(No Model.)

R. BAGALEY.

MANUFACTURE OF STEEL FORGINGS.

No. 356,974. Patented Feb. 1, 1887.

Fig. 1.

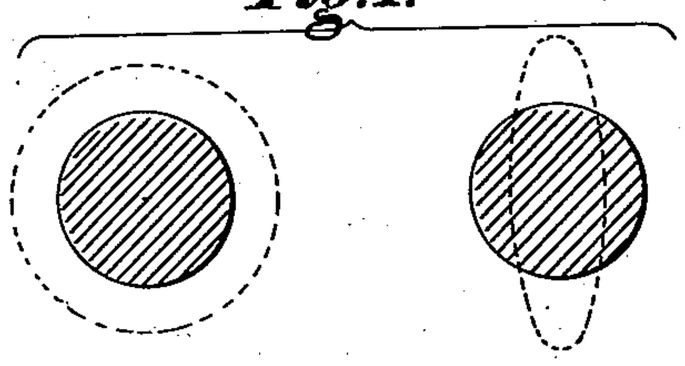


Fig. 2.

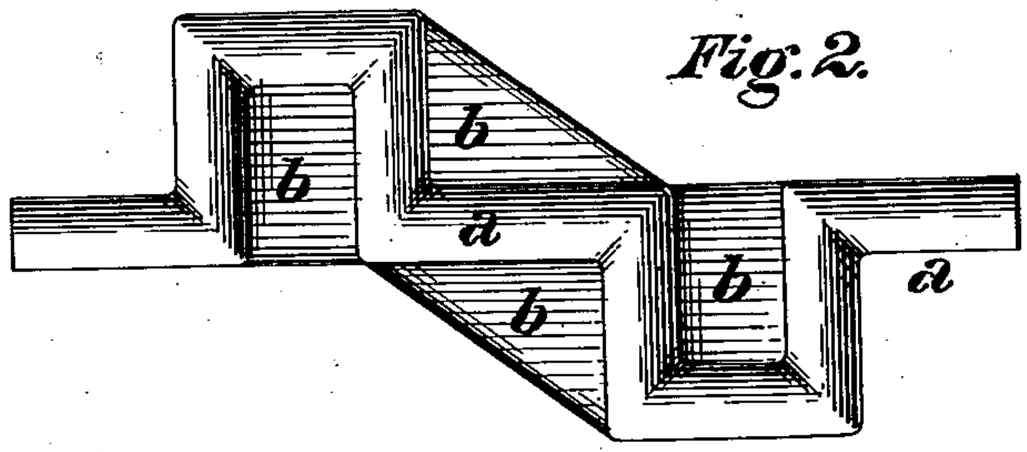


Fig. 3.

