the link, thus finished, are approximate and not exactly true, it is customary to finish them more nearly to absolute truth. This is done by grinding on the radius grinder to a good bearing for the templet shown in Fig. 24, which is itself

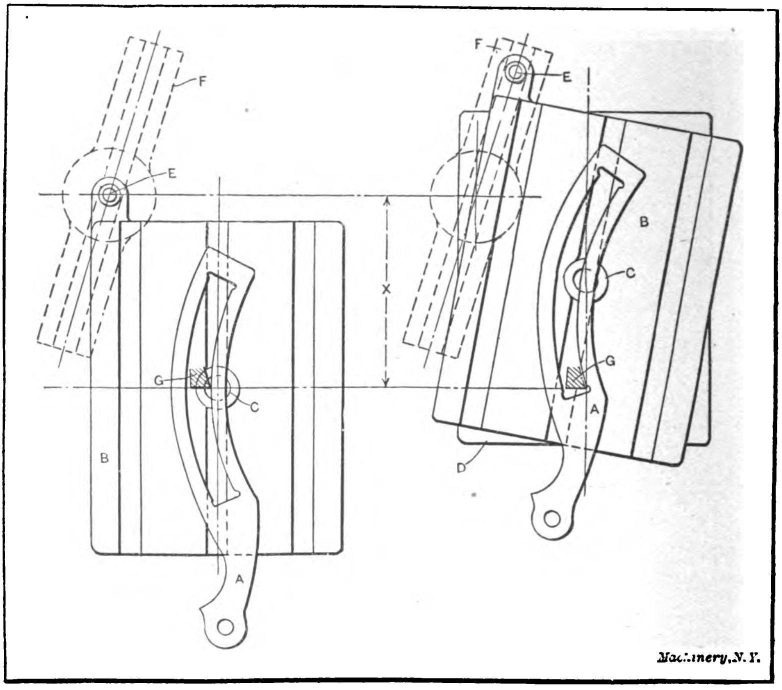

Fig. 23. Principle of Radius Link Planing Attachment for the Planer

accurately machined to the proper radius, and to the proper thickness. It should have been mentioned that the pockets at the ends of the slot have been cut out in a succeeding slotting machine operation to that shown in Fig. 21. These pockets give room for the shaper tool to run out into, as in Fig. 23.

Drilling and Finishing the Link

The slot in the link being the important surface, succeeding operations of importance are located from it. The next thing to be done is the drilling of the holes for the connection with the return crank rod. This operation, which is not shown here, is performed by means of a simple jig, located by a templet fitting the link slot, and carrying a bushing in the proper position for the hole.

The outline of the link has next to be finished. This is done as shown in Fig. 25 in a vertical milling machine, the table being rotated and fed by hand or power as required, following the outline scribed by the templet. Two links at a time are machined in this way, taking up nearly the full width of the cutter shown in use. They are lined

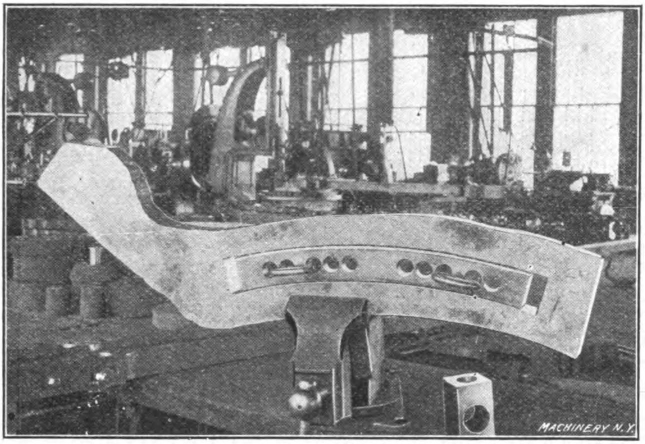

Fig. 24. Templet used for Finishing the Slot in the Link for the Radius Rod

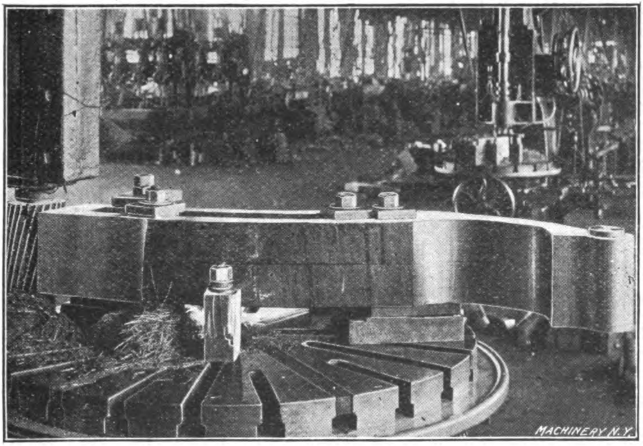

Fig. 25. Outlining the Links on the Vertical Milling Machine

up with each other by a pin through the return crank rod connection hole, and by lining up the sides of the slots.

