Oct. 9, 1951 J. A. SARGROVE 2,570,600

APPARATUS FOR METALLIZING ARTICLES

Filed Feb. 13, 1948 2 Sheets-Sheet 1

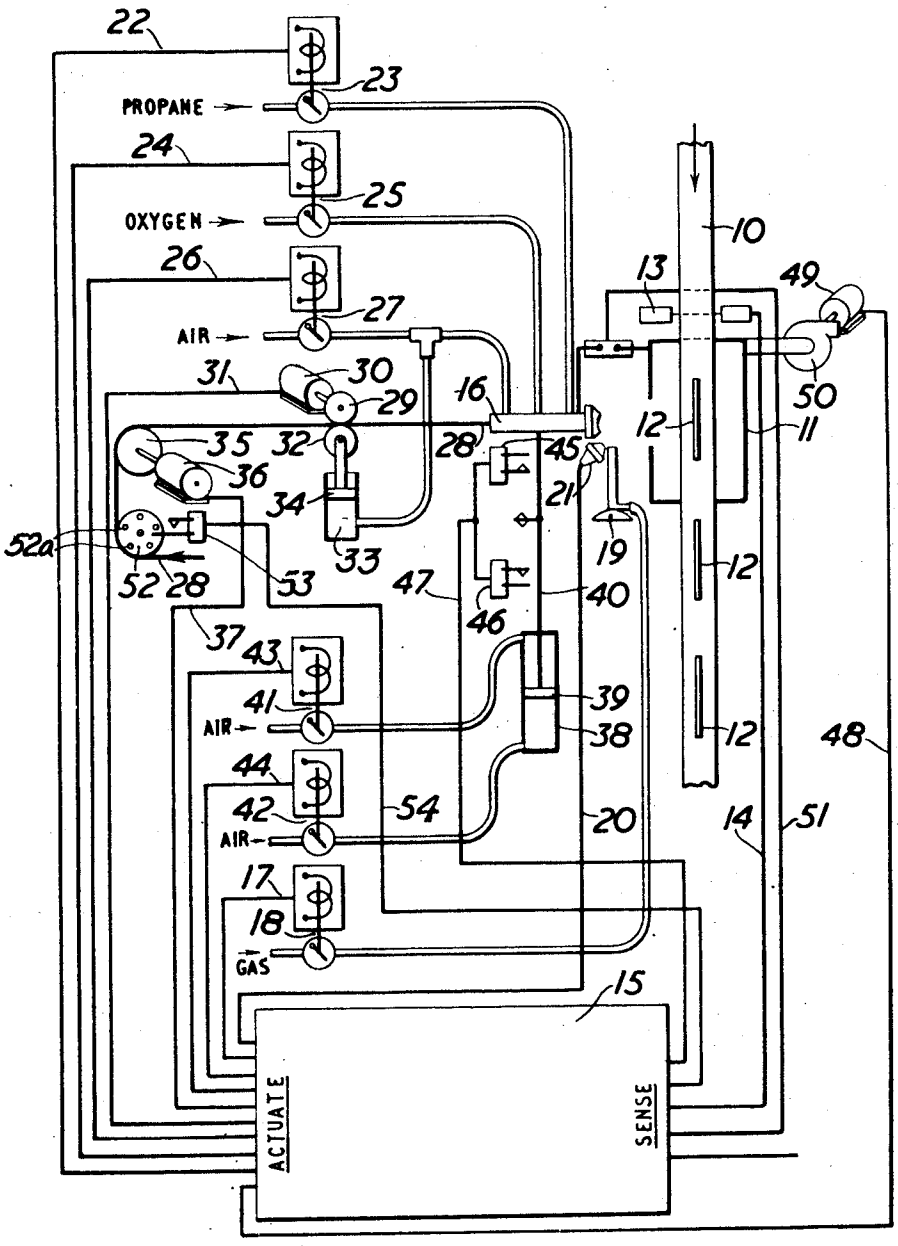


FIG. 1.

