

Dec. 30, 1952

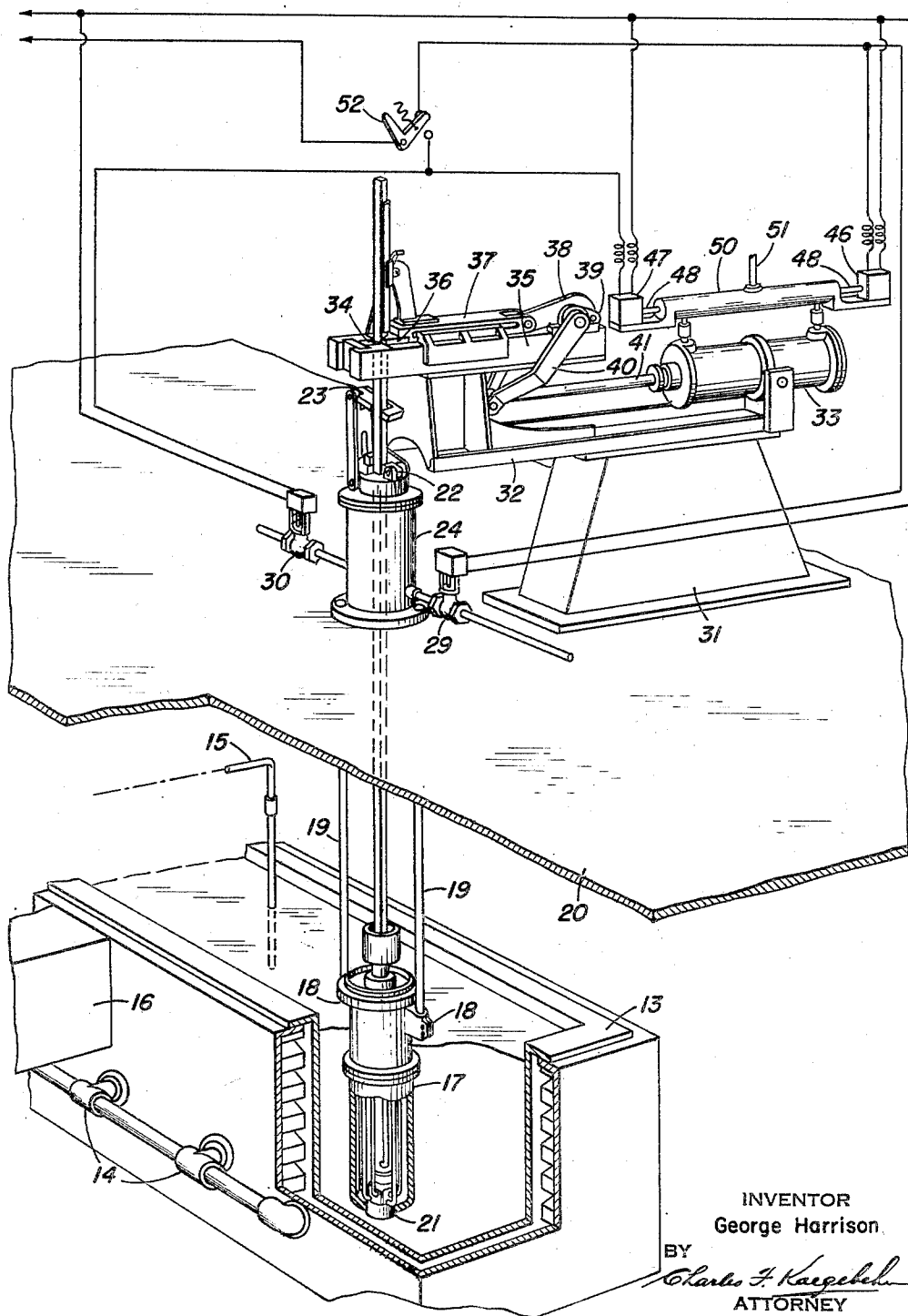
G. HARRISON
ROD CASTING DEVICE

2,623,253

Filed Oct. 27, 1948

4 Sheets-Sheet 1

Fig. 1.



