

July 12, 1960

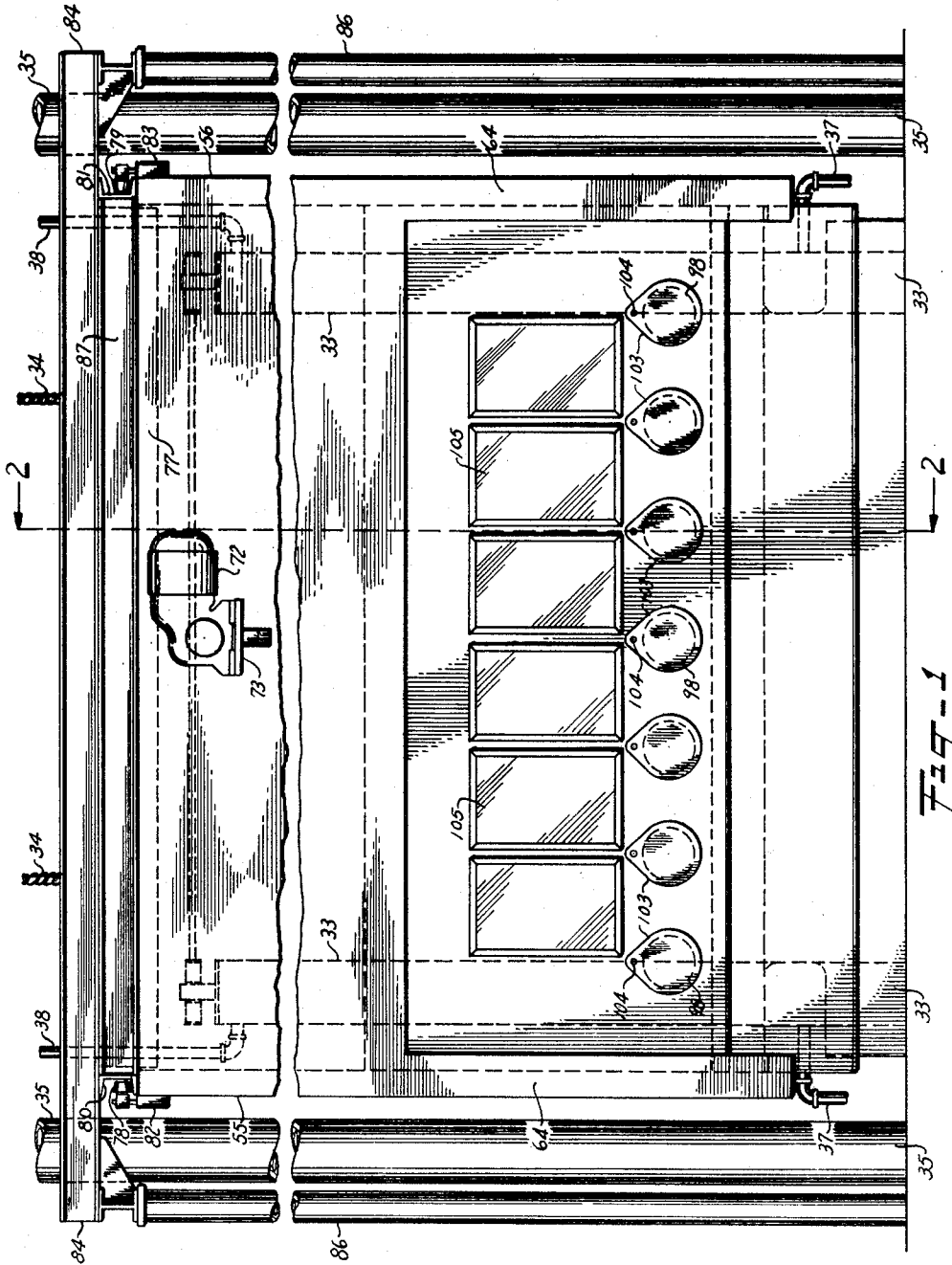
B. F. RAYNES

2,944,500

MACHINE FOR FORMING SHEET METAL

Filed Oct. 22, 1954

3 Sheets-Sheet 1



INVENTOR.

