

Dec. 21, 1954

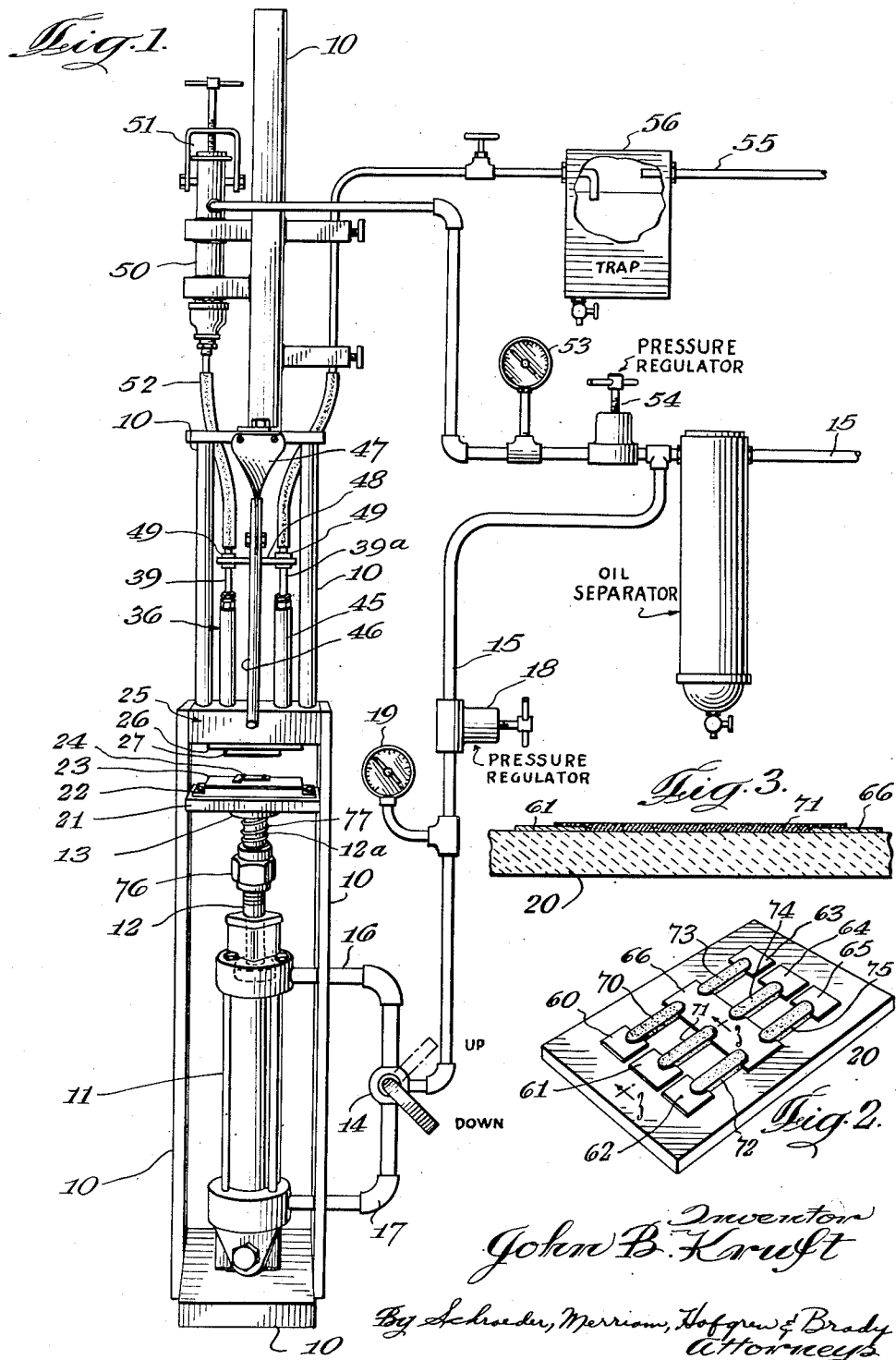
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2,697,253

