A. W. MORRIS.

FORGED CASTING AND METHOD OF MAKING THE SAME.

APPLICATION FILED OCT. 9, 1916.

1,222,786.

Patented Apr. 17, 1917.

2 SHEETS—SHEET 1.

Fig. 1.

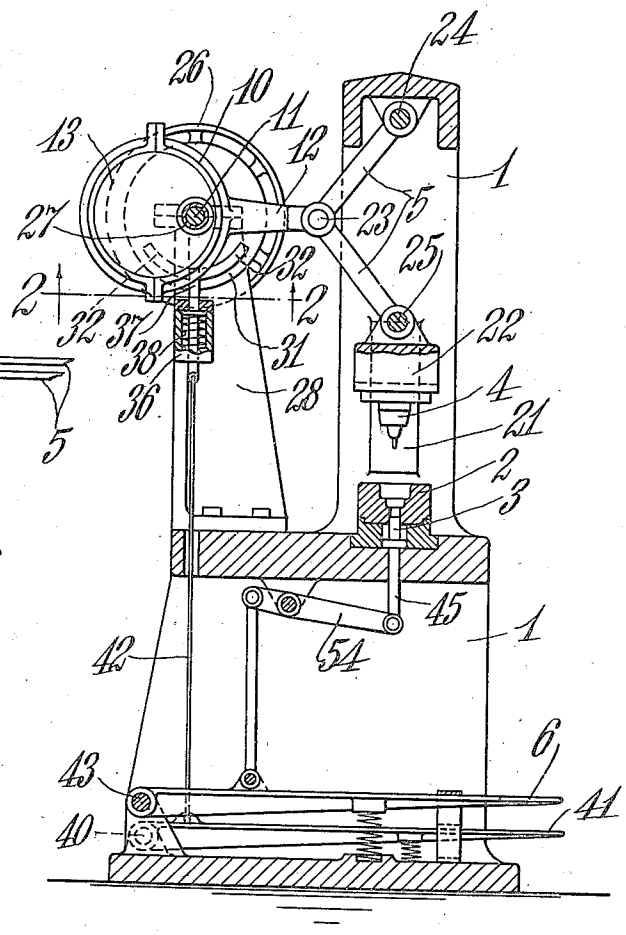
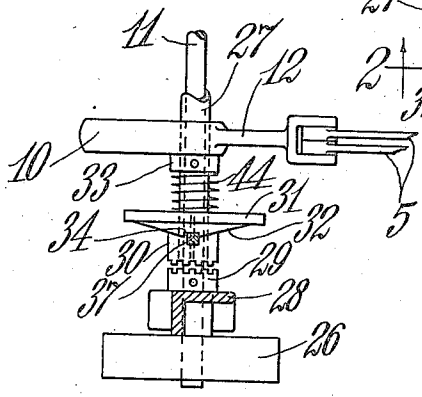



Fig. 2.




WITNESS

H. E. Hartwell

INVENTOR.

Albert W. Morris.

BY Chapin & Neal.