The oil holes have next to be drilled, and the bolt holes for attaching the yokes. In the case of Fig. 18, the bolt holes are drilled in a way similar to that employed for drilling the return rod connection —namely, by means of a jig carrying a templet which fits the slot, and is provided with a bushing set at the proper relation to the templet. The yokes themselves, shown in place in Fig. 27, are drilled by a jig which is located from the pivots on which the yokes swing. The holes for holding together the yokes and link are thus so located that the pivots are in the proper position with relation to the slot, and thus are in line with each other as well. These positions and the location of the holes for the return crank rod being the important dimensions, are all located from the slot of each link, and so are in the proper relation to each other.

Fig. 26 shows the method of locating the saddles or pivot supports used for the link on the light type of valve gear shown in Fig. 2. Here a fixture *J* is set into the link slot which fits it snugly, and is provided with pockets for receiving the saddles *H*, which are thus

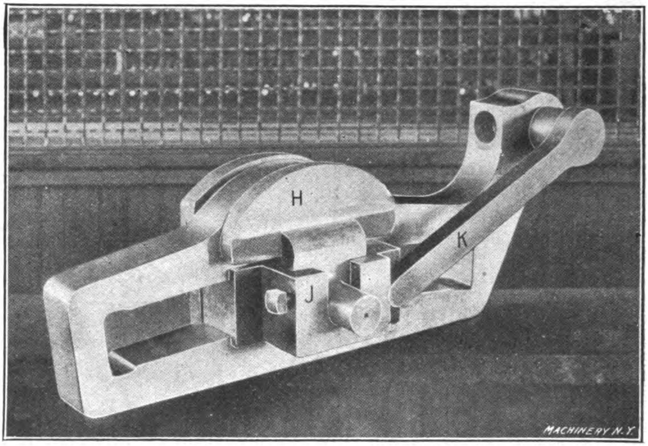

Fig. 26. Jig used for Locating Pivot Saddles on Atlantic Type Link

accurately located from the journals of the pivots. When thus located, each is held in place by a set-screw as shown. The whole attachment is now slid along through the slot until it makes contact with the distance piece *K*, which is mounted on a stud fitted in the return crank rod hole. By this means, the pivots are located as they should be, with proper reference to the slot, and with proper reference to the return rod connection.

After the yokes in Fig. 27 and the saddles in Fig. 26 have been drilled and bolted into place, the outlines of these members are finished off to match evenly with the outlines of the link, making a good smooth job. Figs. 27 and 28 show a completed link of the heavy type, with the block in place ready for assembling in the locomotive.

Manufacturing Methods in Locomotive Building

Locomotives are built at Altoona on a manufacturing basis. When we make this statement, the words "manufacturing basis" mean something different than they do when we say that typewriters or machine tools are so built. In fact the term has a different meaning for all three cases. Manufacturing methods in building locomotives do not involve the use of jigs and fixtures for finishing all the massive parts of which the great machine is built. Jigs and fixtures large enough

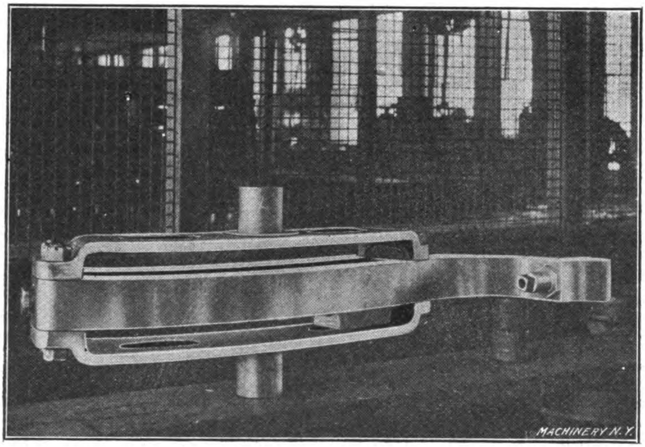

Fig. 27. Complete Pacific Type Link with Yokes in Place

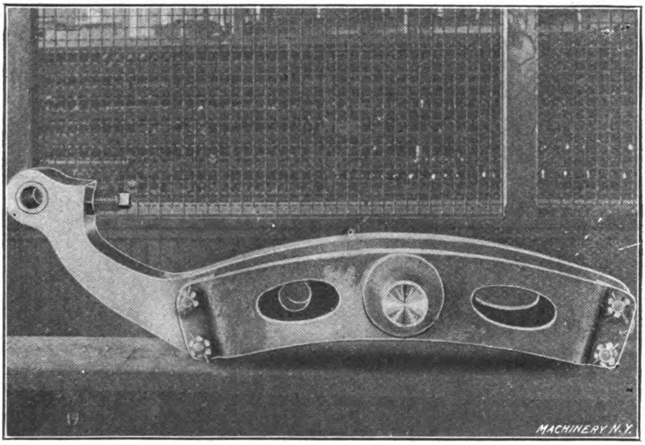

Fig. 28. Another View of the Finished Pacific Type Link

to do this would be prohibitive in size and cost, and practically no advantage would be gained from their use in any event.