APPARATUS FOR CONTROLLED DEPOSITION OF MATERIAL

Filed June 8, 1951

3 Sheets-Sheet 1



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APPARATUS FOR CONTROLLED DEPOSITION OF MATERIAL

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3 Sheets-Sheet 2

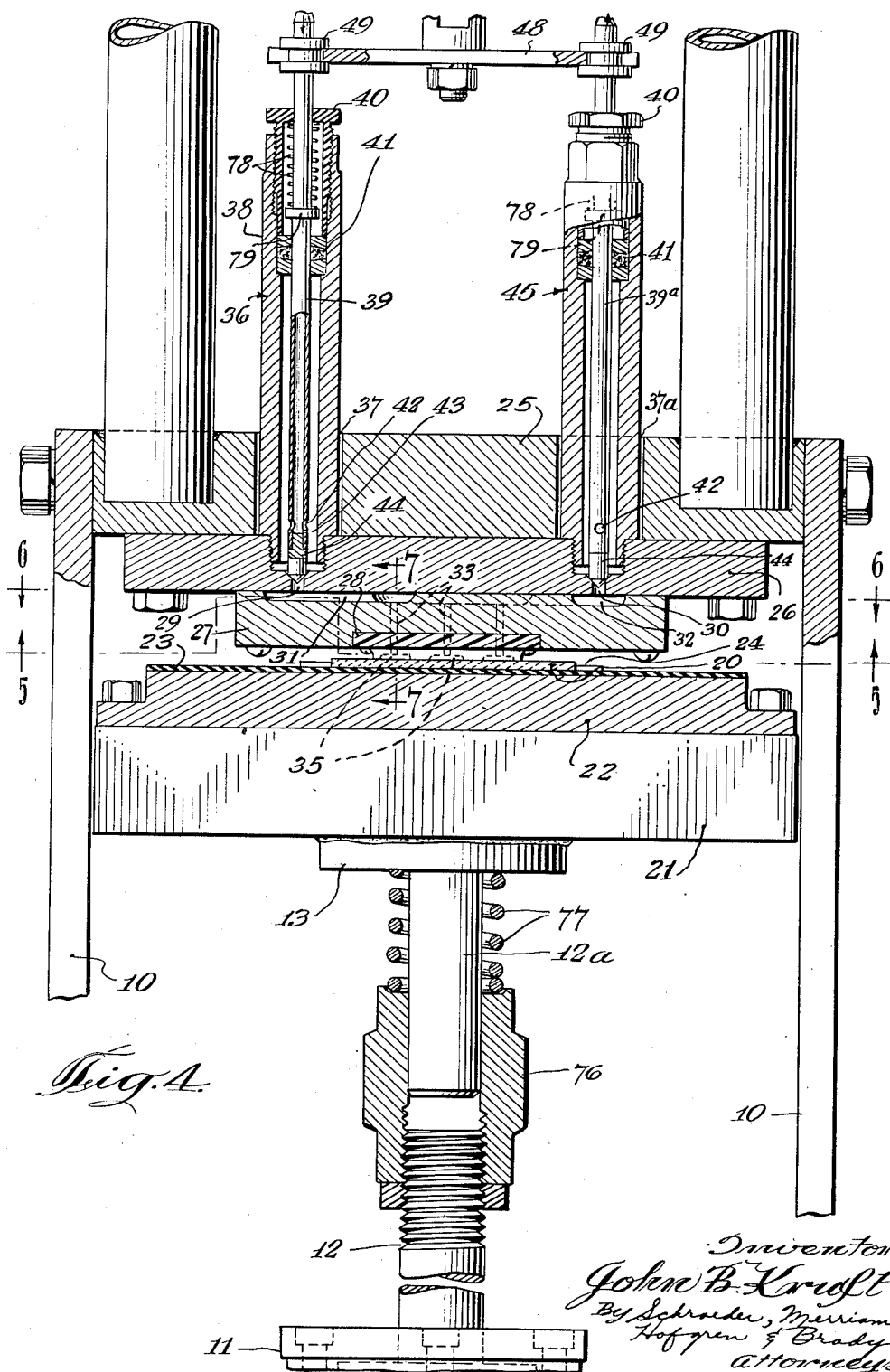


Fig. 4.

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Fig. 5.

