Aug. 25, 1970 G. C. DEVOL 3,525,382

PROGRAM-CONTROLLED EQUIPMENT

Filed Oct. 26, 1967

Fig. 2

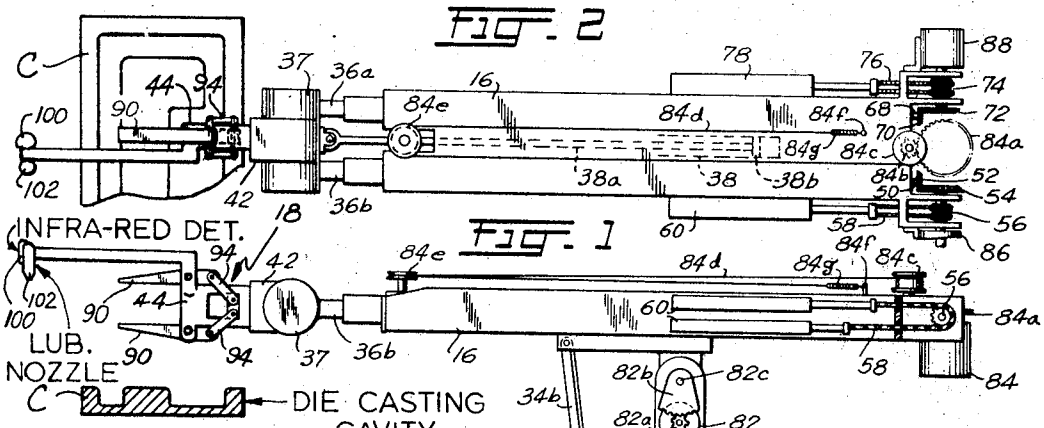


Fig. 1

Fig. 3

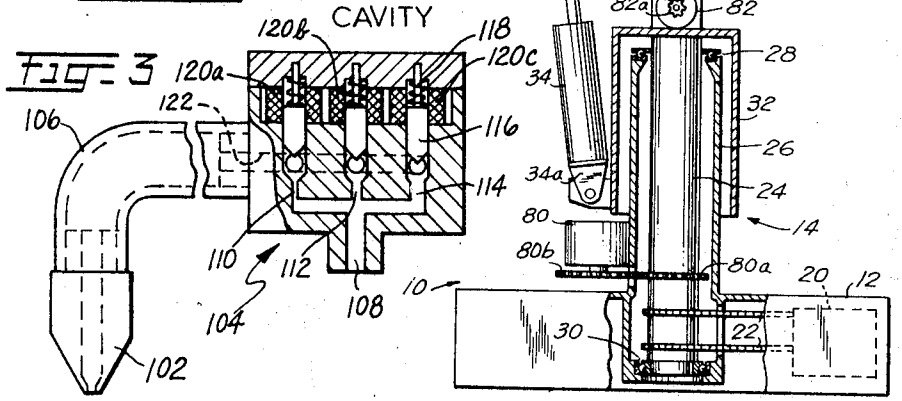
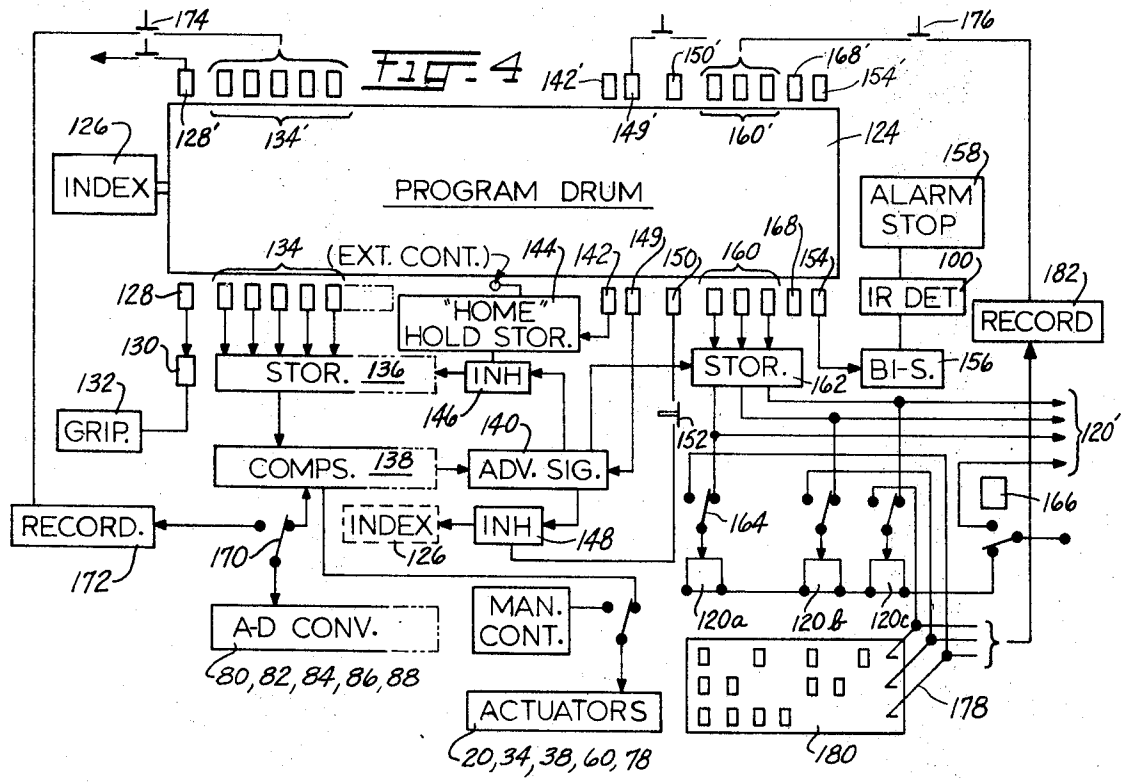


