(No Model.) 2 Sheets—Sheet 1.

A. T. PORTER.

PROCESS OF AND APPARATUS FOR MAKING GEAR WHEELS.

No. 521,178. Patented June 12, 1894.

FIG. 1.

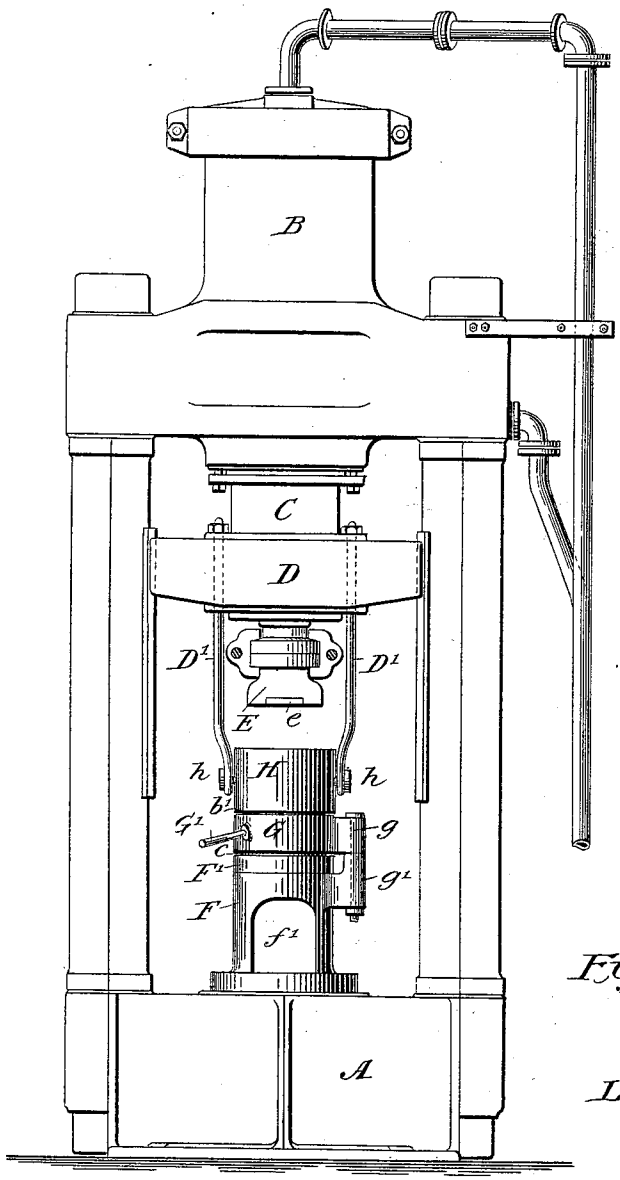


FIG. 2.

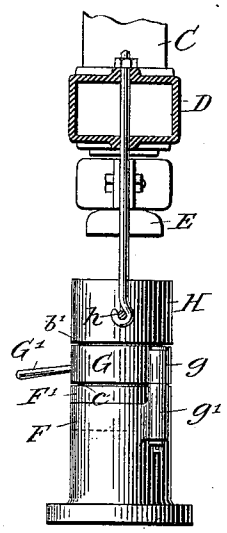


FIG. 3.

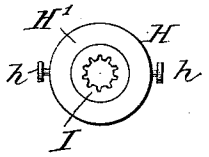


Fig. 7.

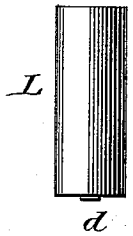
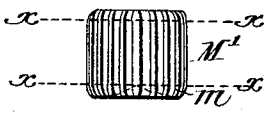


Fig. 8.

Fig. 9.



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(No Model.) 2 Sheets--Sheet 2.

A. T. PORTER.

PROCESS OF AND APPARATUS FOR MAKING GEAR WHEELS.

No. 521,178. Patented June 12, 1894.

FIG. 4.

