

MODERN GRINDING METHODS

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41 One of the oldest, perhaps the oldest, means for reducing material for the purpose of giving it the desired shape, is by grinding. Our ancestors ground their stone axes and arrow points against a rock, by rubbing them back and forth. The next advance in grinding was probably the revolving of a stone on an axle turned by a crank. It was soon discovered that by having water running on a stone, the grinding could be done faster. This discovery was probably made by accident, since at that time nobody would have thought of the reason so long as results were obtained.

42 Grinding had then advanced to a point where the grinding member revolved in a fixed position, but the piece to be ground was held in the hands of the operator, and by manipulating it at different angles to the grinding surface, a shape was obtained which met the requirements reasonably well. The art seems to have remained at this stage for centuries and not until the lathe and other machine tools had been in use for a long time was it thought to hold the piece of work in a fixed position against a revolving grinding member also having a fixed position.

43 The grinding machine as now used is of comparatively recent origin, within the memory of men now living. The first grinding machines suggestive of modern methods of grinding were made in England and America, but it is in America that they have reached their highest development.

44 The invention of emery wheels made it possible to make fairly rapid progress with grinding processes. At first very little work was ground which could be machined and filed. The process of grinding was confined to pieces of hardened steel, but after awhile it was discovered that unhardened pieces could be machined and finished more

accurately and cheaply by the grinding process than by finish turning and filing.

45 The grinding machine for cylindrical surfaces was developed to meet all strains and forces due to the cutting power of the shellac emery wheel; but when corundum and carborundum wheels were put in use it was found that the machinery was not quite strong and heavy enough to resist their cutting power or to resist the vibration. Within the last few years great improvements have been made not only in the cutting quality of grinding wheels, but in the design of the machines themselves; in fact, grinding machinery has become a formidable competitor of the lathe and milling machine and seems to be quite up to the cutting capacity of the wheels.

46 The designers of grinding machinery have had a good many problems to solve. Different materials require different speeds and on the modern grinding machine there must be various speeds for the grinding member as well as for the traverse movement of the work; and for the revolution of the work in the case of the cylindrical grinder. Machines must be designed with water pumps, and the working parts must be protected from water as well as from the grit which comes from the grinding wheel. The grinding member usually moves at a high rate of speed and must have carefully designed bearings which will run freely, yet not allow any back lash, as true surfaces can only be obtained when the work and the reducing member move against each other in fixed positions. Most of these difficulties have been met and further refinements are constantly being made. I will give a few illustrations of such improvements further on.

47 The grinding machines now used can be divided into two large groups; machines for cylindrical grinding and machines for grinding flat surfaces. Cylindrical grinders are well known and have been highly developed by four machine-tool builders in this country. The other style of grinder, the surface grinder, is best known as a planer type machine, with a wheel grinding on its periphery, and fed across the surface in much the same manner as a tool is fed across the surface on a planer or shaper. Another type is the vertical surface grinder with a cup-shaped wheel working in much the same manner as an end mill on a vertical milling machine.

48 In doing work on lathes or milling machines, it is comparatively easy to reproduce several pieces to the same dimensions by adjusting the machine to a size. This is possible because the reducing member, which is the turning tool, will resist wear for a considerable length of time without making any difference in the size of the work.

With grinding machinery this is more difficult since the reducing member is constantly wearing away at a rapid rate. For very close work it is necessary to readjust the machine for every piece to be ground, which of course requires skill and time.