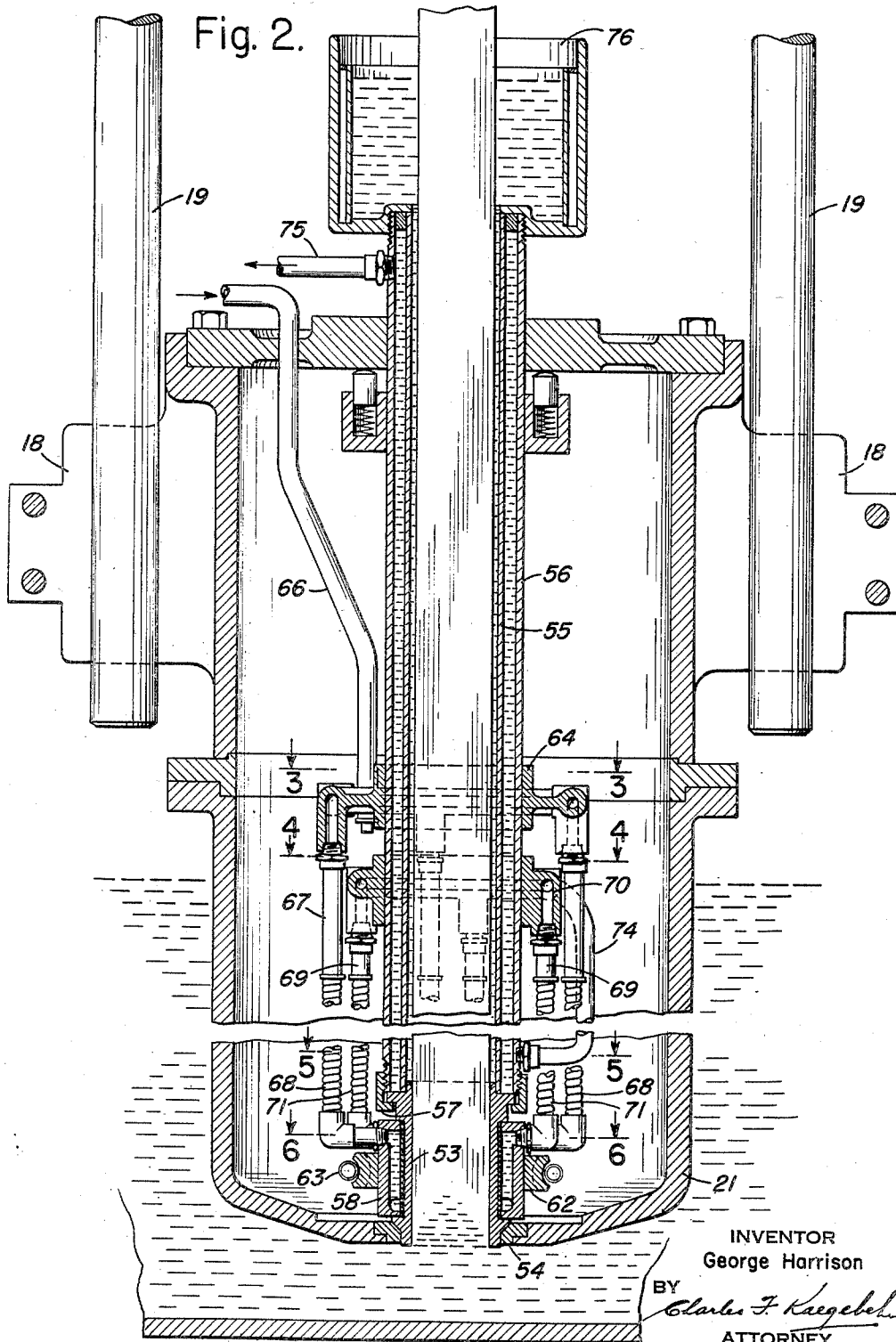
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Fig. 3.

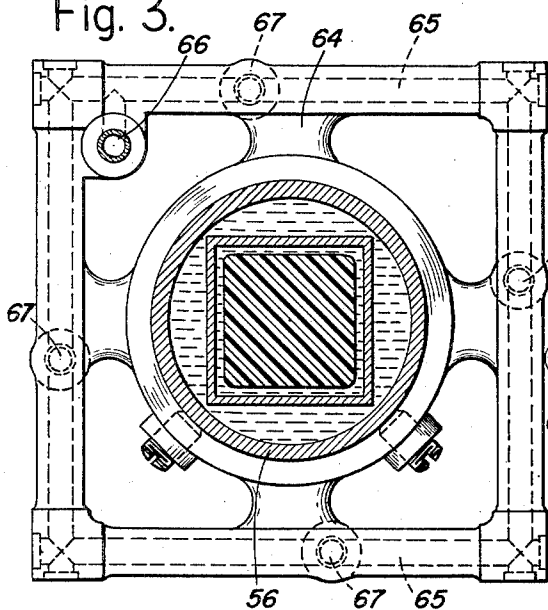


Fig. 4.

