April 25, 1961 W. J. TRABILCY 2,981,818

TYPE METAL TRANSPORTATION SYSTEM

Filed Dec. 17, 1958 4 Sheets-Sheet 1

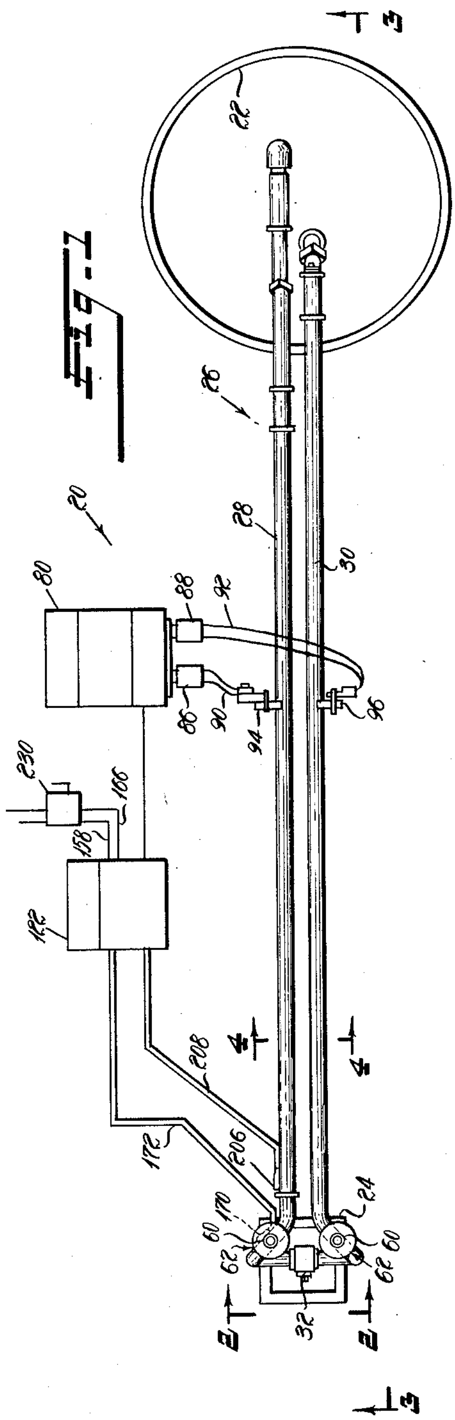

FIG. 1

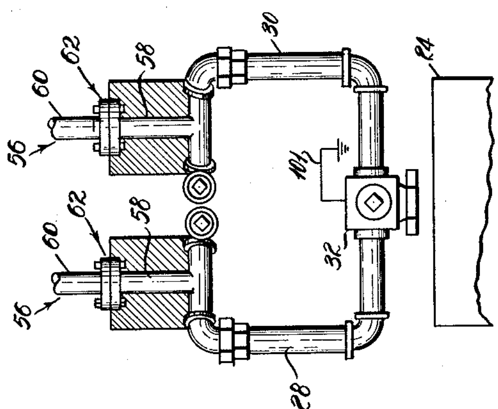

FIG. 2

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TYPE METAL TRANSPORTATION SYSTEM