B.F. RAYNES

BY

S. Tierney Jr.
ATTORNEY

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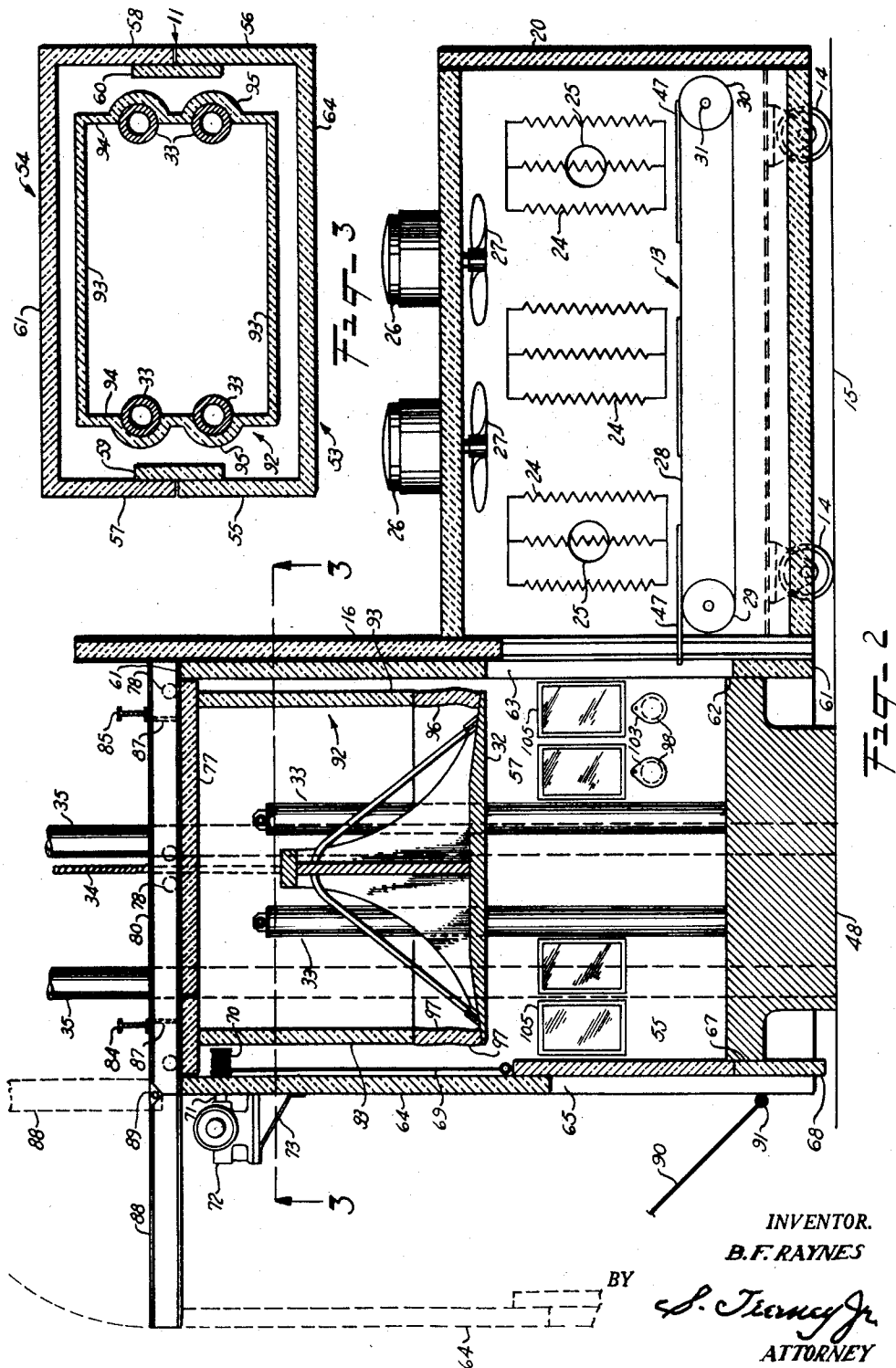
B. F. RAYNES