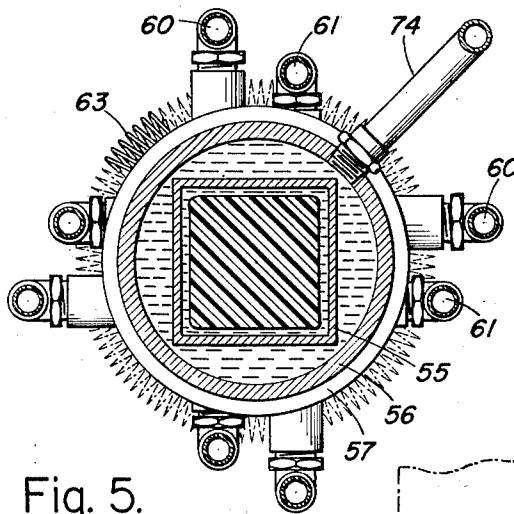
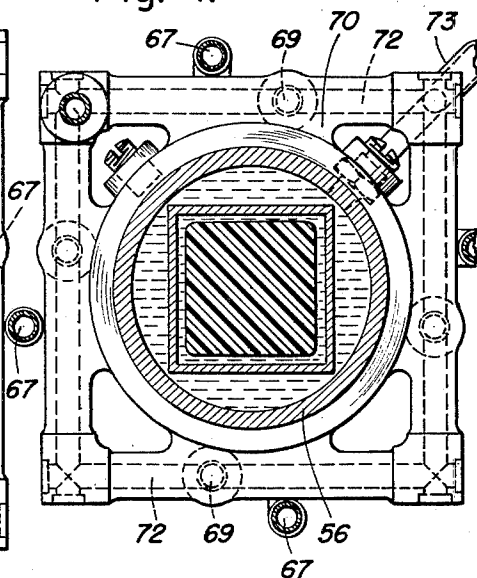


Fig. 5.

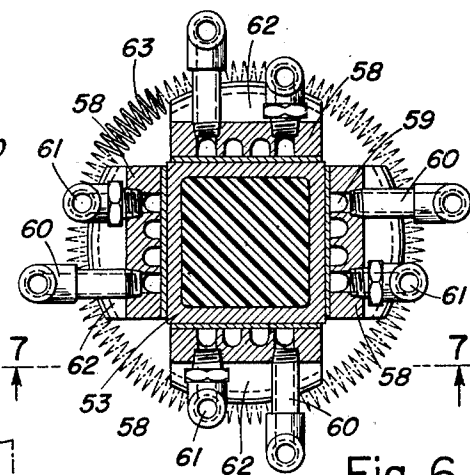


Fig. 6.

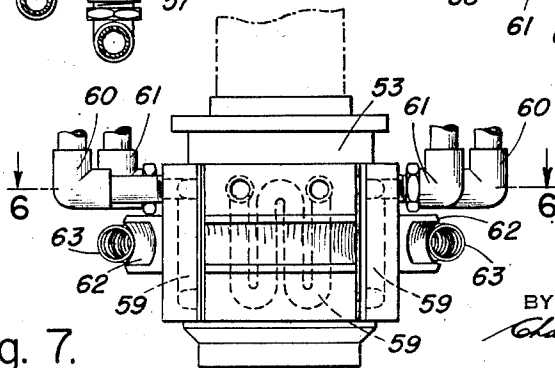


Fig. 7.

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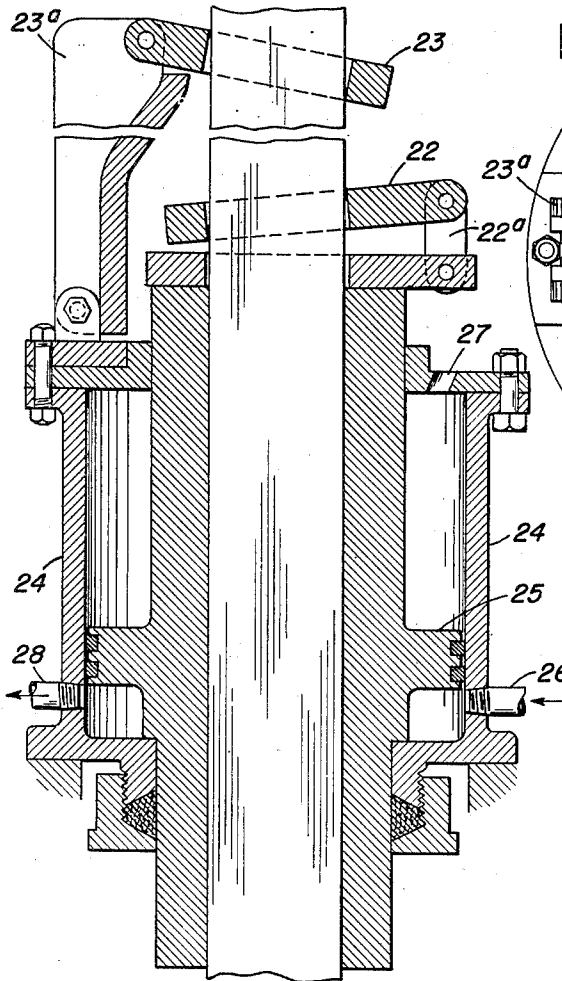


Fig. 8.

Fig. 9.