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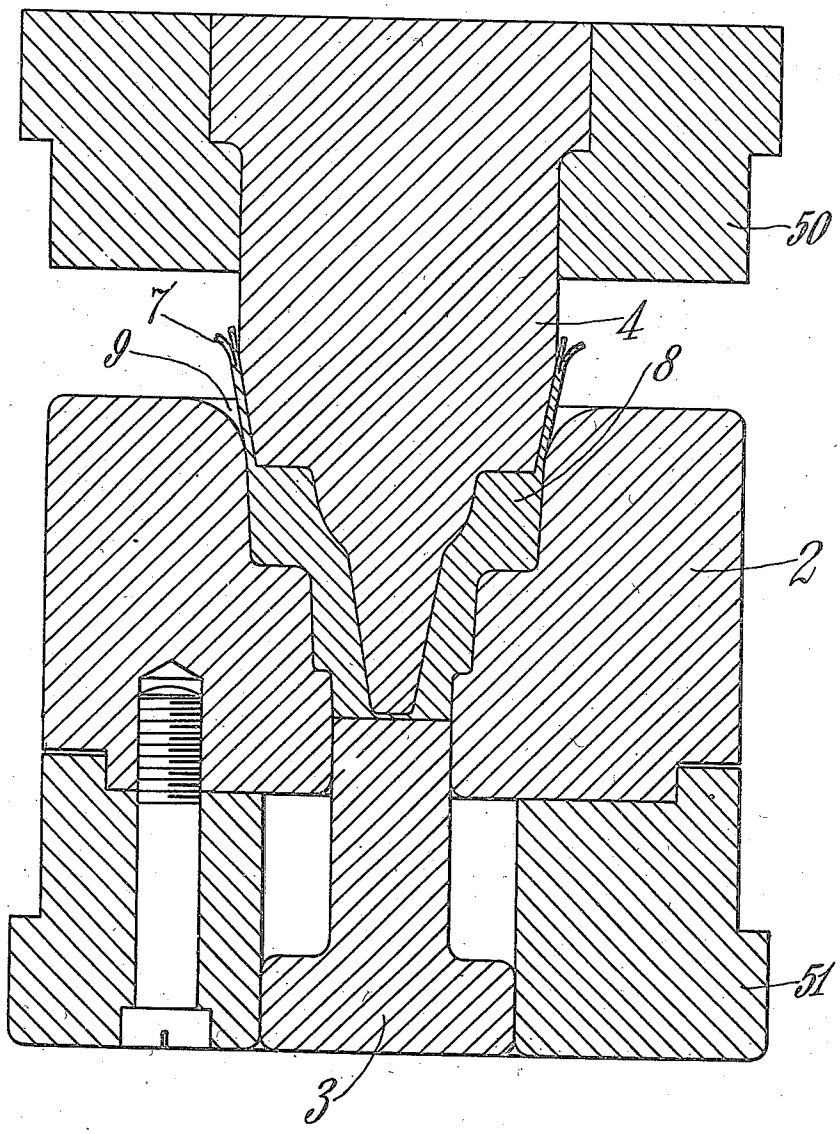
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Fig. 3.




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## FORGED CASTING AND METHOD OF MAKING THE SAME.

1,222,786. Specification of Letters Patent. Patented Apr. 17, 1917.

Application filed October 9, 1916. Serial No. 124,526.

*To all whom it may concern:*

Be it known that I, ALBERT W. MORRIS, a citizen of the United States of America, residing in Springfield, in the county of Hampden and State of Massachusetts, have invented certain new and useful Forged Castings and Methods of Making the Same, of which the following is a specification.

This invention relates to a new article of tenacious or toughened metal to be called a forged casting and to the method of making the same. The invention is particularly directed toward that class of commercially important metals such, for example, as cast iron, certain nickel alloys, alloys in which the aluminum influence predominates, copper alloys, brass, and the like which are characterized by their normal resistance to forging under the known and commercially practical methods heretofore in use. This class of metals is generally called non-malleable metals. In addition to the great importance of forging metals of the particular class defined, there are certain advantages in the method which are important in the art of metal working independently of the class of metals treated, all of which will be herein described.

Referring to the accompanying drawings—

Figure 1 illustrates the operable parts of a machine by which the method may be carried out to advantage.

Fig. 2 is a detail sectional view taken on line 2—2 of Fig. 1 of the power shaft and associated driving mechanism for operating the machine.

Fig. 3 shows in section the die parts chosen for illustrative purposes which may be mounted in the machine. The forged casting is shown in this figure as made under the forging blow.

The frame of the machine 1 has guide blocks 21 on the inner face of each of two spaced vertical standards. The ram carrying member 22 is mounted to slide up and down in the guide blocks. A toggle mechanism is provided to operate member 22 on the slides 21. This mechanism consists of two links 5 one pivoted to the upper cross piece of the frame at 24 and the other pivoted to member 22 at 25. The adjacent ends of the links are pivoted together at 23.