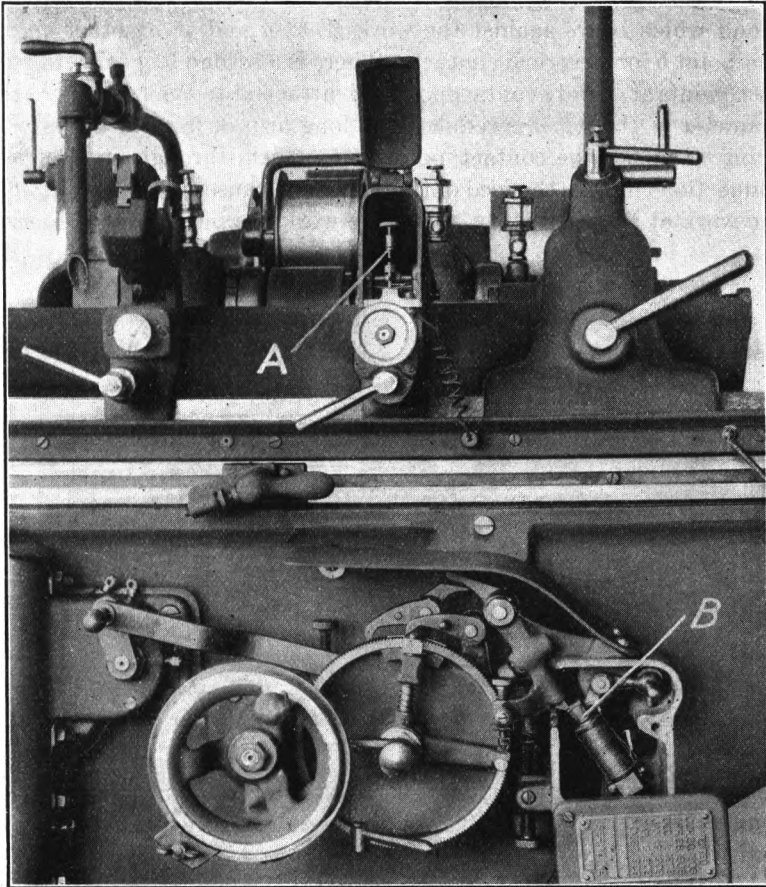


FIG. 34 VIEW SHOWING DEVICE SIZING (AT A) FOR CYLINDRICAL GRINDER, AND MAGNET (AT B) THROUGH THE OPERATION OF WHICH THE FEED IS CONTROLLED

49 The devices shown in Fig. 34 are of such construction that they control the size of the work, no matter how much the reducing member wears away. When the work has reached the desired size, which can be predetermined by suitable adjustments, the machine will auto-

matically throw out the feed and new pieces can be put in, one after another, and these will be automatically ground to practically the same diameter, say within one-quarter of a thousandth of an inch.

50 This result is brought about by controlling the feed of the reducing member electrically. The mechanism of the controlling device is shown in Fig. 35. The lever *A* carries a smooth-pointed diamond which bears against the work *W* at *a* and at its other end is the point *b* for electrical contact. There is a second lever *C* with contact points at *c*, and a contact point *d* is attached to the frame. As the diameter of the work is reduced the long arm of lever *A* drops until point *b* touches the contact point at *c*, which, through an electrical connection changes the feed of the wheel and causes it to move against the work at a slower rate. When the work has been reduced to size,

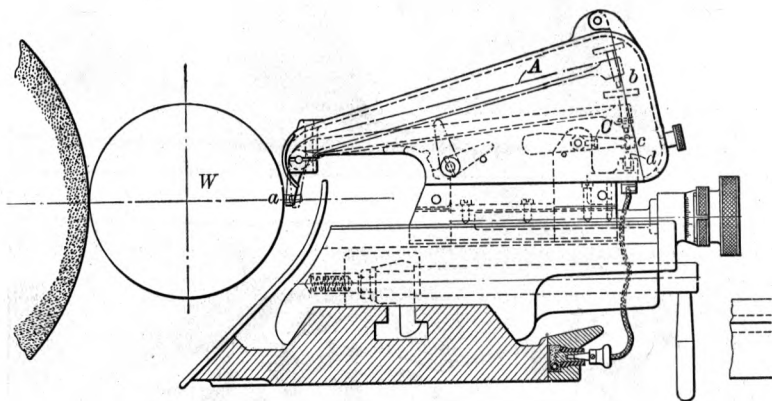


FIG. 35 VIEW SHOWING MECHANISM OF SIZING DEVICE

lever *A* drops still further, carrying with it lever *C*, until an electrical connection is established between points *c* and *d* which throws out the feed.