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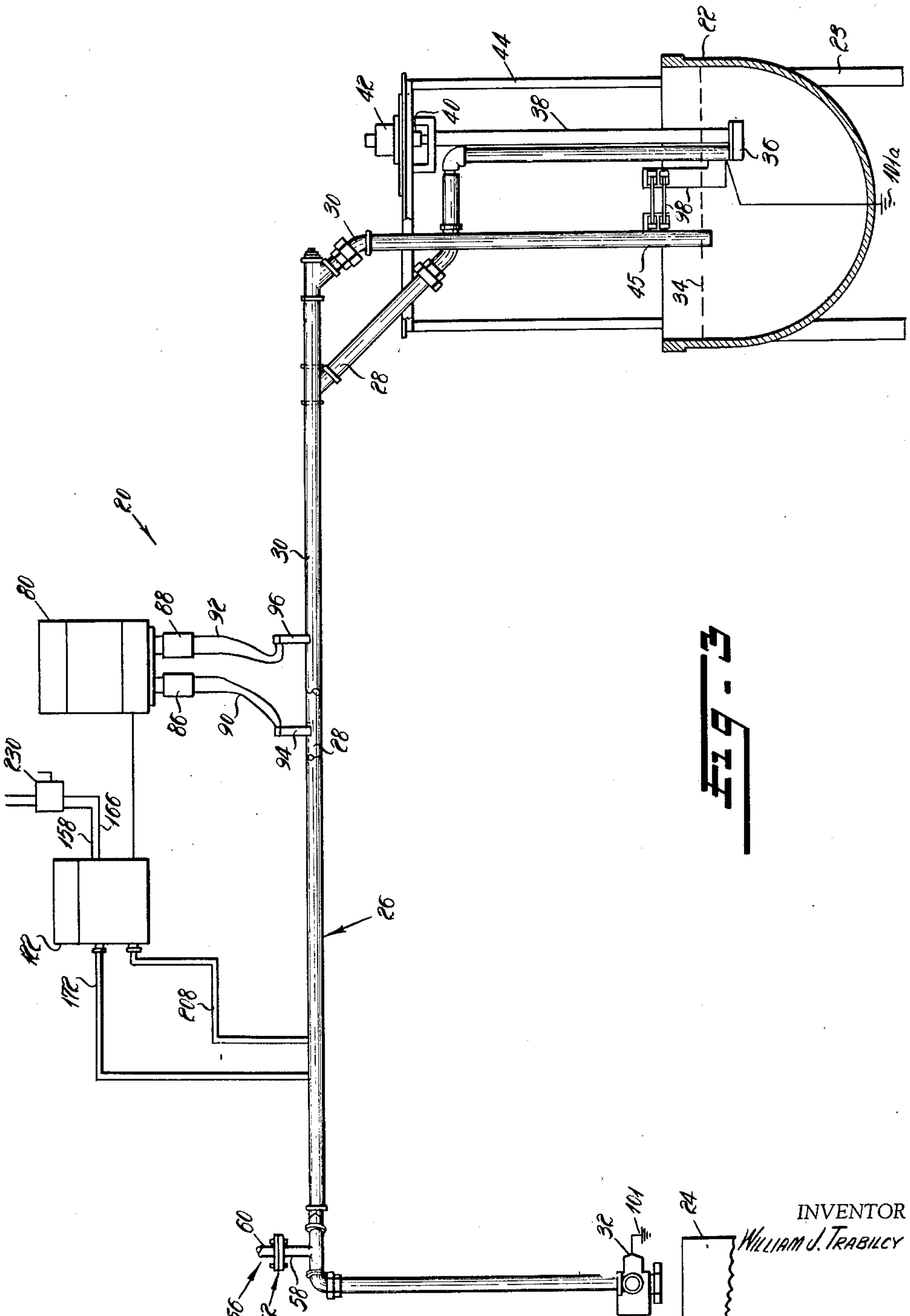

