Dec. 15, 1964 W. F. FISHER 3,160,930

CIRCUIT CASTING APPARATUS

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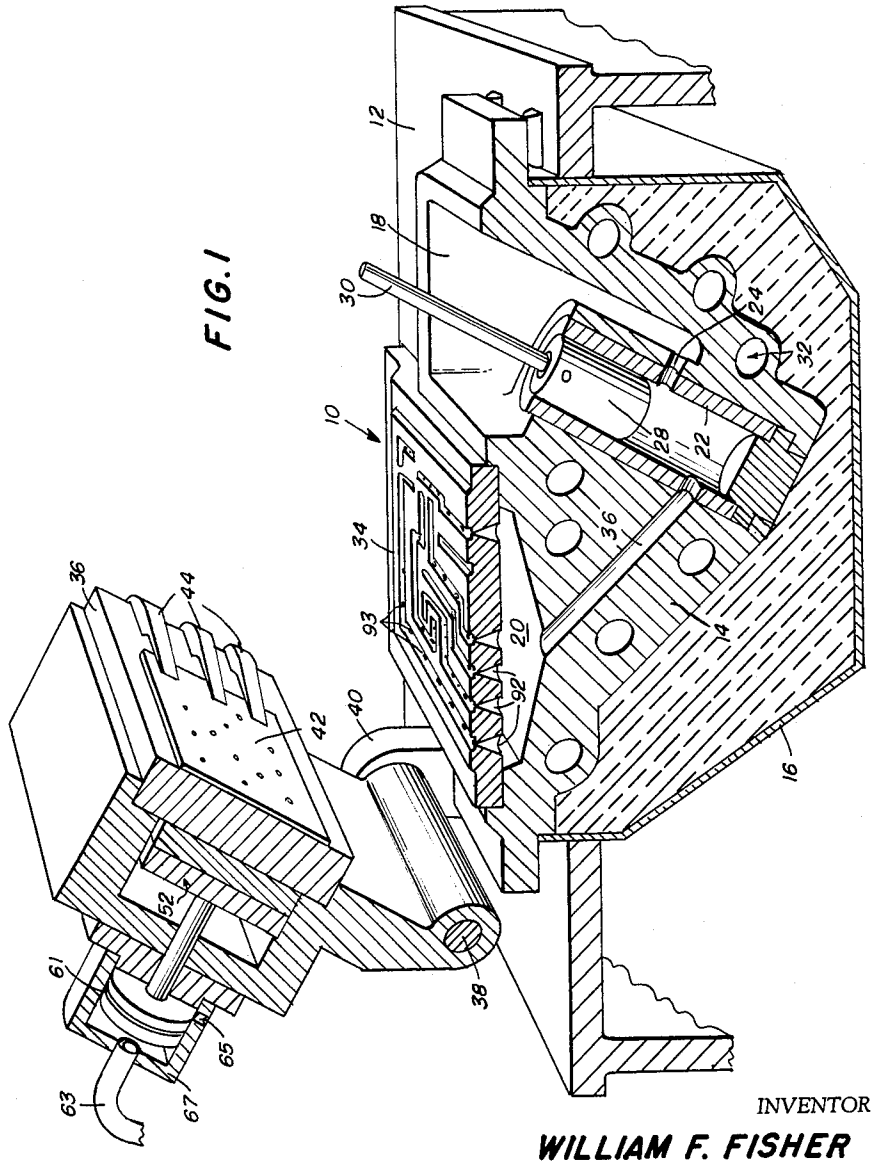
FIG. 1