Fig. 4



United States Patent Office 3,525,382 Patented Aug. 25, 1970

3,525,382

PROGRAM-CONTROLLED EQUIPMENT

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Filed Oct. 26, 1967, Ser. No. 678,340
Int. Cl. B22c 19/04; B22d 47/00; B29c 3/06
U.S. Cl. 164—154 14 Claims

ABSTRACT OF THE DISCLOSURE

The present invention relates to automatic apparatus for servicing the cavity of die-casting machines, forging machines and the like, after each casting or forging cycle, to prepare the die or cavity for the ensuing cycle by clearing it, inspecting it to be sure it is empty, and coating it with lubricants or release agents. One particular aspect of the invention relates to automatic apparatus for treating a casting cavity with controlled amounts of a release agent or lubricant. More generally, this aspect of the invention relates to controlled treatment of various objects with fluids, as by coating an article with paint and sealant, and by applying spots and strips of glue in controlled amounts and at controlled areas. In the discussion that follows, there is specific mention of die-casting machines to which several features of the invention have special application; but that discussion is intended as illustrative, as to features of the invention that have general application.

Die-casting machines customarily have ejector pins for lifting a casting out of contact with the cavity, to be removed by appropriate means. Nevertheless, part of a broken casting or a whole casting could be stuck in a cavity, and in the following cycle this condition could result in damage to the machine or in a defective part. An object of the present invention resides in providing for automatic inspection of the cavity to indicate that a casting or part of a casting is present in the cavity, by an alarm or by stopping the machine, or both.

Attendants of casting machines often have the duty of spraying a release agent or a lubricant into the casting cavity. Some casting machines have been equipped with automatic jets for this purpose. Another object of this invention resides in providing apparatus for automatically limiting the application of fluid to correspond with the area to be coated and, more particularly, for controlling the amount of fluid that is applied to different parts of the area to be coated. A still further object of the invention resides in providing novel apparatus for selecting automatically the material to be applied to each of several different parts of the area to be treated.

A still further object related to the foregoing objects resides in providing integrated apparatus to serve as an automatic attendant to an essentially rudimentary casting or forging press, readily adaptable to machines of different sizes and forms and various shapes of dies or cavities, for executing automatically the various operations following each forming operation, in preparation for the next forming operation. Such preparatory operations optionally include some or all of these functions: (a) To lift the casting from the cavity and transfer it to a receiving station; (b) to apply a cavity-cleaning air blast at critical parts of the casting cavity; (c) to inspect the cavity for detecting any parts of a previous casting that might remain in the cavity; and (d) to select and apply controlled amounts of coating materials to the various parts of the cavity.

A still further object of the invention resides in providing novel automatically controlled means for coating different areas of an article with fluid using a controlled nozzle in coordination with the sequence of motions of

the nozzle and the article relative to each other; more particularly, for controlling the discharge and rate of discharge of fluid in dependence on the outline of the article and on the successive parts of the article to which the fluid is directed.

The foregoing objects and others, and further novel features of the invention, will be more fully appreciated from the discussion that follows of an illustrative embodiment of the various aspects of the invention, which is shown in the accompanying drawings. The described apparatus utilizes an article-handling apparatus of known construction that is capable of gripping and releasing a casting and transporting the casting in any desired path in three dimensions as well as tilting and rotating the casting as it moves from a pick-up position to a delivery position. Successive motions are carried out automatically under control of a program that is established during a preliminary "teaching" sequence of like motions under manual control. Article-transfer machines of this type are shown, for example, in my Pats. Nos. 2,988,237, 3,306,471 and 3,279,624. In my Pat. No. 3,251,483, such apparatus is used for removing a casting from a die-casting machine.