51 It will easily be seen that an operator can manipulate more than one of these machines and that by their use less skill is required to get uniformity of size. In this design the size of the work is controlled by contact with the work itself, which is the preferable way, but the same results could be obtained by contact with the reducing member. This, however, would be more difficult because of the coarseness of the reducing member and its ability to wear away the contact point faster than does the work.

52 Another recent device is the back rest, shown in Fig. 36. It has been found necessary to support the work as rigidly as possible

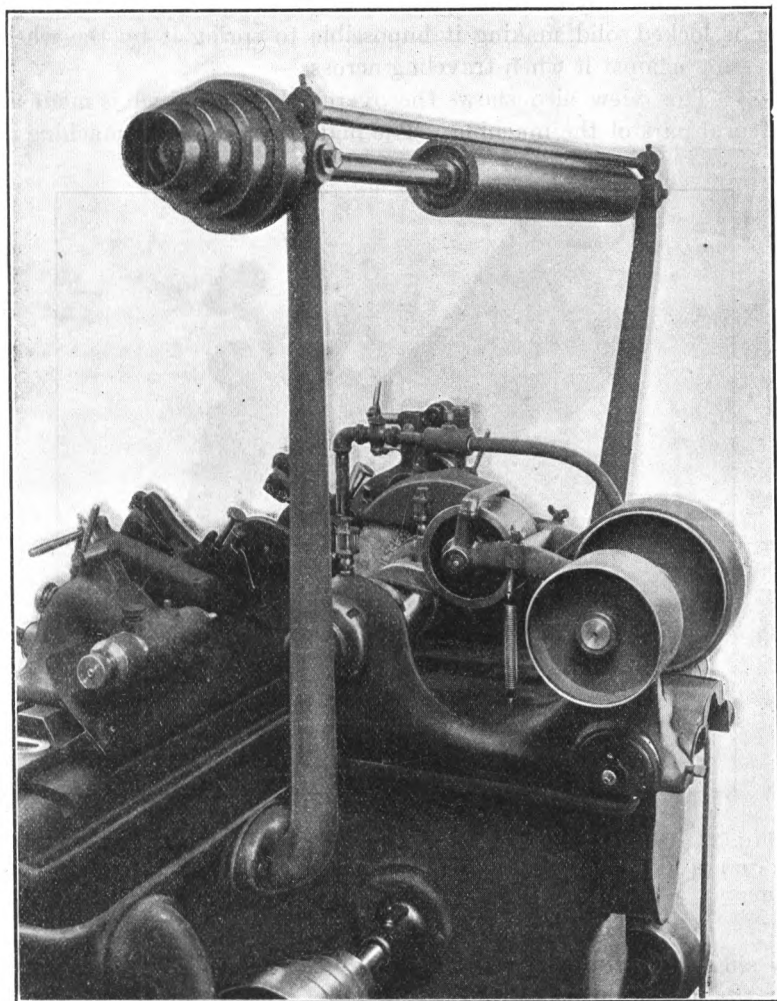


FIG. 36 VIEW SHOWING BACK REST IN PLACE; ALSO OVERHEAD DRUM, WHICH IS MADE AN INTEGRAL PART OF THE MACHINE

throughout its length, but as the work is constantly being reduced in diameter, the back rest must be kept in contact with the work either

by hand or automatically, and hand adjustment requires considerable skill. In the device shown it is accomplished automatically, the back rest advancing at exactly the same rate that the diameter of the work is reduced by the wheel; and as it advances, the back rest member is locked solid, making it impossible to spring it by the wheel pressing against it when traveling across.