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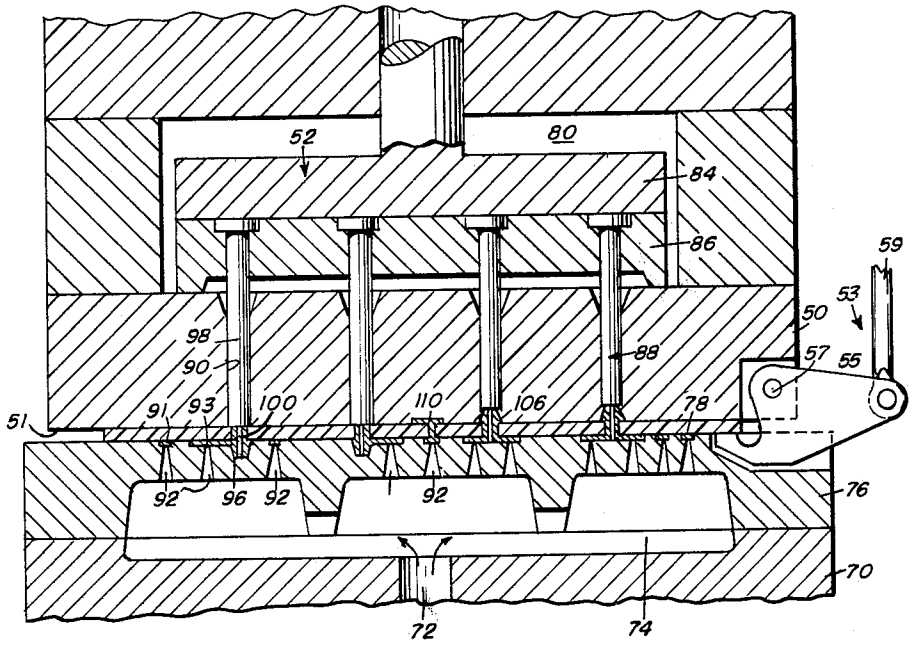

FIG. 2

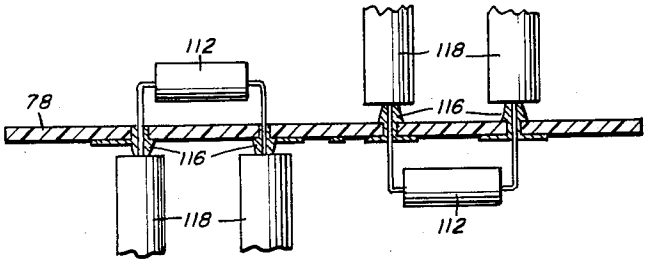

FIG. 3

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CIRCUIT CASTING APPARATUS

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This invention relates to the casting of electrical circuits on suitable boards and more particularly to apparatus for casting electrical circuits directly onto a suitable base.

In recent years, there has been a tremendous development in the field of printed circuits. Many methods and much apparatus have been devised for producing these circuit arrangements. Even so, there are many problems encountered in this work. This invention eliminates a number of problems encountered in the field of cast circuitry. For example, the use of feed runners to feed the molten metal from the reservoir to the circuit board has been eliminated, the molten metal being fed directly from a chamber beneath the die plate up through the die plate into the circuit formation contained therein. In other words, the job turns out to be a single operation which obviously is quite advantageous.

In view of the above, it is an object of this invention to provide die-casting apparatus which will cast a circuit directly upon a suitable base.

It is another object of this invention to provide a die-casting arrangement in which the necessity of using gates and associated feeders to carry the molten metal to the die plate and therethrough is eliminated.

It is a still further object to provide a die plate for the die-casting machine of the above objects which has feed passages closely spaced along the circuit forming channel throughout its entire length, thus affording rapid delivery of molten metal to the desired area.

The above and other objects and advantages will become apparent in view of the following detailed description and drawings, showing by way of example, preferred embodiments of this invention and wherein:

FIGURE 1 is a perspective view partly in action showing the over-all arrangement of the apparatus of this invention;

FIGURE 2 is a vertical cross-sectional view somewhat similar to FIGURE 1 and showing the same type of die plate in cross-section; and

FIGURE 3 is an elevation view showing two examples of securing electric elements to the cast circuit unit.

Referring to FIGURE 1, which illustrates a machine employing a hot chamber, die-casting system modified to produce the cast circuit of this invention, the die-casting machine 10 comprises a supporting frame 12 having an upper aperture which receives the stationary base 14 of the machine 10. An insulating shell 16 fits over the bottom portion of the base to reduce heat loss. The base 14 is a casting having a large molten metal reservoir 18 and a somewhat smaller molten metal reservoir 20. Disposed between these two reservoirs is a pressure cylinder 22 connected to reservoir 18 by channel 24 and to reservoir 20 by passageway 26. A plunger 28 is reciprocably carried in the cylinder and through plunger rod 30 which is reciprocated to pump molten metal from reservoir 18 into and through the reservoir 20. The plunger 28 may be operated by any conventional means. A hydraulic arrangement for actuating such a plunger is disclosed in U.S. Patent No. 2,072,864.