FIG. 3

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Fig. 6

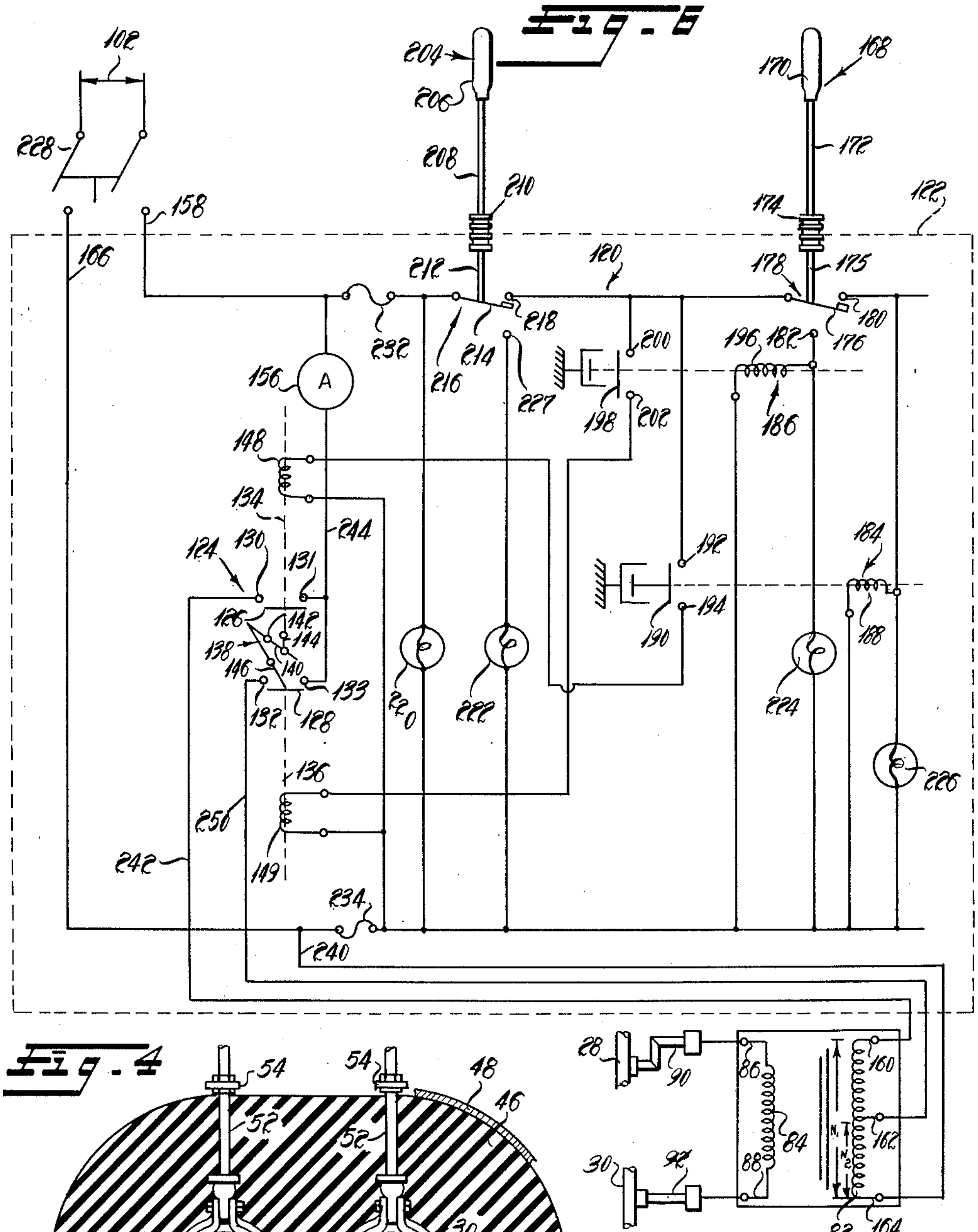
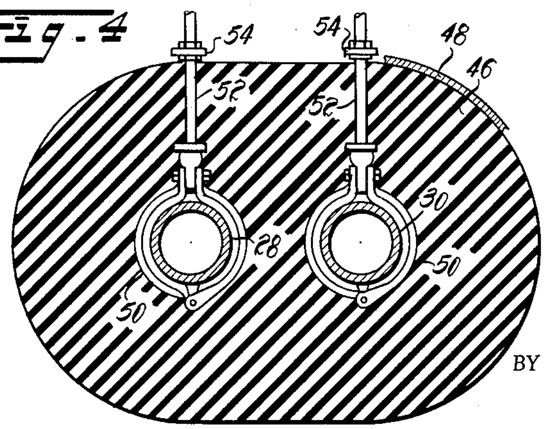


