A. L. WARNER.

CRANK SHAFT FORGING APPARATUS.

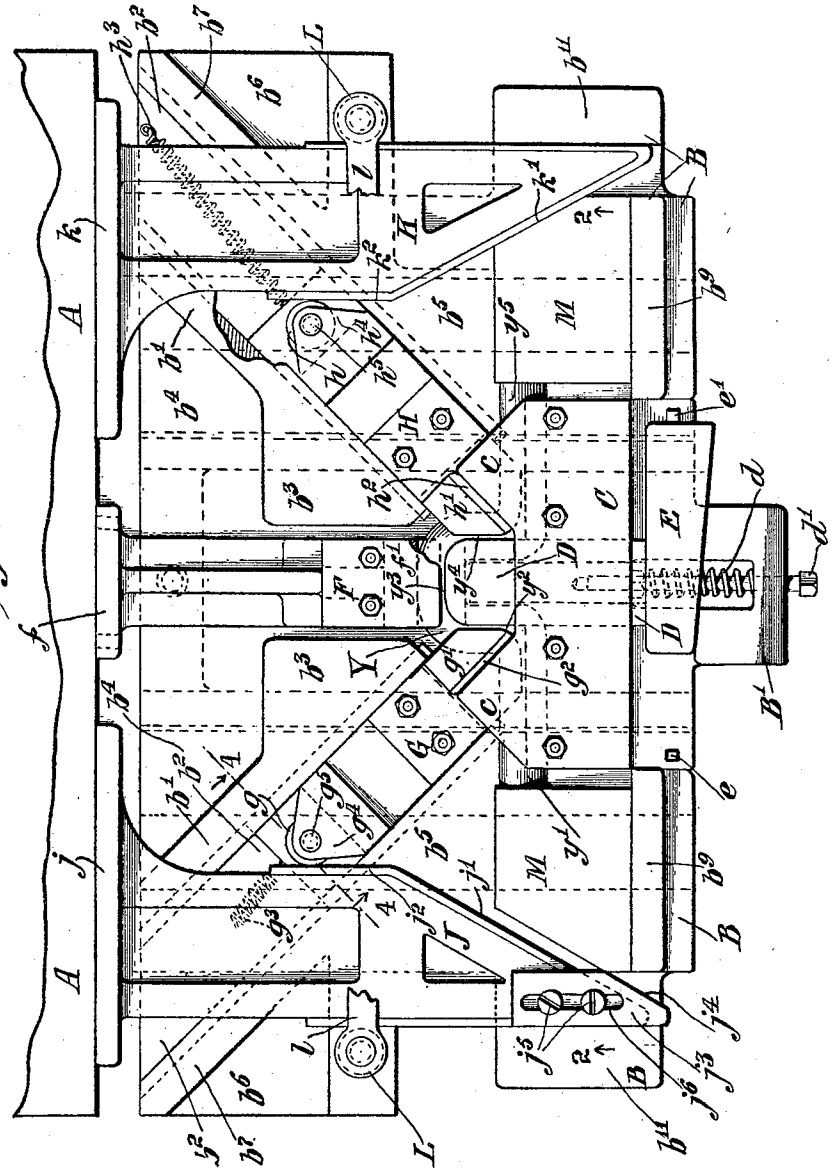
APPLICATION FILED JUNE 24, 1911.

1,108,954.

Patented Sept. 1, 1914.

2 SHEETS—SHEET 1.

Fig. 1.



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2 SHEETS—SHEET 2.

Fig. 2.

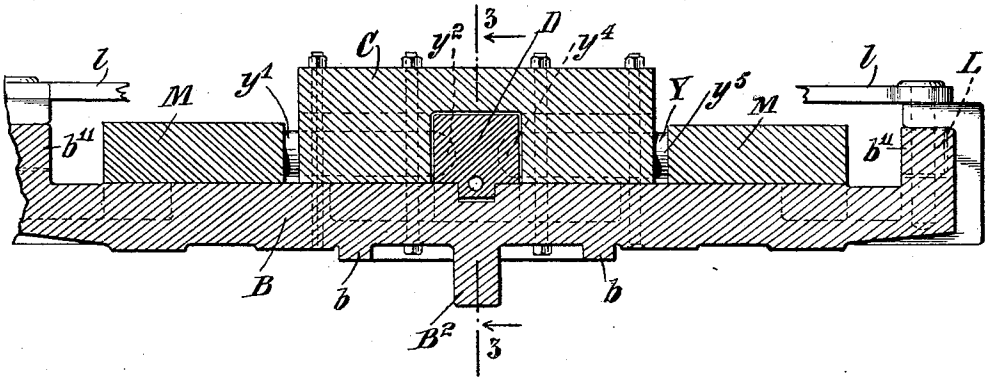


Fig. 3.