The "manufacturing basis" on which the locomotive is built involves the use of templets for laying off all important outlines, holes, etc. Comparatively few holes are drilled in jigs, those so drilled being mostly the ones on which the accuracy of the valve gear lay-out depends, such as the radius rod and yoke connections in the link we have just described. In locomotive manufacture large use is also made of fixed gages for all the vital measurements of the frame, axles, etc., and for such other parts as are likely to require renewal. These parts are thus practically made on the interchangeable plan, though no such extreme of refinement is needed as that necessary in making typewriter parts interchangeable.

It will be seen that the tools required for this manufacturing work are of the simplest possible nature. The templets are made of sheet iron; the gages are made from bar steel, drawn down and ground at the points to the proper dimensions; and the fixtures are, in general, of a rugged and simple construction. By following this plan, the expense for tools is of comparatively small importance, even when building only two or three locomotives of a kind. At the same time advantage is taken of about all the benefits of accuracy and interchangeability which can be secured on such large work.

The New K-2 Pacific Type Locomotive

It may be interesting to give a few particulars of the locomotive shown in Fig. 1. This is, as may be seen, of the Pacific type, which has come to be a standard machine for hauling the heavier high-speed passenger trains. The Pennsylvania R. R. has hitherto been able to maintain the schedules on its passenger runs with locomotives of the Atlantic type (see Fig. 2) of considerable lighter weight than other roads had found necessary for the same purpose. It was decided, however, a short time ago, to experiment with heavier machines, and the K-2 locomotive shown herewith is the result. This is probably the heaviest passenger locomotive ever built, outside of the Mallet articulated machines furnished to the Santa Fe, which are in a class by themselves.

The total weight of the engine alone is 270,000 pounds, of which 176,500 pounds are on the driving wheels. The wheels are 80 inches in diameter. A straight boiler is used 80 inches in diameter at the front end. The grate area is 61.8 square feet. The total heating surface is 4427 square feet. The cylinders are 24 inches in diameter with a 26-inch stroke. The total cylinder horsepower developed is something over 2000, giving about 134 pounds weight per horsepower for engine and boiler. Comparison with any figures which might be taken from stationary practice of similar size would show a tremendously higher ratio than this, giving a good idea of the high degree of specialization which has been reached in locomotive design.

The diameters of the wheels and boiler are so large that even the liberal clearance allowed by the Pennsylvania R. R. have necessitated the shortening of the stack and domes to an unusual degree.

CHAPTER II

SPECIAL TOOL-ROOM APPLIANCES*

The tool-room at the Juniata Shops of the Pennsylvania Railroad, at Altoona, Pa., is remarkable for the range in size and accuracy of the work it is called upon to perform. Not only do they make here the rough dies required for bull-dozer and other machine forging operations, but the workmen are prepared at a moment's notice to break off on such work and undertake the building of the fine instrument parts for a locomotive test plant or a precision dynamometer car. Besides this ability to do fine work, there is a large fund of

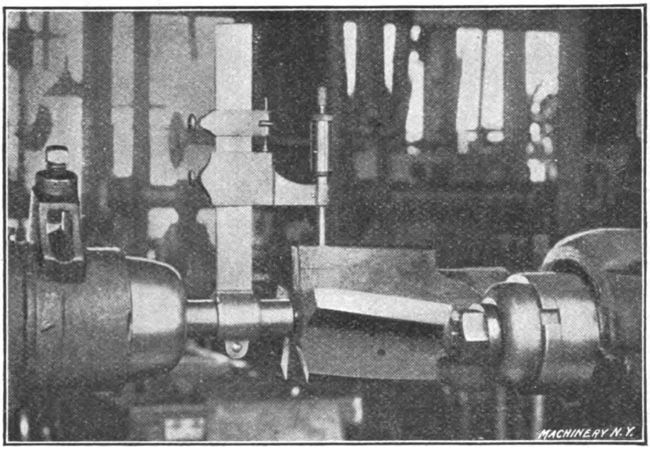

Fig. 29. Micrometer for Measuring Odd-fluted Reamers, etc.

ingenuity in the organization. The tools and devices herewith illustrated and described will give ample evidence of the truth of this assertion.

Micrometer for Odd-fluted Reamers

Fig. 29 shows a simple special micrometer. It is used for measuring the diameters of counterbores, reamers, etc., with odd numbers of flutes. It performs this awkward operation in a simple and easy manner. As may be seen, the instrument resembles a vernier caliper, having a blade provided with a split hub for clamping to the tail center of the grinding machine; the usual adjustable jaw and fine adjustment slides are provided. There are, however, no scale or vernier graduations. What would ordinarily be the jaw carries a micrometer spindle instead.