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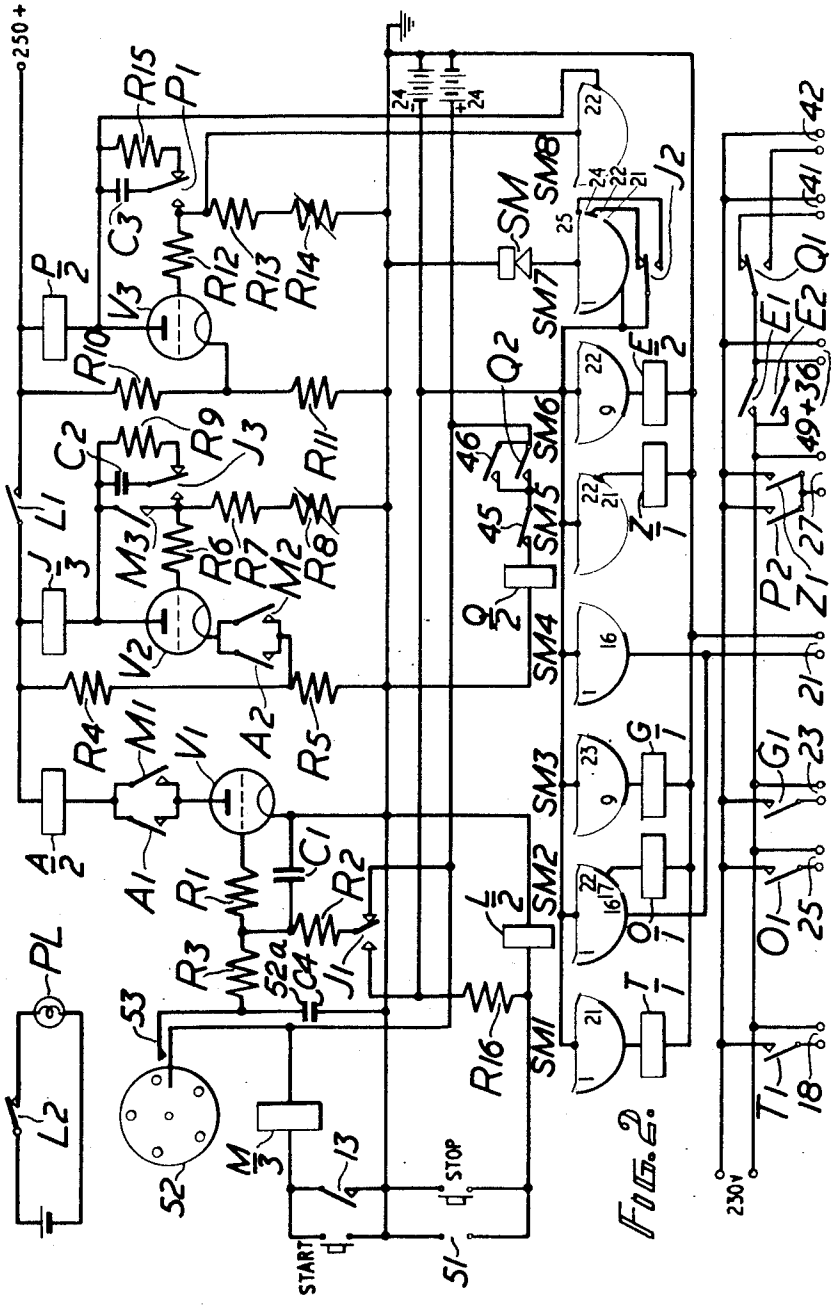


FIG. 2.

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APPARATUS FOR METALLIZING ARTICLES

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In Great Britain February 19, 1947

13 Claims. (Cl. 91—12.2)

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This invention relates to apparatus for metallizing articles.

In my co-pending U. S. application, Serial No. 549,770, filed August 16, 1944, now Patent No. 2,474,988, there is disclosed a method of producing radio and kindred apparatus which involves the production, for example by a moulding process, of an insulating panel in which are formed grooves and depressions of particular shape; metal is then deposited upon the panel and in the grooves and depressions the excess metal on the surface of the panel being subsequently removed to leave formed upon the panel some or all of the components of the apparatus together with the wiring thereto. It is to this process that the present invention is primarily, but not exclusively applicable.

In carrying into effect this process, it is most desirable that there should be completely automatic operation, and the reduction to a minimum of the need for human supervision of the process. It is, therefore, necessary to provide means for starting and stopping the apparatus automatically and also for stopping the apparatus if any stage of the process should cease to operate satisfactorily, so that a number of reject articles may be reduced to a minimum. It is also desirable that the various stages of the process should be started and stopped only when one of the panels is being handled in order that the material used in each stage of the process is not unnecessarily consumed.

With this object of automaticity in view, it is convenient to effect the metallising deposit by means of metallising guns of known construction to which is supplied the metal to be atomised, usually as wire, and a supply of fuel and other gases for the production of heat, gas pressure and velocity necessary for atomising and spraying the metal. In the automatic operation of such metallising guns, it is thus necessary to control automatically the supply of the gases and of the metal to be atomised, and to effect ignition of the gases.

In the operation of metallising guns it is always a matter of difficulty to start the guns spraying properly, to the extent that hand operation of the guns requires a high degree of skill and, so far as we are aware, automatic starting has never been satisfactorily carried out in practice. The reasons for this are many; in the first place the gases which are used to provide the calorific value of the gas mixture at the gun nozzle are not capable of being readily ignited in working conditions. Propane and

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oxygen are frequently used for generating the necessary heat, with compressed air for producing the blast for directing the molten metal, which is fed as a wire into the flame.

Correct flame conditions, difficult as they are to obtain, are not however sufficient to ensure correct gun operation; correct wire feed is also important since the melting of the wire accounts for a substantial proportion of the heat consumed. If for any reason the wire fails to feed into the gun, the gun nozzle will overheat and may eventually damage the gun. At the same time it is clearly wasteful for the wire to be fed too rapidly in advance of the commencement of the gun operation.