53 This view also shows the overhead drum, which is made an integral part of the machine. The main drive for the machine is

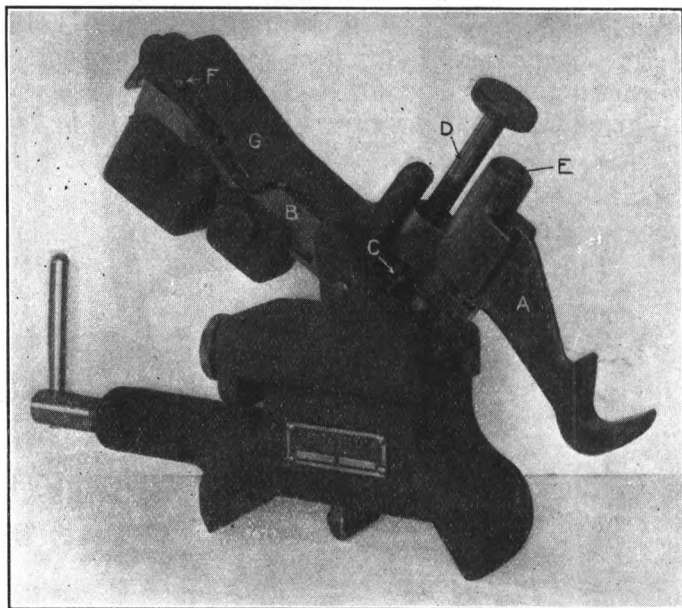


FIG. 37 BACK REST, DESIGNED TO FOLLOW THE WORK AS IT REDUCES IN DIAMETER AND TO LOCK AUTOMATICALLY AGAINST THE PRESSURE OF THE WHEEL

by single belt to a short shaft at the base, from which the drives for the wheel and the drum are belted. This arrangement avoids a complicated overhead countershaft and enables the operator to change the speeds and manipulate the various mechanisms with ease.

54 The operation of the back rest will be understood from Fig. 37. The arm *A* which supports the work is held in contact with the work by means of the weighted lever *B*, fulcrumed in the frame.