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B. F. RAYNES

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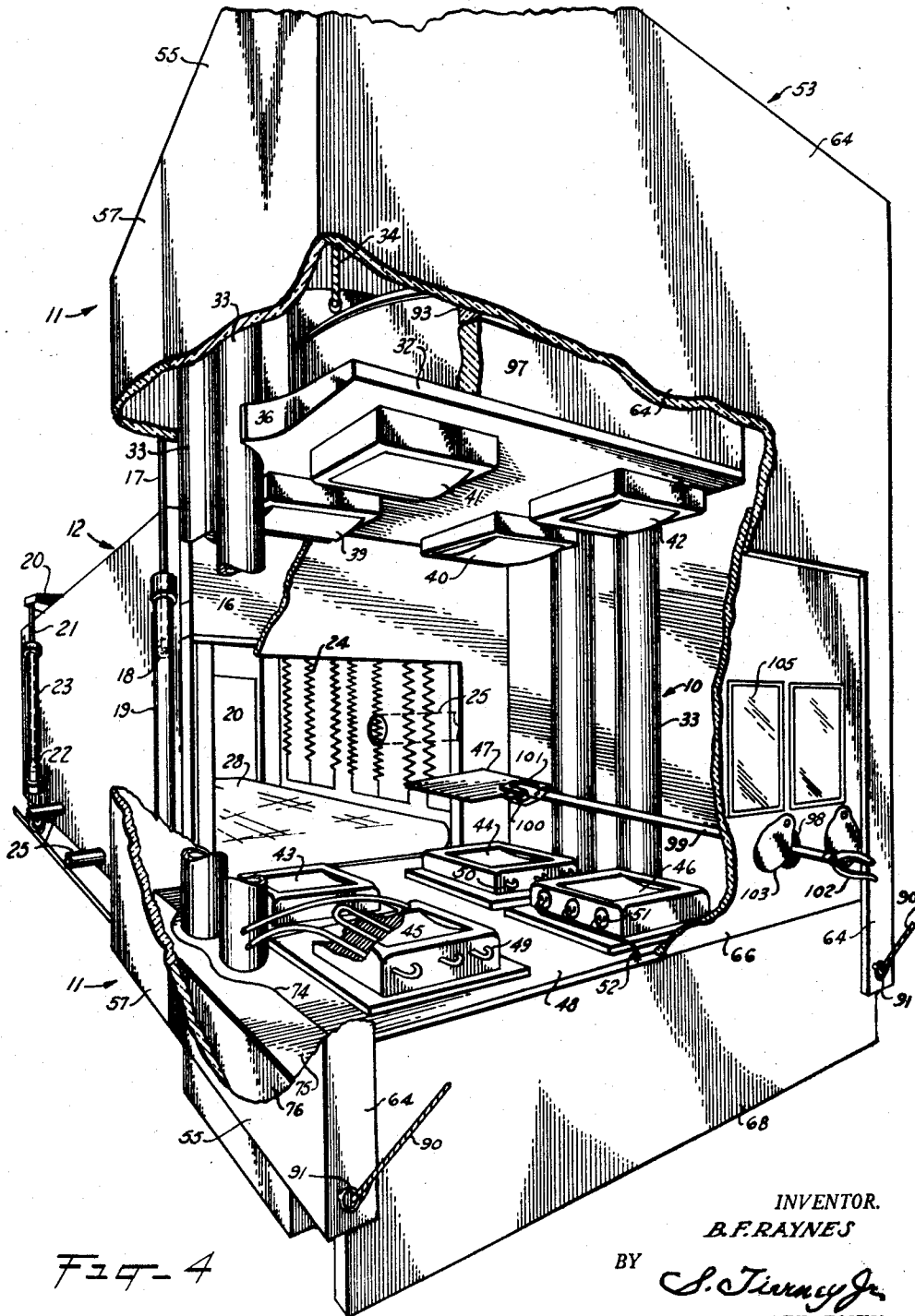


Fig. 4

INVENTOR.
B. F. RAYNES

BY
S. T. TERRY, JR.
ATTORNEY

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2,944,500

MACHINE FOR FORMING SHEET METAL

Burt F. Raynes, Chula Vista, Calif., assignor to Rohr Aircraft Corporation, Chula Vista, Calif., a corporation of California

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10 Claims. (Cl. 113—43)

This invention relates to a machine for forming titanium and other metals which are extremely difficult or impossible to form to the contour of curved dies at usual room temperature.