The base 14 is heated by means of electric resistance coils 32 disposed throughout the base.

A die plate 34 fits down on top of the base 14 and covers the molten metal reservoir 20 so that the molten metal may be forced therethrough to form the cast circuit on a suitable circuit board. A platen 36 is hingedly mounted on the frame 12 by means of hinge pin 38 and supports 40, only one of which is shown. The platen 36 carries the circuit board 42 onto which the circuit is to be cast. This board may be held on the platen by means of side clamps 44 which position the board for proper registering contact with the upper face of the die plate when the platen is brought down thereon.

The arrangement shown in FIGURE 2 is quite similar to that of FIGURE 1 except that the platen 50 in this case is raised and lowered by suitable reciprocating powered means, which is not shown as it is of conventional nature. It will also be observed that the cross-section of FIGURE 2 is at right angle to that of FIGURE 1 so that additional details of this type of die plate will be shown.

As illustrated in FIGURE 2, the base 70 has a passageway 72 leading to molten metal reservoir 74. The die plate 76 fits down on and over the reservoir's upper opening. Platen 50 carries circuit board 78 on its lower face 51 when it is held in position by a plurality of clamp assemblies 53. Each clamp assembly 53 comprises a clamp 55 pivotally mounted by pin 57 supported in the platen 50. The clamp is pivoted about pin 57 by means of rod 59 secured to the outer extremity of the clamp. This rod 59 is actuated by suitable means in timed sequence with the other mechanisms of the die-casting machine. The platen has a hollow portion 89 in which is reciprocably positioned a rod and head assembly 52. The head member 84 of this assembly is secured to a core carrier 86 mounting a plurality of rod-like cores 88 which extend down through openings 90 in the platen to cooperate with the circuit board to form various projections of cast material as desired. Reciprocation of the rod and head assembly 52 serves to insert the cores 90 into proper position with respect to the circuit board 78. As illustrated in FIGURE 1, the rod and head assembly 52 is reciprocated by a hydraulically operated piston 61 actuated by fluid alternately introduced through ports 63 and 65 of cylinder 67.

By referring to the die plates shown in FIGURES 1 and 2 and numbered 34 and 76, respectively, the important features thereof will become more apparent. The upper face of each die plate contains the specific configuration of the circuit to be formed thereby in the form of channels 91 adapted to receive the molten metal. Cone shaped feed passages 92 are cut in the die plate in closely spaced relation along the circuit outline provided on the upper face thereof. The feed passages 92 are formed so that they converge toward the upper face of the die plate and terminate as openings 93 in the channel configuration on the upper face of the die plate. The opening 93 at the top of the cone-shaped passages is quite small, yet sufficient to allow the molten metal to proceed therethrough rapidly into the channels 91.

In addition, it may be desirable to cast projections or protrusions on the circuit board in order to provide means for securing electronic components to the circuit board. Projection 96 is formed by a hole in the circuit board 76 and a hole in the die plate registering with the hole in the board. A core member 98 having a reduced end portion 100 fits down in a hole in the platen so that the lower end of the larger portion of the core is flush with the upper face of the circuit board 78, thus allowing the portion of reduced diameter to extend down through the hole in the circuit board and into the hole in the die plate where it rests against the bottom wall of said hole. Thus, when molten metal is introduced into the die plate openings, a protrusion or projection such as 96 is formed such that a portion will extend beyond the surface of the circuit board 76 with a hole therethrough.

The projection may be made to extend from the other side of the circuit board as illustrated by projection 106. It should be noted that in this arrangement the same type of core is used, however, it is raised so that the lower end of the reduced portion will rest on the die plate recessed portion and thus, the portion that is reduced will extend upwardly into the hole in the platen 50, thereby allowing molten metal to proceed upwardly therein until it hits the lower face of the larger core portion. The hole in the platen in which the core fits may have a slight draft, thereby producing a projection converging upwardly to a slight degree.