*MACHINERY, September, 1910.

To illustrate the use of this instrument, suppose it is desired to grind a counterbore, like that shown, to a diameter of 2.396 inches. First a standard 2-inch plug gage is set on the centers of the grinder, and the slide or jaw carrying the micrometer spindle is adjusted until the graduations on the spindle read to zero when the point of the measuring screw is brought down against the surface of the plug. The micrometer spindle is now screwed back out of the way, and the work is set in place on the centers. The counterbore is to be ground to a diameter 0.396 inch larger than that of the standard plug, or to a radius one-half that, or 0.198 inch, larger. It is therefore ground until, when measured by the micrometer in the way shown in the engraving, the graduations on the barrel of the micrometer

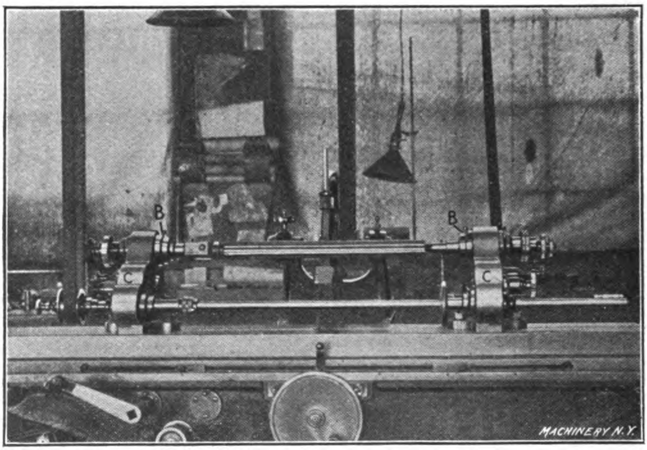

Fig. 30. Eccentric Grinding Device, for Straight and Taper Reamers

read 0.198 inch, which shows that the counterbore has been reduced to the required diameter.

Grinding Reamers with Eccentric Relief

Figs 30 and 31 show an eccentric reamer grinding device, which is in almost constant use, owing to the immense number of straight and (particularly) taper reamers used about a railroad shop. This device grinds the reamers eccentrically, so that they are provided with a better relief at the top of the blades than is given with the old-fashioned straight or concave grinding. The action consists in rocking the reamer about a center, so set as to give the proper contour to the blade being ground. This rocking takes place rapidly and continuously, while the table is moving the reamer back and forth past the wheel by the regular reversing feed mechanism.

The device is operated by a belt from the countershaft, running over the pulley which is mounted on a shaft connecting the two heads *C*. The mechanism is identical in each head. The shaft on which the pulley is mounted is connected by an adjustable cam movement with the sleeves *B* in which the work centers are mounted. This mechanism rocks the sleeves rapidly, and with them the work. The centers of each head may be adjusted in their sleeves to the proper degree of eccentricity and to the proper position. Provision is likewise made for indexing the reamer from one tooth to the other, as each is completed. As shown in Fig. 31, this consists of a gage *D*, provided with a tooth-rest against which each blade of the reamer is lined up in turn, while it is being adjusted for sharpening. This rest is swung out of the way before the rocking mechanism of the attachment is started.

All the various adjustments provided facilitate the operation of the grinding to such an extent that the device is practically as rapid in operation as the old style arrangement giving flat or concave relief; and at the same time it gives far superior results. The heads *C* can, of

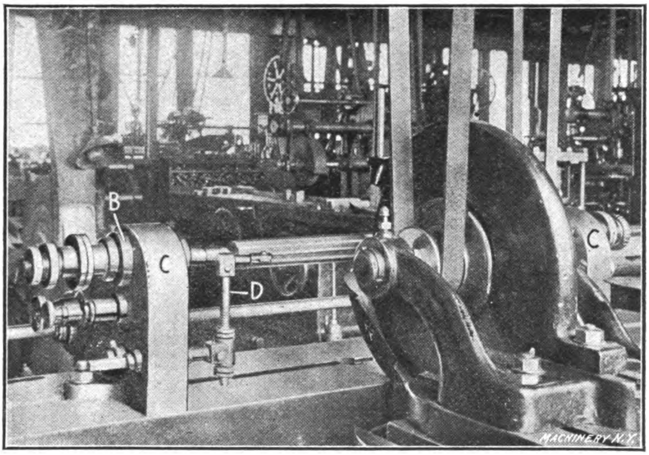

Fig. 31. Rear View of Reamer Grinding Attachment, showing Tooth Gage

course, be set to any center distance, and the table of the machine can be set to any angle for taper reamers. All the other adjustable features of the standard grinding machine have also been retained.