It has been found desirable to form sheet titanium to the shape of a die in a press or drop hammer at a temperature preferably between 400° and 700° F. and this may be done by previously heating it in a furnace. However, due to the heat lost by radiation and convection in the atmosphere while the sheet is being transferred from the heating furnace to the die, it is necessary that the sheet be heated to a temperature of the order of 1100° F. in order that it reach the die at a temperature of 700° F. especially if the sheet is thin as, for example, of the order of $\frac{1}{32}$ inch. However, heating the sheet to this high temperature causes oxidation to occur throughout the body of the metal, the metal becomes brittle and develops physical characteristics which seriously interfere with or prevent its proper forming and its engineering uses after it is formed. If the heating takes place in the air, the nitrogen and hydrogen also present dissolves in the metal at this high temperature and produce a deleterious effect on its formability and physical properties. At the high temperature of 1100° F. an oxide film also forms on the surface of the metal which is difficult and costly to remove.

Many steels may be formed in dies much better when heated than when cold and are preferably formed at definite temperatures. However, due to the heat lost during their transfer from the heating or annealing furnace to the die, it is necessary to heat them to a temperature substantially higher than the optimum forming temperature and many steels decarburize at this higher temperature. This decarburization detracts from their formability and also adversely affects their physical properties after they are formed.

When forming magnesium, aluminum and certain of their alloys, the forming is best done at elevated temperatures. However, the maximum safe temperature to which hard magnesium or 75ST6 aluminum sheet may be heated is approximately 325° F. and that to which annealed magnesium sheet may be heated is approximately 550° F., and if the sheets are heated to these temperatures and formed in the usual manner, they are below the optimum forming temperature by the time they reach the die. It is a purpose of the present invention to provide a machine for forming different metals which form best when heated, whereby the aforementioned disadvantages are overcome.

It is an object of the invention to provide a combination furnace and metal forming means in which the sheet metal is uniformly heated to a predetermined temperature and then quickly transferred to a die through a path which is heated to a temperature so high that the sheet reaches the die and is formed at substantially the optimum forming temperature. If the metal is one which is best formed in an inert atmosphere, it is another object

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to provide a supply of argon, nitrogen, helium or other inert gas for the furnace and forming means.

Another object is to provide means for preheating the forming die or dies to a temperature substantially equal to the temperature of the hot sheet so that substantially no reduction in temperature takes place in the sheet while it is in contact with the die during forming.

A further object is to provide for the heating of the dies by means of heat from the furnace or by a heating medium within the dies.

A still further object is to provide a press or drop hammer to effect the forming and to provide an enclosure around the hammer which has insulating walls to retain the heat, one of the walls preferably having an opening which communicates with the furnace and through which heat is received for the dies.

Another object is to provide a conveyor in the furnace adapted to convey metal sheets through the furnace and deliver them properly heated at the aforementioned opening in the insulating enclosure.

A further object is to provide one or more small openings in the front of the insulating enclosure through which the handles of a pair of tongs may be inserted so that the operator may transfer a heated sheet from the conveyor to the forming dies and from one die to another, when progressive forming is required. Preferably small windows are provided in the insulating enclosure just over these openings so that the operator may easily see the sheet and the gripping jaws of the tongs.

Another object is to provide a door in the front or side of the enclosure which may be opened by the operator to withdraw a workpiece from the dies and enclosure after it has been formed.

A still further object is to provide an enclosure structure for the drop hammer in which the front of the enclosure may be removed to permit a mechanic free access to the dies for their adjustment or removal and replacement by another set.

Further objects will become apparent as the description of the machine proceeds. For a better understanding of the invention, reference is made to the accompanying drawings, in which,

Fig. 1 is a front view showing portions of an installation embodying the invention,

Fig. 2 is a view partly in section on line 2—2 of Fig. 1 on a reduced scale and partly diagrammatic,

Fig. 3 is a partial sectional view on line 3—3 of Fig. 2 and,

Fig. 4 is a perspective view of the installation with portions broken away.