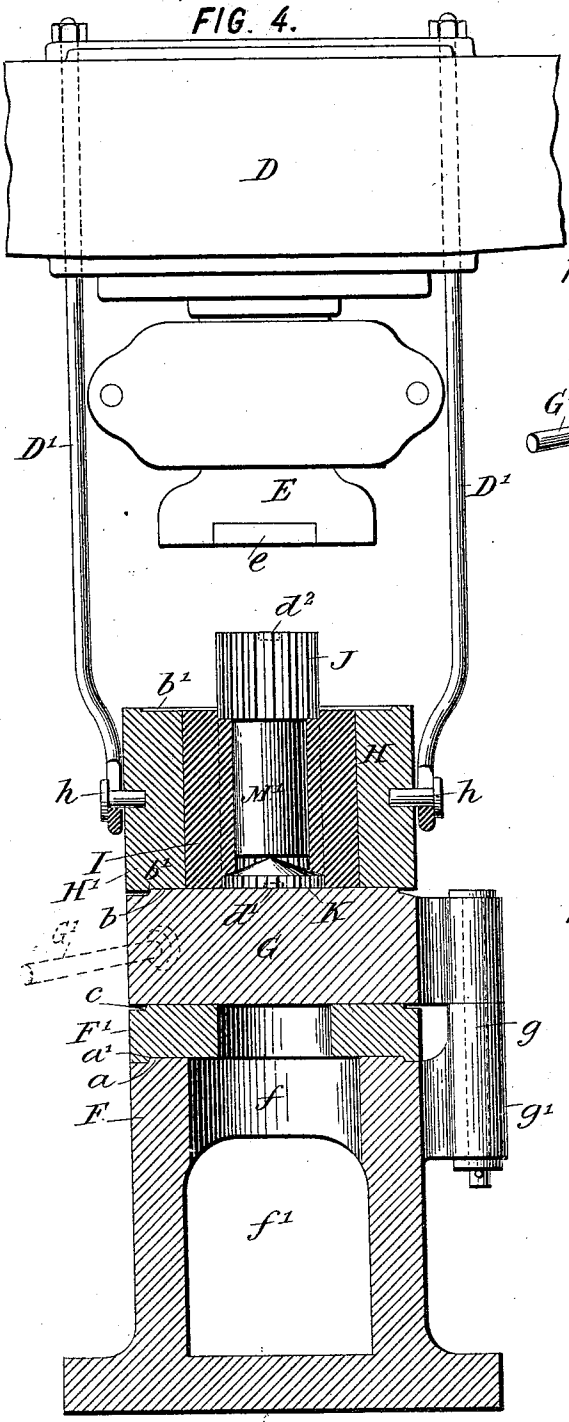


FIG. 5.

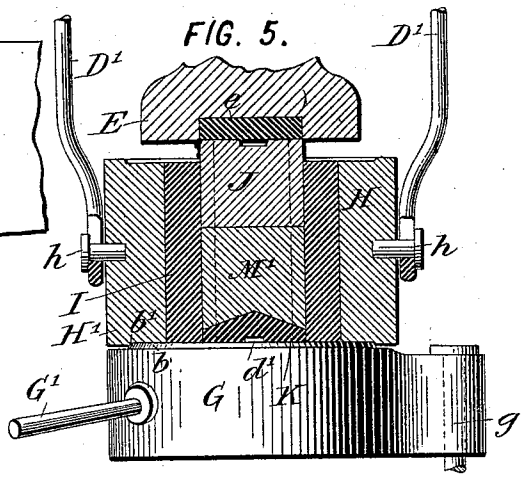
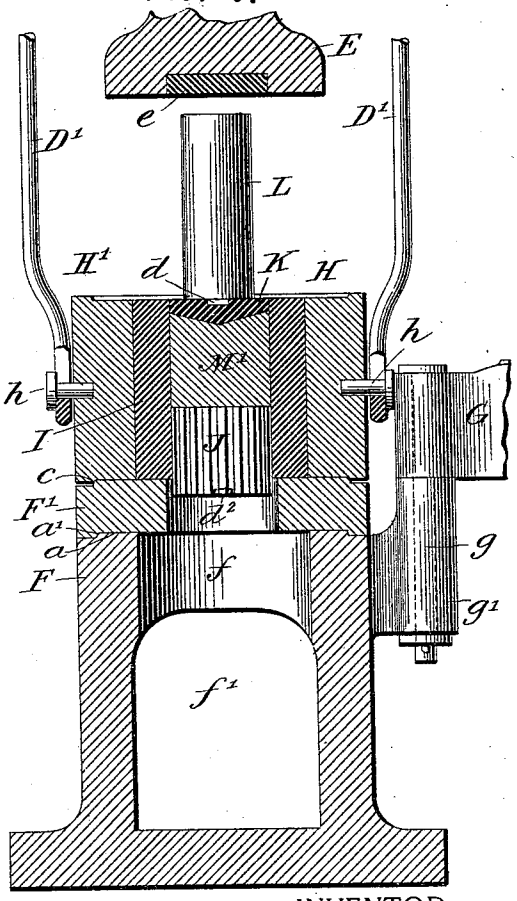


FIG. 6.