The Thread Pitch Testing Machine

In Fig. 32 is shown what is in some respects the most interesting of the special tools which have been made and used at this shop. This is a thread testing device, which finds steady and profitable employment in the measurement of taps, stay-bolts, lead-screws, etc. The device is mounted on a baseplate *E*, and is provided with head- and foot-stocks *F* in which centered work is mounted, and with V-supports *G* for uncentered work. These are shown in use in Fig. 34. The V-supports are provided with vertical adjustments for bringing the center line of the work parallel with the base, and at the same height as the measuring points of the instrument.

The instrument or indicator itself is most plainly shown in the detail view in Fig. 33. It comprises a standard on which is pivoted a sensitive spring pointer *H*, and a stationary pointer *J*. The latter is mounted on a bar *K*, which may be minutely adjusted lengthwise by the adjusting screw *L*. The indications of pointer *H* are read on dial *M*, whose support may be adjusted in a circular dove-tailed slot about the center of the pivot of *H*, to bring the reading to zero whenever desired. This adjustment is effected by screw *N*, and is clamped

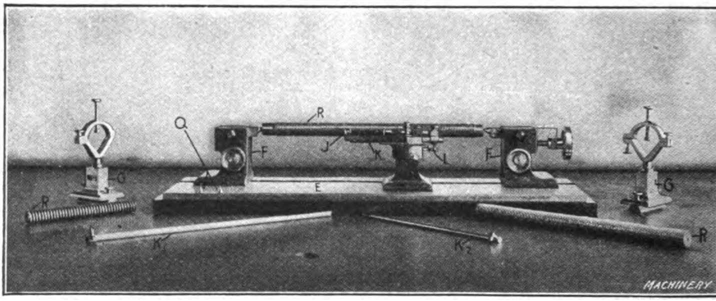

Fig. 32. Instrument for Testing the Accuracy of the Pitch of Screw Threads

by screw *O*. Spring stop-screws *P* limit the extreme movements of the needle.

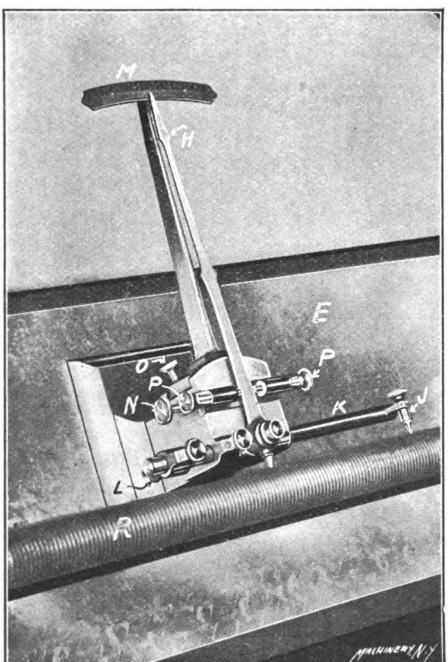

Fig. 33. Detail View of the Thread Indicator

The method of using this instrument will be readily understood from the engravings. One form of test which may be made with it is that of investigating the uniformity of the lead of a supposedly accurate screw. In Fig. 32, for instance, the points are adjusted to span any suitable number of threads, and the instrument is pushed up to the screw to be measured until the measuring points are firmly pressed into the threads. Scale *M*, see Fig. 33, is then adjusted until the pointer indicates zero. The instrument is then moved from one place to another, along the thread, and in all positions the pointer should evidently indicate zero, if the thread is uniform in pitch through its entire length. If it is not uniform, this will be shown in the variation from zero in one direction or the other of the pointer on the dial; and the amount of variation can be read, since the dial is graduated to thousandths of an inch.

Another use of this tool is finding the amount by which threads are longer or shorter than the true pitch. In this kind of investigation the indicator is first set to zero, as previously described, on a model screw of known accuracy. The unknown screw to be tested is then put in place in the machine and measurements are taken at various points along its length. The readings given on the dial then show whether the pitch is long, short or irregular, and how much it is out in either case.

This instrument has the advantage of measuring on the sides of the thread at or near the pitch line. The indicating points are given the shape of balls, and various sizes are provided to suit various pitches and shapes of threads. An extra set is shown at *Q* in Fig. 32. Various model screws for comparative measurements are also shown in this