The installation comprises four main units, a drop hammer 10, an insulating casing 11 around the hammer, a furnace 12 for heating the parts to be formed and a conveyor 13 for conveying the parts through the furnace to the hammer. Referring to Figs. 2 and 4 the furnace is preferably mounted on casters 14 which rest on stationary floor 15 and permit the furnace to be readily moved. At its end adjacent the hammer the furnace has a door 16 which may be raised and lowered by a pair of piston rods 17 (only one being shown) attached to its top at its ends, each rod being operated by a piston 18 slidable in a pneumatic cylinder 19 to which compressed air is supplied by known means (not shown) to raise and lower the piston. At its opposite end the furnace has a door 20 which may be raised and lowered by a pair of piston rods 21 (only one being shown) attached to the top of the door at its ends, each rod being operated by a piston 22 slidable in a pneumatic cylinder 23 similar to cylinder 19. Along each side wall of the furnace are disposed a plurality of electrical heating elements 24, three being shown, to one, two or three of which electrical current may be supplied from a control switch (not

shown) to regulate the temperature in the furnace. While electrical heaters have been shown it will be understood that the furnace may be heated by burners burning gas or other fuel, in which case the fuel supply is preferably regulated to provide a reducing atmosphere in the furnace. When an inert atmosphere is desired in the furnace and around hammer 10, a large tank (not shown) of nitrogen, argon or helium may be connected to a pair of pipes 25 which pass through the wall of the furnace and convey the inert gas into it. These pipes preferably terminate just behind two of the heaters 24 so that the inert gas is heated as it enters the furnace or the gas may be preheated before entering it. All the furnace walls and the doors 16, 20 are filled with insulating material, as shown, to retain the heat. Two or more small electric motors 26 mounted on the top of the furnace drive a pair of fans 27 when it is desired that the air or inert gas in the furnace be circulated. The operation of these fans expedites the flow of the heated gas in the furnace, or from the furnace into casing 11 to heat the drop hammer 10 and dies thereon to a desired temperature.

Conveyor 13 comprises a plurality of spaced apart sprocket chains 28 which pass over sprocket wheels 29, 30, the shaft 31 of the wheels 30 extending outside the furnace and being driven by a gear reducer from an electric motor (not shown).

Drop hammer 10 is preferably of the type disclosed in patent application Serial No. 342,523, filed March 16, 1953, now Patent No. 2,719,443, and has a vertically reciprocable ram 32 slidable along four hollow vertical guide columns 33, the ram being raised to its top position, shown in Fig. 4, by a pair of wire cables 34 whose upper ends are wound around a cylindrical drum (not shown) supported at the top of the four posts 35. In order to cool the columns 33 so that the portion of each column which is engaged by the guide lug 36 attached to ram 32 (see Fig. 4) may retain lubricant, a water supply pipe 37 is connected to each column near its base (see Fig. 1). Water is supplied to these pipes from any suitable source, the water leaving the tops of the columns via pipes 38 which convey the heated water out of enclosure 11 to a suitable discharge outlet.

The base of ram 32 is of generally rectangular shape and attached thereto are shown four male dies 39, 40, 41 and 42 which cooperate respectively with the registering female dies 43, 44, 45 and 46 in the progressive forming of a flat sheet metal workpiece 47. The female dies are secured to a generally rectangular shaped stationary anvil 48. In forming certain metals it is desirable to heat the female dies internally and any suitable means may be provided for this purpose. In the embodiment shown, dies 43, 45 and 44 have coils of pipe 49, 50 embedded therein through which heated liquid from a tank (not shown) is circulated.

Die 46 has electric heaters 51 disposed in it, electric current being supplied to these by the supply wires 52 from a suitable source (not shown).

The insulating casing 11 about the hammer comprises a movable front section 53 and stationary rear section 54 each of generally channel shaped cross section, the side walls 55, 56 of the front section abutting the side walls 57, 58 of rear section 54 in a vertical plane (see Fig. 3) and these walls engaging and overlapping a pair of vertical insulating panels 59, 60 so that a substantially tight joint results. Rear wall 61 of section 54 abuts the front door of the furnace and the straight rear face 62 of anvil 48 and has a large rectangular opening 63 which admits the heated gas from the furnace into casing 11 when door 16 is open. The front wall 64 of casing section 53 at its bottom is provided with a rectangular shaped door opening 65 behind which is a slidable door 66 whose rear face engages the straight front face 67 of anvil 48 when door 66 is closed. For a purpose to be later described an auxiliary rectangular panel 68 may be attached to the

bottom of door 66 by any suitable readily detachable connection which will permit panel 68 to be quickly attached or detached. Door 66 is raised or lowered by a wire cable 69 whose ends are connected to the top of the door near its ends and whose intermediate portion is wound around a drum 70. The drum is attached to and rotated by the slow speed output shaft 71 of a reversible electric motor and gear reducing unit 72 supported on a bracket 73 attached to the front wall 64.