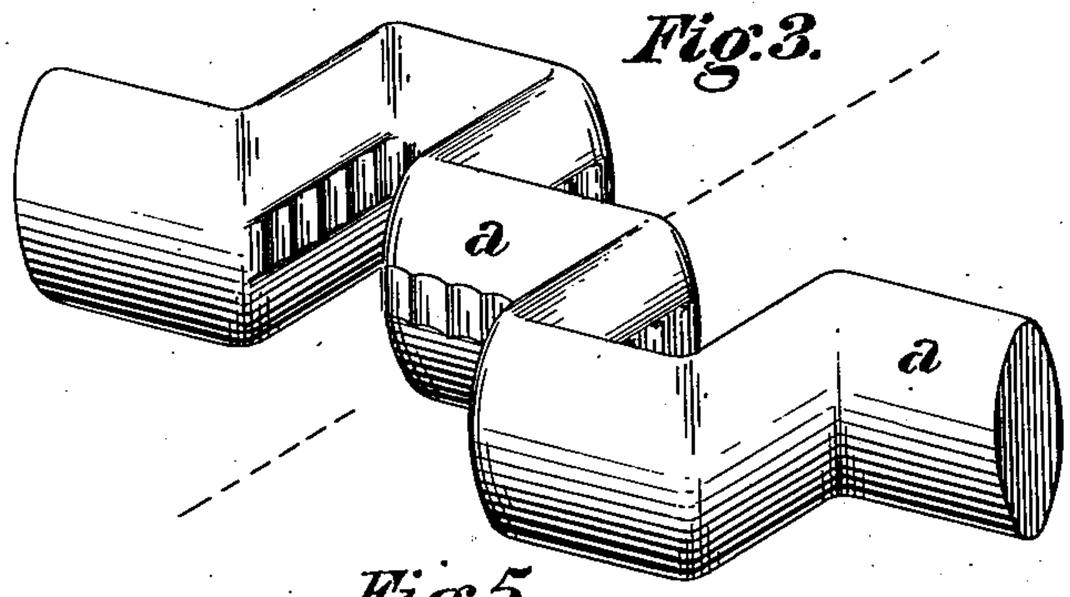


Fig. 4.

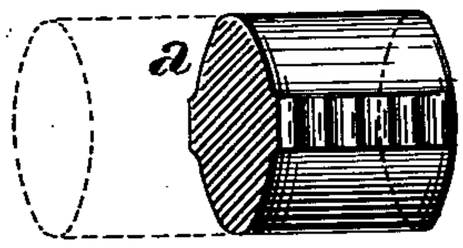


Fig. 5.

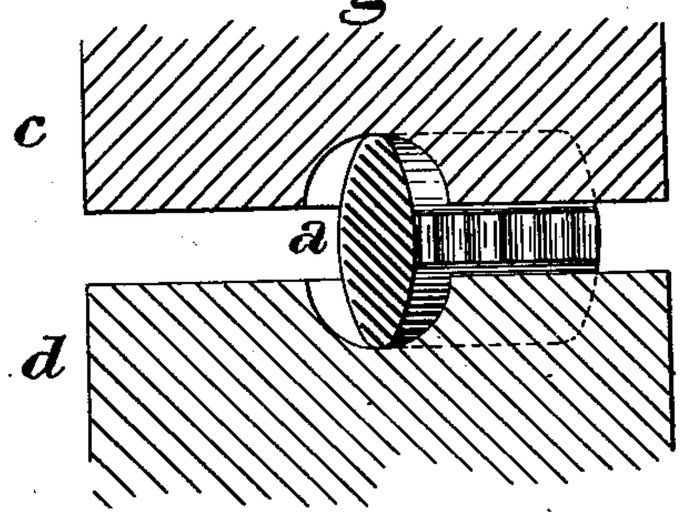
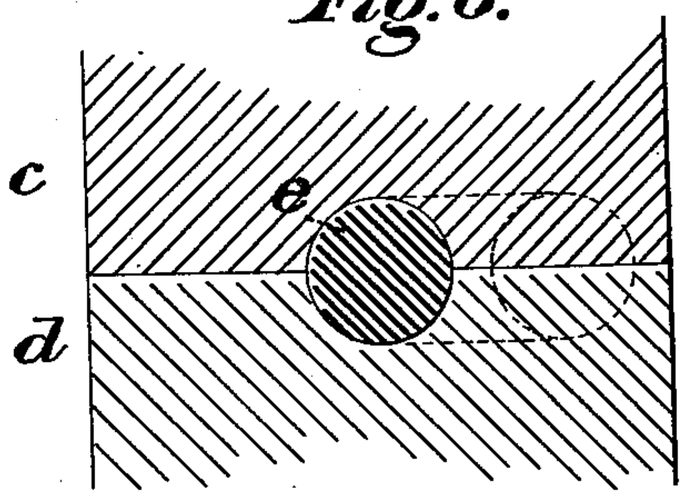


Fig. 6.



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RALPH BAGALEY, OF PITTSBURG, PENNSYLVANIA.

MANUFACTURE OF STEEL FORGINGS.

SPECIFICATION forming part of Letters Patent No. 356,974, dated February 1, 1887.

Application filed June 14, 1886. Serial No. 205,137. (No model.)

To all whom it may concern:

Be it known that I, RALPH BAGALEY, of Pittsburg, in the county of Allegheny and State of Pennsylvania, have invented a certain new and useful Improvement in the Manufacture of Steel Forgings, of which improvement the following is a specification.