According to one feature of the present invention therefore we provide means whereby the wire feed in a metallising gun can be controlled, and according to the invention there is provided a wire feed mechanism which is controlled by an air-operated clutch, from the same air supply as that supplied to the gun for producing the blast from the nozzle. It will be realised that while this feature is of particular importance in an automatic apparatus, it is also applicable to manually operable guns.

In a fully automatic metallising apparatus according to the present invention means are provided for starting the metallising process automatically on the perception of an article to be metallised and for stopping the metallising when such article has passed the metallising station or after a predetermined time, and means are also provided for stopping the process if there is an excessive or insufficient supply of the metal being atomised, or if any of the gas or other supplies is not present in sufficient quantity or pressure.

To secure fully automatic and economic operation of any apparatus it is necessary to make provision not only for starting the apparatus automatically, but also for stopping it in the event of faults or abnormal operation. Automatic operation of any apparatus is not justified if the production results in any excessive number of reject articles, and it is therefore necessary to ensure that the apparatus will be stopped if anything occurs which would result in a defective panel. For example with metallising apparatus the apparatus must stop if the gun flame should be blown out, or if any one or more of the gases supplied to the gun should fail, which would result in the metal not being melted and sprayed.

According to a further feature of the present

invention means are provided whereby, in the event of the wire being fed from the gun without being melted and sprayed the unmelted wire makes contact with a conducting member, and the making of an electrical connection is used to initiate corrective action, in this case stopping the apparatus.

Although this arrangement is simple and can be easily arranged upon the spraying apparatus, the making of the contact will be an indication of several abnormal conditions. Thus, the wire will be fed unmelted, and the contact made, if there is a failure in the supply of any one or more than one of the three gases fed to the gun, if the flame does not ignite properly, or if the flame is extinguished, or if the wire should be supplied at excessive speed. In this way there can in fact be given by this arrangement in a very simple way warning of the occurrence of nearly all abnormal conditions of the spraying apparatus likely to cause the production of reject panels, with the exception of underfeeding or stoppage of the wire to be metallised.

According to a further feature of the invention, wire underfeed, including complete failure of the wire to feed, is indicated by arranging that the wire is passed over a pulley, upon rotation of which a pair of contacts are momentarily closed at intervals as the pulley rotates, and means are provided to stop the apparatus if closure of these contacts is not effected within predetermined time intervals.

One embodiment of the invention will now be described with reference to the accompanying drawings. In these drawings:

Figure 1 is a diagram showing the general arrangement of a metallising stage such as may be adopted as one stage of a process for the manufacture of electrical apparatus in accordance with my aforesaid co-pending application.

Figure 2 is an electrical circuit diagram of the arrangement of Figure 1, showing in particular the control unit therein.

The apparatus for carrying out this process comprises a series of cubicles through which the articles to be treated are conveyed by means of a suitable multi-section conveyor **10**, and after initial treatment in certain of such cubicles by grit blasting and cleaning, the articles are presented to the metallising cubicle **11**, shown in Figure 1.

As the panel **12** or other article approaches or enters this metallising cubicle **11**, it initiates the operation of the metallising apparatus; this may be effected by means of a presence detector **13** such as a mechanical latch switch or trolley switch, or a light source and a control photocell. The presence detector **13** is coupled over a control line **14** to a main control unit **15**. This unit, which is shown in more detail in Figure 2 and will be described with reference to that figure hereinafter, is arranged to be responsive to a number of supervisory or sensing devices which are connected to input terminals Sense to control certain operations from output terminals Actuate.

The first stage in starting the operation of the apparatus is the ignition of the flame from the metallising gun **16**.

Preferably metallising guns are arranged on opposite sides of the conveyor through the cubicle **11** and may consist of batteries of guns; these batteries may be arranged in the manner disclosed in another of my co-pending applications Ser. No. 10,702, filed February 25, 1948.

To avoid waste of sprayed metal it is desirable that the metallising guns should be ignited and operated only when the metallising of a panel is being carried out, and unit **15** is therefore arranged automatically to ignite the gun when a panel is presented to the metallising apparatus, and to permit the spraying process to continue for a time sufficient for one panel to be sprayed and then to stop the spraying process. If however a further panel is presented to the apparatus, the spraying will continue for a further period, and so on.

The control unit is arranged to ignite the main flame from the gun by means of a primary jet; over a control line **17** the unit energises a normally closed, electromagnetically operated valve **18**, which thereby permits a fuel gas, such as town's gas, of a more easily ignitable nature than the gas supplied to metallising gun **16** to be fed to a pilot burner **19**. Over a control line **20** the control unit **15** operates a sparking plug **21** of the usual type, and thereby ignites the primary jet. If there is used a battery of guns **16** arranged one above the other in each battery, it may be desirable to provide an additional burner, similar to burner **19**, for each gun, the additional burners being directed horizontally but arranged substantially one above the other and the primary burner directly vertically upward and arranged below the lowest additional burner. The primary burner then ignites the secondary burners (which are not provided with sparking plug igniters), which are in turn arranged to ignite the main guns. It is difficult to ignite a series of guns from the one primary jet as the lowermost gun tends to blow the igniting flame from the upper guns.