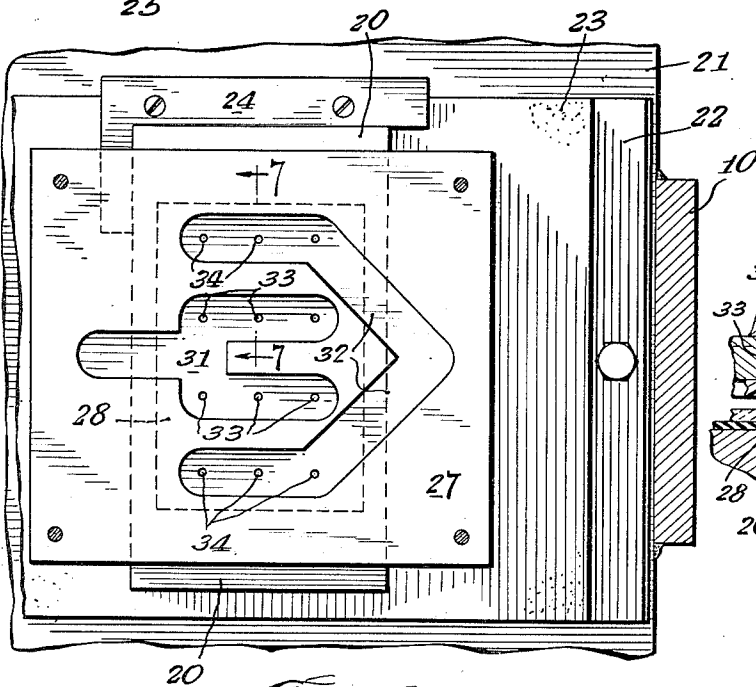
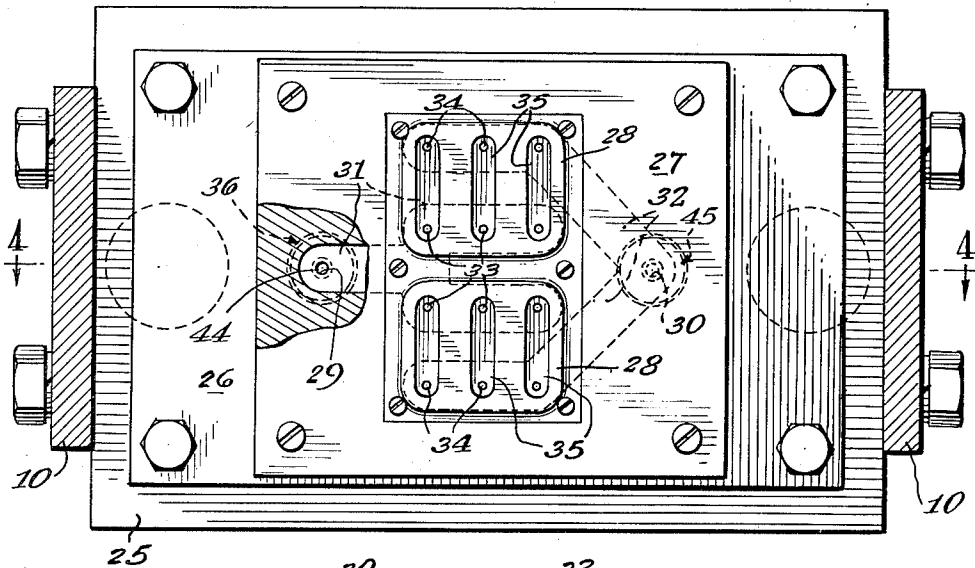


Fig. 6.

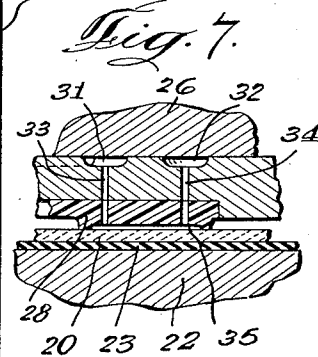


Fig. 7.

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APPARATUS FOR CONTROLLED DEPOSITION OF MATERIAL

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Application June 8, 1951, Serial No. 230,605

5 Claims. (Cl. 18—30)

This invention relates to an apparatus and method for the controlled deposition of material on a work piece and more particularly to depositing all types of molding material on an impervious work piece such as ceramic tile, plastic, or the like, or upon a pervious piece such as paper or cardboard if desired.