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UNITED STATES PATENT OFFICE.

ARTHUR T. PORTER, OF BROOKLYN, NEW YORK, ASSIGNOR TO THE UNITED STATES PROJECTILE COMPANY, OF SAME PLACE.

PROCESS OF AND APPARATUS FOR MAKING GEAR-WHEELS.

SPECIFICATION forming part of Letters Patent No. 521,178, dated June 12, 1894.

Application filed September 23, 1893. Serial No. 486,287. (No model.)

To all whom it may concern:

Be it known that I, ARTHUR T. PORTER, a citizen of the United States, residing in Brooklyn, in the county of Kings and State of New York, have invented certain new and useful Improvements in Processes of and Apparatus for Making Gear-Wheels, of which the following is a specification.

This invention relates to the manufacture of gear wheels or pinions of steel or wrought iron by placing a heated billet of metal in a female die and subjecting it to hydraulic or other heavy pressure sufficient to cause the billet to flow and expand into and fill the teeth formed within the die, thereby forming a compressed gear or pinion having its teeth ready finished and of great strength and toughness. Gears of this character are described and claimed in the patent of E. W. Bliss, No. 472,664, dated April 12, 1892.

The present invention provides an improved process or method for forming such compressed gears, and includes also an improved apparatus for carrying out the new process of manufacture.

According to my invention I provide a female die formed with internal gear teeth conforming to the external teeth to be formed on the gear or pinion in every respect, except that they are made enough larger to allow for the shrinkage of the metal of the gear in cooling, and of a sufficiently greater height than the thickness of the gear or pinion to be made. I provide a male die or punch adapted to enter this female die, and having external teeth adapted to enter and slide into the teeth of the die. A billet of steel or wrought iron is formed of as large a diameter as will easily enter the die, and of a height sufficient to afford the requisite metal, and this billet being first heated and then slightly cooled at one end, is inserted in the die. The punch or male die is then placed against its cooler end. Hydraulic pressure is then applied to force the punch into the die, the latter being suitably supported on the bed of the press, and the billet is pressed down under the extremely heavy pressure and forced to flow or expand outwardly, so that its metal enters and fills the internal grooves or teeth of the die. The billet is then forced out of the die either by pressure applied in the same direction, or preferably by applying pressure in the opposite direction.

Figure 1 of the accompanying drawings is a front elevation partly in section of a hydraulic press to which has been applied my improved apparatus for the manufacture of gear wheels or pinions. Fig. 2 is a fragmentary elevation thereof partly in vertical section. Fig. 3 is a plan of the female die. Fig. 4 is a vertical mid-section of my improved apparatus on a larger scale. Figs. 5 and 6 are portions of Fig. 4 showing the parts in different positions during different stages of the operation. Figs. 7 and 8 are elevations of the auxiliary punch and the lower punch respectively. Fig. 9 is an elevation of the gear or pinion produced by my process as it comes from the dies.

Referring to Fig. 1, let A designate the bed of a hydraulic press, of which B is the cylinder, C the ram, D the guiding cross-head, and E the head piece. These are or may be all of the usual or any suitable construction, except that the head piece E is preferably made with a hardened steel plate *e* inserted in it. On the bed of the press I place a stand F, which has an inner bore *f* and an opening *f'*, both large enough to afford ample room for the pressed gear to pass out through them. The top of the stand F is preferably formed of a steel disk or bed F' having a hole through it sufficiently large to permit the passage of the finished gear. On this disk F' is mounted a table or bed plate G having no hole through it. This bed plate is constructed in any suitable manner, so that it may be readily removed or thrown out of the way, preferably by forming it with a lug and hinging it to a pintle *g* supported in an upright lug *g'* formed on the stand F, as shown. To swing the plate around on this pintle, it is formed with an arm or lever G'.

The female die H is constructed to rest either on the table G, or when this is swung out of the way, on the disk F'. The die is constructed alike at opposite ends and is reversible. To facilitate its reversal, it is hung upon pivot pins *h h* on a diametrical axis intersecting its center of gravity. To enable it to be lifted and lowered with facility, it is

hung by means of these pivot pins from the cross-head D, through the medium of suspension rods D′ D′ which pass freely through this cross-head, so that the head in descending after lowering the die into place, may continue its descent by sliding against the rods.