The control unit also controls the supply to the gun **16** of the necessary gases; over control line **22** valve **23** is operated to supply the fuel gas, such as propane, to the gun, and over control line **24** valve **25** is operated to supply oxygen to the gun. Over control line **26**, valve **27** is operated to feed compressed air to the gun, and with sequence of operation the necessary flame is produced at the gun nozzle or nozzles.

With this operation, however, it is most important that the wire should be fed to the gun; as mentioned above the guns can be damaged if the flame continues without wire being fed. According to a feature of the invention, this wire feed is effected by the application of the air pressure to the gun.

The wire **28** is fed from a drum, not shown, over the face of a drive roller **29** driven by a motor **30**, which is under the control of the unit **15** over control line **31**. The engagement of the wire **28** with the roller **29** is however inadequate to cause the wire to advance, but the necessary friction is obtained by means of a backing roller **32**; this latter roller is movable by means of air pressure device, shown diagrammatically in Figure 1, as comprising a cylinder **33** and piston **34**. The cylinder is supplied from the compressed air line controlled by valve **27**. Thus, as soon as air is admitted to the gun by valve **27**, the backing roller moves toward the roller **29**; the wire is thereby fed to the gun simultaneously with the starting of the gun flame, which is very desirable.

In practice, the rollers **29** and **32** and the air operating means for the latter roller are structurally combined with the gun assembly **16**, and the cylinder **33** may be replaced by a diaphragm or equivalent air operated device.

The wire 29 is drawn from a drum which must be of large capacity in order that the process may run for as long periods as possible without stopping for re-loading. A servomechanism is therefore included to assist the unreeling of the drum. This comprises a capstan pulley 35, driven by motor 36, under the control of the unit 15 over control line 37. So long as there is any slack in the wire between pulley 35 and rollers 29, 32, the wire, which is passed once round the pulley, slips, but when the slack is taken up by the commencement of pulleys 29 and 32 to drive the wire is tightened upon the pulley and motor 36 then takes the major part of the load of drawing the wire from the drum.

For the metallising of many articles it is likely that the spread of the molten spray from the guns is insufficient to produce uniform spraying of the articles. As the articles move horizontally past the gun or guns the spray can be made uniform by moving the conveyor at strictly uniform speed and the speed may be controlled to control the thickness of deposit. If, as is the case when metallising panels made in accordance with the method described in my co-pending application Ser. No. 549,770, the articles are of more than very small vertical dimension as they stand upon the conveyor it is desirable that the guns be rocked so as to spray at varying vertical heights. Preferably this rocking motion should be vertical and linear.

If uniformity of deposit is of importance then this rocking motion cannot be effected by say an eccentrically-driven member, since the resulting motion of the gun will be a simple harmonic motion, and the thickness of deposit will increase at the limits of travel. A simple means for rocking the gun in such manner that its motion is linear, i. e. uniform with respect to time, and which is illustrated more completely in my aforesaid co-pending application Ser. No. 10,702, is shown diagrammatically in Figure 1 and comprises a cylinder 38 within which is a piston 39 mechanically coupled to the gun by a rod 40. The piston is double-acting, and air is admitted to one or other of the ends of the cylinder through air valves 41, 42 under the control of unit 15 over control lines 43, 44 respectively. The rod 40 is also arranged to operate a pair of limit switches 45, 46 which are coupled over the control line 47 to the sense input of the control unit. As each limit of travel of the piston is reached, one or other of the limit switches is operated and the valves 41 or 42 moved under control of the control unit to secure extremely rapid reversal of the movement of the gun.

At a suitable point in the sequence of operation initiated by the presence detector, the control unit 15, over control line 48 starts a motor 49 driving an exhaust fan 50 for the cubicle 11. This causes a flow of air over the panel being sprayed assisting the cooling of the panel, and draws off combustion products from the cubicle.

As thus far described the apparatus which is shown in Figure 1 will, all being well, start the metallising operation and will run for a given period of time, and will then stop unless further panels are presented to the detecting device 13.

For the satisfactory operation of the apparatus it is necessary to ensure that the apparatus is stopped if any conditions arise which produce defective metallising, including no metallising, of the panels. Thus if a metallising gun is not correctly ignited, if the supply of any one or more of the gases to the gun should not occur, if the flame should be extinguished fortuitously, or if the wire feed should fall below the requisite amount, or if the main supply of electric power should fail; in the event of any one or more of these contingencies arising the apparatus must be stopped. Moreover if, say, the power supply should be cut off and then restored, the apparatus must not be left in a dangerous condition or restored to a dangerous condition.

As with all automatic machinery it is not economic to provide for contingencies of very low probability of occurrence since with good practice the machine will be operated with periodic, but not continuous, skilled maintenance. Thus it is no requirement for economic automatic operation to protect the machine against mechanical breakages or derangements since a maintenance engineer can be expected to anticipate such breakages, or to repair them manually. Notwithstanding this, however, the protection of the machine as a whole is a complex matter.