The object of my invention is to enable sound and perfect forgings, either of regular or irregular configuration and closely approximating in form and dimensions to desired finished condition, to be produced from Bessemer steel with materially greater facility and economy than has been attainable in the manner heretofore practiced.

To this end my invention, generally stated, consists in a novel method of first casting an ingot of such form in transverse section as to admit of a lateral instead of a longitudinal flow of the metal under pressure and reducing the ingot to a forging approximating finished form by the application of pressure between swage blocks or dies; also, in first casting an ingot of such form in transverse section as to admit of a lateral instead of a longitudinal flow of the metal under pressure, and having projecting ribs or webs so located as to prevent strain or fracture by shrinkage in cooling, next cutting away the superfluous metal provided for resisting shrinkage-strains, and finally reducing the ingot to a forging approxmating finished form by the application of pressure between dies; also, in an ingot of the form above specified as a new article of manufacture.

The improvement claimed is hereinafter fully set forth.

In the manufacture of various articles of irregular form—as, for example, the crank-shafts of double-cylinder engines having two pairs of cranks and a disk for the support of a governor—their production from wrought-iron by the ordinary methods of forging is a matter of so much difficulty and involves so large an expense both in forging and finishing as to be substantially impracticable. When made in steel castings, they are also expensive and necessitate the undesirable construction of being made in separate sections, which are afterward united or built up, and they are further subject to the liability of being so defective as to be useless by reason of the existence of shrinkage-holes, blow-holes, honey-combs, and brittleness due to shrinkage-strains. Defects of such character are frequently developed after the articles have been wholly or partially finished at considerable cost, the expense of the work which has been done upon them constituting an additional element of loss. Their strength in any event is uncertain, and in many cases they are subject to the risk of breakage in service from internal strains, which it is impossible to detect. A large reduction in cost would be attained, as compared with ordinary steel castings, by the use of Bessemer steel ingots; but these are, as is well known, extremely brittle, are subject to great shrinkage in cooling, and, as heretofore employed, have been useless in the arts until by thorough rolling or hammering they have been changed from castings to wrought metal and the inherent strains and other defects induced in the cooling of the castings have been eliminated. Where the articles required are of such regular form that they can be rolled from ingots, the utilization of Bessemer steel becomes readily practicable; but irregular shapes having numerous projections—as, for example, such as above referred to—cannot be produced by rolling, nor can they be forged by the presses heretofore known.

My invention renders practicable the use of Bessemer steel for the formation of forgings of any desired character, which can be readily and economically manufactured, and will be produced free from strains and defects and of uniform dimensions so nearly those of finished size as to reduce to a minimum the cost and waste of metal due to finishing.

In the accompanying drawings, Figure 1 is a diagram illustrating the principle of reduction of an ingot to a forging in the ordinary manner and under my invention, respectively; Fig. 2, a view in elevation of an ingot for the formation of a crank-shaft forging by my invention; Fig. 3, a view in perspective, and Fig. 4 a transverse section, through the same; Fig. 5, a similar section of a pair of swage-blocks with a crank-shaft ingot in position to be forged, and Fig. 6 a similar section at the completion of the forging operation.

In the practice of my invention, I first make an ingot or casting for the article to be produced preferably in Bessemer steel, by reason of its economy, although steel of other descriptions may be employed, said casting being of such form in transverse section as to admit of a lateral flow or movement of the particles of the metal under compression to a sufficient extent to change the character and the transverse section of the body of metal from a casting, the dimensions of which are greater in one direction and less in the other than those of the required article as completed in readiness for the finishing or smoothing off of irregularities in its surfaces to a compact and perfect forging corresponding, substantially, in form and transverse section with the article desired, and exceeding only in slight degree the required finished dimensions thereof. I likewise form upon the casting, adjoining and extending to a sufficient distance from such of its members, if any, as project materially from its main body, and consequently tend to develop injurious strains due to shrinkage in cooling, a series of what may be termed "shrinkage-resisting webs or ribs," extending in substantially straight lines from one portion to another of the casting, the function of which webs is to sustain and obviate fracture or weakness of the casting by reason of strains of such character.