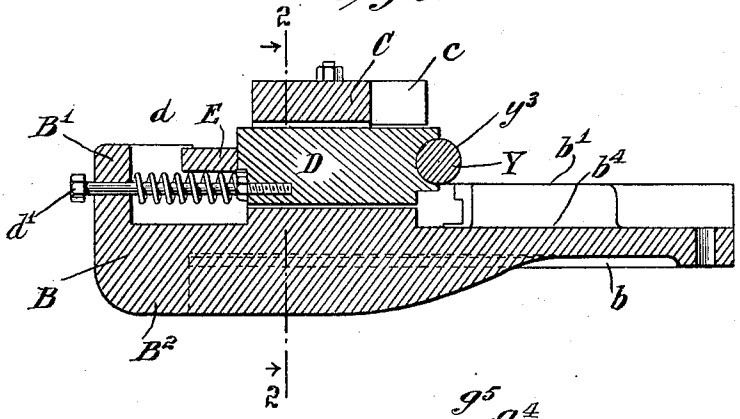


Fig. 4.

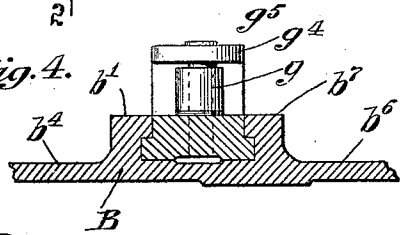
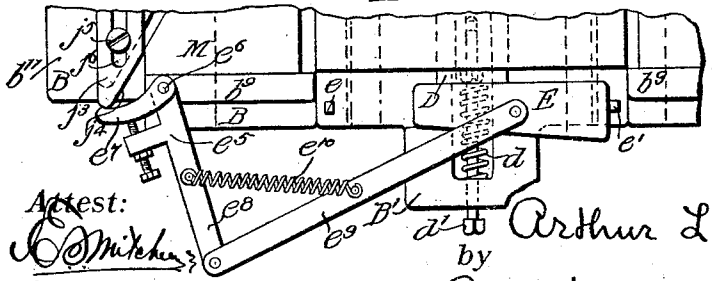


Fig. 1ª



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UNITED STATES PATENT OFFICE.

ARTHUR L. WARNER, OF MOLINE, ILLINOIS, ASSIGNOR TO WILLIAMS, WHITE & COMPANY, A CORPORATION OF ILLINOIS.

CRANK-SHAFT-FORGING APPARATUS.

1,108,954. Specification of Letters Patent. Patented Sept. 1, 1914.

Application filed June 24, 1911. Serial No. 635,112.

To all whom it may concern:

Be it known that I, ARTHUR L. WARNER, a citizen of the United States, residing at Moline, in the county of Rock Island and State of Illinois, have invented certain new and useful Improvements in Crank-Shaft-Forging Apparatus, of which the following is a specification, reference being had therein to the accompanying drawing.

My invention relates to apparatus for forging crank shafts, and more particularly to a set of dies and their fittings and supports adapted to be operated by power for the bending and forging of crank shafts.

The apparatus herein to be disclosed is shown of a nature permitting it to be employed on various power operated machines or presses whether horizontal or vertical, such for example as the ordinary punching press or a hydraulic press or the machine known as a bulldozer; there being in each instance a reciprocating part such as the crosshead of the bulldozer, with which certain of the die mechanism coöperates, and a stationary member to which other parts of the die mechanism are secured. The present improvements are particularly intended to be operated by power in one way or another.

An object of the present invention is to enable the production of crank shafts with full stock at the corner of the bends and in an efficient and satisfactory way, this being one of the problems with which forge shops have always contended.

Another object is to permit the bending of the shaft and the upsetting or the formation of full stock at the corners in a single operation and by the single apparatus hereof.

Crank shafts made in a drop forge have required a tedious and expensive operation and machinery, the finished shaft being forged down out of large sized material and the material thereby considerably distorted. By the present invention the making of a crank shaft partially by bending and partially by upsetting in one continuous operation, affords the important advantage that the natural grain or fiber of the metal lengthwise of the shaft is not disturbed or distorted to any substantial extent and consequently a stronger crank shaft is obtained by my method and apparatus than with a drop forge.

Other objects include the adaptability of the apparatus to adjustment for different lengths of throw of crank shaft and in other respects, and the use thereof for producing either round or flattened crank shaft arms with equal facility.

Other objects will appear hereinafter in the following description.

The present invention consists of the novel apparatus and parts, devices and combinations thereof as illustrated in the accompanying drawings and described in the following specification.

While I claim to be the first to propose not only the apparatus hereof but the disclosed method of procedure or process, I do not in this application make claim to such method or process, but reserve the same as the subject-matter of a separate patent application to be filed by me.