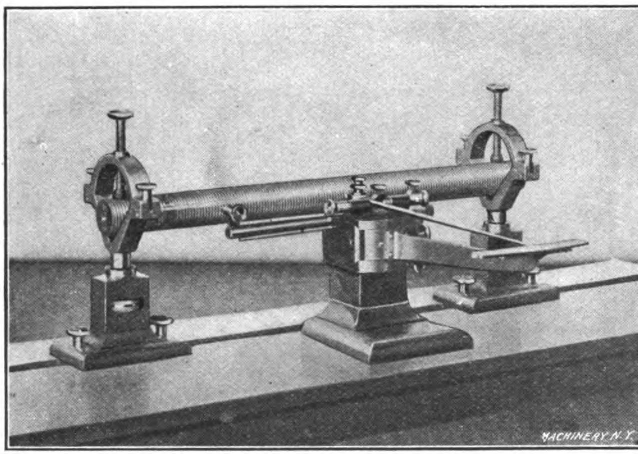

Fig. 34. Thread Testing Instrument with V-block Work-holders in Use

engraving at *R*, and bars of various lengths for carrying the fixed indicating point are shown at K_1 and K_2. The whole arrangement makes the instrument practically universal in application, since base-plates of any length may be used, or long lead-screws may be held on any plane surface, suitably supported with their center lines parallel with the base and at the right height for this instrument. The thread indicator described, as well as the eccentric grinding attachment, were designed by Mr. Epright of the Juniata shops.

CHAPTER III

MILLING CUTTER PRACTICE IN A RAILROAD SHOP*

In MACHINERY'S Reference Book No. 79, "Locomotive Building, Part I, Main and Side Rods," the practice at the Juniata Shops of the Pennsylvania Railroad in making locomotive main and side rods, is described. Fig. 8 in that Reference Book, shows the operation of channeling the main rods on a heavy planer-type milling machine. The accompanying illustration, Fig. 35, shows a nearer view of the cutters and the work. The intermediate support for the arbor between the two cutters is here plainly shown. As was stated, the use of this support has materially increased the output of the machine, since it practically does away with the tendency to chatter, and with the consequent disintegrating effect on the cutting edges.

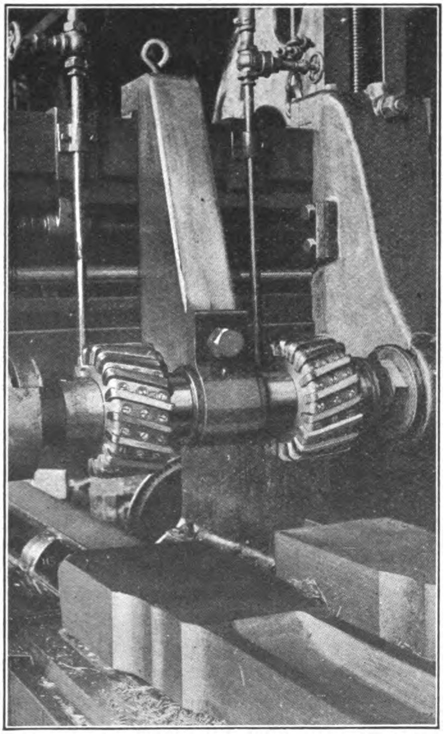

Fig. 35. Helical Blade Channel Milling Cutters, with Intermediate Arbor Support

The size of the arbor is also an important consideration. The hole in the cutters is made approximately one-half the cutter diameter. If the cutter diameter is, say, 8 or 8½ inches, the hole for the arbor is made 4 inches; or if it is 4½ inches, the arbor hole will be 2¼ inches, and so on. This practice has eliminated the troubles due to bent, twisted or broken arbors.

The principal point of interest in Fig. 35, however, is the construction of the cutters themselves. These, it will be seen, are of the inserted tooth type, with the blades held in place by screws and cylindrical bushings, the latter having flat tapered faces which wedge against the blades when the screws are tightened up. The novelty in

* MACHINERY, Railway Edition, October, 1910.

the construction of these cutters lies in the fact that the blades and the grooves in which they are set are formed to true helices, instead of being straight as is the usual practice. The importance of this construction has been pointed out in connection with the Taylor-Newbold inserted tooth milling cutter, described in a paper read some years ago by Messrs. Lewis and Taylor before the American Society of Mechanical Engineers. The use of the helical blade gives a constant cutting angle for the full width of the cutter. Otherwise, a variable cutting angle is obtained, which is too acute at one end, too obtuse at the other, and right only in the middle.

The method of cutting slots for receiving the helical blades is shown in Figs. 36 and 37. A Richards type shaper is used, as shown in

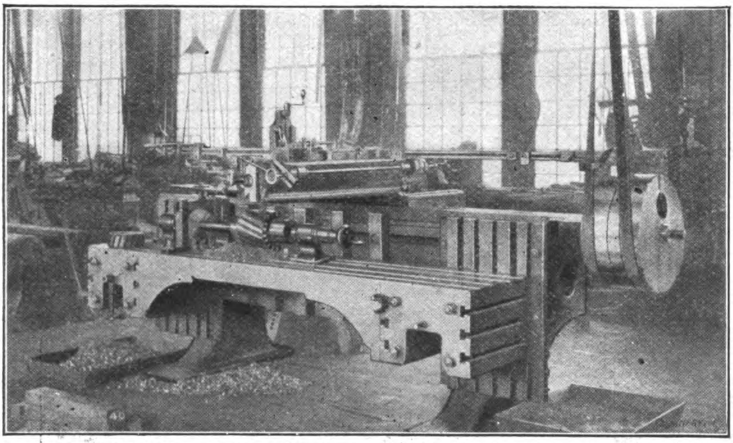

Fig. 36. Richards Type Shaper fitted with Attachment for Grooving Milling Cutter Bodies