To attain the greatest economy, particularly where the forgings are to be duplicated to any considerable extent, I prefer to use iron molds; but dry-sand molds may be employed, or molds composed partly of iron and partly of sand, where the same may be found necessary or desirable to overcome the tendency to fracture in castings of irregular form.

The distinguishing characteristic in the formation of the casting, and that in which it differs materially from those designed to be forged in the manner known prior to my invention, is that its depth or height—that is to say, its dimensions in the plane in which it is to receive the subsequent forging pressure—shall exceed those desired for the forged article, while its width or dimensions in a plane at right angles to the direction of said pressure shall be less than those of the forged article. Thus the casting for a crank-shaft which is designed to be cylindrical would be made elliptical in transverse section, with a major axis greater than and a minor axis less than the diameter of the completed shaft, and the casting for an article having a body square in section would be of rhombus section.

In the ordinary treatment of steel and iron for the production of forgings by hammering or rolling the ingot or bloom, as the case may be, is reduced materially in transverse section in its conversion to a forging, the requirement in forgings for the government service being a reduction of one-third, and, being subjected to pressure in all directions about its axial line, such reduction consequently effects a longitudinal as well as an inward flow of the metal, and a corresponding elongation of the forging as compared with the ingot or bloom from which it is produced.

Under my invention the flow of the metal is wholly lateral, and no elongation takes place, the flow of the metal at and near the outer portions of the longer axis of the transverse section of the casting being toward the axial line thereof, while that of the metal at and near the outer portions of the shorter axis of the transverse section of the casting is in the opposite direction, or away from its axial line. Space being afforded in the forging-dies for such outward flow, no elongation of the casting will take place in the operation.

Another essential feature of castings made under my invention is that where they are of such form as to embody a member or members projecting to any material extent from their bodies each of the same shall be supported by a web or rib of metal extending substantially in a straight line from its outer portion to the main body of the casting; and hence adapted to sustain and resist the strain resultant upon shrinkage in cooling.

Medium-sized holes or openings, when required, may be formed by being punched through the hot ingot or casting, and these may be brought nearly to the finished size by the insertion of steel pins or mandrels, which should be made slightly tapering, so as to be driven out after the forging is completed. Holes of very large diameter must be cast in the ingot, and for this purpose I prefer to employ hollow cores supported by internal helical springs, the same being sufficiently strong to sustain the molten metal until it has set, but not so rigid as to resist the crushing-strain induced by the shrinkage of the ingot. Where cores of such character are employed they must be properly vented by an opening through the mold, and the pouring-hole must be so located that the falling metal will not strike against and crush them.

The ingot or casting, having one or both of the features above described, is removed from the mold as soon as it has set sufficiently to admit of its removal being properly effected, and, if embodying a shrinkage-resisting web or webs, is conveyed to a suitable machine by which the superfluous metal included in such web or webs is gouged or cut away from its main body. This operation may be most desirably performed while the ingot is still hot, less power being required in such case than when cold and less risk of fracture being involved. The heat remaining from the melting process being thus utilized, the further advantage of avoiding an additional heating operation is attained.

The ingot or casting is finally converted into a forging by being forced into the form of the article required by compression between swage blocks or dies having recesses of such shape that when the faces of the swage-blocks are brought into contact, or nearly so, their surfaces conform to those of the forging desired,

and the action of the swage-block surfaces under pressure upon the interposed casting effects a lateral flow or movement of the particles of the metal thereof both inwardly and outwardly, converting it from a cast to a wrought material and reducing it without elongation to normal completed form. The pressure required may be applied in any suitable manner known in the art of metal-working, as by the employment of a drop, a steam-hammer, or a hydraulic press, the latter being preferable in many particulars, among which are the reduction of liability to breakage of the swage-blocks and an economical utilization of power in moving heavy swage-blocks as compared with their movement when attached to a hammer-head.