In the accompanying drawings forming a part hereof, Figure 1 is a top plan view of an apparatus embodying my invention and capable of carrying out the method hereinafter described, said view indicating a reciprocating portion A, A of a bulldozer or other power press. Fig. 1ª is a view similar to Fig. 1 of the lower left-hand portion thereof with certain mechanism added constituting a modification of the principal embodiment of the invention. Fig. 2 is a cross-section on the plane 2—2 of Figs. 1 and 3, the reciprocating dies and wedges being omitted. Fig. 3 is a vertical section on the plane 3—3 of Fig. 2. Fig. 4 is a vertical section on the plane 4—4 of Fig. 1 showing the fitting of the die slides and their rollers.

Similar letters of reference designate corresponding parts in the several figures of the drawings.

The apparatus hereinafter described which illustrates one embodiment of my invention, is capable of carrying out the hereinafter described method of forging crank shafts consisting in bending the metal to the general shape of the crank shaft and in the same operation causing its upsetting for filling out the corners by a die movement toward a yielding anvil and by forcing the shaft ends inward after the bending. As will be more clearly seen the apparatus for carrying out such method is one comprising an anvil device of a shape to extend between the arms of the forged shaft and two or more movable dies converging toward and opposed by said anvil, there being shown a

middle die that moves longitudinally and two side dies set at opposite inclines, the latter effecting the bending, followed by the operation of the middle die which moves inwardly toward said anvil, the latter being made capable of yielding so that the die and anvil move together causing the metal to be upset and form the corners of the bends with full stock. Members also are provided bearing on the shaft ends for forcing them inward toward each other after the bending so as to fill out the lower corners of the shaft.

The head or crosshead A may be considered as the reciprocating crosshead of a bulldozer or other power press, the same to be operated at any speed which may be found desirable for the purpose of forging crank shafts. The remainder of the bulldozer construction is not indicated in the drawings as this is a well known machine and its details *per se* form no part of the present invention. It might be stated, however, that the movement of the crosshead A is longitudinal of the machine and the bulldozer also has a longitudinally arranged bed comprising for example a pair of side frame parts upon which the crank shaft forging apparatus can be mounted.

The bed frame B of the die apparatus is a casting of somewhat heavy construction intended to be bolted down upon the bed of the bulldozer, said bed frame having two longitudinal ribs b, b at its lower side as in Figs. 2 and 3, spaced apart such distance as to fit within the side frame parts of the bulldozer for affording an extremely rigid permanent connection between the two when the dies are mounted for operation upon the bulldozer. The bed frame B has a forward projection B′ near the center, it being recessed for certain purposes, and beneath said projection and extending nearly to the rear of the casting B is a central rib B^2 for giving added strength to the casting. The upper surface of the bed frame casting B is generally flat but there are higher surface portions b', b^3, b^5, etc., and lower surface portions b^2, b^4, b^6, etc., some of which will be individually referred to hereinafter in connection with the description of the mechanism fitted upon the bed frame. Attention may here be called to the bent crank shaft Y whose full width is seen in the cross-section Fig. 3 and at the ends y', y^5, Fig. 1, said crank shaft comprising not only the said end portions but the two crank arms or webs y^2, y^4 and the pin or wrist y^3 extending between them, the parts y^2, y^3, y^4 forming a U-shaped bend in the shaft. In Fig. 1 the three converging dies are seen beyond the crank shaft, and on the side nearer the observer is an anvil device, said dies and anvil device concealing the greater part of the crank shaft owing to the curved or concave faces of the dies and anvil, as more clearly seen in Fig. 3, which therefore overlie the shaft.

Referring now more particularly to what I term the anvil device which is in reality in the nature of a fixed die, opposed by the action of the movable dies, the former comprises an anvil block C which is bolted down to the bed frame so as to be incapable of movement, but preferably in such a way as to permit shifting adjustment when desired. The anvil block C is shown as centrally recessed to form a longitudinal aperture for an anvil member D which extends not only through the aperture in the anvil block C, but extends beyond the same away from the observer, as plainly seen in Fig. 1 where it lies between the two side arms of the crank shaft. The anvil block C and the anvil member D coöperate to form the anvil for opposing the action of the movable dies, and they are easily capable of adjustment relative to the dies and relative to each other so that for example by longitudinally adjusting the anvil member D the throw of the crank shaft may be altered.

The anvil member D according hereto is adapted to be fixed at certain times and yielding at other times. For rendering it rigid to resist the tendency to move while the bending of the crank shaft is being performed, a stop may be employed such as the wedge stop E which abuts against the end of the anvil member and also against the two unrecessed side portions of the projection B′ of the bed frame. The wedge stop E is intended to be movable between two pins e, e', it being shown in engagement with the right-hand pin e' in which position a slight yielding of the anvil member D is permitted, namely to the extent of the distance between the anvil block C and the wedge block E. In Fig. 1 this yielding is shown to have taken place, the dies being at the end of their operations, but in the normal state of the apparatus the anvil member D would be caused to stand slightly farther forward by the action of a spring d, and the wedge block E would stand at its left-hand position against the pin e so as to close up the space referred to and prevent any movement or yielding of the anvil member. As will be explained the anvil member is to be held rigid while the shaft is being bent and is only allowed to become yielding after the bending and during the upsetting of the metal of the shaft for filling out the bends of the latter.