The machine is driven from a pulley or driving gear 26 keyed to power shaft 11. The latter is mounted to rotate in suitable bearings in the bracket 28 supported from the frame 1. Fixed to the power shaft is a clutch member 29 (Fig. 2) and loosely mounted on the shaft is a sleeve 27. A companion clutch member 30 integral with a disk 31 is splined to sleeve 27 to move into and out of engagement with clutch member 29. A coiled spring bears against collar 33 (pinned to sleeve 27) and the face of disk 31. A disk 13 is fixed eccentrically on sleeve 27 to rotate therewith. An eccentric strap 10 embraces the disk and has a fork member 12 pivoted to the adjacent ends of links 5. An arcuate cam 32 having the broad V form shown in Fig. 2 is mounted on the face of disk 31. At the apex of this cam a shallow slot provides two shoulders arranged at right angles to the direction of rotation of the shaft. A square rod 37 mounted for vertical movement in guide box 36 is spring pressed upwardly into normal engagement with the face of cam 32. The spring 38 in box 36 carried by bracket 28 bears against the bottom of the box and a collar on the rod 37 to press the latter upwardly at all times. The rod is limited to vertical movement, as its opening through box 36 is just sufficient to receive the rod.

A foot lever 41 pivoted to the frame 1 at 40 is connected to rod 37 by link 42. When the operator desires to have the machine pass through a complete cycle of operations he presses foot lever 41 and immediately releases the lever so that it will return to normal position as shown. The operations then take place as follows: Rod 37 is pulled out of cam slot 34, spring 44 snaps clutch members 30 and 29 into engagement, sleeve 27 rotates with shaft 11, the eccentric strap 10 is moved back and forth and its connection with links 5 operate this toggle mechanism to move the ram carrying member down with decreasing speed and increasing force. When the foot lever 41 is released, rod 37 is pressed toward its normal position so that as disk 31 rotates, cam 32 bears against rod 37 and cams the clutch member 30 out of engagement with member 29. The shallow slot 34 is designed to receive stop rod 37 just as the clutch members are disengaged and hold the disk 31 against further movement.

The die parts 2 and 4 are mounted in the machine in any suitable manner. As shown the ram 4 is rigidly held in position by shoulders in the face block 50. The latter is then slid transversely in suitable ways in the lower part of the solid ram carrying

member 22 so that the latter backs up the upper face of ram 4. The die member 2 is bolted to block 51 received in a suitable bed of frame 1. The ejector 3 is slidably mounted in a recess in block 51 and forms the "kicker" member of die part 2. The spring pressed foot lever 6 pivoted at 43 is pressed down to rock lever 54 which lifts rod 45 and the ejector 3.

With the mechanism as shown, I carry out my method as follows: I place liquid metal in the anvil or die part 2, somewhat in excess of that needed for the finished piece 8. The liquid cools with the assistance of the metal parts 2 and 3 until it reaches approximately its normal freezing temperature. At this time a critical stage is reached which I may call a critical time, temperature, or condition. In this critical condition the metal will normally change from a liquid to a solid and in so doing does not theoretically change its temperature. At some period during this change from liquid to solid, I have found that there is a malleable condition of the commonly called non-malleable metals. If I apply the ram quickly enough and at the proper period, the metal is caught in the malleable condition. Therefore, when the metal is practically changing from a liquid to a solid or the metal is in what may be called a nascent condition, I trip the cam operating means described of the toggle 5. The eccentric cam makes one complete revolution and moves the ram 4 from the position shown in Fig. 1 to that shown in Fig. 3 and back to that shown in Fig. 1. In this cycle of operations, all the nascent metal except the flash 7 is subjected to concussion and great pressure due to the measured forging blow delivered by the ram 4. The crystals, fibers, or granular particles of the metal at their birth are packed and shrunk into closely locked and intertwisted relation due to the concussion and great pressure thereon as the blow is received. The metal struck by the blow has been confined except for the limited and restricted annular opening 9 between the ram 4 and die part 2. The blow delivered preferably has, as indicated in Fig. 1 by the cam operated toggle mechanism, the following characteristics; the speed is greatest and the force is least as the ram first enters the metal; the speed gradually decreases and the force increases until the ram reaches the limit of its travel; up to this time the force of the blow is unrelaxed. The great pressure delivered throughout the mass of the metal is due to an unrelaxed percussive forging blow from the time the ram enters the metal until it has traveled a measured distance into the metal.

The particular characteristics of the blow which I consider essential are the characteristics which I have termed unrelaxed and percussive while the other characteristics, the variation of the speed and force, are desirable but not essential.