Fig. 4



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TYPE METAL TRANSPORTATION SYSTEM

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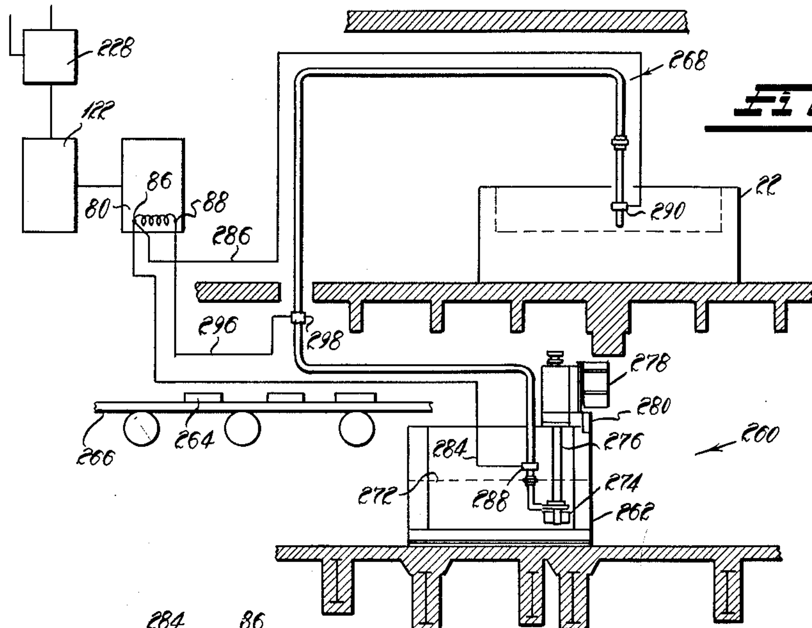

Fig. 7

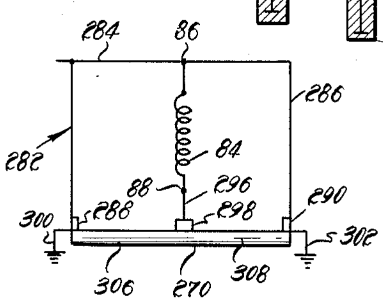

Fig. 8

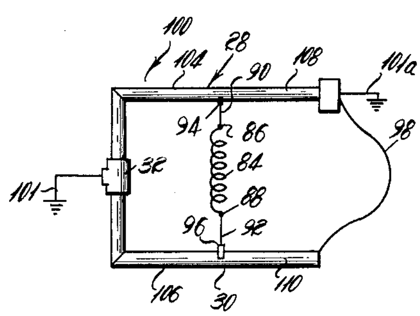

Fig. 5

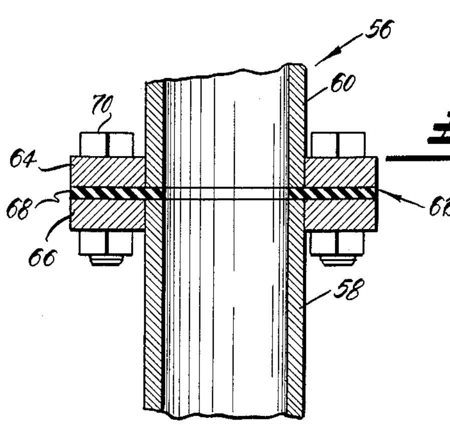

Fig. 9

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United States Patent Office

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TYPE METAL TRANSPORTATION SYSTEM

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Filed Dec. 17, 1958, Ser. No. 780,974

13 Claims. (Cl. 219—19)

This invention relates to a heating and transportation system for distributing a fluid and is more particularly concerned with a system for the transportation of a fluid through a pipe line which is heated by an electrical current passing therethrough.