The lateral movement of the wedge block E may easily be accomplished by hand and a handle might be added for that purpose, or on the other hand an automatic connection could easily be added for that purpose, for example through a bell crank lever operated by the throw of the crosshead A for shifting the wedge block at the desired point

in the stroke. Thus the bell crank lever e^5 indicated in Fig. 1ª is pivoted to a fixed part of the frame at e^6, and has an arm e^7 adapted to be, and is shown as just having been, contacted and moved by the member J. The other arm e^8 of the lever has its extremity connected by the link e^9 with the sliding wedge E. These devices have caused the wedge block to be slid to the right as shown thus permitting the retraction or yielding of the anvil member D. When the bull-dozer cross-head A returns, it disengages the bell crank lever and a spring e^{10} serves to restore the parts to original position, moving the wedge block to the left and advancing the anvil D to inward position.

Coming now to the movable dies of the present invention, there are seen to be two converging dies G, H, set at an incline shown as substantially 45 degrees, so as to give the best access for the purpose of bending the shaft parts as shown. In fact there are three converging dies since the side dies G, H and the middle die F are all directed toward the anvil. The three dies all take their motion in one way or another from the reciprocating crosshead A, A of the bull-dozer, thus for example the support of the die F may have a foot f bolted to the cross-head A. The diagonal side dies may slide along their respective directions and be actuated through rollers g, h respectively on said slides, the rollers in turn actuated by cam members J, K respectively whose feet j, k are, like the foot f, secured to the reciprocating crosshead A for giving the necessary reciprocation to the cams and through the cams to the diagonal dies.

Referring now more particularly to the middle die F, it will be understood that this has substantially no bending to perform since the bar which is to be bent into a crank shaft extends originally along the same line or direction as that in which the wrist or pin portion y^3 is shown. The die F therefore will substantially have no work to do while the diagonal dies are performing their bending, and the length of the support of the die F will be determined in accordance with this fact. The details of said support are of no consequence and need not be referred to excepting in this particular that it is adapted to have a removable or changeable die face f' secured to it, and their will preferably be lengthwise adjustment either of the die support or of the connection between the support and die face so that the exact stage or point at which the die F will come against the work may be properly determined and fixed.

Referring now to the diagonal dies G and H, they and their fittings are substantially the same and the following detailed description will be confined to one of them, for example H. The removable face h' will be seen, it corresponding substantially with the previously described removable face f' of the die F. The face of the die H, however, is of a different shape since it is intended to produce not only the bend between the crank wrist and the crank web, but also the bend between the web and the shaft proper or end portion y^5. The die face therefore has two portions at substantially right angles to each other, one bearing against the web y^4 and the other against the shaft y^5 as shown. The continued forcing inwardly of the die against the plastic metal serves eventually to change it from the shape of a straight rod to that indicated. The die H is guided in its to and fro diagonal movements by an undercut guide or slide-way formed between two of the raised surface portions or ribs b', b^3 at one side, and similar raised portions or ribs b^5, b^7 on the other side of the die H, all of said raised portions being integral parts of the main bed frame casting B as previously explained. Fig. 4 shows the relation between the slide and the guide in cross-section. In addition to the guidance thus given to the dies G, H, further guidance and resistance is afforded during the critical part of the inward motion thereof by a triangular projection c from the anvil block C, said triangular projection being engaged and contacted by a vertical central rib or projection h^2 formed on the die H or on the die face h', it being understood that the die partly slides under the horizontal projection c while the rib h^2 transmits a part of the side strain to projection c as the die comes inward.

The idle or outward position of the die H is sufficiently removed from the position shown to permit the original straight bar to be inserted in forging position, and the diagonal die is normally brought to or maintained in outward position either by the same cam which afterward forces it inwardly, or preferably by spring g^3, h^3 as shown. To move the diagonal die inwardly the roller h is engaged by the cam K as already stated, that cam being of the form having an inclined face k' which performs the work of driving the die inwardly, and a longitudinal face k^2 which serves when engaged with a roller to maintain the die without movement in its inward position. The cam K may be of any desired construction, the only essential features being the foot k for attaching it to the crosshead A, and the two faces k', k^2 for engaging the roller h. The connection between the die H and the roller h may be the simple one shown in which an angularly shaped piece of metal h^4 extends over to form an upper bearing while the slide itself forms the lower bearing, the roller being mounted on pin h^5 passing vertically through it from one bearing point to the other. To take the

side thrust of the cams J, K, which tends to force them apart while driving the dies, a pair of rolls L, L is employed indicated in dotted lines in Figs. 1 and 2, and across the top of the machine from one roller L to the other is a rod l that is actually shown as broken away near both ends in order not to confuse the remainder of the drawings.