By an unrelaxed blow I mean that kind of a blow which is percussive and transmits the shock of collision through a given distance without yielding to resistance. By the use of the words percussive and collision I distinguish from an application of the ram to the metal such as used in ordinary die drawing operations in which the punch die is pressed slowly into the metal to avoid a shock. To subject the metal to concussion a blow is necessary. It is only necessary to deliver this blow sharply enough for the shock to penetrate the mass of the metal. Such a blow is evidenced by the flash or extrusion of excess metal which necessarily appears on my forged casting but which does not necessarily appear in die drawing operations. The speed I use in applying the ram to the metal as compared to a die drawing operation is fast. As compared to a drop forging operation it is slow. It is thus between the speeds used in die drawing and drop forging operations as far as any general comparison can be made. My method as compared in results to drop forging has the advantage that the non-malleable metals may be forged and both malleable and non-malleable metals are greatly improved throughout their structure. As compared to die drawing operations my method has the advantage of fixing the metallurgical structure in improved form from its birth instead of pushing the metal into shape without the benefit of the forging blow to toughen it.

When the blow is delivered the metal is confined except for the restricted opening to permit the excess to run into a flash 7. This opening permits a slight yield in the metal in the nature of a safety outlet, permits the metal to mix at the critical time just before it sets, and allows the dross and other impurities to be driven into the flash. The relative position of a restricted opening for the flash as well as the design of the die part 2 and ram 4 may, of course, be varied widely without departing from the invention.

After the forging blow has been delivered, the ram is preferably withdrawn without any appreciable dwell. The force applied to the metal, therefore, is due to an unrelaxed percussive forging blow. The characteristics of the blow as described are important for the best results. The ram, if operated quickly enough to put the unrelaxed percussive blow on the mass of the metal at the critical time, forge it as desired, and get out again, will do satisfactory work.

With regard to the force delivered by the blow, I wish to point out that very great force is used. For example, the piece 8, shown in Fig. 3 at approximately full size, has been subjected in the making to a force

of four hundred tons with good results. In this particular example, the cam shaft rotates at a speed of 32 revolutions a minute so that the unrelaxed force is applied in approximately one second. This is the tim measured from the entrance of the ram to the end of the stroke during which time the force of the blow is unrelaxed, and the forming crystals are being packed, intertwisted and set, throughout the mass of the metal Delivered at the critical time the blow prevents the formation of coarse structure and weak streaks for such structure cannot form under the forging blow. Without any appreciable dwell the ram is entirely withdrawn so that the forged casting may be ejected from the die within about three seconds from the time the metal was liquid and began to set.

The example given is, of course, applicable to specific conditions. I wish to make it clear, however, that the placing of the liquid metal in the die, the application of the unrelaxed forging blow, and the ejection of the forged casting from the die takes only a few seconds. The die and the ram may be made of steel to advantage. The metal, when poured, will then be quickly cooled to the desired point. The cooling may be assisted by a blast of air on the surface. It is an advantage after placing the metal in the die to have it cool rapidly to the freezing temperature as this improves the metallurgical qualities of the finished piece. Between operations, the dies may be cooled by a blast of air and oiled. The steps of the method described herein are carried out quickly and in this respect the method is more closely analogous to a drop forging method or blow than to the slower pressure casting or die drawing methods.

I have found that metals characterized by their normal resistance to forging and more particularly to a forging blow because brittle, are all distinctly malleable at some time when passing through the change from a liquid to a solid state. It is difficult to apply the forging force to this class of metals when in a malleable and critical condition because the time of this condition is so short. It is customary in working non-malleable metals to avoid subjecting them to any considerable shock such as a forging blow. My method of treating such metals is radically different for I subject them to a distinct shock but at a critical time when the shock will not fracture the metal but toughen it. I desire to improve the metal treated in its qualities of toughness, tenacity, density, impermeability, and homogeneity, so that a new article of manufacture is produced. The liquid metal, as it cools toward the freezing point, approaches the stage of crystalline, granular, or fibrous formation. There is a critical or "nascent" condition when the metal should be hit to produce the desired results in the birth of the crystals or other structure. This critical condition may be considered as a time element with reference to the time of crystalline or fibrous formation. It may be considered as a temperature point at which the metal reaches its nascent condition when being cooled and is theoretically the freezing temperature. The condition varies with different metals and under different conditions, but the time to apply the ram may be readily determined by one ordinarily skilled in metal working for a given metal under given conditions by proceeding as I describe herein.