A number of difficult problems arise in attempting to deposit substantially identically equal amounts of molding material on a number of work pieces. These problems can be illustrated in the printing of electrical circuits on insulating work pieces such as ceramic tile, plastic, or the like. In printing a resistance element, it is very important that substantially identically the same length, width and depth of resistor material be deposited each time as the electrical resistance is very sensitive to small changes in the volume of material deposited and an electrical resistance variation of more than a few per cent is often critical in the operation of a circuit. Among other things, it is necessary to completely fill the matrix cavity used in depositing the material with resistor molding material for each depositing operation. This is very difficult when one realizes that the insulating work piece is impervious to air or gas at the temperatures and pressures used in the printing operation. No resistor material in excess of the amount filling the cavity can be allowed to deposit on the insulating work piece. In addition, the surface of each insulating work piece, particularly if it is a ceramic, is usually at least slightly irregular and wavy. To deposit substantially the same amount of resistor material on separate insulating work pieces requires that the contour of the matrix cavity surface conform substantially with that portion of the work piece on which the resistor material is to be deposited. Still another problem remains. Generally, the conducting lines and terminal spots of silver or the like are first formed on the work piece and this is followed by "printing" the resistance elements. These elements are located between the ends or terminal spots of the silver conducting lines and to ensure good electrical contact, a portion of each end of a resistance element laps over the end portion of the silver lines. Thus, in printing the resistance element, a portion of the matrix surface engages the raised step of the silver lines. It is very essential that the matrix surface engage in intimate, sealed contact the surfaces of both the raised silver line and the insulating work piece during printing to prevent seepage of the resistor material deposited on the work piece surface beyond the limits prescribed by the shape of the matrix cavity. This is also true for other steps or irregularities which might be present on the insulating work piece surface.

As disclosed hereinafter, this invention has features which solve these problems and as a result it is now possible to deposit substantially identically the same amount of molding material (well within limits of $\pm 5\%$ in resistance value, for example) on any number of separate work pieces. Other features and advantages will be apparent in the following specification and the drawings, in which:

Figure 1 is a front elevational view of the material depositing apparatus;

Figure 2 is a top elevational view of a representative work piece, a ceramic tile having silver conducting sections and resistor elements deposited by the apparatus;

Figure 3 is a cross-sectional view along the line 3—3 of Figure 2;

Figure 4 is a fragmentary enlarged vertical sectional view of a portion of the apparatus;

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Figure 5 is a bottom plan view of the matrix element, along the line 5—5 of Figure 4, partly broken away;

Figure 6 is a top plan view of the matrix element, along the line 6—6 of Figure 4;

Figure 7 is a fragmentary vertical sectional view, along the lines 7—7 of Figures 4 and 6.

In the particular embodiment of the invention as illustrated the printing apparatus is mounted in an upright press frame having a base and a pair of upright standards on which are fixedly mounted a matrix and the apparatus for feeding material to the matrix and for venting the matrix cavity when a work piece is in sealed contact with the matrix. The work piece is moved in a vertical direction away from and toward the matrix by raising and lowering a shaft on which is mounted a locating table supporting the work piece. This shaft is connected to a pneumatic ram actuated by a combination of a valve and air pressure. In this particular apparatus, the work piece is moved to engage the matrix surface. It is to be noted that one skilled in the art would have no difficulty in making the work piece support stationary and causing motion of the matrix.

Turning now to a more detailed description of this apparatus and particularly to the movable work piece portion, a pneumatic ram 11 having a vertically movable shaft 12 is mounted on the base of a press frame 10. This shaft is actuated up or down by a combination of air pressure and a valve 14, the air pressure being supplied through lines 15, 16, and 17 by air pressure source not shown in the drawing. A pressure regulator 18 located in the pressure line 15 controls the air pressure delivered to the pneumatic ram and the amount of this pressure is measured by the pressure gauge 19 also located in line 15. Valve 14 is located at the junction of the three pressure lines and when in the up position completes a pressure connection to the bottom of the ram cylinder causing the shaft 12 to move upwards and when in the down position effects movement of the shaft in a downward direction. Threaded on top of the shaft 12 is an adjustment sleeve 76, the top portion of which houses the shank portion of the rod 12a. This rod is freely movable in a vertical direction within the sleeve. Mounted atop the rod 12a is a bed 13 carrying a locating table which supports the work piece 20. A spring 77 surrounding the rod 12a bears on the top surface of the sleeve 76 and the bottom of the bed 13 and is in compression when the work piece and the matrix are in intimate contact. This spring serves as the means of accurately controlling the amount of pressure exerted by the work piece against the matrix. In this particular apparatus, the locating table consists of a lower press plate 21, welded to the bed, a locating table 22 bolted to the top surface of the lower press plate, and a make-ready pad 23 covering the top surface of the locating plate. This pad acts as a cushion for the work piece 20 and may be made of rubber or any other suitable material. Locating jigs 24 are rigidly mounted on the top surface of this pad, serving to properly align the work piece with the rigidly positioned matrix member located above it.