With one feature of the present invention, a particularly simple arrangement is adopted to give warning of a number of possible defects of the apparatus. If any of the gases supplied to the gun fails, or the flame is extinguished, the wire will continue to feed from the gun and will emerge as an unmelted wire from the nozzle. According to the invention the gun, which is in electrical contact with the wire to be melted is insulated from a member immediately in front of the gun and with which the wire will contact if not melted. This member is conveniently provided by the frame of the cubicle itself, from which the gun or gun battery is electrically insulated. The completion of an electrical circuit between gun and cubicle is used over control line 51 to control one of the sense inputs of the unit 15, which thereupon effects the desired control operations.

Where the arrangement of the gun assemblies is as described in my co-pending application No. 10,702, the insulation of these assemblies is simply effected by mounting the rocking means for these assemblies in suitable insulating bushes. It will be clear that it is necessary also to insulate the wire and the wire reels from electrical contact with the main body of the cubicle and this is conveniently effected by providing for the wire in its passage from the reel to the guns guide pulleys over which the wire passes and which are mounted so as to be insulated from the cubicle. If the reels for the wire are of metal, it is necessary also for these to be insulated from the cubicle by means of suitable insulating washers.

In order to check that sufficient wire is being fed to the gun, we prefer to make use of one of the guide pulleys for example the guide pulley 52 and to arrange for pins 52a on such pulley to operate in its rotation a pair of contacts 53, motion of the pulley successively closing these contacts; as shown in my co-pending application Ser. No. 10,702, the contact mechanism 53 is so constructed that any stoppage of the pulley, even at the moment of contact, is arranged to open the contacts. Over the control line 54 the periodic closure of contacts 53 is applied to a sense input of the control unit 15. As will be described below, the contacts are employed on each closure to remove a normally prohibitive bias on the grid of a valve; if the contacts are not closed again within a given time the prohibitive bias is restored, but on each closure of

the contacts the bias is again moved from the prohibitive value. It will be observed that this arrangement is self monitoring in that valve failure, in which the anode current of the valve falls to zero, has the effect of stopping the apparatus.

To stop the metallising process should the electric supply fail while metallising a panel all the gas supplies are controlled by electromagnetic valves of the type which close in the absence of energising current. Valves of the so-called motorised types which require electrical energy to effect opening and closing are not suitable; it is preferable to use valves of the type where closure is effected by gravity or spring return whilst electrical energy has to be applied all the time the valve is open.

In Figure 2 of the accompanying drawing is shown by way of example one circuit arrangement of a control unit such as 15. In this diagram the various control lines connected to the unit 15 are not drawn as extended lines, but for convenience the diagram has been made more compact. The diagram of Figure 2 therefore includes the electrical circuit of the unit proper, and includes as elements the various gas and other valves.

Before describing the arrangement of Figure 2, however, it is desirable to indicate the relation of this metallising stage with the associated stages with which it forms a complete and automatic machine for producing substantially complete electrical apparatus. Upon presentation of a moulded panel to the machine, the first stage of the machine, namely the grit blaster, is started and the succeeding stages are brought to a state of readiness to receive the panel as it is presented to them.

As the panel proceeds through each stage of the machine it starts the processing in that stage, and after some or each of the stages the processed panel is tested. If the panel differs from a standard by more than a tolerable amount, the relevant stage of the machine is adjusted if that is practicable; if not, the relevant stage and all the preceding stages are stopped, but the succeeding stages are not affected. If adjustment is made and still does not result in the production of satisfactory panels, the relevant stage will be stopped after, say, three panels have been produced with characteristics outside the permitted tolerance. An alarm or indicator is also operated to call the attention of the maintenance engineer.

In the particular apparatus in which the arrangement of Figure 2 is intended to be incorporated, two metallising stages are incorporated; the arrangement of Figure 2 relates to the first stage.

In this arrangement, the operation is initiated by closure of contacts 13 of the presence detector bearing that reference in Figure 1; for test purposes there is provided a push button Start in parallel with these contacts. Closure of contacts 13 completes the circuit of a relay M/3 between earth and positive terminal of a +24 volt earthed-negative supply. On operation of the relay M/3 its contacts M1 close, and thereby complete the anode circuit of a valve V1, of which the cathode is earthed, and the anode is connected through contacts M1 and a relay A/2 to a source of anode supply. The grid circuit of valve V1 includes a grid resistor R1 shunted by a condenser C1 and, under the control of changeover contacts J1, the grid is returned through a high value resistor R2 either to the line 24— or to a line 24+ connected to the positive terminal of an earthed-negative supply. The potential of the grid of the valve V1 is also controlled from the contacts 53 on pulley 52; these contacts are connected to the line 24+ and through the resistor R3 to the grid of the valve. A condenser C4 is connected between the contacts and earth.

With the contacts J1 in the position shown, there is placed upon the grid of the valve V1 a substantial positive bias, so that upon closure of the contact M1 a large anode current flows in the valve and relay A/2 operates.