It is a known fact that the freezing temperature point of a substance ordinarily varies with the pressure. In the case of a metal which contracts on freezing, the freezing temperature point is raised by pressure. This variation is slight and is generally negligible. The enormous force which I apply in the application of my method, however, I believe materially raises the freezing temperature point of the metal. I make use of this fact to advantage by applying the force of the blow to the metal before it has set so that it will be frozen or set under the force of the unrelaxed blow. As a practical matter, there is a slight range of time in which the force or blow may be applied. The metal starts to freeze at the freezing temperature (determined by a pyrometer or by change in color known by metal workers) and proceeds progressively from the cooler outer surfaces toward the center of the mass. The more refractory the metal, the less time is taken for freezing. During this time of crystalline or other structural formation, the metal is malleable. The time to strike the blow is when the metal is just about to set and before it has had time to pass beyond the loose structural condition in which the concussion can catch and set it for my purpose. The concussion and the enormous pressure which I apply simultaneously to the metal at this time breaks up the nascent structural formation and welds all the metal into one tenacious mass. I believe that the partially frozen metal is remelted or entirely reformed and set on account of the mechanical mixing of all its parts under the concussion and pressure of the blow. This remelting or reforming is practically instantaneous and at a temperature which, because of the concussion and the enormous pressure applied results in quick freezing.

I have found that the enormous pressure on the metal due to the blow when applied at about the freezing temperature will cause the metal to freeze more quickly than it otherwise would. The cooling effect of the dies made of heat conducting walls also effect a quick freezing. These factors cause the critical condition of the metal to occur at

the time the metal is subjected to simultaneous pressure and concussion due to the forging blow. Thus if the ram is applied within limits of time which may be recognized by those skilled in the art and which I describe and term as about the freezing temperature, the beneficial results of my invention will be attained. It is necessary to apply the ram quickly enough and with enough force to transmute the metal to a forged casting throughout its mass and to cause the metallurgical structure of the metal tc be born under the unrelaxed force of the blow. If the ram is applied after the metal has set to any material extent the metal if malleable, will not be forged throughout its mass and if non-malleable the metal or dies will be fractured. If the ram is applied slowly, as in a die drawing operation, even though applied at or about the freezing temperature, the metal will be pushed about and arranged in accordance with the dies, but the shock to set and fix the metallurgical structure will not be obtained and the metal will not be toughened and improved throughout its mass according to the object of my invention.

My understanding of the theory on which I work the method, has been of considerable advantage to me in determining the best mode of operation in actual practice. It is, therefore, of considerable importance in disclosing the invention itself because of the necessarily varying conditions under which different metals have to be worked.

In making a forged casting of cast iron or metals of similar characteristics, it is desirable for the ram to get to the metal quickly, deliver the unrelaxed forging blow to work the metal, and retire quickly. The forged casting made is immediately ejected by the part 3 and cooled slowly. If this method be followed, the cooling metal will not have time to shrink on the ram, and the slow cooling will allow the shell to be reheated by the metal of higher temperature in the interior of the forged casting. The latter, as soon as it leaves the cooling contact of the good conducting surfaces of die 2 and ram 4, will come to an even heat and then, will go through a self annealing process. The quick forging of the metal starting with a liquid and then the rapid ejection of the piece from the die is in the case of cast iron and the like of very great importance where a chilled casting is not desired. The finished piece made as described is machinable. The improvement in the quality of cast iron worked under my method makes it suitable for many uses in the arts not heretofore practical.