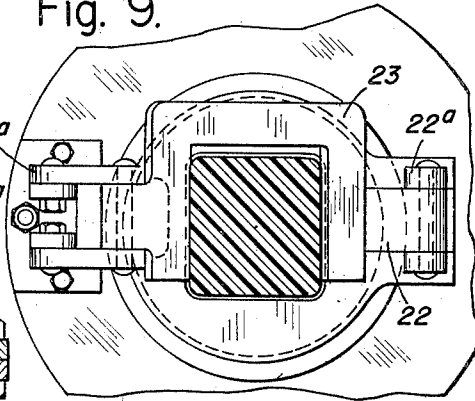


Fig. 11.

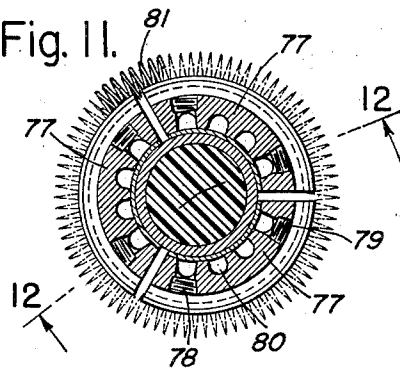


Fig. 12.

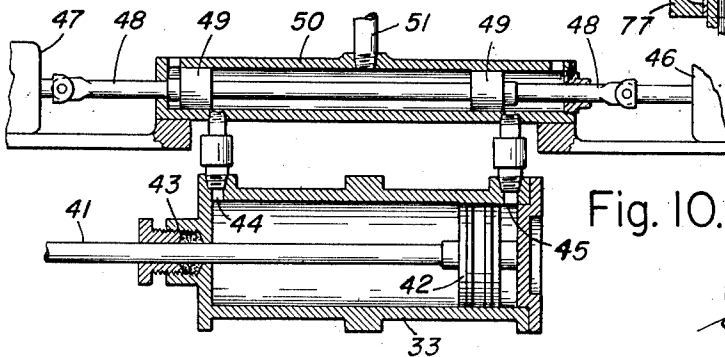
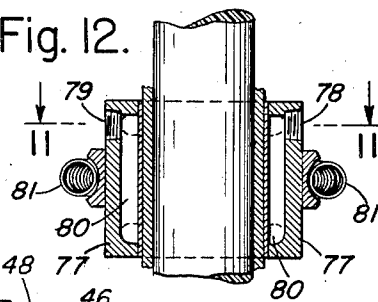


Fig. 10.

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2,623,253

ROD CASTING DEVICE

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Application October 27, 1948, Serial No. 56,864

2 Claims. (Cl. 22—57.2)

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This invention is a machine and method for continuously casting metal rods including within this term tubular and other sectional shapes, the general object being the obtainment of rods of continuously homogeneous texture at lower cost than currently possible by other methods. It is herein described as employed for casting zinc base alloys but the principles involved are applicable to all metals or substances of which the conditions at the cast temperature are not harmful to the casting mechanism, as will presently be seen.

In the accompanying drawings:

Fig. 1 is a broken out, somewhat condensed perspective view of a rod casting machine incorporating the invention.

Fig. 2 is an enlarged axial section of the casting die and related mechanism.

Fig. 3 is a section of Fig. 2 taken along the lines 3—3.

Fig. 4 is a section of Fig. 2 taken on the lines 4—4.

Fig. 5 is a section of Fig. 2 taken along the line 5—5.

Fig. 6 is a section of Fig. 2 taken along the line 6—6.

Fig. 7 is an elevation of the die shown in the sectional view Fig. 6.

Fig. 8 is an axial section of the rod guiding and withdrawing mechanism.

Fig. 9 is a plan detail view of the elevating dog.

Fig. 10 is a sectional view of the piston control for operating the rod cut-off device.

Fig. 11 illustrates a plan view of an alternative embodiment of the die shown in Figs. 6 and 7.

Fig. 12 is a sectional view of the die shown in Fig. 11.

The metal stock to be formed into rod is held as a molten bath in a receptacle or kettle 13 heated by flues and burners indicated at 14 and equipped with a heat regulating system adapted to hold the bath at a constant temperature. The regulating system may be organized according to known principles and is represented in Fig. 1 simply by the thermostat 15 dipping into the bath. This will be understood to be appropriately connected in governing relation to the fuel system, and to be of such type as to hold the temperature steady with little variation, preferably not more than 5 degrees plus or minus, a constant temperature being important. The bath is desirably maintained at not more than a few degrees, say 10°, above the melting point of the metal, the amount above the melting point being referred to as the superheat.

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Fresh metal is added to the bath as it is used up and at a rate equal to its consumption, so that the bath level is held substantially constant as suggested by the dash line in Fig. 2. Metal feeders suitable for holding constant levels are known and such a feeder will be understood to be represented by the part marked 16 in Fig. 1, and to be automatic in its action.