Such apparatus is utilized here for three special functions auxiliary to the operation of the illustrative machine. It carries multiple nozzles whose motion and aim are operated through sequences of program-controlled motions to scan the cavity while, in coordination, valves are controlled to release blasts of air at certain parts of the cavity and to issue controlled amounts of selected lubricants or release agents to the casting cavity. Further, a heat detector is moved in a scanning pattern for indicating whether any part of a die-casting has inadvertently been left in the cavity. This indicator can be used to sound an alarm or to shut down the casting machine, or both.

The heat detector is especially effective here, where it can function when merely directed toward the cavity, and can scan across the cavity and trace the pattern of the cavity. However, other forms of detector for a retained casting are contemplated, such as a switch with a resilient probe, or a switch actuated by pressure build-up in a resilient-tube probe that directs an air jet against the cavity. Such probes are carried in a scanning or tracing motion across the cavity, but the motion-control program will then include motions of the probe into the cavity.

Multiple nozzles can be operated selectively to determine the fluid that is released and the amount of the selected fluid can be varied under program control. In coordination, the nozzle(s) can be moved in a pattern of program-controlled motions. Where the nozzles are used to coat a forging die or a casting cavity with a lubricant or release agent, each part of the die or cavity can receive the right amount of the selected fluid and different fluids may be used in different areas. This is of obvious advantage over simple "on" and "off" control of a nozzle to spray a whole cavity, where excessive lubrication in some areas is wasteful and a harmful accumulation could develop in some areas.

The nature of the invention, together with the foregoing and other novel features and advantages, will be better appreciated from the following detailed description of the illustrative embodiment shown in the accompanying drawings which form part of the disclosure of this embodiment.

In the drawings:

FIG. 1 is a lateral view of the novel program-controlled apparatus shown together with a cavity of a die-casting machine, portions being broken away and shown in cross-section;

FIG. 2 is a plan view of the apparatus in FIG. 1;

FIG. 3 is a view drawn to greatly enlarged scale of one of the nozzles forming part of the apparatus in FIGS. 1 and 2, together with a fluid-supply control valve; and

FIG. 4 is a block diagram of the control and coordinating portions of the apparatus of FIGS. 1–3, including control means for coordinating this apparatus with a casting machine.

Referring now to FIGS. 1 and 2, an article-handling unit **10** is shown having a pedestal **12**, a post assembly **14**, an arm **16** and an article holder **18**.

Pedestal **12** encloses a drive unit **20** having a dual sprocket-and-chain connection to rotatable shaft **24**. Fixed cylinder **26** on pedestal **12** carries an upper bearing **28** for shaft **24**, and lower rotary thrust bearing **30** for shaft **24** is also provided in pedestal **12**.

Arm **16** has a horizontal pivotal axis defined by suitable bearing detail (not shown) at shaft **82***c* at the top of shaft **24**. A cylindrical guard shell **32** surrounding cylinder **26** is fixed to shaft **24**. Near the bottom of this guard shell there is secured one part **34***a* of hydraulic actuator **34**, while the extensible shaft **34***b* connected to an internal piston in actuator **34** is secured to arm **16** for effecting vertical motion of arm **16** about its bearing aligned with the axis of shaft **82***c*.

A pair of tubular shafts **36***a* and **36***b* are telescopically received in bores in arm **16**. Shafts **36***a* and **36***b* carry head **37** of the article holder **18** and accommodate radially outward and inward movement, and hydraulic actuator **38** moves head **37** to project and retract article holder **18**. Hydraulic actuator **38** in arm **16** includes a piston **38***b* and a rod **38***a* connected to head **37**. Depending on admission of hydraulic fluid to one side or the other of piston **38***b*, head **37** moves in or out.

Suitable mechanism contained in head **37** operates article holder **18** to make wrist motions about the axis of the cylindrical portion of head **37** and to make a twist motion about an axis between jaws **90**. A suitable mechanism in head **37** providing these motions is shown and described in detail in my Pat. 3,306,442, being omitted here in the interest of conciseness. Shaft **50** (at the right in FIG. 1) is suitably coupled to the wrist-motion mechanism in head **37** and carries a bevel gear **52** meshed with driving bevel gear **54**, and the latter is itself driven by a dual sprocket-and-chain connection **56**, **58** to two-part hydraulic actuator **60**. Chains **58** are pulled at one end or the other by two-part actuator **60** and causes wrist-motion of head **37**.