It is also possible to cast a circuit on both sides of the circuit board 76 as indicated by numeral 110 by merely recessing the lower face of the platen 50 and cutting a hole in the circuit board to connect a recessed portion in the die plate with the recess in the platen face.

The advantages of the above features will be readily apparent to one skilled in this art. These advantages are further illustrated in FIGURE 3 showing electronic elements being fastened to the circuit board. Electronic element 112 with leads 113, 114 positioned within projections 116 is held in place and heat applying members 118 are brought against the free end of the projections to cause same to melt and form a solid joint securing the leads 113 and 114 to the cast circuit. The same arrangement is shown in the other half of FIGURE 3 wherein the projections face upwardly and the electronic member is secured to the underside of the circuit board.

It is believed that the operation of this apparatus is now quite clear, however, a brief description follows: The base 14 will be heated to the temperature of the molten metal while the platen 36 will be comparatively cool. The platen can be heated to any desired temperature, if necessary, to assist the flow of metal when casting a circuit on both sides of the board. The die plate 34 having the desired circuit configuration is placed in position on the base 14 and the circuit board 42 is clamped onto the platen 36. Molten metal in reservoir 18 is maintained at such a level that the level of molten metal in reservoir 20 will touch or come very close to the bottom of the die plate 34. With everything in position, as above, the platen is brought down in position causing the circuit board 42 to fit down flush against the die plate, then the core pins are inserted, whereupon plunger 28 starts its downward stroke, first shutting off flow of molten metal from reservoir 18 through channel 24 and then forcing the molten metal up into the reservoir 20 and through the die plate feed passages 92 into the channels 91 which form the desired cast circuit.

The molten metal sets instantaneously upon being injected. The platen is then lifted, taking with it the circuit board which is held against the platen by virtue of the fact that the cast metal has shrunk on the core pins. With the platen lifted, the core pins are retracted, thus releasing the circuit board. The fingers 44 which are used to hold the board to the platen prior to casting, are also withdrawn after injection of the metal. After this the cast circuit board unit is removed from the platen and the cycle is complete.

There are many advantages in the above apparatus and method of producing cast circuits. One of the main features or advantages is the casting of the circuit in a single rapid operation without employing gates and feed runners. In this invention, the molten metal is introduced directly from the reservoir 20 up through feed passages 92 into circuit forming channels 91 in the upper face of the die plate. In other words, there is no flow through gates or long feeders, which makes this apparatus

and method superior in speed and simplicity to other apparatus used for this work. The speed of such a casting operation is quite impressive when the matter of economies of operational equipment is considered.

What is claimed as new and desired to be secured by Letters Patent is:

1. Apparatus for direct casting of metal onto a board to form a cast circuit unit, said apparatus comprising a pair of spaced molten metal containing reservoirs, a pressure cylinder interposed between said reservoirs, passage means connecting each reservoir to the pressure cylinder, a plunger reciprocably carried in said cylinder to pump molten metal from one reservoir to and out the other, one of said reservoirs having an open face, a die plate positioned on the reservoir having the open face so as to seal same, the effective area of the died plate being generally co-extensive with open face of said reservoir, heating means for maintaining the reservoirs, the pressure cylinder, the passage means connecting each reservoir with the pressure cylinder and die plate at a temperature to retain the molten metal in said molten condition, the die plate having channels on its upper face defining the circuit to be cast therein and feed passages in the lower face extending upwardly into the channels in the upper face of said die plate, the lower face of said die plate being positioned immediately adjacent the level of molten metal in the respective reservoir so that the molten metal flows directly from the reservoir through the die plate, and a platen assembly mounted for movement to and away from the upper face of the die plate, said platen being adapted to carry a board on its lower face so that when the platen is moved toward the upper face of the die plate the board will engage and register with the die plate.

2. The invention as described in claim 1 and including core members passing through the platen and into engagement with the die plate so that projections will be produced around these cores to provide means for receiving the leads of components adapted to be attached to the cast circuit.

3. The invention as described in claim 1 and wherein the feed passages are cone-shaped and converge upwardly toward the channels in the upper face of the die plate.

4. The invention as described in claim 3 and wherein the feed passages are closely spaced to assure rapid, even and full flow to the channels in the upper face of the die plate.

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