At each side anvil 48 (see Fig. 4) terminates in a curved surface 74 and a flat filler plate 75 is secured to the anvil, this plate having an inner face shaped to conform with surface 74 and a straight vertical outer face 76 against which the side walls of the casing fit. Anvil 48 and filler plates 75 thus effectively close the bottom of casing 11 and substantially prevent the leakage of the hot gas out of the casing through its base. As shown, the vertical walls of casing 11 do not extend to the floor 15 so that coolant air may circulate around the base of anvil 48 to prevent an excessive rise in its temperature.

The top wall 77 of casing 11 is stationary and the casing sections 53 and 54 are supported by sets of spaced apart rollers 78, 79 which run along the flanges of pair of horizontal channel beams 80, 81. Rollers 78 are rotatably supported by brackets 82 secured to side walls 55, 57 and rollers 79 are supported by similar brackets 83 secured to side walls 56, 58. Beams 80, 81 (Figs. 1 and 2) are secured to the bottom flanges of a pair of cross beams 84, 85, each of which is supported at its ends by a pair of vertical columns 86. The top wall 77 is secured to the bottom flanges of beams 87. The entire insulating casing 11 is thus supported independently of the drop hammer. All the walls of casing 11 and door 66 are preferably made of a central fiber glass blanket enclosed between thin sheets of stainless steel, the steel sheets being held in assembled relation by any suitable known means. A wall thickness of 3 inches has been found to provide adequate insulation.

In order to give ready access to the drop hammer, means is provided whereby front casing section 53 may be moved forward and elevated so that it is out of the way. This means comprises a pair of channel beams 88 which are pivotally attached by pivots 89 to the front ends of beams 80, 81 so that the bottom flanges of the beams are in alignment. As section 53 is moved forward the rollers 78, 79 on this section leave beams 80, 81 and roll along the flanges of beams 88 until the casing section is in the position shown in dash lines in Fig. 2. The section is then raised, pivoting on pivots 89, by an electric motor driven drum (not shown) around which the upper portion of a cable 90 is wound, the bottom ends of this cable being attached to two eye bolts 91 secured to front wall 64 near its base. As the section is raised, beams 88 move up to the position shown in dash lines remaining connected to beams 80, 81 by the pivot pins 89.

To protect the major portion of ram 32 and lifting cables 34 from the hot gas around the dies, an insulating container 92 is secured to and depends from top wall 77, this container having rigid straight front and rear walls 93 and side walls 94 which have curved offsets 95 that engage and partly surround the guide columns 33 (see Figs. 2 and 3). Secured to the bottom of these walls is a flexible strip 96 formed of a central fiber glass mat disposed between and secured to fabric sheets 97 made of asbestos or similar insulating material. As the ram 32 is raised, just before it reaches its topmost position shown in Figs. 2 and 4, the peripheral portion of the top of the ram engages the bottom of strip 96 and the strip flexes somewhat, as indicated, as the ram continues to the end of its stroke. The container 92 together with top wall 77 thus provide an insulating enclosure around most of the ram all the time it is in its topmost position, to keep the ram at as slow a temperature as possible.

To permit the sheet 47 to be moved into position on the dies without opening front door 66, the door near its base

is provided with a plurality of circular openings or apertures 98 through which the tongs 99 may be inserted, the tongs illustrated having a fixed gripping jaw 100 and an upper movable jaw 101 which is operated by a lever 102 pivoted at the front end of the tongs. Each opening 98 is normally closed by a shutter 103 suspended on a pivot pin 104. Above the shutters 103, the door has a series of rectangular openings therethrough which are covered by transparent windows 105 made of glass or other material capable of withstanding a high temperature. Similar windows 105 and openings 98 (see Fig. 2) may be provided in one or more of the casing side walls 55, 56, 57, 58.