Relay M/3 when operated also closes contacts M2 which are included in the cathode circuit of a second valve V2. The cathode of this valve is thereby connected to a point upon a potential divider formed by resistors R4, R5 across the anode supply, the cathode thereby being connected to a point of positive potential with respect to earth. The grid of valve V2 is connected to earth through three resistors R6, R7, R8 of which R8 is variable, but by a contact M3 of relay M/3 the grid can be connected over a direct path through to the anode of the valve through resistor R6. With contacts M3 closed therefore the valve conducts, and the anode current in this condition is sufficient to operate a relay J/3 included in the anode circuit of the valve.

The initial operation of contacts 13, or the start button will be momentary, and to prevent the relays A/2 and J/3 dropping out when the contacts 13 open, contacts A/1 of relay A1 are arranged in parallel with contacts M1 to maintain the relay A/2, and contacts A2 are in parallel with contacts M2. Contacts M3 are not shunted by any contacts of relay A/2.

The operation of relay J/3 as described above is employed to set in motion a multi-bank stepping switch of usual construction having banks SM1 to SM8, each bank having 24 positions and one "home" position. The drive magnet SM of this switch is connected between the wiper arm of the bank SM7 and earth, and contacts 1 to 21 of this bank are connected to 24— and to the moving contact of changeover contacts J2 of the relay J/3. Contacts 22 to 24 are connected to one of the stationary contacts J2, and the home contact 25 of the bank is connected to the other stationary contact J2.

As soon as contacts J2 change over, the home contact of bank SM7 is connected to the voltage line 24— and the wipers of all the stepping switches step rapidly to position 22, and in doing so the sequence of starting the metallising process takes place. As soon as position 1 is reached, bank SM1 completes the circuit of a relay T/1 across terminals earth and 24—; the relay operates and its contacts T1 energize the electromagnetic valve 18 of Figure 1, and town gas is applied to the primary jet 19. This valve remains open until position 21 of the switches is reached.

At position 1, banks SM2 and SM4 are connected in parallel to supply current to the primary winding of the ignition device 21; parallel contacts are used as a comparative large current is required for this purpose. The ignition device continues to operate over positions 1 to 16 of the switches.

At position 9, bank SM3 completes the circuit of a relay G/1, the contacts G1 of which energise the valve 23, and thereby feed propane or similar

fuel gas to the metallising guns, and this gas will continue to be fed whilst the switches are on positions 9 to 23. Also at position 9 and at succeeding positions up to 22 bank SM6 energizes relay E/2 the contacts E1, E2 of which, in parallel to increase their current-carrying capacity, supply power to the exhauster motor 49 and to the motor 36 for the capstan pulley 35.

At position 17 banks SM2 and SM4 stop supplying the ignition device 21, and bank SM2 energizes relay O/1 the contacts O1 of which supply power to valve 25 and cause oxygen to be fed to the guns.

At position 21 and also at position 22 bank SM5 energizes relay Z/1 the contacts Z1 of which cause operation of valve 27 to apply compressed air to the guns and to cause the zinc wire to feed. At position 21, as described above, the town gas supply valve closes, and the stepping switch comes to rest on position 22, since the drive magnet is deenergized on reaching contact 22 of bank SM7.

As soon as the switch bank SM6 reaches position 9 and relay E/2 operates, voltage is applied through contacts E1 and E2 and through contacts Q1 of a relay Q/2 to one or other of the valves 41 or 42 controlling the oscillation of the gun. The coil of the relay Q/2 is connected between earth and 24+, and includes contacts of the limit switches 45 and 46 in series, the contacts 46 being shunted by contacts Q2 of the relay. Contacts 45 are normally closed and are momentarily opened at the limit of movement of the gun, while contacts 46 are normally open and are momentarily closed at the other limit of movement. As shown in the position of Figure 2 contacts 46 and Q2 are opened, and the relay Q/2 is deenergized; contacts Q1 are as shown, and valve 41 is operated. Air is thereby admitted to the upper side of piston 39 which accordingly moves downwardly until it reaches the lower limit of movement and switch contacts 46 are closed. Relay Q/2 then operates, changing over contacts Q1 to energise the valve 42 to reverse the direction of movement of the piston 39. Contacts Q2 close, so that the relay Q/2 remains operated after the limit switch contacts 46 are opened. The piston moves to the other limit of movement; contacts 45 are opened, relay Q/2 drops out and the cycle of movement is continued. The metallising process should now be performed satisfactorily.

It is necessary to stop the apparatus after a predetermined time interval, representing the time taken to process one panel, and this is effected by means of a time-delay resistance-condenser combination associated with the grid circuit of the valve V2. This grid circuit includes a condenser C2 which, when relay J/3 is not operated is discharged through contacts J3 and a resistor R9. When a panel is presented to the apparatus, as described above, the relays M/3 and J/3 operate, and in this condition the condenser C2 is connected in parallel with contacts M3, and the condenser terminals are therefore at the same potential.