As already explained the dies F, G, H are so timed that the dies G, H first strike and bend the metal to substantially the shape shown, after which in order to upset and fill out the two corners between the crank wrist and the two side arms, the die F comes into action, it operating directly on the wrist portion y^3 of the crank and tending to drive it inwardly. It is at this point that the wedge block E is shifted to the right so as to allow the anvil block D to yield, whereby the die F may have room for the action of forcing the crank wrist bodily inward so as to cause a flow of metal toward the corners, thereby enlarging the amount of metal at the corners and causing them to be filled out as desired. By this arrangement sufficient material is gathered at the corners not only to fully fill them out and render them as strong and thick as any other portion of the crank, but in fact to make the crank if desired thicker and stronger at the corners than elsewhere.

As already stated the active faces of the dies are shown as concave for the purpose of maintaining the roundness of the metal, but if desired the faces in the case of dies G and H may be changed and the corresponding faces of the anvil part D may be changed to a flat form so that the two webs or arms of the crank will be of the flat species as is frequently desired. This is permitted by the removability and adjustability of each of the parts as already explained. In making flat faced arms much more pressure of the dies is required and the lugs or projections c, c are provided more particularly for this use.

In order to upset, or rather to further upset, the metal for the purpose of filling out the inner corners of the crank, namely where the crank arms meet the shaft proper, the following mechanism may be employed, and it being substantially the same on both sides of the machine it will be only particularly described in connection with one side, namely the right-hand side. This operation is performed through a laterally moving member M, preferably in the nature of a block and fitted to slide between the raised portions b^5 and b^9 of the bed frame B. This moving block or member which may be termed an upsetting block is constructed so as to engage with the end y^5 of the bent crank shaft so as to be able to move the shaft lengthwise of itself, that is to say laterally of the machine.

In order to effect the movements of the upsetting block M, I take advantage of the cam K already referred to whose extreme end, of a somewhat pointed character, when nearly at the extreme of its inward movement enters the space between the upsetting block M and a raised portion b^{11} of the bed frame, as clearly seen in Fig. 1. The space between M and b^{11} is also seen in Fig. 2 in which the cam K is omitted. To facilitate the operation the corner of the block M which lies nearest to the cam K may be beveled as shown, thus giving a longer contacting surface between M and K. The cam inserting itself between the block and the portion b^{11} wedges the former toward the left and causes it to drive endwise on the end y^5 of the crank shaft, forcing it bodily inward and in that way causing the plastic metal to flow at the corner or bend and to fill up the entire corner space determined by the surfaces of the anvil block C and the anvil member D. The shaft end is not held so tightly between the die H and the anvil C but that the sliding block M may force it inwardly for the purpose of upsetting as described. As a modification, an adjustable coöperation is shown between the cam J and the block M at the left not shown in the case of the cam K at the right previously described. As shown an adjustable extension j^3 is provided with an inclined surface j^4 that coöperates with the block M at the left. The extension j^3 is secured, for example, by screws j^5 arranged in a slot formed at j^6 in the extension, so as to permit longitudinal adjustment, thereby varying the relative point of time at which the block M is actuated. The upsetting operation is the same as in the case of the block M at the right.

It will be understood that the last described upsetting operation takes place only after the crank shaft has been bent into substantially the form shown, but if desired such upsetting action may take place at the same time with the upsetting action caused by the die F in coöperation with the anvil member D; and the cams and the different members moved thereby will be adjusted or designed in accordance therewith. It will thus be seen that the completely forged crank shaft is produced in a single operation which takes care not only of the formation of the two arms and the wrist, but also of the filling out of the four corners. As compared with the ordinary drop forging process this enables a crank shaft to be manufactured from smaller diameter of material because no further relative enlargement of the corners is necessary nor reduction of the remaining parts of the crank and shaft. In these ways not only labor but material is saved. By way of a summary the preferred operation of the described ap-

paratus will now be stated. The crosshead being in its withdrawn or outward position considerably removed from the observer in Fig. 1, the dies G, F and H will all stand back so far as to permit a straight bar to be easily inserted laterally between the anvil device on the one hand and the three converging dies on the other hand. In this condition the anvil member D will have been forced by the spring *d* toward the die F and wedged firmly in that position by the wedge E. The upsetting blocks M will be outward or apart from each other. The movement of the bulldozer will now commence and a blow or pressure produced first by the dies G and H diagonally upon portions of the bar, causing the same eventually to be bent inwardly in substantially the form indicated in Fig. 1. When this shape has been arrived at the dies G and H will be sufficiently inward to permit their rollers *g*, *h* to dwell on the cams J, J and said cams in the latter part of the operation will pass farther forward to the position shown, while at the same time the die F is brought forward to the position shown. At substantially the same period of time the wedge block E will be moved to the position shown, thus enabling the anvil block D to yield. When the parts have reached this stage the inward movement of the crosshead A causes the two following operations. First, the die F presses the wrist portion of the crank shaft forcibly against the anvil part D, causing the latter to yield so that F and D move together, the metal being thereby compressed and caused to flow endwise whereby the outer and inner corners are upset or filled up with metal flowing both from the webs or arms and from the wrist or pin of the crank. Second, the upsetting blocks M move inwardly toward each other forcing the shaft ends inwardly and in that way compelling the metal to flow more completely into, so as to fill out, the corners nearest the observer. The entire process may be gradual or abrupt as desired, and in some cases a hammering action may be employed. Finally the crosshead A moving away to outward position is there stopped leaving the dies in their withdrawn position so that the operator may readily abstract the now completely forged crank shaft.