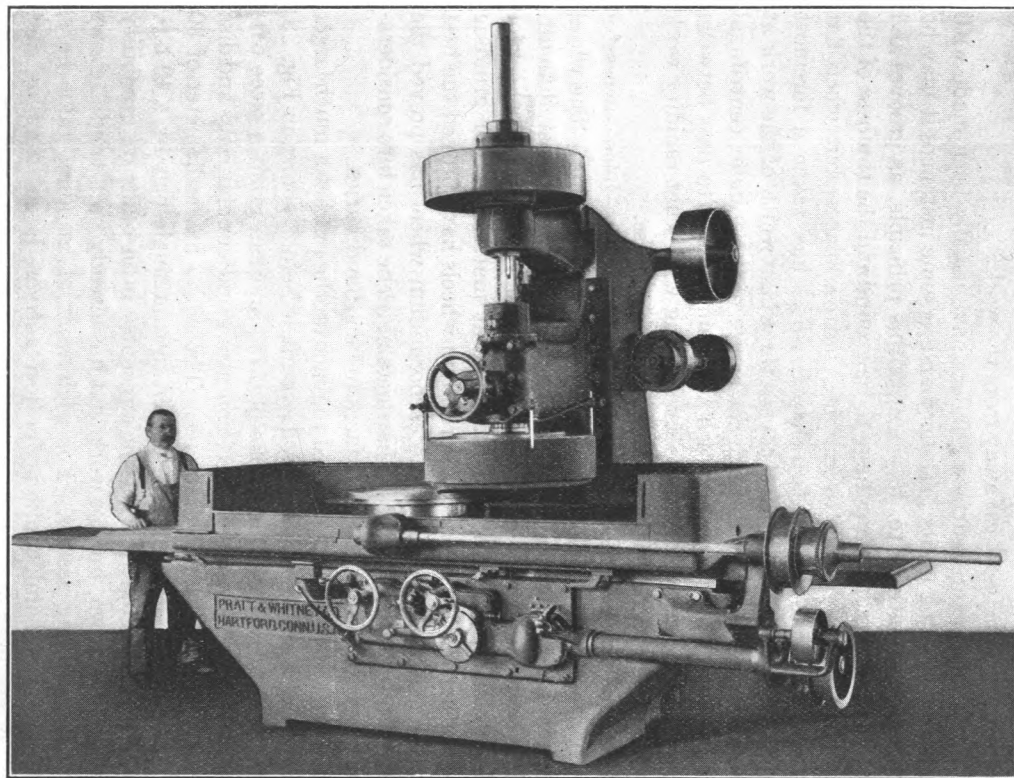


FIG. 38 SURFACE GRINDER, 25 IN. BY 60 IN., 30-IN. WHEEL; DRIVEN BY A 40-H.P. MOTOR

against the adjusting screw *D* at point *C* and causes the arm to slide in an upward direction on pin *E*. As lever *B* is depressed a roller *F* travels downward into the V-shaped space formed by the upper surface of lever *B* and the lower surface of the casting *G*, this roller preventing any upward movement of the lever and consequently any movement of the back rest away from the work.

55 As said before, surface grinders have usually been made with the wheel grinding on its periphery and in some instances it may be necessary to continue to do work on this principle, as grooves and irregular shapes sometimes have to be ground and the thinness of the wheel makes it possible to get into narrow places; but when flat surfaces are wanted, the cup-shaped wheel has taken a foremost place in grinding. The wheel covers the whole width of the work at once and water is forced through the center of the spindle, centrifugal force throwing the water outward and compelling it to pass between the work and the wheel. It is astonishing with what rapidity work can be reduced to a flat surface under this process.

56 This method of grinding would never have been successful if it had not been for the advancement in wheel making. The wheel problem in connection with the machine has been most difficult. It has been found very essential to select the right kind of wheel for different classes of work and for different materials. For grinding steel, either hardened or soft, corundum wheels have proved the best and for grinding cast iron the carborundum wheel has proved the best. The different degrees of hardness must be taken into consideration when the width of the surfaces to be ground varies.

57 The makers have decided to place on the market a much larger machine of this type than they have made before, shown in Fig. 38. This machine has a table stroke of 6 ft., and can grind a piece 6 ft. long and about 25 in. wide. It can also grind circular rings and disc surfaces up to 30 in. in diameter. The wheel has a diameter of 30 in. and the whole machine is driven from a single belt by a 40-h.p. motor. As this machine has just recently been built, its capability is not fully known, but for work that has already been tried it shows very encouraging results. For such work as grinding guide bars, slide valves and link motions for locomotives, large stamping dies such as are used in electric works, facing automobile cylinders and automobile engine frames, I believe it will show its superiority over any other method by several hundred per cent. In one of the trials a surface of cast iron, 6 ft. long and 20 in. wide was reduced in thickness 0.01 in. in five minutes, leaving an excellent finish and an exact

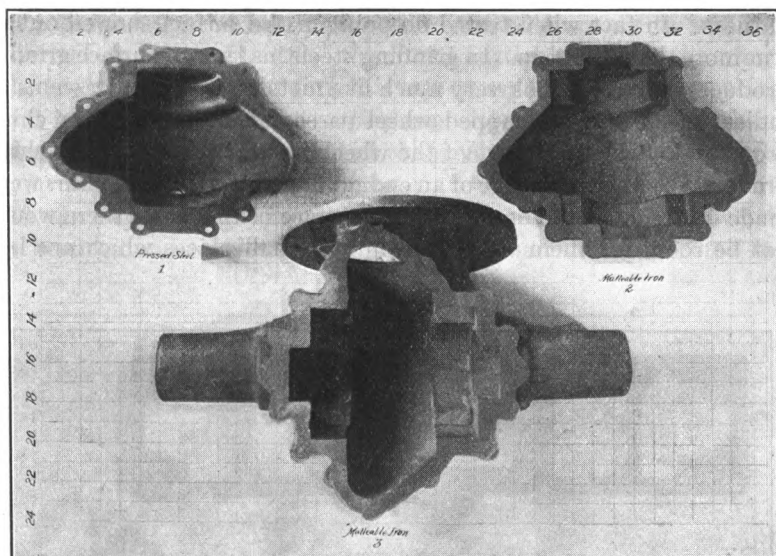


FIG. 39 EXAMPLES OF GRINDING: NO. 1, PRESSED STEEL, 15 PER HOUR; NO. 2, MALLEABLE IRON, 15 PER HOUR; NO. 3, MALLEABLE IRON, 12 PER HOUR