In order that the known results of using my invention may be definitely appreciated, I shall describe its specific application to a given metal and compare its advantages over the ordinary casting method. A commercially important brass metal is an alloy of 58.6 copper and 40.5 zinc and the remaining 0.9 usually impurities. This is commonly called Munz metal. The best results known commercially in casting this metal are obtained by casting it at a temperature of 973 degrees cent. The casting temperature is known to be important because, if too high or too low, the casting does not test as well as if poured at a fair temperature found as well known by those skilled in the art. This casting temperature is further defined as the one at which the metal may be poured to properly fill the mold and start to set without any substantial delay. The brass cast as stated will test approximately 18.88 maximum stress tons per square inch and 15 per cent. elongation in 2 inches. By filling the female die part 2 with the same metal at substantially 1000 degrees cent. and watching the appearance of the metal until it changes color so that it looks muddy (a change understood by the skilled man in the art as indicating the freezing temperature) or until a pyrometer shows approximately 973 degrees cent. and then applying the ram as described, the desired forged casting will result. This metal is believed now to actually have a different molecular structure for, as evidence, it tests between 25 and 33 maximum stress tons per square inch and 40 to 60 per cent. elongation in 2 inches. It is this remarkable increase in advantageous qualities which leads me to believe I have produced a new article of manufacture as well as a method.

The almost infinite number of alloys which may be commercially important makes it clear that the invention is applicable to a class of metals as described and to any metals with which in practice it is found to work with the advantages contemplated. For example, an alloy in which the aluminum influence predominates will be made impermeable to gases, of great toughness and strength, and suitable for many uses not heretofore practical so far as I am aware for such an alloy. Without regard to the particular class of metals used, there are certain advantages in my method of making forged castings, starting from liquid metal which I desire to claim as incidental to the main purpose of the invention. It is to be understood that the latter is directed to a particular class of metals and the improvement in the qualities of that class of metals which greatly extends their commercial importance in that they may be substituted for more expensive metals heretofore thought necessary for use under fixed specifications.

What I claim as new in my method is the treatment of non-malleable metal, at the setting point, subjecting it to simultaneous

pressure and concussion due to the unrelaxed forging blow. The improved characteristics produced in the non-malleable metal are those not hitherto possessed or attributed to non-malleable metals as compared to malleable metal such as tenacity, hardness, density, tensile strength, freedom from impurities, and improved metallurgical structure. I claim also the same treatment of malleable metal which greatly increases those characteristics throughout the mass of the metal, hitherto imparted to such metal for a limited depth only by the ordinary drop forging operation.

In toughening metal by pressure casting, expensive and cumbersome apparatus is necessary to obtain the large degree of desirable pressure. It is necessary to wholly confine the metal in the die if any considerable degree of pressure is applied. The pressure is not applied equally in all directions for the metal cannot transmit the pressure uniformly, and there are frequently weak streaks in the metal as a result. In toughening metal, when malleable, by drop forging, the forging blow does not, as a rule, penetrate as far as desired so that only the shell to a given depth is toughened. In any event, the ordinary forging method acts on the crystals or fibers after they are formed in the metal. Furthermore, there are some metals, as cast iron, certain nickel alloys, aluminum alloys, and copper alloys, for example, which are classed as non-malleable metals but which are actually forged while in malleable condition at a critical time by the use of my invention.

The scope of the invention is particularly pointed out in the appended claims.

What I claim is—

1. The method of making a forged casting which consists in placing the liquid metal in partial confinement, rapidly cooling it until it is at or about its freezing temperature and then striking it a measured and unrelaxed forging blow with a suitable ram to increase its partial confinement and drive the impurities of the metal into a fin or flash, whereby the metallurgical structure of the metal is fixed under the blow.

2. The method of making a forged casting which consists in placing the liquid metal under partial confinement in a female die, rapidly cooling it until it is at or about its freezing temperature and then striking it a measured and unrelaxed forging blow with a suitable ram to confine the metal except for a restricted opening for an extrusion whereby the metallurgical structure of the metal is fixed throughout its mass by the unrelaxed blow.

3. The method of making a machinable forged casting of cast iron and the like which consists in placing liquid metal in a female die part, permitting it to cool, and subjecting it to a measured and unrelaxed forging blow by a ram quickly applied at or about its freezing temperature, whereby the metal is confined except for a restricted opening for an extrusion, and then quickly withdrawn, then permitting the resultant piece to cool slowly at a heat substantially uniform throughout its mass.