Shaft **68** (at the right in FIG. 1) produces a twist motion of article holder **18**. Shaft **68** is driven by bevel gears **70** and **72**, a sprocket-and-chain drive connection **74**, **76**, and another two-part hydraulic actuator **78** like actuator **60**. Through the transmission described, actuator **78** twists article holder **18** about its axis between and parallel to its jaws **90**.

From the foregoing, there are seen to be five motions carried out by the apparatus in five degrees of freedom, effected by actuators **20**, **34**, **38**, **60** and **78**, respectively. The position of each driven part is represented by so-called analog-to-digital encoders or shaft-position encoders. Thus, for indicating the rotary position of shaft **24**, gears **80***a* and **80***b* couple encoder **80** to shaft **24**. For each significant, discrete position of of shaft **24** in its total range of motion (300°, for example), encoder **80** produces a distinctive, unique code which is a numerical representation of that position. Likewise, arm-positioning encoder **82** is coupled by gear **82***a* and drive sector **82***b* to shaft **82***c* that is fixed to arm **16**. Encoder **84** for indicating the radial position of head **37** is coupled via gears **84***a*, **84***b*, to an internally spring-tensioned drum **84***c* about which is wound a cable **84***d*. The latter extends about an idler **84***e* fixed to rod **38***a*, and to a pin **86***f*, via tensioning spring **84***g*. Encoders **86** and **88** likewise provide digital codes representing, respectively, the wrist position of part **42** and the twist position of part **44**.

Head **37** carries a pair of jaws **90** for seizing and releasing an article. Jaws **90** are pivoted on pins in twist part **44**. A piston in a cylindrical bore in part **44** is connected by pairs of links **94** to jaws **90**. Fluid under pressure is admitted to one side of piston **92** from a suitably controlled source of pressure. Jaws **90** are normally biased open by suitable spring means. The jaws are closed by controlled supply of air or liquid under pressure.

The article handling unit **10** thus far described is a known unit that is well suited to the purposes of the present invention. That unit is shown and described in my Pat. 3,306,471, issued Feb. 28, 1967, where it is shown that the actuators for producing motions in the five degrees of freedom are operable under digital-code control, or under other forms of program control such as a continuous-path contour recording on a magnetic record, and other well-known types of control. The control programs are recorded (as described below) in an initial manually controlled sequence of operations. Subsequently the operations are repeated automatically under control of the recorded program. Such a machine is said to be "teachable," for carrying out new motions as required from time to time.

The presently preferred form of recorded-program control for the above-described actuators uses a digital code that is recorded on a magnetic drum, further described below. See also the forms of control shown and claimed in my Pats. 2,988,237 and 3,279,624.

The article-handling unit as thus far described is capable of seizing and releasing castings and of carrying the article holder through motions determined by program recordings. Machines of this form have heretofore been used in many widely varying applications, including the job of removing newly finished heavy, hot castings from a die-castiing machine.

In FIGS. 1 and 2, head **18** carries a number of devices for automatic cooperation with a casting machine (and similar apparatus such as molding machines) to carry out further purposes. After a casting has been removed from the die-casting cavity, head **18** is programmed to scan the cavity repeatedly for auxiliary operations concurrently and/or during successive scanning cycles:

(A) A heat-detector, especially an infra-red cell, is caused to "inspect" the cavity during the motion of article holder **18** as it carries a just-released casting to a discharge position. If the casting were to be frail so as to be subject to breaking, then the detector would be programmed to scan different parts of the cavity to detect broken parts of a casting remaining in the cavity.

(B) A high-pressure jet of air is directed at the various parts of the cavity, either continuously or at critical moments, for blasting residual bits of material from the different parts of the cavity.

(C) A lubricant or release is appled in controlled amounts at different parts of the cavity, or different lubricants may be applied at various parts of the cavity, the material thus applied being delivered as a spray or as a jet, and being a liquid or a powder such as graphite entrained in an air stream.

For this purpose, head **18** carries an infra-red detector **100** and a nozzle **102**. This nozzle may be supplied selectively with various fluids, or nozzle **102** may represent one or more additional nozzles for providing an air blast, a lubricant and a second lubricant, as may be appropriate. A suitable form of control for supplying lubricant to nozzle **102** is shown in FIG. 3. Different amounts of material can be dispensed at different parts of the traverse of of nozzle **102** along the contour of the cavity, the variation being in accordance with a prescribed program. A valve **104** suitable for "digital" program control is connected by a tube **106** to nozzle **102**. Inlet passage **108** is connected by three valve-controlled orifices **110**, **112** and **114** that are small, medium and large, proportioned to provide (for example) a minimum stream, twice the minimum and four times the minimum stream, respectively.