When the trailing edge of the panel passes the presence detector its contacts 13 open, and relay M/3 is de-energized; relay A/2 remains operated and the anode and cathode circuits of valves V1 and V2 are complete. As soon as the contacts M3 open, however, the short circuit is removed from the terminals of the condenser C2 and the condenser begins to draw a charging current through relay J/3 and resistors R7, R8. As the voltage on the condenser increases so the grid of the valve becomes more negative and the anode current decreases; there are accompanying effects in that the grid current decreases as the grid potential decreases, but the resultant is that after a time delay, adjustable by resistor R8, the anode current of valve V1 drops to a value where relay J/3 is no longer held operated.

When relay J/3 drops out, contacts J2 change over and the drive magnet SM is energised over the contacts 22 to 24 of the switch bank SM7, and all the switches return to the home position. The oxygen control valve 25 is released at position 22 and the fuel gas valve at 23 and the exhaust motor is de-energised at 22. In practice it is found to be desirable to leave the metallising guns with a short length of wire, about half-an-inch long, protruding from them, and means are therefore provided for maintaining the power supply to air valve 27 for a short time after the other supplies are cut off. With this object there is provided a valve V3 which is somewhat similar to valve V2 in its operation. The cathode of the valve is connected to a point of positive potential upon a potential divider formed by resistors R10, R11 and the anode circuit of the valve includes a relay P/2. The grid of the valve is returned to earth through resistors R12, R13, R14—of which the last is adjustable. In the normal condition there is placed between grid and cathode of the valve a bias which is sufficient to prohibit anode current; the relay P/2 is therefore normally released.

When the switch bank SM8 passes over position 22, however, the resistor R12 is connected between grid and anode of the valve, anode current flows and relay P/2 operates. Contacts P1 of this relay change-over and thereby disconnects a condenser C3 from a discharge resistor R15 and connects it between anode and grid circuits of the valve; as described in connection with valve V2, this arrangement sustains the anode current of the valve while the condenser charges up. The relay P/2 also has contacts P2 in parallel with the contacts Z1 of relay Z/1, so maintaining operation of air valve 27 and thus feed of the wire for a time determinable by the value of the adjustable resistor R14.

It is also necessary to stop the apparatus if the wire is not fed at sufficient speed, and this is done by controlling the grid potential of valve V1 by contacts 53. When the apparatus is started and relay J/3 is operated, its contacts J1 remove the grid return of valve V1 from 24+ and connect it to 24−, but owing to the inclusion of resistor R2 and the condenser C1 in the grid circuit a time delay occurs before the grid potential of the valve has fallen to a value sufficient to cause relay A/2 to release and, by breaking the cathode circuit of valve V2 at its contact A2, causing the relay J/3 to release and stop the apparatus in the manner described above.

If the contacts 53 are periodically closed, however, as when the wire is feeding at the correct speed, the contacts periodically charge a condenser C4 from the line 24+ and this charged condenser is connected to the grid of valve V1 through resistors R3 and R1. This condenser augments the charge on condenser C1 and thus delays the change of anode current necessary to release relay A/2; if the condenser is recharged sufficiently rapidly the anode current change is delayed indefinitely.

The apparatus must also be stopped if con-

tact is made between the gun and its cubicle, presenting a short circuit on the control line 51, as will occur if the wire is fed unmelted. For this purpose a relay L/2 is provided normally energised through a resistor R16 from the line 24—, the relay contacts L1 controlling the anode supply to the valves V1 and V2. When contact is made across the line 51 a short circuit is placed on the winding of the relay L/2, and the relay releases contacts L1 opening and removing anode supply voltage to valves V1 and V3. Contacts L2 of this relay close when the relay releases, and completes the circuit of a pilot warning lamp PL. A stop push button Stop is also provided, its contacts in shunt to the line 51.

As thus described the arrangements of Figures 1 and 2 provide a fully automatic, self-monitoring metallising apparatus, which has been found satisfactory and reliable in operation. For the purpose of carrying out the process of my co-pending application Ser. No. 549,770 however, it is desirable that the metallising should be effected in two stages, and the equipments of Figures 1 and 2 are therefore largely duplicated, and are interlocked so that if the first of the two stages should fail or become defective for any reason the second may continue to operate, whilst if the second should fail, both stages are stopped.

Moreover, three stages may be provided, the control units of which may be interlocked so that any two stages may operate, the third stage being brought into service as soon as one of those two units becomes unserviceable.

I claim:

1. A metallising device including a spray gun to which metal is fed as a wire for melting and ejection from the nozzle of the gun as a molten metallic spray, means for feeding wire in continuous form to said gun, means for supplying combustible gases to said gun and igniting the same for melting the wire as it is fed to said gun, means for supplying pressure gas to said gun for ejecting the molten metal from the gun nozzle, and means responsive to the projection of unmelted wire from the gun nozzle in the event of failure of the gun to melt the wire for halting said wire feed and cutting off said gases.

2. A metallising device according to claim 1, wherein said wire is electrically conductive, said wire feed and gas supply means are electrically controlled and the said means for halting the wire feed and cutting off the gases is controlled by circuit means completed through contact of the unmelted leading end of the wire with a stationary contact member disposed in the path of the wire.