When forming parts on shallow dies, the panel 68 is not attached to front door 66 and casing section 53 is moved forward along beams 88 and then raised out of the way by the drum which pulls cable 90. The operator then attaches dies 39, 40, 41, 42 to ram 32 and the dies 43, 44, 45 and 46 in the proper positions on anvil 48. A source of hot Hydrotherm or other fluid having a high boiling point is then connected to the circulating pipes in the dies and if any of the dies are electrically heated, the heating current is turned on. Hydrotherm is capable of heating the dies to a temperature of approximately 600° F. and for forming certain metals this temperature is adequate. In forming certain parts with titanium, a temperature up to 1,000° F. may be indicated, in which case all the dies may be heated electrically by means of electric heaters disposed in the dies. Casing section 53 is then lowered and pushed rearward to its initial position shown in full lines in Fig. 2. With the front door 16 of furnace 12 closed, rear door 20 is opened and a number of the metal sheets 47 are placed on chains 28 one in advance of the other. Door 20 is then closed and electric current supplied to one or more of the electric heaters 24 depending on the temperature to which the metal should be heated. In forming hard magnesium sheet the temperature in the furnace should be kept somewhat below 325° F. and for annealed magnesium sheet somewhat below 550° F. For forming commercial grade of sheet titanium the sheet is uniformly heated to a temperature between 500° and 700° F.

When the sheets are heated door 16 is raised and, if necessary, conveyor 13 operated to bring one of the sheets over sprocket wheels 29, as shown in Fig. 2. The operator while looking through a window 105, grasps the sheet with the tongs 99 and places it on die 43 and if desirable, may then close furnace door 16. The operator allows ram 32 to fall, thus forming the sheet between dies 39 and 43. He then raises ram 32, grasps the partially formed sheet with the tongs and places it on die 44. Ram 32 is again allowed to fall, thus forming the sheet to the contour of die 44. This operation is repeated on dies 45 and 46 whereupon the sheet is fully formed to the desired shape. After raising ram 32, the operator controls electric motor 72 to raise door 66 enough to permit the operator to insert tongs under the door and grasp the formed workpiece with the tongs (not shown) and withdraw it from casing 11. Should the gas around the dies not be heated sufficiently by the heat radiated from them so that the workpiece is cooled while being transferred from chains 28 to die 43, the front door 16 of the furnace may be left partially open to permit heated gas from the furnace to circulate around the dies and heat them. In this way if the furnace atmosphere is an inert gas supplied by pipes 25, a heated inert gaseous atmosphere may also be maintained around the forming dies so that the entire heating and forming of the sheets can be carried out in a non-oxidizing atmosphere. If a reducing atmosphere is maintained in the furnace in case it is heated by liquid or gas, a reducing atmosphere may be maintained around the dies by leaving the furnace door 16 partially open. In annealing steels of certain compositions in furnace 12 preparatory to forming, such a reducing atmosphere is desirable.

After the formed workpiece is withdrawn, front door 66 is again closed and, if necessary, door 16 opened. Conveyor 13 is again operated to advance another sheet or sheets 47 to a position above sprocket wheels 29; this sheet is grasped by tongs 99 and the forming operation above described is repeated.

While forming on four dies has been illustrated, one or two of the dies may be omitted and certain parts may be satisfactorily formed by two dies. The steps to effect such progressive forming will be obvious from the above description. Other parts may be satisfactorily formed on one set of dies as, for example, dies 42, 46 and the invention includes such forming. In this case, however, it may not be necessary to open door 66 after each workpiece is formed, the workpiece being lifted from die 46 by the tongs 99 and deposited on the top of anvil 48. Another sheet 47 is then transferred from chain 28 to the die, formed, removed from the die and placed on anvil 48. These operations may be repeated until several formed parts have accumulated on anvil 48 when front door 66 is raised and all the parts removed from the casing 11.

If the lower die or dies are higher than the openings 98 so that tongs 99 cannot be moved over them, the insulating panel 68 is attached to the bottom of door 66 and the door and panel raised by motor 72 to bring the openings 98 to a level slightly above the tops of the dies. The bottom portion of panel 68 is then in engagement with face 67 of anvil 48 to prevent any substantial heat loss from the casing in this region. Also the tongs 99 may now be manipulated over the tops of the dies to take sheets from chains 28 and transfer them to the dies and from one die to another.

While in the illustrated form of the invention the movable dies are actuated by the ram of a drop hammer, it will be understood that they may be actuated by the ram of a known type of press in which one or more hydraulic cylinders are used. Typical sheet compositions in percent by weight adapted to be formed in the manner described are:

- (1) Titanium 99.6; balance minor impurities.
- (2) Aluminum 3.0; zinc 1.0; manganese 0.2; balance magnesium and minor impurities.
- (3) Zinc 5.5; magnesium 2.5; copper 1.5; chromium 0.3; manganese 0.2; balance aluminum and minor impurities.