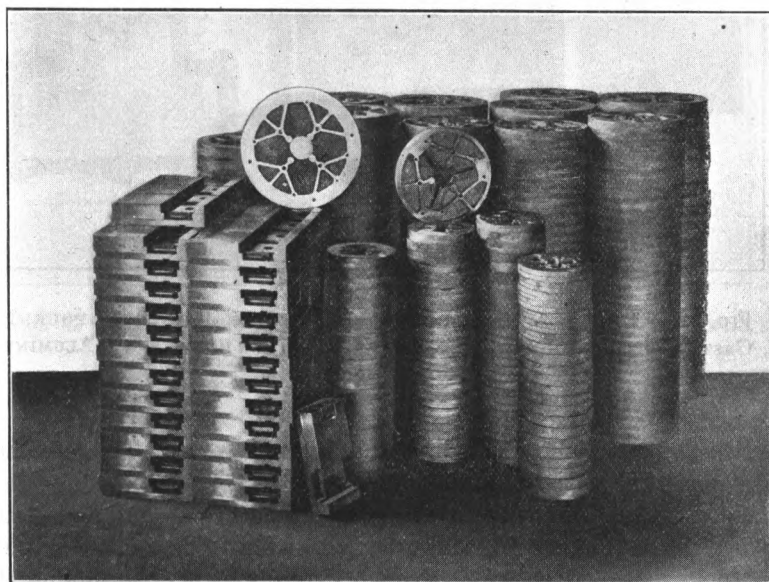


FIG. 40 EXAMPLES OF GRINDING: CHUCK PLATES, GROUND BOTH SIDES, 6-IN. 20 PER HOUR; 9-IN. 15 PER HOUR; 12-IN. 10 PER HOUR; VISES, GROUND ON TWO EDGES, TOP AND ONE SIDE CLEANED ONLY, 20 PER HOUR

flatness. In fact when tested no point in the surface showed out of true more than 0.0005 in. In grinding steel this type of surface grinder produces chips that look very much like metallic wool, which seems to indicate that when a cupped wheel passes over the work, the chips are made by the outer edge of the wheel in the same manner as chips produced by the outer edge of an end milling cutter. If the chips were made underneath the broad contact surface of the wheel there would not be room for them to curl up in the small places which are left