These orifices are controlled by valves **116** that are biased closed by springs **118** and opened by coils or electromagnets **120***a*, **120***b* and **120***c*, all three orifices when open communicating with exit passage **122**. "Off" plus seven different rates of flow can be provided, by energizing coils **120** in various combinations. Other adjustable valves may be suitably adapted to program-control.

The illustrative apparatus thus far described is controlled and coordinated with a casting machine by teachable control apparatus shown diagrammatically in FIG. 4. This control apparatus here includes a magnetic recording drum **124** that is indexed stepwise by a drive **126**. In any one of its positions, drum **124** presents a "slot" of discrete control spots for concurrent sensing at rest by the magnetic pick-up heads represented by small rectangles appearing diagrammatically in a row below drum **124**. These may be of a form described (for example) in my Pat. 2,988,237 and other patents mentioned there. Magnetic recording heads diagrammatically represented as being separate from the sensing heads are shown as a row of small rectangles above drum **124**. Other "teachable" forms of program-control are known and, if preferred, may be used in place of the sense-at-rest form of magnetic control used here, such as high-speed magnetic drums or discs with gated pick-up heads, magnetic tape, and other; and see my Pat. 3,279,624 wherein a "teachable" punched-tape program-control system is used. Various types of sensing elements (such as electric, electromechanical, fluid-amplifier and photoelectric) may be used with perforated tape.

Sensing head **128** controls gripper jaws **90**, responding to "set" and "reset" a bistable device **130** to activate and release the jaw control **132** such as a solenoid-operated fluid-pressure control valve for the piston that operates jaws **90**.

A series of sensing elemens **134** are provided, one group for each degree of freedom and including as many sensing elements per group as there are bits in the combinational code (gray code, binary or other) used to represent digitally the positions or coordinates of each significant point in the pattern of motions to which the five programmed parts of the apparatus are to move head **18**. The codes sensed by the heads **134** are transferred to storage elements collectively designated **136**, which may be magnetic (Pat. 2,988,237) or solid-state or fluid-logical or other, as deemed suitable. The output of storage assembly **136** is applied to a comparison device **138** to which there is also applied the output of analog-to-digital converters **80**, **82**, **84**, **86** and **88**. Comparison device **138** may take various forms, as in my Pat. 2,998,237 or 3,308,471; or in Pat. 2,927,258 of Bernard Lippel. When the apparatus has been operated to the positions represented in a given "slot" of drum **124**, comparison device **138** produces an output signal actuating "advance" signal generator **140** to activate storage apparatus **136** to register the codes of the next "slot" of drum **124** sensed by elements **134** and, immediately thereafter, to cause drive **126** to advance drum **124** to the next slot.

The drum has a certain maximum capacity, and most programs use only part of the capacity of a drum. It is customary to provide suitable controls to advance the drum from the end of the program cycle to "home," for example, the start of the program. During this advance, the whole apparatus is held stationary under control of the codes retained in storage apparatus **136**. At the end of a program, sensing element **142** applies a signal to bistable unit **144** that acts on an inhibit gate **146** to prevent resetting of the storage assembly and, at the same time, unit **138** continues to supply "advance" control via normally operative inhibit gate **148** for repeated or continuous operation of index drive **126**. Head **149** senses a sequence of gating spots between the end of the program and its start, to assure a continuous train of index-advance pulses to unit **140**.

When the end of the program has been reached, unit **144** sends an external control signal to start the casting-machine cycle. Sensing head **150** supplies a signal before the "home" or start-of-program slot of the drum is reached for interrupting the advance of drum **124**, acting via normally closed switch **152** and inhibit gate **148**. With output from sensing head **150** and drum **124** at rest, the control apparatus awaits completion of the casting cycle. Then the casting machine opens switch **152** briefly, and inhibit gate **148** transmits an "index" signal so that the drum completes its return "home," to start a new cycle. Elements **144** and **152** thus coordinate the illustrated apparatus with a casting machine so that each executes its cycle and then starts the cycle of the other.

When the cavity C of the die-casting machine is open, and the ejector pins have lifted the casting from the cavity wall, the apparatus of FIGS. 1 and 2 can be operated to seize the hot casting, and then remove it to a delivery point. Head **18** is equipped with a heat detector **100** such as a photoelectric cell responsive selectively to infrared light. The selectivity may be due to the characteristic of the cell, or a cell that is photo-sensitive over a broad spectrum may be made selective to heat radiation by a filter that excludes other wave-lengths. During the same operation of head **18** in removing a casting under program control, detector **100** is caused to scan the cavity C. The article transfer apparatus carries out the program-controlled motion of transferring a hot casting from the cavity; and during this same motion and without requiring allowance of time for a separate detection sequence, the detector is effective to signal failure of the intended removal of a casting. The heat detector **100** is located on arm **16** beyond the gripper jaws **90**, if the sensing motion is to be a retraction stroke. In any case, detector **100** is directional, the scan trailing the gripper **90** in its casting-removal stroke, and is disposed to avoid responding to the casting that is held by jaws **90** as that casting is being removed from cavity C.