The forging operation must be obviously conducted while the ingot or casting is in a heated condition, and in cases where the same has been provided with shrinkage-resisting webs, unless sufficient initial heat remains after cutting away the same, the casting must be reheated to a proper degree. Castings which are unprovided with said webs should be forged as soon as removed from the molds, in order to utilize the heat remaining after the setting of the metal and avoid a subsequent reheating.

It is further desirable that the swage-blocks should be maintained at a reasonably high heat, in order to prevent them from chilling the ingot unduly during the forging operation, and this may be conveniently effected by the use of jets of gas or other flame playing continuously upon the swage-blocks from nozzles or burners properly located so as not to interfere with the closing of the swage-blocks, or automatic slides may be employed to move the nozzles or burners close to the swage-blocks when open, and to withdraw them to a sufficient distance before being closed.

In the case of forgings having ends of cylindrical form—as, for example, crank-shafts—I prefer to effect the compression of the central portion only, which includes such projecting members as the cranks and governor-disk, and to compress the plain cylindrical ends under an ordinary steam-hammer, thereby avoiding the use of unduly large and heavy swage-blocks, and correspondingly economizing the expenditure of power in a hydraulic press.

Large forgings may be produced with a comparatively small hammer by the use of a large lower swage having a recess corresponding in form and dimensions to one-half of the forging and a small upper movable swage-block to be moved by hand, which receives the blows of the hammer. In many forgings, the greater part of which are cylindrical, or nearly so, a small half-round upper swage-block will suffice for the entire length, while such portions of the casting as are of special shape will require a suitable corresponding swage-block to break down the casting at these points to the form desired. Forgings may be thus produced under a steam-hammer of adequate stroke or a slide drop, which could not otherwise be made except by the use of an expensive hydraulic press. Suitable rollers should be provided on which the lower swage-block may be moved into different desired positions. Two or more sets of swage-blocks and two or more heatings of the ingot or casting may be necessary in some cases to finish a specially intricate forging.

In the manufacture of forgings under my invention the precise transverse area of the laterally-swelled ingot or casting relatively to that of the completed forging cannot always be determined with absolute accuracy, because of the possibility of more or less open space, caused by blow-holes or honey-combs, and in such case, where an excess of metal is provided in the casting, thin lateral fins or webs will be formed by the projection of the metal beyond the recesses of the swage-blocks and between their faces. Such fins may be readily and inexpensively removed by the use of a band-saw, the forging resting upon adjustable pins or supports on a traveling table so as to maintain the fin or web at a proper level relatively to the saw throughout the length of the forging. The table being then moved forward, the band-saw will, without the use of water or other lubricant, quickly slit off the fin from the main body of the forging, the thickness of the fin not being sufficiently great to unduly heat the teeth of the saw as they successively make their cuts, and the teeth being cooled in their passage through the air before making another cut. When shoulders are reached on the forging, a small circular saw or disk may be conveniently employed to sever the fin by a cross-cut, after which the portion of the fin up to such cross-cut drops off, and the traveling table being moved into proper position the operation of the band-saw is resumed to remove the remaining portions of the fin.

Referring to the drawings, the diagram, Fig. 1, illustrates in dotted and in full lines, respectively, an ingot or bloom and the forging produced therefrom, the left side of the diagram indicating the ordinary method of reduction by hammering or rolling a body of metal, the pressure acting in all directions toward its axial line, and reducing its transverse section at the same time that it increases its length. The right side of the diagram indicates the change of transverse section effected in converting an ingot to a forging in accordance with my invention—that is to say, from an ellipse to a circle—the flow of the metal being both inward and outward in the decrease of the major and the increase of the minor axis under pressure without elongation of the ingot.

Fig. 2 shows in elevation the ingot *a* for a crank-shaft provided with shrinkage-resisting webs *b*, Fig. 3 illustrating the same in perspective after the webs *b* have been cut away, and Fig. 4 showing the form of transverse section. The forging of the ingot is effected between the swage-blocks *c d*, Figs. 5 and 6, the recesses of which are of semi-cylindrical sec-

tion along the body of the shaft and crank-pins, and of rectangular or other desired section where they receive the crank-arms. The complete forging *e* of circular section is formed by the closure of the swage-blocks under a sufficient degree of applied pressure.