The internal surface of the die H is made of chilled cast iron in order to afford such extreme hardness as will resist the cutting or tearing tendency of the billet during the formation of the pressed gear and its expulsion out of the die. To resist the bursting pressure, this inner chilled portion lettered I is surrounded by a thick cast steel ring H′ which is shrunk upon it. The inner face of the die is formed with internal gear teeth conforming exactly to the exterior teeth upon the gear or pinion to be made, excepting only that they are sufficiently larger to allow for the shrinkage of the compressed gear in cooling. The height of the die is also considerably greater than thickness or width of face of the gear or pinion to be made.

The male die or punch J is constructed to enter the female die, being formed with external gear teeth conforming to the internal teeth of the die, and adapted to slide into the die with a free or loose working fit. By preference I employ also a lower punch or bottom piece K having teeth like the upper punch J, but made preferably as a shallow disk, either flat topped or with a slight coning, as shown.

The only remaining part of the apparatus is an auxiliary punch shown in Fig. 7.

In order to properly center the several parts, they are provided with interfitting concentric projections and depressions. Thus the stand F has on its top a projection a engaging a depression a' in the bottom of the disk F′. The swinging table G has on its top a projection b, which is engaged by a depression b' in either one end or the other of the female die. When the table G is swung out of the way and the die lowered upon the disk F′, its depression b' fits over a projection c on this disk, whereby it is centered. To center the auxiliary punch L relatively to either the lower punch or bottom piece K or the upper punch J, it is provided with a projection d which is adapted to enter a depression d' in the bottom of the punch K, or a like depression d^2 in the upper punch J.

The apparatus being now understood, I will proceed to describe the process of manufacture.

The billet M′ (Fig. 4) is made cylindrical and slightly smaller than the internal diameter of the female die within its gear teeth. The length of the billet is sufficient to afford the requisite metal for making the required gear or pinion, and will vary according to the thickness or width of face desired in the gear. The billet is heated to a red heat, its upper end is slightly cooled, and the billet is then dropped into the die, the bottom piece or lower punch K having been first placed therein. The upper punch J is then inserted in the die so that it rests on the top of the billet. The press is then operated, bringing the head piece E down on top of the punch J, and forcing it down into the die, thereby squeezing out the metal of the billet and causing it to expand and flow into the teeth of the die. The pressure must be exceedingly heavy, for which purpose a hydraulic press is required. The metal of the billet consequently takes an exact impress of the interior of the die, and as the teeth thereof are smooth, the teeth formed on the billet or gear are made smooth so as to require no after finishing. Fig. 5 shows the dies at the end of this forcing operation. The press is then run up so that its cross-head D, acting through the suspension rods D′, lifts the die H, whereupon the table G is swung out of the way, and the die H is then swung over or inverted, whereupon the press is run down, thereby lowering the die H onto the disk F′, as shown in Fig. 6. The auxiliary punch L is then placed on the bottom piece or punch K, being centered therewith as shown. The head of the press is then again lowered, and striking the auxiliary punch L, communicates pressure through it and the bottom piece K to the pressed billet or gear M′, thereby forcing it down through the female die and out through the hole in the disk F′, dropping it into the cavity f' of the stand F. The punch J is at the same time forced out in advance of the billet. The punch and billet or molded gear are taken out through the opening f' by tongs, the gear then appearing as in Fig. 9, that is to say, its teeth are slightly rounded at m, being the end against the bottom piece or punch K. To avoid this defect it would require a pressure so much in excess of that necessary to make an otherwise perfect gear, that it has been found better to form the gear enough longer than is required, and afterward cut it off at both ends on the lines x—x to remove the slightly imperfect portions at its ends. It is afterward bored, and if desired a key-way is cut.

The cooling of the upper end of the billet before commencing the forging operation is practically a very important step in the process. This cooling is for the purpose of rendering this end of the billet more resistant than its remaining portion, in order that it may sustain the strain communicated through it to the lower portion of the billet, it being understood that by reason of the resistance of the heated metal to pressure, the downward pressure per square inch is greater toward the upper end of the billet than it is toward its lower end, the tendency of which is to expand the billet to fill the die at the upper end in advance of its expansion into the die at its lower portion. Another serious difficulty is overcome by this means, namely, that with a billet heated uniformly throughout, the metal at the upper end of the billet is apt to flow under the pressure, not only

into the teeth of the female die, but upwardly in the form of a feather or fin within the narrow spaces between the teeth of the punch J and of the female die. These fins as they harden, which they quickly do by reason of their thinness and the large surface of the metal of the die and punch with which they are in contact, are liable to cut or score the teeth of the die and punch. Any injury thus done to the teeth of the die results in a corresponding imperfection in the teeth of the pinions that are subsequently formed in it. These difficulties are entirely overcome by the slight cooling of the upper end of the billet in order that it shall sufficiently resist pressure to retard its flow into the teeth sufficiently to avoid forming fins, and to communicate the requisite pressure downwardly to the lower portion of the billet.