The upsetting may be so extensive in the above described improvement as to form actual collars, for example where the crank arm and shaft meet. Adjustment of crank throw may be secured by changing the wedge block for a narrower one, also the initial or normal position of the anvil member D, that is, the extent to which it projects inward of the anvil block C, is regulated by the long set screw *d'*, capable of being adjusted and locked as desired. The extent of yield determines the action of the upsetting die F and hence the extent of upsetting at the two bends between the crank wrist and webs. Many of the features hereinabove may be used where only one web or arm is produced, that is, only two bends, by the omission of one of the dies G or H.

In one aspect the present improvement involves the base or frame or bed, the movable head or actuator, the main anvil and the shifting anvil both mounted on the bed, one or two benders or diagonal dies constituting bending means for making all of the two or four bends of the crank, connections whereby the actuator actuates each bender in the first part of its forward stroke, and a middle or upsetting die or upsetter actuated by the actuator for displacing the crank wrist toward the shaft line after the benders have acted but in the same actuator stroke. By displacing the crank wrist I of course mean the wrist and the adjacent corners. By one forward stroke I mean substantially one operation of the head as distinguished from successive, distinct operations; for example, a series of impulses or short small advances would constitute a single stroke. When I describe the bed as stationary and the actuator movable, that is a relative designation, since an inversion or reversal in that respect would not alter the principles of the operation. The benders are diagonal members which first bend, and then stop to act as anvils maintaining the shaft and web shape during upsetting. The upsetter does not become active until it reaches the crank wrist after the benders are through bending. The shifting anvil opposes the benders and maintains the interior form during both bending and upsetting. It is fitted so as to hold its forward position during bending, thereafter yield and recede during upsetting, and finally hold firmly in receded position during the final pressure in which the wrist and in fact the entire crank is shaped and the crank completed. These elements will serve to efficiently shape the crank and upset all four corners, although the upsetting blocks at the shaft ends can be additionally employed where desired.

Since many modifications and developments of the different features and details hereof may be made without departing from the spirit of the present improvements, I do not wish to be limited to said features or details except as set forth in the claims hereof. The described method and structure possess many advantages already referred to and others will be obvious to those skilled in the art.

The various dies and anvils may be termed shapers, but the upsetting blocks M do not give shape to the article. At the forward side of the straight blank are located the interior shaper or shifting anvil D, and at either side of it, a portion of the main

anvil, which two portions may be termed end shapers, as they maintain the shape of the shaft ends beyond the wrists. At the rearward side of the blank is the wrist shaper or die F together with one or two bending shapers or diagonal dies G, H. These latter are in the first stage of the operation active shapers producing the bends, and they thereupon become passive, preserving the web shape and confining it while the wrist shaper acts as described.

What I claim and desire to secure by Letters Patent is:—

1. In a crank shaft forging apparatus, the combination of an actuator adapted to make a forward stroke, mechanism actuated by said actuator operative in the first part of each forward stroke for producing all the bends of the crank, and mechanism actuated by said actuator operative in the last part of each forward stroke thereof for upsetting the corners by displacing the crank wrist relatively toward the shaft line.

2. In a crank shaft forging apparatus the combination of a movable actuator or head, a shaft bending means for making all the bends of the crank, connections whereby the actuator actuates said bending means, and an upsetting die for displacing the crank wrist toward the shaft line after said bending means has bent the shaft, and connections whereby the actuator actuates said die, said respective connections being such that a single operation of the actuator causes the operations in the order named.

3. In a crank shaft forging apparatus the combination of a movable actuator or head, a shaft bending means for making all the bends of the crank, connections whereby the actuator actuates said bending means, an upsetting die actuated by said actuator for displacing the crank wrist toward the shaft line after said bending means has bent the shaft, a shifting anvil, and means whereby said anvil may be caused to resist said bending means during bending and may be caused to thereafter yield.

4. In a crank shaft forging apparatus the combination of a movable actuator or head, a shaft bending means for making all the bends of the crank, connections whereby the actuator actuates said bending means, an upsetting die actuated by said actuator for displacing the crank wrist toward the shaft line after said bending means has bent the shaft, and a shifting anvil having means to cause it to resist said bending means during bending and thereafter to yield and recede during forging against the pressure of said upsetting die, and finally come to a stop to resist said die in the final pressing operation.