4. The method of making a forged casting of cast iron and the like which consists in placing the liquid metal in a female die part, permitting it to cool rapidly to a point at or about its freezing temperature, then subjecting it to a measured and unrelaxed forging blow quickly applied by a male die part adapted to permit an extrusion of excess metal into a fin or flash and removing the resultant piece immediately after the blow is delivered.

5. The method of making a forged casting of a metal characterized by its normal resistance to forging as cast iron, aluminum alloys, and the like, which consists in placing the liquid metal in the female part of a die, permitting the temperature to fall toward the freezing point and forcing the ram or other part of the die against the metal by a quick blow at or about the temperature point when the metal will freeze before the force of the blow is relaxed.

6. The method of making forged castings of metal characterized by its normal resistance to forging, which consists in placing the fluid metal in a female die, permitting the temperature to fall toward the freezing point, and suddenly forcing a ram or other part of the die against the metal at a time when the extra cooling effect of the additional die part will cause the metal to freeze while the force is applied thereto.

7. A method of making a forged casting of a metal characterized by its normal resistance to forging which consists in placing liquid metal in a female die and then applying the forging blow by means of a ram or male die part at a time when the metal is just about to crystallize so that the crystals may form before the pressure of the forging blow is relaxed.

8. The method of making forged castings of a metal characterized by its normal resistance to forging which consists in placing an excess amount of liquid metal in a female die part, then applying the forging blow to force a ram or male die part into the metal at a time when the latter is just about to crystallize so that the excess metal will take the form of an extrusion, the metal will be mixed just before it crystallizes, and the crystals may form before the pressure of the forging blow is relaxed.

9. The method of making forged castings which consists in placing excess liquid metal in the female die part, permitting it to fall in temperature, then applying a forging

blow to the metal at a time when its crystals are just about to set and providing at least one limited opening for the excess metal to extrude as the forging blow is applied whereby the metal is mixed throughout its mass and the crystals are set under the force applied.

10. The method of making forged castings which consists in placing liquid metal in partial confinement, permitting it to cool until it is at or about its freezing temperature and then striking it a measured and unrelaxed forging blow to increase its partial confinement and rush the metal through the change from a liquid to a solid under the force of the blow.

11. The method of making a forged casting which consists in placing the liquid metal in partial confinement, letting it cool until it is at or about its freezing temperature and then striking it a measured and unrelaxed forging blow with a suitable ram to increase its partial confinement and controlling the ram so that as it enters the metal its speed is maximum and gradually decreases while the force applied is at a minimum and gradually increases throughout the distance traveled by the ram in applying the blow to the metal.

12. The method of making forged castings which consists in placing molten metal in an open female forge member, applying pressure and concussion to said metal by a male forge member at the time of the setting point of said metal.

13. The method of making forged castings of metal characterized by its normal resistance to forging which consists in placing molten metal in an open female forge member, applying pressure and concussion to said metal by a male forge member at the time of the setting point of said metal.

14. The method of making forged castings which consists in placing molten metal in an open female forge member, applying great pressure and concussion simultaneously to said metal by a male forge member at the time of the setting point of said metal.

15. The method of making forged castings which consists in placing molten metal in an open female forge member, applying pressure and concussion to said metal by a male forge member at the time of the setting point of said metal and providing a restricted exit between the forge members for excess metal to extrude.

16. As a new article of manufacture, a forged casting having improved toughness and strength and made of metal characterized by its normal resistance to forging, comprising a metal in which all the crystals retain the closely locked and interwoven relation in which they have been packed and shrunk by the unrelaxed force of a forging blow applied to toughen the metal at the time when the crystals set.

17. As a new article of manufacture, a forged casting having improved toughness and strength, comprising a metal in which all the crystals retain the closely locked and interwoven relation in which they have been packed and shrunk by the unrelaxed force of a forging blow applied to toughen the metal at the time when the crystals set.

18. As a new article of manufacure, a forged metallic casting formed by pressure and percussion applied to the metal at the time the latter is at the setting point.

19. As a new article of manufacture, a forged casting composed of a metal characterized by its normal resistance to forging, the metallurgical structure of which has been fixed under an unrelaxed forging blow applied to the metal at the time the latter is at the setting point.

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