This invention may be embodied in other forms or carried out in other ways without departing from the spirit or essential characteristics thereof. The present embodiment of the invention is therefore to be considered as in all respects illustrative and not restrictive, the scope of the invention being indicated by the appended claims, and all changes which come within the meaning and range of equivalency of the claims are intended to be embraced therein.

Having thus described my invention, what I claim as new and useful and desire to secure by Letters Patent is:

1. A machine for forming a sheet of metal comprising in combination: a die having a curved face; means for heating the die to a temperature at which the metal is substantially more ductile than at ambient air temperature; a power operated member arranged to press the sheet against the face of the heated die; and a heat insulating enclosure surrounding and insulating the aforementioned elements, said enclosure comprising a rear section having vertical side walls; a movable front section having vertical side walls in engagement with the side walls of the rear section; and substantially horizontal parallel guideways disposed at a level above the top of said enclosure for supporting said front section for bodily movement away from said rear section.

2. A forming machine as claimed in claim 1; in which said enclosure has a stationary top wall in engagement with the sidewalls of the front and rear sections.

3. A forming machine as claimed in claim 1; in which

a pair of stationary insulating panels have faces with which the vertical side walls of the said front section have slidable engagement.

4. A forming machine as claimed in claim 1; in which the front portions of said guideways are pivotally supported to permit said movable front section to be elevated when positioned on the front portions of the guideways.

5. A drop hammer for forming a sheet of metal comprising, in combination: a lower die; a complemental upper die; a plate supporting the upper die; means for raising said plate; means for heating the metal sheet to a temperature at which the sheet is substantially more ductile than at ambient air temperature; a first heat insulating enclosure surrounding and insulating said dies and plate; and a second heat insulating enclosure within said first enclosure and having its lower end in engagement with said plate when the plate is raised.

6. A machine for forming a sheet of metal to a desired shape comprising, in combination: means including a die for forming the sheet to said desired shape; a heat insulating enclosure surrounding said forming means and including a side wall having an opening therein; a furnace disposed in abutting heat sealing engagement with said side wall and having a first door for closing said opening and a second normally closed door for admitting the sheet into the furnace; means for admitting an inert gas into the furnace; means within the furnace for heating said gas and said sheet therein to a temperature substantially below the melting point of the sheet but high enough to substantially increase the ductility of the sheet; means for circulating said heated gas within the furnace and along a path through said opening to the die when said first door is opened thereby to heat the die and said path thereto from the furnace; means operable by an operator positioned outside the enclosure for transferring the heated sheet from the furnace to the die along said heated path; said enclosure having means including at least one aperture for opening the enclosure to the surrounding atmosphere, said aperture being disposed at a level above the top of the die; said transferring means being extended through said aperture whereby heated gas moves from the furnace through the opening into the enclosure and out of the aperture as the sheet of metal is moved to the die; and said enclosure having a transparent window disposed relative to said aperture so that the operator can see the die and the sheet within the furnace through said opening in the enclosure.

7. A forming machine as claimed in claim 6, said die having means individual thereto for heating the same substantially to said temperature.

8. A forming machine as claimed in claim 6, said sheet

transferring means comprising tongs manipulatable by the operator outside the enclosure and constructed to grip the sheet and move the same onto the die under control of the operator.

9. A forming machine as claimed in claim 6, said enclosure having a normally closed door through which the formed sheet may be withdrawn from the enclosure.

10. Means for forming a sheet of metal to a desired shape comprising, in combination: a hollow furnace having walls composed of heat insulating material; means including a body of gas heated within said furnace for heating a sheet of metal placed therein to a temperature high enough to increase substantially the ductility of the metal; a drop hammer having a die of the desired shape disposed near said furnace; a heat insulating casing enclosing said drop hammer; said furnace and casing having abutting walls and aligned openings therein for passing the sheet from within the furnace to the die; said casing having means including at least one aperture for opening the casing to the surrounding atmosphere and a transparent viewing window above said aperture; means for circulating said heated gas within the furnace and through said openings along a path to said die thereby to heat the die and said path thereto from the furnace; and means manually operable through said aperture and visible through said window and constructed to engage and transfer the heated sheet from the furnace to the die along said path whereby heated gas moves from the furnace through the openings into the casing and out of the aperture as the sheet of metal is moved to the die.

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