My improvement attains the same result upon the ingot in converting it from a cast to a wrought material that is accomplished by the ordinary rolling or hammering operation, relieving the ingot of all strains caused by shrinkage in cooling, and rendering practicable the manufacture of a new line of steel forgings which cannot be produced by any of the known processes.

Among other advantages may be noted that of freedom from liability to vary the normal relative position of projections from the body of the forging—as, for example, crank-arms on a shaft—as would tend to be done in the ordinary manner of making forgings, or by the rolling process, if such were practicable. The use of the swage-blocks insures the absolute correct relative position of all projecting elements, and duplicate forgings must be absolutely uniform in dimensions.

It will be seen, further, that forgings may be made more nearly to their finished size than in the ordinary manner, and much expensive machine-work in finishing is thus avoided.

The particular mechanism employed in carrying out my invention is not herein claimed, as the same, so far as it may embody novel and patentable subject-matter, will form the subject of a separate application or applications for Letters Patent by me.

I am aware that it has heretofore been proposed to manufacture cast-steel car-wheels by casting a blank with a hub and web of substantially the shape and proportions of the finished wheel and with a flange or tread wider and of less diameter than is required in the finished wheel, and thereafter subjecting said blank to the action of rolling-dies, which true the web and hub without compacting the metal, and which compress and compact the flange or tread. Such process, which I hereby distinctly disclaim, differs essentially from that practiced under my invention in the particular that the only compacting action proposed to be exerted in said process is that of a roll which exerts inward pressure upon the tread or periphery of the wheel, to the end of increasing its density or closeness of texture thereat, and no forging action is proposed whereby the body of the wheel is compacted and reduced in thickness simultaneously with the production of an outward flow at the periphery against the forging surfaces.

I am also aware that the manufacture of steel car-wheels by successive compressions of an ingot in a series of dies or molds by which it is progressively increased in diameter and its periphery pressed against the inclosing-surfaces of the molds has been heretofore proposed, and such process, which involves the use of three compressing-surfaces, I likewise disclaim.

I claim as my invention and desire to secure by Letters Patent—

1. The improvement in the manufacture of steel forgings, which consists in casting an ingot whose transverse section is greater in one direction and less in the other than that of the forging desired, so as to induce a lateral instead of a longitudinal flow of its metal under pressure, and converting said ingot or casting into a forging by reducing it to desired form by the application of pressure between forming-dies, substantially as set forth.

2. The improvement in the manufacture of steel forgings, which consists in casting an ingot whose transverse section is greater in one direction and less in the other than that of the forging desired, and converting said ingot or casting into a forging by reducing it to desired form by the application of pressure applied in the direction of the longer axis of its transverse section, substantially as set forth.

3. The improvement in the manufacture of steel forgings, which consists in first casting an ingot whose transverse section is greater in one direction and less in the other than that of the forging desired, so as to induce a lateral instead of a longitudinal flow of its metal under pressure, and having one or more shrinkage-resisting webs or ribs, each extending from the outer portion of a projecting member to the main body of the casting, next cutting or gouging away said web or webs, and finally converting the ingot into a forging by reducing it to desired form by the application of pressure between forming-dies, substantially as set forth.

4. The improvement in the manufacture of steel forgings, which consists in first casting an ingot whose transverse section is greater in one direction and less in the other than that of the forging desired, converting said ingot or casting into a forging by reducing it to desired form by the application of pressure applied in the direction of the longer axis of its transverse section, and removing the fins or webs remaining after subjecting it to pressure by the action of a saw, substantially as set forth.

5. As a new article of manufacture, an ingot for forging, which is cast of transverse section greater in one direction and less in the other than that of the forging desired, so as to induce a lateral instead of a longitudinal flow of its metal under the application of pressure between forming-dies, substantially as set forth.

RALPH BAGALEY.

Witnesses:
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R. H. WHITTLESEY.