3. In a metallizing spray gun apparatus of the type utilizing a combustible gas having a high calorific value for melting the metal and compressed air for spraying the molten metal from the gun, means for supplying a readily ignitable gas to said gun, and means for igniting last said gas to form a primary flame for igniting said high calorific gas.

4. A metallizing spray gun apparatus as defined in claim 3 wherein said primary flame is established prior to admission of said high calorific gas and compressed air, and continued for a predetermined time.

5. Apparatus for the metallization of articles comprising a metallizing spray gun, a conveyor disposed to transport articles to be metallized past said spray gun, electro-actuated means controlling admission of a readily ignitable gas to said gun, second electro-actuated means for igniting said gas to form a primary flame, third electro-actuated means for controlling admission of a combustible gas to said gun having high calorific value for melting the metal to be sprayed, fourth electro-actuated means for controlling admission of compressed air to said gun for discharging the molten metal in a spray, an electro-responsive presence detecting device disposed adjacent said conveyor on the approach side to said spray gun and controlled by the article thereon for producing a presence signal upon approach of the article to said spray gun, a step switch mechanism controlling the operating sequence of each of said electro-actuated means, and means responsive to said presence signal for initiating an operating cycle of said step switch mechanism.

6. Apparatus for the metallization of articles comprising a spray gun, means for feeding metal in continuous wire form to said gun, means for melting and spraying from said gun the metal fed thereto, and control means including a pair of contacts adapted to be actuated periodically at a rate proportional to the rate of feed of said wire to the gun for terminating operation of the latter upon a drop in the wire feed rate to a predetermined minimum value.

7. Apparatus for the metallization of articles as defined in claim 6 wherein said wire is fed over a pulley having means thereon for actuating said contacts at a rate proportional to the pulley speed.

8. Apparatus for the metallization of articles comprising an electro-controlled metallizing spray gun, a conveyor disposed to transport articles to be metallized past said spray gun, an electro-responsive presence detecting device disposed adjacent said conveyor on the approach side to said spray gun and controlled by the article for producing a signal upon the approach of an article to said spray gun, a thermionic valve, relay means connected in the anode circuit of said valve and which control operation of said spray gun, means controlled by said signal for changing the anode current of said valve from its initial value to a value sufficient to effect operation of said relay means thereby initiating operating of said spray gun, and means for thereafter restoring the anode current of said valve to its initial value after a predetermined time interval to effect release of said relay means thereby terminating operation of said spray gun.

9. Apparatus for the metallization of articles as defined in claim 8 wherein said valve in the absence of an input signal is arranged with its anode circuit opened by contacts therein, and wherein, with said contacts closed, there is placed upon the grid of the valve a bias with respect to the cathode sufficient to prevent operation of said relay means, and wherein to permit operation of said relay, the grid of the valve is connected over a direct current path including a second set of contacts and a resistor therein to a point of positive potential.

10. Apparatus for the metallization of articles as defined in claim 9 wherein the grid of the valve is arranged to be connected via a resistor to the anode of the valve, and wherein said second set of contacts are adapted to be bridged by a condenser arranged to be charged up slowly upon opening of said second set of contacts and thereby to reduce the grid poten-

tial to a value to cause release of said relay means.

11. Apparatus for the metallization of articles as defined in claim 9 wherein the grid of said valve is arranged to be connected via a resistor to the anode of said valve, and wherein said second set of contacts are adapted to be bridged by a condenser of adjustable capacity arranged to be charged up slowly upon opening of said second set of contacts and thereby to reduce the grid potential to a value to cause release of said relay means.

12. Apparatus for the metallization of articles comprising an electro-controlled metallizing spray gun of the continuous wire feed type, a a conveyor disposed to transport articles to be metallized past said spray gun, an electro-responsive presence detecting device disposed adjacent said conveyor on the approach side to said spray gun and controlled by the article for producing a signal upon the approach of the article to the spray gun, a thermionic valve, relay means connected in the anode circuit of said valve and which controls operation of said spray gun, means controlled by said signal for changing the anode current of said valve from its initial value to a value sufficient to actuate said relay means thereby initiating operation of said spray gun, a delay acting condenser-resistance network connected in the grid circuit of said valve and effective upon said change in anode current to gradually restore the same to its initial value thereby effecting a release of said relay means, and means including a set of contacts actuated at a rate proportional to the rate of feed of said wire for modifying the effect of said condenser-resistance combination on said anode current.

13. Apparatus for the metallization of articles comprising a metallizing spray gun, a conveyor disposed to transport articles to be metallized past said spray gun, a conduit for delivering a combustible gas to said gun, valve means in said conduit controlling the flow of said combustible gas, means for feeding wire in continuous form to said gun for melting of the leading end thereof by the heat produced by combustion of said gas, a presence detecting device disposed adjacent said conveyor on the approach side to said spray gun and controlled by the article to be metallized for actuating said gas valve to open position for a predetermined period of time and effecting operation of said wire feed means for a slightly longer period of time.

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