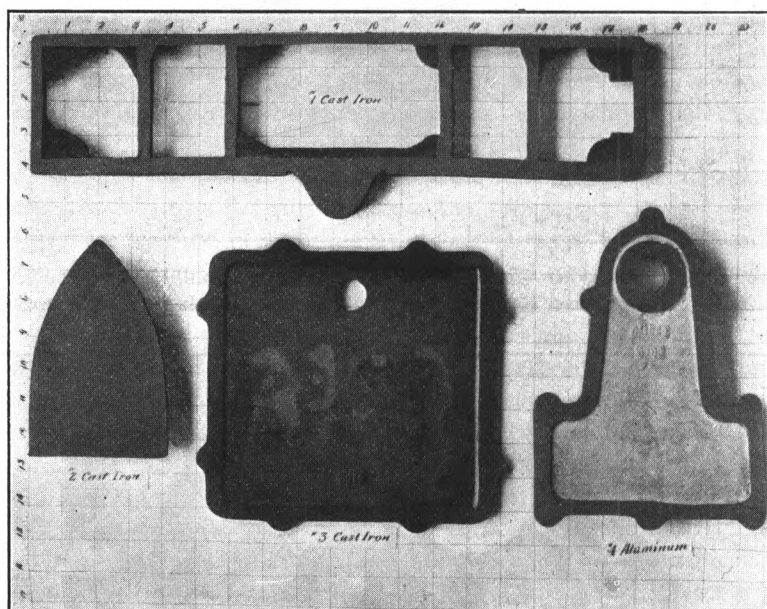


FIG. 41 EXAMPLES OF GRINDING: NO. 1, CAST IRON, 15 TO 20 PER HOUR; NO. 2, CAST IRON, 60 PER HOUR; NO. 3, CAST IRON, 25 PER HOUR; NO. 4, ALUMINUM, 30 PER HOUR

between each cutting particle of the grinding wheel. The large surface in contact with the work simply smooths the surface.

58 The table on these machines is provided with different feeds. It is difficult to make an exact rule as to what feeds to use for different materials, but the operator can determine this by running the machine a few minutes. The difficulty lies in the fact that wheels supposed to be made to the same specifications, vary considerably

and consequently the feed has to be regulated not only to suit the material being ground but also to suit the cutting ability of the wheel to be used. At the present time it is safe to say that grinding machinery is fully developed to the cutting capacity of the wheels and there will probably not be any essential changes until the grinding wheels have reached a higher development.

59 In Figs. 39 to 42 several photographs are shown of work which has been ground on vertical cupped-wheel machines. In some in-

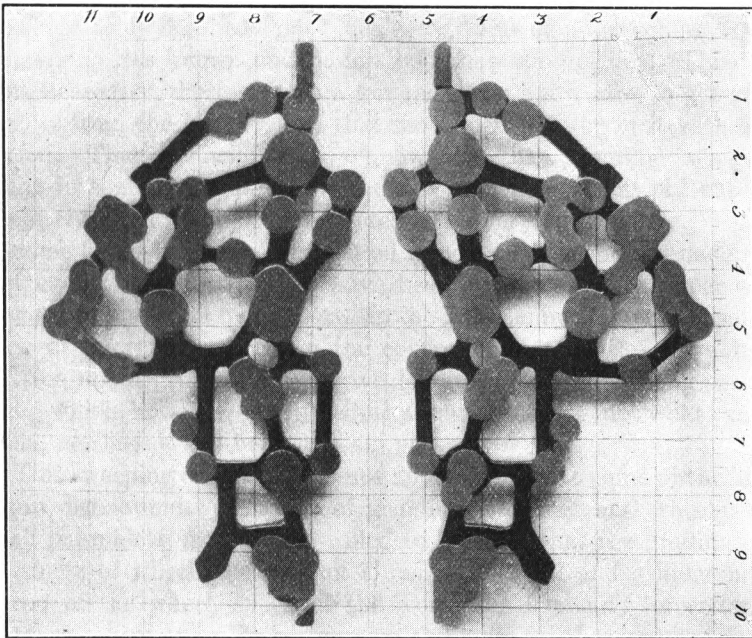


FIG. 42 EXAMPLE OF GRINDING: ADDING MACHINE FRAME, CAST IRON,
15 PER HOUR

stances such as in the production of small gun parts, like hammers and triggers, the work has been done from fifteen to twenty times faster than it can be milled and it has a smoother and more accurate surface. This is especially true where the surfaces are not too wide.

60 To give an idea of the capacity of a grinding machine having a cupped wheel for grinding flat surfaces, compared with a grinding machine having a wheel grinding on its periphery and working on the principle of a planer, it is worth while to note the following:

61 The traversing speed of the work or the work table can be assumed to be the same. If a piece is 6 in. long and 3 in. wide, the machine grinding on its periphery will take about 48 strokes to cover the surface, assuming $\frac{1}{16}$ -in. feed for each stroke. The cupped-wheel machine will do the same amount of work with one stroke or in about $\frac{1}{24}$ the time. These proportions are essentially true on hardened steel or on any kind of work where a nice finish is required.