Output from the detector **100** in excess of a normal level representing the temperature of the die-casting cavity will indicate the presence of part or all of a die-casting still present in the cavity, and this level of output causes an indicating means **158** to turn on an alarm or stop the whole apparatus, or both.

As head **18** advances to seize a casting that is ordinarily lifted clear of the cavity wall by ejector pins, detector **100** ordinarily sweeps across the casting, although sometimes the program of motions can be complicated to avoid this effect. Likewise, plural detectors **100** can be interconnected by an "or" gate to a common output point and moved across the cavity side-by-side if all parts of the cavity are to be inspected. Accordingly, a control recording is provided on drum **124** opposite pick-up head **154** in that "slot" of the recording drum that corresponds to the start of the scanning operation for detecting a retained part of a casting. Drum **124** also has another recording opposite pick-up head **154** at the next slot of drum **124**, or at the slot corresponding to the end of the casting-removal stroke. Plural slots might be used for this phase of the program, so that detector **100** can be carried through a program of motions to trace cavity C, looking for a broken part of a casting that might remain in the cavity. Bistable device **156** responds to the first recording detected by element **154** for turning "on" the infrared detector (or for enabling unit **158** to respond to the detector) and later, when the scanning motion of detector **100** is complete, the bistable device **156** is reversed by a signal from pick-up **154** so that the detector **100** and the indicating means **158** are disabled.

Assuming that there is no difficulty, preparations for another casting operation continue. The program of drum **124** causes the head **18** to execute one or more scanning motions with nozzle **102** (or another nozzle, not shown) directed at the cavity. The aim of the nozzle can be varied during the scanning motions, and where there are multiple

parts of the cavity to be scanned, this is also readily included in the program of motions. One nozzle **102** may deliver a high-pressure air jet. Nozzle **102**, or other nozzles like it, may deliver a fluid lubricant or release agent, such as graphite carried by an air stream, or a liquid, as determined by the application. The amount of fluid that issues from nozzle **102** is controlled by valves **120***a*, **120***b*, and **120***c*, and the fluid can be turned on and off and varied from point-to-point during the scanning operations. For controlling rate-of-flow, sensing heads **160** are included to sense a portion of the recorded program on drum **124**, and transfer the sensed combination code to storage unit **162**. The output of storage unit **162** acting through selector switch **164** energizes valve electromagnets **120***a*, **120***b* and **120***c* in selected combinations. Switching relay **166** may be operated under control of a further sensing element **168**, also optionally through a storage element (not shown) to connect storage unit **162** to another set of fluid supply valve electromagnets **120'**. In this way, the particular material that is emitted may be selected automatically and it may be changed at different parts of the scanning motion. Moreover, the amount of fluid that issues from nozzle **102** or any selected nozzle carried by head **37** can be adjustably controlled from point to point during the scanning motion of head **37** over the pattern of the casting cavity.

A recording on drum **124** is provided for detection by sensing element **142** at the completion of the sequence of auxiliary functions executed by head **37**. This will cause unit **144** to retain in storage unit **136** the coordinates that determine the position of head **37**. At the same time, unit **144** will emit an "external control" coordinating signal to start the casting machine cycle. The comparison units **138** would be "satisfied" because the value in storage unit **136** and that provided by the A–D converters would match. Drum **124** continues to advance from slot to slot, and sensing element **149** provides input to "advance" signal generator **140** to step the drum from the end of the program toward the start.

Just before the return of the drum to the home position, sensing element **150** detects a control recording providing control for inhibitor gate **148**, thus interrupting advance of the drum. Upon completion of the casting cycle, the casting machine opens switch **152** for releasing gate **148** to resume indexing of the drum to the starting position, thereby to commence a new sequence of auxiliary operations of head **37**.