The parts specifically concerned with the conversion of the molten metal into rod are enclosed in a pot or well 17 so operated that it dips more or less into the metal in the kettle to receive the molten material from a point removed from the side walls as well as from the bottom of the kettle where the temperature is least subject to fluctuation, and the metal is free from contact with surface drosses. For this purpose the pot is supported by guide ears 18 on two vertical frames 19 which are rigidly secured to and depend from an upper deck 20 fixed in position over the metal at a suitable distance above it. The bars 19 are arranged so that the pot may be raised on them clear of the metal when that is desired. For normal use, the pot is lowered until its bottom 21 is close to the kettle bottom but it may be held at any depth of immersion according to conditions and by an equivalent mechanical structure.

The deck supports the mechanism for intermittently withdrawing or removing the rod as produced by the casting agency in the pot. This mechanism comprises a pair of dogs 22 and 23. Dog 22 is hingedly attached to link 22a which is hingedly mounted on the top of an extended central portion of piston 25 and is adapted to grip and elevate the rod at intervals. Dog 23 is hingedly attached through support arm 23a to the frame of cylinder 24 and holds the bar in position when the dog 22 is being lowered on the cast bar. This mechanism is operated as is shown in detail in Fig. 8 and comprises a cylinder 24 in which is placed piston 25 to which is suitably attached the dog 22. Compressed air entering inlet 26 acts to force piston 25 upwards, the air exhausting through the bleed hole 27, which in turn causes dog 22 to grip and raise the cast rod the length of the piston stroke. The air then present in the cylinder is exhausted through opening 28 and the dog and piston fall by gravity to their original position with the piston near the bottom of the cylinder. If desired suitable connections may be arranged to supply compressed air to the top of piston 25 to force this member downward at appropriate intervals in the event more positive action is neces-

sary. While the piston and dog 22 are lowering, the cast bar is held in place by the action of dog 23, which automatically grips it and prevents it sliding back down with the piston and dog 22. Air passage through the apertures 26 and 28 is controlled electrically by corresponding solenoid valves 29 and 30, which are combined in an electrical circuit which includes control of the mechanism for severing or cutting off sections of the cast rod as hereinafter described in more detail.

Also mounted on the upper deck 20 is the mechanism for severing sections of the cast rod which in the embodiment shown comprises a shearing device generally mounted on frame 31. Attached to an upper portion of this frame 31 is sub-frame 32 which carries at one end the elevated cutting off blades and at the other, the operating air cylinder 33. The shearing blades comprise stationary blade 34 which is mounted at or near the extremity of a suitable horizontal elongated bed 35 and a movable blade 36 which is slidably arranged on bed 35. Movable blade 36 is mounted at the extremity of sliding member 37 which is in turn connected by suitable lever 38, crank 39 and lever 40 to the extending piston rod 41 which is attached to piston 42 riding in cylinder 33. Control of the movement of the movable blade 36 to shear off sections of the cast rod is obtained by a piston controlling mechanism shown in detail in Fig. 10. The piston 42 is enclosed in cylinder 33 equipped with packing gland 43. In opposite ends of the cylinder sidewalls are apertures 44 and 45 through which compressed air may be admitted to force the piston to one end or the other of the cylinder and thus move the movable blade 36 away from or towards the cast rod. Electric control of the air entering this piston mechanism is obtained by an assembly which consists of solenoids 46 and 47 which are connected by bar or rod 48 having two pistons 49 riding in upper cylinder 50. Compressed air inlet 51 admits compressed air to the upper piston chamber from which it may flow to either side of the actuating piston 42, depending on the position of the upper pistons 49 with respect to apertures 44 and 45 as is evident. Actuation of the solenoids 46 and 47 is electrically integrated with the action of solenoid valves 29 and 30 which control the rod lifting mechanism.

Placed directly above the rod withdrawing mechanism is limit switch 52. This switch is disposed in axial alignment with the cast rod as it emerges from the casting, withdrawal and shearing mechanism, and is spaced above the shearing blades 34 and 36, a suitable distance governed by the desired length of rod sections to be produced. Cast rod is delivered upwardly by the withdrawing mechanism, as hereinbefore described, and passes through the shearing blades until the uppermost extremity of the rod strikes limit switch 52. Actuation of this switch by the extremity of the rod closes the electrical circuit connected to solenoid switch 47, which allows compressed air to enter cylinder 33, through aperture 44, resulting in actuation of movable blade 36 which shears off the rod section. During the time interval before the rod is progressing upwardly to the extent that it strikes limit switch 52, the circuit connected with solenoid 46 is closed resulting in air pressure maintaining the movable blade 36 and its actuating mechanism substantially in the position shown in Fig. 1, where the rod passes freely by stationary blade 34. Thus the electrical

control results in production of rod sections of predetermined, uniform length.