If desired, the pressed billet or gear M′ may be forced out of the die without inverting the die. In this case, after the table G is swung out of the way, the die is lowered without inverting it until it rests on the disk F′, and the auxiliary punch L is then placed on the punch J and the head piece brought down to force the punch through the die. I find this method inferior to that first described, because it has the effect of more rapidly wearing the die, so that after manufacturing a certain number of gears, there is a great appreciable difference in their sizes, it being understood that the gears grow larger as the die wears away. In case by reason of breakage or any other imperfection occurring in the teeth of the die at its upper portion while leaving its teeth perfect and complete beneath, the die may still be used by forcing the billet down through it without inverting it, according to the method last described.

It will readily be understood that my invention may be otherwise varied or modified without departing from its essential features. Those features which are believed to be essential to my invention are hereinafter defined in the claims.

I claim as my invention the following-defined novel features, substantially as hereinbefore specified, namely:

1. The improved process of making compressed wrought gears, consisting in placing a heated billet in a die having internal gear teeth and subjecting it to heavy pressure from a punch entering said die, so that its metal is caused to flow outward and fill the teeth of the die, and subsequently forcing it out of the die.

2. The improved process of making compressed wrought gears, consisting in placing a heated billet in a die having parallel internal gear teeth and subjecting it to heavy pressure from a punch entering said die, so that its metal is caused to flow outward and fill the teeth of the die, and subsequently applying pressure to its opposite end to force it out of the die through the same end thereof at which the punch entered it, whereby the teeth are smoothed and finished by rubbing against the parallel surfaces of the die.

3. The improved process of making compressed wrought gears, consisting in placing a heated billet in a die open at both ends and having internal gear teeth and subjecting it to heavy pressure between a punch entering said die at one end and a plate closing the other end, so that its metal is caused to flow outward and fill the teeth of the die, and then removing such plate and applying pressure to the end of the billet to force it through the die.

4. The improved process of making compressed wrought gears consisting in placing a heated billet with its end cooler than its remaining portion in a die having internal gear teeth and subjecting it to heavy pressure from a punch entering said die, and acting against said cooler end of the billet, so that the metal is caused to flow outward and fill the teeth of the die.

5. A die for the manufacture of compressed wrought gears having its inner portion formed of chilled cast iron with internal gear teeth, and an outer portion consisting of a steel ring shrunk upon said inner portion to reinforce it.

6. The combination of a female die open at both ends having parallel internal gear teeth, a male die or punch having external teeth adapted to freely enter the teeth of the female die, and a table for supporting the female die and closing its lower end.

7. The combination of a female die open at both ends having parallel internal gear teeth, a table for supporting it, a bottom plate or punch adapted to fill the lower end of the female die, and a male die or punch adapted to enter the upper end of the female die.

8. The combination of a female die having internal gear teeth, a male die or punch adapted to enter said female die, a removable table for supporting said female die during the operation of forming the pressed gear, and a supporting stand having a hole through its top adapted to support the die during the operation of forcing out the gear from the die.

9. The combination with the female die H, male die J and stand F, of the removable table G hung to the stand on a pintle *g*, whereby it may be swung out of the way.

10. The combination with a press having a vertically movable head, of a female die, a stationary support therefor, and suspension devices connected to said die and adapted to be lifted by the ascent of the head in order to lift the die off from said support.

11. The combination with a press having a vertically movable head, of a reversible female die having opposite pivot pins, and suspension rods engaging said pins and connected to the head of the press, whereby the ascent of the head acts through the suspension rods to lift the die, and the die when lifted may be swung upon its pivots to invert it.

12. The combination of stand F, removable

table G, female die H, male die J, movable cross-head D, and suspension rods D′ by which the die can be lifted off the table G, the latter then moved out of the way, and the die lowered upon the stand.

13. The combination of stand F having top disk F′ with centering projection *c*, removable table G having centering projection *b*, female die H having centering recesses *b*′ adapted to fit either of said projections *b* or *c*, and means for raising or lowering the die.

14. The combination of stand F, table G, female die H, male die or punch J, and auxiliary punch L for forcing the compressed gear from the die.

In witness whereof I have hereunto signed my name in the presence of two subscribing witnesses.

ARTHUR T. PORTER.

Witnesses:
JOHN B. WETHERBEE,
JOHN CARLSON.