5. In a crank shaft forging apparatus the combination of a movable actuator or head adapted to make a forward stroke, a shaft bending means for making all the bends of the crank, connections whereby the actuator actuates said bending means in the first part of its stroke, and an upsetting die actuated by said actuator in the latter part of its stroke for bodily displacing the crank wrist toward the shaft line.

6. In a crank shaft forging apparatus the combination of a movable actuator or head adapted to make a forward stroke, shaft bending dies for making all the bends of the crank, connections whereby the actuator actuates said bending dies to move inwardly in the first part of its stroke, and thereafter holds them inwardly, and an upsetting die actuated by said actuator in the latter part of its stroke for displacing the crank wrist toward the shaft line.

7. In a crank shaft forging apparatus the combination of a movable actuator or head adapted to make a forward stroke, shaft bending dies for making all the bends of the crank, connections whereby the actuator actuates said bending dies to move inwardly in the first part of its stroke and thereafter holds them inwardly, an upsetting die actuated by said actuator in the latter part of its stroke for displacing the crank wrist toward the shaft line, and an anvil movable during forging to permit the wrist displacement while preserving the interior shape of the wrist and web.

8. A crank shaft forging apparatus comprising in combination a head or actuator adapted to make a single stroke for each shaft manufactured, together with active dies, and shaped anvil portions opposed to said dies, one of said anvil portions corresponding to the crank wrist being capable of receding during the forging of the shaft, said dies comprising a pair of converging dies for producing bends in the shaft, and a wrist die for displacing and shaping the wrist after the action of said converging dies; and connections between said actuator and said dies for operating the latter in the order named in one stroke thereof.

9. A crank shaft forging apparatus comprising in combination a head or actuator adapted to make a single stroke for each shaft manufactured, together with five active dies and three anvil portions surrounding the shaft to be forged, the middle anvil shaped to the crank wrist and webs and being shiftable, the middle die fitted to press the wrist against said middle anvil, the dies on either side of the middle fitted to operate diagonally to bend the shaft about and against the anvils, and the outermost dies fitted to force the shaft ends inward; and connections whereby said actuator in one stroke causes first the operation of the diagonal dies and then the action of the middle and outermost dies.

10. A forging apparatus comprising in

combination a main anvil, a moving member which first acts as a bending die and then becomes stationary to serve as an anvil, a moving die which operates to upset metal at the corners while said member acts as an anvil, and actuating means which operates said member and die in harmony.

11. A forging apparatus comprising in combination a main anvil, a moving member which first acts as a bending die and then becomes stationary to serve as an anvil, a moving wrist die which operates to upset metal at the corners while said member acts as an anvil, and actuating means which operates said member and die in harmony, said anvil having means for permitting it to recede during the action of said die.

12. A forging apparatus comprising in combination a main anvil, an anvil portion capable of receding, an upsetting die opposed by said anvil portion, and means for bending the work about said anvil portion, and operating means whereby said die is adapted to come into play after bending, and said anvil portion is adapted to recede as the die advances.

13. In a crank shaft forging apparatus, opposed members stationarily bearing against the work, a movable die having means for advancing it between said opposed members, and a shiftable anvil member adapted to recede as said die is advanced, whereby the metal is upset at the corners.

14. In a crank shaft forging apparatus, opposed members stationarily bearing against the work, a movable die having means for advancing it between said opposed members, and a shiftable anvil member adapted to recede as said die is advanced, whereby the metal is upset at the corners, means for positively holding said anvil member in its advanced and receded position, and for releasing it from advanced position to permit it to move with said die.

15. A crank shaft forging apparatus comprising in combination active dies and a shaped anvil portion opposed to said dies, said anvil portion corresponding to the crank wrist and being capable of shifting during forging, and said dies comprising one or more bending dies for producing bends in the shaft, and a wrist die for pressing the wrist while the wrist anvil shifts, said wrist anvil having means to first hold it in initial position and then yieldingly oppose the wrist die while shifting.

16. A crank-shaft forging apparatus comprising in combination active dies and shaped anvil portions opposed to said dies, one of said anvil portions correspinding to the crank wrist being capable of shifting during forging, and said dies comprising a pair of converging diagonal dies for producing bends in the shaft, and a wrist die for pressing the wrist while the wrist anvil shifts, said wrist anvil having means to lock it in initial position and resilient means to cause it to oppose the wrist die when shifting.

17. A crank-shaft forging apparatus comprising in combination five active dies and three anvil portions surrounding the shaft to be forged, the middle anvil shaped to the crank wrist and webs and being shiftable, the middle die fitted to press the wrist against said wrist anvil, the dies on either side of the middle fitted to move diagonally to bend the shaft about the middle anvil and against the other anvils, and the outermost dies fitted to force the shaft ends inward, said middle anvil having means for locking and unlocking it, and means for causing resistance when the middle die is in operation.