The operation and coordination of the electrical units will be apparent from the schematic wiring diagram shown as part of Fig. 1. It will be noted that the electrical controls for operating shearing blades and the mechanism for withdrawing the rod are inter-connected. Intermittent application of compressed air through port 26 to the rod withdrawal mechanism is obtained by a timing control device, not shown; and the electrically operated valve 29 is normally open to allow entrance of compressed air at predetermined intervals to cylinder 24, and subsequent bleeding out when the pressure is released. During these operations, valve 30 is normally closed to seal the cylinder chamber. Also during this period solenoid 46 is operating to maintain port 45 open, enabling compressed air to be supplied to that side of the control cylinder 50 which holds the movable blade 36 away from the cast bar. When the cast bar has progressed upwardly to the point where its extremity strikes limit switch 52, the circuit controlling solenoid 47 is actuated and current is shut off from the circuit controlling solenoid 46. This results in admission of compressed air through the port 44 in cylinder 33 in turn actuating the levers which move the blade 36 against the cast rod. At the same time, solenoid valve 30 is opened and solenoid 29 is closed. Operation of these two solenoid valves results in cutting off compressed air to cylinder 24 and opening the cylinder to the atmosphere so that no movement is imparted to the cast rod by the withdrawal mechanism during the time of operation of the shear blade 36. After the top section of the rod has been severed, limit switch 52 automatically returns to its original position; this results in actuation and reversal of the positions of solenoids 47 and 46 which allows compressed air to enter the other side of piston 42 which moves the shear blade 36 back to its original open position. At the same time, solenoids 29 and 30 are actuated to open port 26 and close port 28; thus, allowing intermittent application of compressed air to cylinder 24, as before described. Thus, by the interconnection of these controls, the shearing blade is automatically operated when a predetermined length of cast rod has been withdrawn. At the same time, through electrical interconnection with the solenoids which form part of the withdrawal apparatus electrical control, the cast bar is maintained stationary during the shearing operation.

The casting operation proper takes place as stated within the enclosure of the pot 21. Specifically the act occurs in a die tube 53 which, as shown in Fig. 2, is a tube with a head by which it is secured to the bottom of the pot by means of adapter ring 54. Immediately above the die and communicating therewith is guide tube 55 which is of slightly larger internal diameter and which is provided with water jacket 56. Guide tube 55 is connected to the upper part of the die tube by means of coupling ring 57. The die tube and preferably also the guide tube are made of very hard material of a kind not attacked or dissolved by the metal of the bath at the casting temperature and is smooth and polished on its inner surface which surface can also be hardened by nitriding or the like. A satisfactory material, for use with zinc-aluminum alloys, is one of the so-called hard steel alloys of the air-hardening class which is capable of resisting thermal shock and retains its hardness at red

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heat or high temperatures. The dimensions of the die tube are determined to a considerable extent by the size of the rod and the rate of production higher rates generally requiring longer die tubes. For $1\frac{3}{4}$ inch square rod, for example, it is practicable for the die to be about $3\frac{1}{4}$ inches long with a wall thickness in the jacketed portion of about .05 inch. It can be lined with graphite or ceramic material when that is necessary to resist attack by the particular molten metal. It may advantageously be slightly tapered, with the dimensions at the bottom of the order of 5 to 10 thousandths of an inch smaller than those at the top. The guide tube is slightly larger in inside diameter than the die tube so that a lubricant which also acts as a heat transfer medium may be fed through the space between the cast rod and the tube, as will presently be described.

Being located in the submerged bottom part of the pot, molten metal flows into the tube and longitudinally or upwardly therein by virtue of its hydrostatic head, which, under the conditions is maintained substantially constant. Metal enters the die at a rate equal to the rate at which the rod is withdrawn from the upper end of the guide tube by action of the gripping dogs and this rate must, of course, conform to or balance with the rate at which heat is removed from the die, so that metal passes through the die as fast as and no faster than it solidifies or freezes therein. For casting zinc-base alloy (such as Zn 96%, Al 4%, with some Mg), a lift of about 2 inches, at the rate of about 12 lifts or strokes per minute has yielded excellent results for long runs ($1\frac{3}{4}$ inch square rod), but both lift and interval are subject to variation according to conditions, so long as the progress through the die conforms to the rate at which the heat is removed.

Transfer of heat from the die occurs partly in the lateral sense, that is, through the die tube wall to a surrounding cooling medium within the pot, which includes a water jacket on the tube as presently described, and partly in the longitudinal sense through the conducting path provided by the rod itself which extends to a cooled or cooler region above. The quantity of heat to be thus removed is the latent heat of the metal plus its superheat, being therefore different for different metals and different sizes of rod. By virtue of the location of the cooling agencies within the pot their operation is away from the influence of atmospheric conditions, the space inside the pot being otherwise automatically maintained at constant temperature by reason of its immersion in the constant temperature metal bath. Thus, regulation of the cooling effect is exceptionally positive and the balance referred to having been once established is easily maintained for long periods.