Each of the sensing elements **128**, **134**, **152**, etc., has a corresponding recording head **128'**, **134'**, **142'**, etc., here shown as a separate head. These recording heads are energized by various related manually controlled switches during preliminary "teach" operations. For the purpose of "teaching" the described apparatus to execute the necessary operations, the apparatus of FIGS. 1 and 2 is operated under manual control to assume the appropriate sequence of positions. During this time, a selector switch **170** is set to the position opposite to that illustrated, for connecting the analog-to-digital converters **80**, **82**, **84**, **86** and **88** to a recording signal generator **172**, connected in turn via manual switch **174** to the recording heads **134'**. At each distinctive position in the path of motions carried out by head **18** under manual control, switch **174** is closed to record the coordinates represented by the analog-to-digital converters. In each slot corresponding to any given set of head-position coordinates, there may also be recorded the necessary controls for the other functions in the above-described sequence of operations. For the purpose of determining the amount of fluid that is to be supplied by nozzle **102**, subsequently under program control, switch **164** may be set to the position opposite to that illustrated. In that setting, recording heads **160'** are connected by manual switch **176** to a series of brushes **178** that scan a combination-code pattern of contacts **180**. Brushes **178** can be manually adjusted relative to the encoding contacts **180**. During the teaching phase of operation, positioning of member **180** adjustably relative to brushes **178** will operate solenoids **120***a*, **120***b* and **120***c* in various combinations, thereby to control the amount of fluid that issues from nozzle **102**. When the desired amount of liquid is flowing from the nozzle, switch **176** is pressed and unit **182** energizes recording heads **160'** in selected combinations. Subsequently, during the program-controlled operation of the apparatus, the combination code recorded by heads **160'** will be sensed by elements **160**. Fluid will then be discharged at the same rate under program control of the adjustable valve assembly shown in FIG. 3. The rate of fluid delivery may be changed from point to point in the course of the manually controlled scanning operation, by changing the setting of combination control contacts **180**, in coordination with the motions of head **37** executed under manual control and recorded by heads **134'**. The particular liquid that is dispensed may also be controlled by appropriate recordings made by head **168'**, later to be sensed by head **168** and used to control relay **166** for selecting which one of plural fluids shall be discharged during any given part of the sequence of scanning motions.

All the program controls mentioned above in connection with the automatic operation of the apparatus are recorded by appropriate recording heads during a manually controlled sequence of operations. Those recording operations are not detailed here since they will be readily understood from the description above of how recording heads **134'** and **160'** are used. The described apparatus is notably effective and meets long-standing needs in die-casting machines. However, it will be appreciated that certain features are more broadly useful. The use of coordinated control of the motions of nozzle **102** and of the discharge of fluid, both as to the amount of the discharge and "on" and "off" control of the discharge, are widely useful. Thus, the arm may be programmed to traverse an article to be painted in a succession of motions chosen to cover the area, and the flow of paint may be coordinately controlled by recorded program so as to limit the flow to the outline of the article to be painted or certain areas of the article, to vary the amount of flow in different areas for improved uniformity, and to select multiple coating materials to be applied to different parts of an article.

As described above, after jaws **90** grip a casting, the same motion of head **37** for removing a casting from cavity C is utilized for causing detector **100** to scan the cavity. For this reason detector **100** is spaced far enough from jaws **90** to avoid responding to the hot casting being removed. By like token, in case the lubricant is also to be discharged during the casting-removal stroke of head **37**, the nozzle **102** is spaced far enough from jaws **90** so that the casting being removed does not obstruct the discharge of lubricant. Where there is only time for a single stroke of head **37** across the cavity, it will be of advantage to use plural nozzles **102** moving in side-by-side paths, each being independently controlled in the manner described.

The novel features of the foregoing illustrative embodiment of the invention will be readily modified by those skilled in the art, and various other applications of those features will be evident; and therefore the invention should be broadly construed in accordance with its full spirit and scope.

What is claimed is:

1. Apparatus for attending a die-casting machine and the like, including a heat-responsive detector for sensing a newly formed hot article present in a forming cavity of the machine, means automatically operable after the cavity has been opened for removing a formed article from the cavity, program controlled means automatically operable after the formed article has ostensibly been removed for causing the detector to execute a scanning pattern of motion relative to the cavity, and means responsive to said detector at successive parts of the scanning pattern of motion for selectively indicating when at least a part of a formed article has remained in the cavity.

2. Apparatus for attending die-casting machines and the like, including a metal-shaping cavity, a head having supporting means and actuating means for moving the head in three-dimensional paths, program control means including a stored program and sensing means therefor for causing the head to move through a sequence of prescribed motions, said head carrying a heat-responsive detector and fluid-emission means, and said program control means including portions for causing said head to move said heat-responsive detector through a program of motions to explore said metal-shaping cavity and said detector being responsive to any hot metal parts that may remain in said cavity, said program control means including portions for causing said head to direct said fluid emission means to various parts of said cavity successively and for coordinately controlling the emission of fluid in relation to the successive parts of the cavity toward which the fluid emission means is directed.

3. Apparatus in accordance with claim 1, wherein said fluid emission means includes at least one nozzle carried by said head and a high-pressure air supply for clearing said cavity of residue.