Turning now to the feeding and venting features relating to a matrix member and to the matrix itself, reference will now be had to Figures 1, 4, 5, 6 and 7. An upper press plate 25 is rigidly bolted to the upright standards of the press frame so that its bottom surface is directly above and parallel to the locating table. This plate serves as a cross member of the press frame and is a support for the upper portion of the frame. In addition, it carries a valve plate 26 bolted in face to face contact with its bottom surface which in turn carries a matrix block 27 rigidly fastened to the bottom surface of the valve plate. The flat bottom surface of this matrix block has a recess containing a securely imbedded resilient matrix insert 28. The combination of the matrix block and the imbedded matrix insert comprise the matrix member in this particular apparatus.

The preferred resilient insert is an element of material which is reluctantly deformable under pressure and which is not dissolved, softened, swelled, or otherwise deleteriously effected by the molding material. Such substances as styrene resins, vinyl resins, polyethylene having a molecular weight of at least 6000, butyl synthetic rub-

bers and the like are examples of the kind of material having properties which I prefer.

Particular attention will now be paid to the system of passages by which the material is led into the matrix cavity and to the passages for venting the matrix cavity (see Figs. 4-7). The valve plate 26 contains an inflow passageway 29 and an outflow passageway 30, each extending through the plate and leading to a plurality of inflow channels 31 and outflow channels 32 recessed in the top surface of the matrix block 27 but separate from each other. A plurality of inflow ducts 33 and outflow ducts 34 lead from the respective inflow and outflow channels through the matrix block 27 and the resilient matrix insert 28 to a plurality of separated cavities 35, there being one inflow duct and one outflow duct leading to each cavity. By means of these inflow passages, molding material is lead to the cavities and at the same time any gas or air trapped in the cavities 35 when the work piece 20 and matrix insert 28 are in intimate, sealed contact can be vented through the outflow passages. It is to be understood that the particular arrangement of channels, passageways and ducts can be varied greatly.

The feeding of molding material to the matrix cavity is controlled by an inflow valve 36 (Figures 1 and 4) which extends through a hole 37 in the upper press plate 25 and is threaded in the inflow passageway hole 29 of the valve plate. It has a vertical valve tube 39 along the center vertical axis of the valve housing 38 and extends above the housing. The portion of the valve tube 39 within the valve housing is sealed in the middle portion of the housing by a packing gland 40 and packing 41. A compression spring 78 mounted within the valve housing and surrounding the valve tube 39 bears on the bottom surface of the packing gland 40 in the housing and a ring 79 secured to the valve tube to urge the valve tube towards the closed position. Near the bottom of the valve tube is an aperture 42 leading from the tube to an annular chamber 43 surrounding the tube. This chamber extends to the base of the valve housing and leads directly into the inflow passageway 29. A push-off plunger 44 having a conical shaped point is connected to the end of the valve tube 39, this tube terminating a short distance below the aperture. The plunger blocks off the inflow passageway when the valve tube is in the down position as shown in Figure 4 preventing any molding material from flowing to the matrix cavity and also serves as the means for retaining any molding material present in the ducts 31 at the time of closing. When in the up position, the valve permits the flow of molding material to the matrix cavity through the inflow passages.

To completely fill the matrix cavity when the work piece is in intimate sealed contact therewith, it is necessary to vent the air and gas present in the cavity during feeding of the material. As disclosed in this particular apparatus, the venting of the matrix cavity is accomplished by including a vacuum. A vacuum line 55 connected to a vacuum pump not shown leads through a trap 56 and is connected to the outflow valve tube 39a. This tube of the outflow valve 45 has exactly the same structure and operates in exactly the same manner as the inflow valve 36. It in turn is connected to the outflow passageway 30 of the valve plate. Thus, when the valve tube is in the up position, a vacuum is drawn in the matrix cavity. When the valve tube is in the closed position, the vacuum is shut off and any material which happens to be in the outflow passages between the matrix cavity and the plunger is retained in the passage. It is to be understood that although a vacuum means of venting is herein disclosed, this invention is not limited to this particular means of venting.