Fig. 36, with the bridge piece inserted to make a continuous worktable. On this are mounted the head- and tail-stock centers, *A* and *B*, more clearly shown in Fig. 37. Between the centers is held an arbor *D* carrying at one end the cutter body *C* to be grooved, and at the other an index plate *E* provided with a number of notches, to correspond with the number of teeth the cutter is to have. On the hub of this index plate is loosely mounted a spur gear *F* which meshes with a short rack *G*, free to slide crossways of the axis of the work in the slots formed to receive it in the two uprights *H* as shown. A latch *J*, which is attached to gear *F*, may be engaged with any one of the notches in index plate *E*.

To the ways on which the tool carriage slides is attached the bracket *K*, on which is mounted the guide *L*. Block *M*, pivoted to rack *G*, is confined in the slot of guide *L* and is free to slide in it. *L* may be set to any desired angular position on *K*, through a wide adjustment, being provided with circular slots and adjusting bolts.

The operation of this fixture will be readily understood. As the tool carriage *N* is traversed back and forth on the cutting and return strokes, bracket *K* and guide *L*, being connected with it, are given the same motion. The inclination at which the slot in *L* is set, thus gives a back-and-forth cross motion to rack *G*, which in turn imparts a back-and-forth rotary motion to gear *F* and the work *C*. By setting the slot in *L* parallel with the ways in the tool carriage, no motion would be given to *G*, and a straight slot would be cut in *C*; the more the inclination given to guide *L*, the greater the angle of the helix cut in the work. After each slot has been cut, the tool is withdrawn, latch *J* is raised, and the work is indexed to a new position, latch *J* being dropped into the next notch. The next slot is then cut, and so on. This scheme works out somewhat better for the Richards type of shaper than it docs for the standard machine shop design.

After the body of the milling cutter has had the slots planed in it, it is drilled and counterbored for the bushings which hold the blades

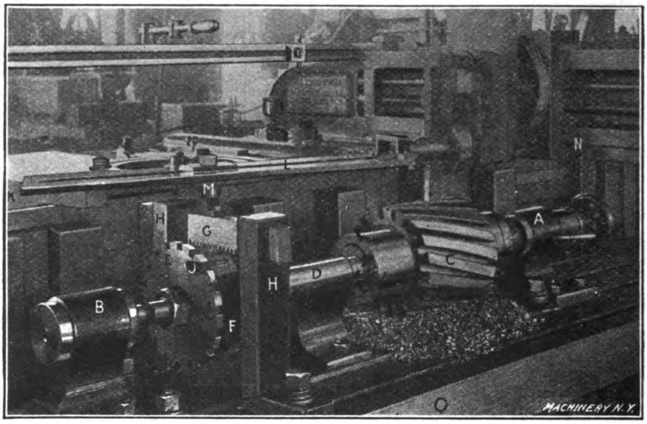

Fig. 37. Details of Helical Cutter Grooving Attatchment

in place. The method of drilling and counterboring the holes for these bushings is shown in Fig. 38. The same fixture is used as in Figs. 36 and 37, though the rack and the slotted yoke mechanism is discarded, and a bracket *P* is clamped to the base of the device as shown. This knee *P* is provided with ways on which may be adjusted the slide *Q*, carrying the drill bushing. *Q* is adjusted on *P* by hand-wheel *R* and the lead-screw to which it is connected. Besides carrying the bushing, slide *Q* is provided with a guide which fits the slots cut in the work in the previous operation.

The whole fixture, as thus arranged, is set up on the table of the drill press. Slide *Q* is then adjusted until its guide enters one of the slots and locates the work, with the bushings set at the proper distance from the edge for the first hole. This is drilled. Then *Q* is adjusted still further to the right to the proper position for the second hole, which is drilled; and then for the third hole in turn, and to still more, if there are more than three clamp bushings to each blade. Slide *Q* is then withdrawn to allow the guide to enter the next slot, when the operation is repeated, all the bushing holes being drilled in a similar manner. For the counterboring, the slide is set to bring the drill spindle into the proper position for a hole in the first row, the counterbore is put into place, the slide moved to one side, and the hole is counterbored to the proper depth. The work is rotated to the next hole in the same circle, which is also counterbored, and so on. The fixture is then set for the second and third rows of holes in turn. It will be seen that the fixture, when used in this way, locates each hole from the slot carrying the blade which is to be clamped by the bushing in that hole, and thus all the holes are accurately located.