18. A crank-shaft forging apparatus comprising in combination five active dies and three anvil portions surrounding the shaft to be forged, the middle anvil shaped to the crank wrist and webs and being shiftable, the middle die fitted to press the wrist against said wrist anvil, the dies on either side of the middle fitted to move diagonally to bend the shaft about the middle anvil and against the other anvils, and the outermost dies fitted to force the shaft ends inward, said middle anvil having means for locking and unlocking it, and means for causing resistance when the middle die is in operation, and mechanism for causing said diagonal dies to operate in advance followed by the operation of said middle and end dies for upsetting the metal at the four corners.

19. A crank-shaft forging apparatus comprising an anvil device of a shape to extend within the forged shaft, and three movable dies opposed by said anvil, the middle die moving longitudinally and the side dies at opposite inclines, and means to actuate said dies whereby the side dies reach their inward position in advance of the middle die; said anvil constructed with a recessed fixed part and a yielding part movable in said recess, the latter opposed to the middle die and having means for temporarily fixing it.

20. In a crank-shaft forging apparatus, the combination of two dies converging toward an anvil member, said anvil member, and means for adjusting the anvil member during the operations upon a shaft, and a spring opposing such adjustment.

21. A crank shaft forging apparatus comprising in combination, at one side of the work active dies including an upsetting die, and at the opposite side of the work stationary dies for holding the work and an anvil opposed to said upsetting die, and means whereby said anvil may be caused first to resist said upsetting die and then shift to permit upsetting.

22. A crank shaft forging apparatus com-

prising in combination, at one side of the work active dies including an upsetting die, and at the opposite side of the work stationary dies for holding the work and a shifting anvil opposed to said upsetting die, said shifting anvil having means for initially holding it stationary, thereafter permitting it to recede during said upsetting die's operation, and lastly holding it stationary, during a single operation of the apparatus.

23. A crank shaft forging apparatus comprising in combination, at one side of the work, active dies, including a pair of benders with an upsetting die between them, and at the opposite side of the work a pair of stationary dies, with a shifting anvil between them and opposed to said upsetting die.

24. A crank shaft forging apparatus comprising in combination, at one side of the work, active dies, including a pair of benders with an upsetting die between them, and at the opposite side of the work a pair of stationary dies, with a shifting anvil between them and opposed to said upsetting die, an actuator having connections for actuating in one operation first said bending dies and then said upsetting die, and means for holding stationary said anvil during the bending die's operation and permitting its yielding during the upsetting die's operation.

25. Apparatus for forging crank shafts comprising in combination, means for bending the heated bar to produce the web and wrist portions of the crank shaft with an excessive throw of crank, and means for thereafter causing the relative displacement of the crank wrist toward the shaft line or axis, whereby the correct throw is obtained and metal is caused to flow into the corners of the bends.

26. In a mechanism for making crank shafts, the combination of means for bending the blank to produce the webs and the wrist of greater throw than finally desired, and means for displacing the wrist and the shaft relatively toward each other and upsetting the webs endwise, to give the crank the desired throw.

27. Apparatus for forging crank shafts comprising in combination, means for bending the heated bar to produce the web and wrist portions of the crank shaft with an excessive throw of crank, means for thereafter causing the relative displacement of the crank wrist toward the shaft line or axis, and means for giving interior support to the webs during bending and during displacing and to the interior of the wrist during bending and after displacing, whereby the correct throw is obtained and metal is caused to flow into the corners of the bends.

28. Apparatus for forging crank shafts comprising in combination, an interior shaper for the webs and wrist, means for bending the heated bar around the shaper to produce the web and wrist portions of the crank shaft with an excessive throw of crank, and means for thereafter causing the relative displacement of the crank wrist toward the shaft line or axis, accompanied by the relative displacement of the shaper, whereby metal is caused to flow into the corners of the bends.

29. For the forging of crank shafts or similarly shaped articles, an apparatus in which at one side of the straight blank are interior and end shapers, and at the other side a wrist shaper and at least one bending shaper combined with mechanism for relatively operating the shapers so that the bending shapers first operate to produce all the bends, and thereupon become passive shapers, while the wrist shaper operates to upset the metal into the corners of the bends; whereby in a single operation or a stroke without exchange of shapers the crank shaft is completely forged.

30. For the forging of crank shafts or similarly shaped articles, an apparatus in which at one side of the straight blank are interior and end shapers, and at the other side a wrist shaper and at least one bending shaper combined with mechanism for relatively operating the shapers so that the bending shapers first operate to produce all the bends, and thereupon become passive shapers, while the wrist shaper operates to upset the metal into the corners of the bends, and the interior shaper readjusts to reduce the crank throw; whereby in a single operation or a stroke without exchange of shapers the crank shaft is completely forged.

In testimony whereof I affix my signature in presence of two witnesses.

ARTHUR L. WARNER.

Witnesses:

HARRY AINSWORTH,

C. R. ROSBOROUGH.

Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."