One of the unique features of this invention is the design of the cooling jacket assembly surrounding the die which is more particularly shown in Figs. 6, 7, 11 and 12. This cooling jacket is composed of a plurality of sections held in position substantially surrounding the outer surface of the die by tension means such as a spring. In the embodiment shown in detail in Figs. 6 and 7, the cooling jacket assembly comprises 4 sections 58, each of which contacts or abuts against one outer surface of a square cross-section die tube. Each section comprises a block of metal of suitable dimensions having a circuitous passage incorporated therein and suitable means 60 for connection with a cooling medium supply and an outlet connection 61 for the same. The water pas-

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sages may be advantageously made by first forming these passages as ducts or grooves in the face of a suitable metal block and subsequently welding or brazing a plate to cover the surface of this block and enclose the so-formed passages. The plate may advantageously be fashioned from a good heat conducting metal such as copper. The sections additionally are provided with attached grooved blocks 62 arranged in substantially horizontal alignment.

In assembling the cooling jacket proper from the individual sections, tension means such as spring 63 is arranged to encompass the outer periphery of the four sections and, lying in the grooves and being under tension, holds the four jacket sections firmly in abutment against the outer surface of the die tube. By such arrangement, the die sections are not fixedly attached with respect to each other but rather flexibly connected so that some relative movement is possible during expansion and contraction of the die during the casting operation.

In order to provide a uniform distribution of cooling medium to the various sections of the die cooling jacket, a distribution manifold 64 is provided and may be, for convenience, clamped to the jacket 56 surrounding the guide tube 55. This manifold, as shown in detail in Fig. 3, comprises a ring or pipe 65 disposed generally above the supply pipe connections in the die cooling jacket below. Pipe 65 is supplied with cooling medium through communication with inlet pipe 66 which may be in turn connected to a convenient source of cooling medium such as water supply. Communicating with pipe 65 and projecting downward from the manifold at convenient locations are jacket supply pipes 67. These supply pipes are conveniently connected to inlet connections 60 of the die cooling jacket sections. Pipes 67 are further characterized by the provision of a flexible portion for at least a part of their length. Such flexible portion may form the lower part of said tubes and be conveniently formed of flexible metal hose, as illustrated at 68. Distribution of cooling medium through manifold 64 and the various supply pipes insures a uniform supply of cooling medium to the jacket sections 58. The cooling medium flowing out of the various die sections through connections therein 61, is in a like manner conveyed through suitable pipes 69 to another collector or manifold 70. This manifold 70 may also be conveniently clamped around the cooling jacket 56 and preferably below the supply manifold 64. Pipes 69 are also constructed so that at least a portion thereof is resilient or flexible and may, in similar manner, as pipes 67, be formed partly of flexible metal hose, as at 71. Manifold 70 is provided with peripheral pipe 72 into which are connected the upper ends of pipes 69. The outlet from pipe 72 is connected by a suitable fitting 73 to pipe 74 which is connected to the bottom of the guide tube cooling jacket 56. Water or cooling medium thence flows upward through the cooling jacket 56 and is finally exhausted through a suitable outlet 75. Thus, it is seen that the cooling medium enters the system and is distributed originally by manifold 64, passes through the die tube cooling jacket sections 58, is then collected by manifold 70 and subsequently passes through jacket 56 before being exhausted through outlet pipe 75. While the above-described arrangement of the various elements comprising the cooling system is preferred, other equivalent arrangements may be employed if desirable. Thus, the

supply and return lines to the die cooling jacket and the guide tube cooling jacket may be separated and individual supply and outlet pipes suitably arranged.

Lubrication and efficient further cooling of the cast rod while passing upward through the casting pot is accomplished by providing a lubricant well 76 at the top of the guide 55. This well communicates with the crevice or space between the cast rod and the interior walls of the guide tube so that a film of lubricant is present at all times in this space. In addition, the lubricant may penetrate to some extent into a crevice formed between the bar, after solidification, and the die tube wall. This lubricant film while effecting some lubricating action performs an important function in assisting heat transfer from the cast rod to the inner wall of the guide tube.

In the case where round rod is to be cast, a die tube of circular cross section will necessarily be used. The water jacket surrounding the die may be constructed according to the embodiment shown in Fig. 11 and Fig. 12. The jacket in this case may be suitably divided into several sections for instance, three as shown at 77. Each section carries provisions for an inlet 78 and outlet 79 for cooling liquid communicating with passages 80 for a flow of coolant similar in arrangement to those shown in the previously described die cooling jacket. The three sections are not rigidly clamped around the die but are resiliently maintained in position around the die tube by tension means as spring 81.