In order to operate the inflow and outflow valves concurrently, a lever 46 is pivoted to bracket 47 secured to the frame and a link is pivoted to both the lever and the yoke 48. In this way, motion of the handle portion of the lever concurrently and simultaneously moves the tube members of the valves in an up or down vertical direction. The yoke 48, having bifurcated ends is secured to the valve tubes by means of couplings 49 secured to the portions of the valve tubes extending above the valve tube housing.

A reservoir 50, supported by cross members connected to the frame and located above the inflow valve tube 39 serves as the means for storing and supplying the molding material. This reservoir has a removable sealed top and clamp assembly 51 and is open at the bottom, having

a hose connection 52 leading from the bottom to the inflow valve tube 39. Air pressure is here supplied to the top surface of the molding material through a pressure line 52 which is connected to the reservoir and leads through its wall above the level of the molding material, a pressure regulator 54 controlling the air pressure delivered to the reservoir.

In operation, the work piece is brought into intimate, sealed contact with the resilient matrix insert by raising shaft 12 until the piston hits the top of the cylinder or some other appropriate mechanical stop. The spring 77 which surrounds the rod 12a on which is mounted the locating table supporting the work piece is then in compression and exerts the force necessary for obtaining a sealed contact between the matrix insert and the work piece. It is to be noted that by adjusting the sleeve 76, one is able to accurately control the amount of pressure existing between the matrix insert and the work piece when the shaft 12 is raised to its top position. When the work piece and matrix insert surfaces are in intimate, sealed contact, the operator opens the inflow and outflow valves by raising the lever arm 46. Molding material is then pressure fed from the reservoir through the inflow valve tube and passages to the matrix cavity. At the same time, a vacuum is being drawn in the matrix through the outflow passages of the outflow tube valve, the vacuum line thereby assisting the complete filling of the cavity. After a short period of time, when the cavities are completely filled, the operator closes the inflow and outflow valves by lowering the lever arm. As a result, the flow of material to the matrix is shut off at the inflow passageway and the outflow venting is shut off at the outflow passageway. At the same time, any material remaining in the inflow or outflow passages immediately above the mold cavity is retained therein so that when the work piece is moved away from the matrix, no added material remaining in the inflow or outflow passages is pulled back and deposited thereon.

Referring now more particularly to Figures 2 and 3, a representative product of my method and apparatus is illustrated in more detail. The work piece 20, to which reference has been made, may be a small ceramic tile, for example. As part of the process of making it a finished resistor block, it would have been primarily printed with conducting spots or terminal portions here identified as 60-66, the spots 60-62 being in a row at one end; the spots 60-65 being in a row at the other end, and the larger center conducting portion 66 being the common connection of all of the resistor elements in a particular circuit. The matrix element used in my apparatus may have six mold cavities therein, as has been illustrated, of the same or different sizes depending upon the resistance values desired, thereby resulting in the deposit of the six resistors 70-75 illustrated.

As is more particularly shown in accentuated form in Figure 3, the silver conducting areas 61 and 66, for example, by virtue of their thickness above the surrounding surface of the tile (which would normally be in the neighborhood of 1 or 2 thousandths of an inch) create a "step" over which the resistor deposit 71 must be accurately molded. The use of a resilient matrix element providing a perfect seal despite this step, and despite any minute irregularities in the intermediate surface of the tile, has proved extremely important in maintaining close tolerances of accuracy in the resistance values of the resistors thus printed. In order to prevent undue compression of the resilient insert, with possible variations in the volume of the mold cavity, I prefer to use a material of the kind described earlier which may be considered as "reluctantly" or only slightly yieldable. By virtue of the venting provided as the mold cavities are formed, a complete filling of the mold cavities on each operation is insured; and the provision of appropriate means in both the inflow and outflow ducts for holding any material therein prevents pull-back of this material when the mold is separated from the work piece, also improving the accuracy and uniformity of quantity of material deposited at each operation.

Certain aspects and features of the invention disclosed but not claimed herein are claimed in my copending continuation-in-part application, Serial No. 304,598, filed August 15, 1952, and assigned to the assignee of this application; and such aspects and features are not to be considered abandoned or dedicated to the public.

While I have shown and described certain embodiments of my invention, it is to be understood that it is capable of many modifications. Changes, therefore, in the construction and arrangement may be made without departing from the spirit and scope of the invention as disclosed in the appended claims.