The blades used are drop forged to true helical form, in dies whose shape is given them in the same fixture as that used in Figs. 36 and 37, for planing the grooves in the cutter bodies themselves. Assurance is thus given that the blades will be shaped to accurately fit in

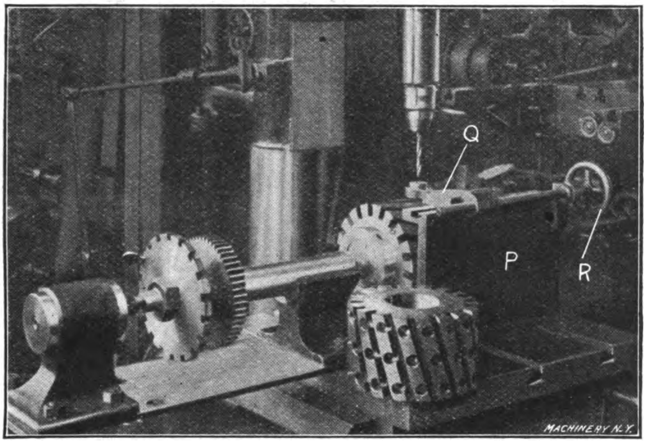

Fig. 38. Jig for Drilling and Counterboring Holes in Cutter Body

the slots, leaving nothing more than a smoothing off of the scale to be done when fitting them into the bodies.

Another interesting point in the cutter practice of the Juniata Shops relates to the method of sharpening the inserted blades of rotary planer heads. They have experimented at the shop with various forms of grinding devices, including those in which the cutters are sharpened while in place in the heads of the machine. The main objection to this method of sharpening is that it ties up the machine while the blades are being ground. It was considered that this disadvantage more than offset the advantage of convenience, which this grinding attachment certainly possesses.

The standard practice now followed for rotary planer heads is to keep two sets of blades for each head, of which one set is in use in the machine, while the other set is being ground and held in reserve in the tool-room. All the blades of each set are ground at the same time, in a fixture which insures that the length over-all of all the blades in the set will be identical. The heads themselves (see Fig. 39,) are provided with abutments which locate the rear end of the blades, and thus give assurance that the cutting edges of all of them will project to exactly the same distance from the face of the head.

In Fig. 39, this abutment consists of a ring, supported on studs, as shown, and carefully located so as to have its inner face set at the same distance from the face of the cutter head all around. In Fig 40 is shown another head, which has a ring bolted to the back face,

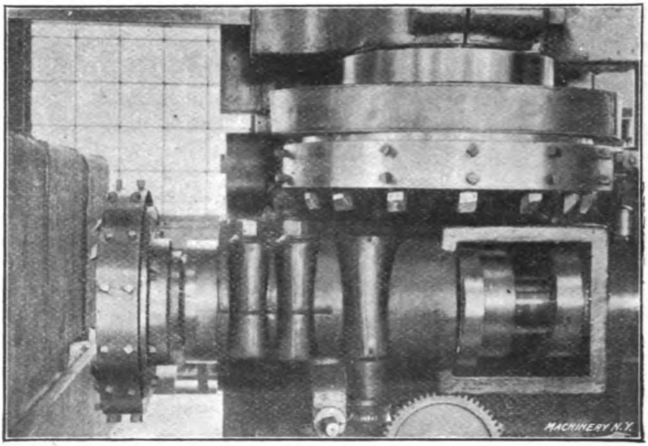

Fig. 39. Rotary Planer Heads, with Abutment Ring for Locating Removable Blades

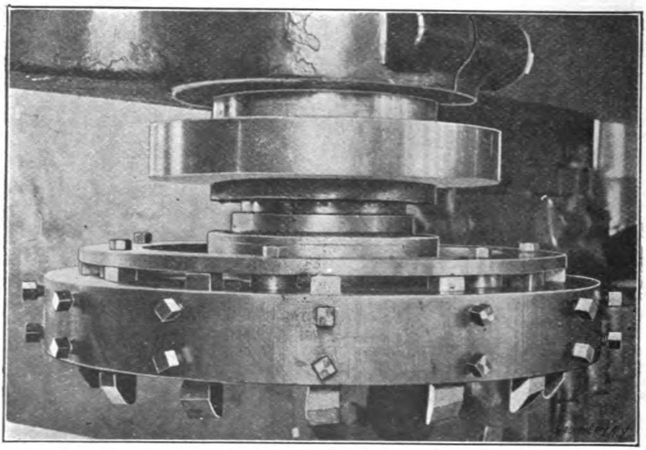

Fig. 40. Another Design of Cutter Head with Abutment Ring

closing the ends of the slots in which the blades are set. The blades are backed against this ring to give them the desired setting.

With the cutting edges accurately ground on all the blades, both with relation to the side of the blade on which they are clamped and the end of the blade by which they are located, assurance is given that they will all be set properly so that each will do its share of the work and leave a true surface.

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