4. Apparatus for attending die-casting machines and the like, including a detector for sensing an article present in a forming cavity of the machine, said detector being heat responsive in the infra-red temperature range of an article newly formed of heat-softened metal, program-controlled means automatically operable when the forming cavity of the machine is open and after a formed article has ostensibly been removed from the cavity for causing said detector to sense the cavity, and means responsive to said detector selectively for indicating when at least a part of a formed article has remained in the cavity, said apparatus further including an article gripper for seizing a formed article, and means for causing the article gripper to remove a newly formed article from the cavity and for causing the heat-responsive detector to sweep across the cavity in the same motion, trailing the article being removed.

5. Apparatus in accordance with claim 2, wherein said fluid emission means includes at least one nozzle carried by said head and article-releasing fluid supply means connected thereto.

6. Apparatus for treating an object with fluid, including fluid emission means comprising a nozzle for emitting fluid, means for supplying fluid to said nozzle, and means for controlling the rate of fluid emission from said nozzle, said apparatus also including program control means comprising a stored program and means responsive thereto, and actuating means controlled by said stored-program responsive means for directing said nozzle toward various parts of an object successively, and for coordinately causing automatic variation in the amount of fluid emitted by said nozzle in accordance with the various parts of the object toward which the nozzle is directed.

7. Apparatus in accordance with claim 7 wherein said fluid emission means includes a manual control for adjusting the amount of fluid emission from said nozzle, and wherein said apparatus includes program recording means for establishing said stored program and means operable coordinately with said manual means for controlling said program recording means to establish portions of said stored program for subsequently controlling the automatic variation of fluid emission as aforesaid.

8. Apparatus in accordance with claim 6 wherein said fluid emission means includes a manual control for adjusting the amount of fluid emission from said nozzle, and wherein said apparatus includes combination-code program recording means for establishing at least parts of said stored program and means operable coordinately with said manual means for providing combination codes for said program recording means to establish portions of said stored program for subsequently controlling the automatic variation of fluid emission as aforesaid.

9. Apparatus for attending die-casting machines and the like, including a head having supporting means and actuating means for moving the head in three-dimensional paths, program control means including a stored program and sensing means therefor for causing said actuating means to move the head through a sequence of prescribed motions, and lubrication emitting means including a nozzle and lubrication supply means, said head carrying an article holder and said nozzle, and said program control means including program portions for causing said article holder to seize a newly formed article and for causing removal of an article from the cavity in which it was formed by program controlled motion of the head and said program control means including portions for rendering said lubrication emitting means selectively operable in accordance with motions of the head traversing the cavity.

10. Apparatus in accordance with claim 9, further including an article sensing detector carried by said head and carried into cooperation with said cavity under program control.

11. Apparatus for attending die-casting machines and the like, including a nozzle for dispensing lubricant for the cavity in which articles are formed, adjustable means for supplying variable amounts of lubricant to the nozzle, means automatically operable when the cavity is open to direct the nozzle to different parts of the cavity, and means coordinated with said automatically operable means to control said adjustable means for causing variation in the amount of fluid dispensed by the nozzle in accordance with the various parts of the cavity toward which the nozzle is directed.

12. Apparatus for treating an object with fluid, including a head having supporting means and actuating means for moving the head in three-dimensional paths and for controlling the attitude of the head, program control means including a stored program and stored-program responsive means for controlling said supporting and actuating means to move said head through a sequence of prescribed motions and attitudes, fluid emission means including a nozzle carried by said head and operable therewith in three-dimensional paths and aimed thereby in accordance with the attitudes of the head, and means for supplying fluid to said nozzle, said stored program including program portions for controlling the emission of fluid from said nozzle in coordination with the motion and aim of said nozzle under program control.

13. Apparatus in accordance with claim 12, wherein said fluid emission means includes a manual control for adjusting the amount of fluid emission from said nozzle, and wherein said apparatus includes program recording means for establishing said stored program and means operable coordinately with said manual means for controlling said program recording means to establish portions of said stored program for subsequently controlling the automatic variation of fluid emission as aforesaid.

14. Apparatus in accordance with claim 2, wherein said fluid emission means includes means responsive to a portion of said program control means for varying the rate of fluid discharge in coordination with the direction of fluid emission to various parts of the cavity caused as aforesaid under control of the program control means.

References Cited

UNITED STATES PATENTS

2,349,176	5/1944	Kopitke	18—5
3,303,537	2/1967	Mislan	18—16
3,306,442	2/1967	Devol	214—1
3,417,810	12/1968	Tiskus et al.	164—150

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U.S. Cl. X.R.

18—16; 164—269