I claim:

1. Apparatus of the character described for depositing a precise quantity of material on a work piece element to form a printed electrical circuit element, comprising: a matrix member including a block element of a material having a resiliency of the same order as the resiliency of polyethylene having a molecular weight of at least 6,000 having a surface with a relatively shallow cavity therein; means for causing relative movement of said element toward and away from each other, said means being adapted to bring a surface of the work piece element and said matrix surface into intimate, sealed contact, said matrix insert having sufficient resiliency to effect a seal with the surface of said work piece element, and having sufficient rigidity to prevent deformation of said cavity; an inflow duct passing through the matrix block element to the matrix cavity; means for feeding the material into the matrix cavity through the inflow duct; an outflow duct leading from the matrix cavity; means for venting the matrix cavity through the outflow duct when the work piece surface is in intimate, sealed contact with the matrix so as to permit complete filling of the matrix cavity, said outflow duct being so restricted relative to the material that it in cooperation with said vent means is adapted to retain any of the material passing thereinto; and means for stopping the feeding of material when a desired quantity has been delivered, said inflow duct being so restricted relative to the material that it in cooperation with said feed stop means is adapted to retain any of the material in the inflow duct.

2. Apparatus of the character described for depositing a precise quantity of material on an impervious work piece element to form a printed electrical circuit element, comprising: a matrix member including a matrix block and a matrix insert of polyethylene having a molecular weight of at least 6,000 and having limited resiliency imbedded in a surface of the matrix block, said matrix insert having a surface with a cavity therein; a locating table positioned in alignment with said matrix insert surface; means for causing relative movement between the locating table and the matrix insert surface so as to effect an intimate, sealed contact with a precisely predetermined pressure of a surface of the work piece element atop the table with said matrix insert surface, said matrix insert having sufficient resiliency to effect a seal with the surface of said work piece element, and having sufficient rigidity to prevent deformation of said cavity; inflow ducts feeding material under pressure into the cavity and onto the work piece surface; and a valve means for stopping feeding of material to the cavity, said inflow ducts being so restricted relative to the material that they cooperate with said valve means, retaining any of the material in the inflow ducts.

3. Apparatus of the character described for depositing material on a work piece element, comprising: a matrix element having a surface with a cavity therein; means for causing relative movement of said elements toward and away from each other, said means being adapted to bring a surface of the work piece element and said matrix surface into intimate sealed contact, the

contacting portion of at least one of said elements being of polyethylene having a molecular weight of at least 6,000 and having sufficient resiliency to effect a seal between said surfaces and having sufficient rigidity to prevent any effective change in the volume of said cavity; and means for feeding material to the matrix cavity when said surfaces are in sealed contact.

4. Apparatus of the character described for depositing a precise quantity of material on a work piece element, comprising: a matrix element having a surface with a cavity therein; means for causing relative movement of said elements toward and away from each other, said means being adapted to bring a surface of the work piece element and said matrix surface into intimate, sealed contact with a precisely predetermined pressure, the contacting portion of at least one of said elements being of a material with a resiliency of the same order as the resiliency of polyethylene having a molecular weight of at least 6,000, having sufficient resiliency to effect a seal between said surfaces and having sufficient rigidity to prevent any effective change in the volume of said cavity; feeding means including an inflow duct leading to the matrix cavity; and means for stopping the feeding of material when a desired quantity has been delivered.

5. Apparatus of the character described for depositing a precise quantity of material on a work piece element, comprising: a matrix element having a surface with a cavity therein; means for causing relative movement of said elements toward and away from each other, said means being adapted to bring a surface of the work piece element and said matrix surface into intimate, sealed contact, the contacting portion of at least one of said elements being of polyethylene having a molecular weight of at least 6,000, having sufficient resiliency to effect a seal between said surfaces and having sufficient rigidity to prevent any effective change in the volume of said cavity; means for introducing the material to the matrix cavity; means for venting the matrix cavity when the work piece and the matrix surface are in intimate contact with each other so as to permit complete filling of the matrix cavity, said means including a source of vacuum and an outflow duct leading from the cavity, said outflow duct being so restricted relative to the material that it in cooperation with the rest of said vent means is adapted to retain any of the material passing thereinto; and means for stopping the feeding of material when a desired quantity has been delivered.

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