It will be appreciated that any desired cross-section of rod may be produced by the machine of this invention. Suitable configuration may be imparted to the die tube and the sectionalized cooling jackets correspondingly modified. It is essential, however, that the die cooling jacket be constituted of a plurality of sections resiliently maintained in position. In the case where rectangular rod is to be produced, under some conditions when the width of such rod is very large compared to the thickness thereof, forming substantially a rectangular tape, the die cooling jacket sections may be applied only to the lateral faces of the die tube. It has been found that under these conditions, effective cooling and proper solidification is obtained without the necessity of supplying cooling medium to the relatively minor edge areas of the die tube.

For starting operation, a starting rod is placed in position as is well known in this art. As the withdrawing mechanism successively draws up the rod, metal flows into the bottom of the die. As the cast rod becomes longer, it strikes the switch causing the shear blades to cut off the bar at predetermined intervals. The operation is thus automatic.

While the embodiment described and illustrated utilizes a shearing device for severing the rod sections other suitable methods may be employed. For instance, a power saw may be arranged with interconnected controls to function to sever rod sections in generally the same manner.

The particular advantages of the apparatus of this invention are in part due to the novel design of the die tube cooling jacket. As a result of the sectionalized construction of this cooling jacket it has been found that free passage of the cast rod through the die tube is obtained. The precise nature of the action taking place in the die during conversion of the initially molten metal to solid cast rod is not well understood. It is postu-

lated however, that during the cycle which includes the introduction of molten metal, freezing of the same and withdrawal of the solid rod, thermal effects are created which result in periodic expansion and contraction of the die. The design of the cooling jacket according to this invention permits free expansion and contraction of the die and this avoids excessive pressures and friction between this member and the solid rod. Hence, the cast rod shrinking to a size slightly smaller than the diameter of the column of originally molten metal is frozen into solid rod passes through the die without binding or sticking to the interior walls thereof. The free passage of the cast rod through the die and associated structure is assisted by a slight leakage of lubricant from the guide to above into the crevice formed between it and the rod. Additionally, this film of lubricant is important in that it facilitates the heat transfer from rod to guide tube, and cooling medium, since any liquid film is a much better conductor than a layer of air or gas. Any suitable lubricant may be employed but the invention prefers one that has a high boiling point and is completely volatile such as paraffin. Such a lubricant leaves no carbonized residue on either the die wall or the cast rod which must later be cleaned off.

It will be appreciated that while pneumatic means have been described for actuating several elements comprising the device of this invention other methods may be equivalently employed such as hydraulic power.

In the description of the invention above, and the annexed claims, the sections forming the die cooling jacket are referred to as "substantially" surrounding the die tube. By this term "substantially" is meant surrounding, not necessarily completely, but to an extent where efficient cooling action is maintained. It will be noted in the annexed drawings that minor spaces appear between the jacket sections, although these sections almost completely surround the die tube. It is necessary that sufficient clearance be allowed between the jacket sections to compensate for probable thermal contraction and expansion, and aside from this factor, adequate cooling must also be effected. In the case of the cooling jacket used in production of flat tapes, the jacket sections on either face will provide adequate cooling for thin diameter tapes and no end cooling jacket sections will be necessary. To the extent, however, that these sections obviously surround a substantially and major part of the die tube, such construction is indicated to be included within the term "substantially" surround.

It will be apparent that for rods of different cross section areas, or metals of different melting points, appropriate mutual adjustment of the several variable factors is required in order to maintain a constant rate of production with the necessary constant balance between input and outgo of heat. In a given machine, larger rods will in general require a slower progress through the tube, or a tube of greater length, except of course, to the extent that cooling action may be augmented to accommodate the greater heat input. The nature of such adjustments will be apparent to those understanding the principles involved which have been above described and which can obviously be applied singly or otherwise and in machines widely varying in function and design, and it will be understood that in its broader aspects this patent is intended to be without limita-

tions to any particular machine construction or to the manner of removing the rod from the die whether intermittently or continuously, or the means for causing such movement or to the casting of any particular kind of metal and further that certain of the features herein disclosed may be used beneficially independently of the others all within the scope of the claims which follow.

I claim:

1. In a machine for casting continuous metal rod in which molten metal is introduced into a die tube and intermittently withdrawn therefrom as cast rod, the combination of a unitary die tube, a cooling jacket composed of a plurality of vertical sections having a horizontal groove in their outer surfaces and resilient tension means in the groove in said sections maintaining said cooling jacket sections abutting, and substantially surrounding said die tube.

2. In a machine for casting continuous metal rod in which molten metal is introduced into a die tube and intermittently withdrawn therefrom as cast rod, the combination of a unitary die tube,

a cooling jacket composed of a plurality of vertical sections having a horizontal groove in their outer surfaces and a coil spring in the groove in said sections maintaining said cooling jacket sections abutting, and substantially surrounding said die tube.

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