One possible application of the present invention is in connection with the distribution of type-metal utilized by newsprinting industries in the production of cast printing plates for rotary printing presses. This type-metal generally is composed of 85% lead and 15% antimony and has a mixture melting temperature of approximately 525° F. The type-metal usually is melted down in large capacity melting pots capable of handling 10 to 70 tons of metal and is pumped therefrom to casting stations where new plates are cast for use in a printing run. After the plates are cast, they are delivered to the pressroom and are mounted on the printing presses for the press run.

At the end of the press run, it has been the customary practice to store the used or dead plates until type-metal is again required for casting new plates. Thus, as the demand for new plates arises, the dead plates are removed from storage and melted down in the melting pots. Consequently, it will be appreciated that the handling of the casting material has a direct influence on the operating costs and productive capacity of the printing plant. The present invention is presently concerned with the handling of casting materials in such an operation to enable more efficient systems to be utilized in the melting and casting of the printing plates.

In the past it has been customary to locate the casting stations in the immediate area of the melting pots so as to reduce the distance over which the molten metal must be conveyed. In this manner, the difficulties encountered in delivering metal in molten state at required unchilled casting temperature are overcome to some degree. Also, the possibility of the molten metal becoming solidified due to exposure to normal room temperatures before it can be introduced into the casting mold is substantially obviated.

While this type of a system overcomes some of the serious problems relating to the physical handling and transportation of the molten metal, it presents other and more serious difficulties relating to plant layout, handling of the cast plates, efficient utilization of plant floor space and interdepartmental coordination, in addition to the usually encountered problem of preventing the molten metal from being chilled which results in defects and surface imperfections in the final cast product.

The plant layout problems arise primarily because of the space required to locate the casting stations close to the melting pots, and the transportation of dead plates to and from a storage area which is usually remote from the press and casting rooms. Thus, substantial costs are involved in the handling, re-handling and storage of the cast plates during movement between the press room, storage and casting areas. Coordination of the individual departments in the intermittent handling of the cast

plates becomes inflexible, often resulting in bottlenecks and inefficient utilization of labor.

As a consequence it has been found to be highly desirable in the promotion of over-all plant efficiency and economy to locate the casting stations substantially remote from the melting pot. In some instances where a large bulk of printing plates is used, it is desirable to provide for a central pot reservoir system to feed a series of smaller melting pots which are connected to the molds of the casting station. With this type of central feeding system, the used or dead plates are transferred from the press room to the central heating reservoir immediately after the press run. There, the dead plates are continually melted down and the temperature of the molten metal is thermostatically maintained at the proper casting temperature. The central reservoir is of adequate capacity to eliminate the necessity of storing the dead plates and further provides adequate molten metal to meet peak demands for new castings. However, due to the size and weight of such a central heating reservoir, it is necessarily located remote from the casting stations on the ground floor or in the basement of the plant. Similarly, where the general location of the printing plate casting stations is not limited by factors involving the handling of the molten type metal, maximum use of plant facilities, space and arrangement of equipment is obtainable to provide for optimum efficiency and economy. In the past, however, no operable transportation system of commercial value has been devised to effect the efficient, dependable and speedy handling of the molten metal between two widely separated points to allow for the casting stations to be remotely located from the melting pot or to permit the employment of a central reservoir heating system.

When electricity became commercially available with the recognition of the numerous advantages offered by heating with an electrical current, several attempts were made to economically transport the type-metal in its molten state from the melting pot to the remote casting station in order to facilitate a more efficient and less costly plant layout. Some of these attempts involved the heating of the pipe line used for conveying the molten type metal with external resistance heating elements generally of the electrical wrap-around cable or rod-heater types. It also has been proposed in the past, to heat the pipe line by passing electrical current through the walls of the pipe line itself. Such prior systems and apparatus, however, have not been found to be commercially satisfactory to keep the type-metal in its molten state during transportation from the melting pot to the remote casting stations.

Among the shortcomings of these prior systems, it has been found that the wrap-around electrical cables tended to become brittle after short periods of exposure to the high operating temperatures resulting in breakage and consequent interruption of the heating current. Moreover, dielectric failures due to the elevated operating temperatures were experienced thereby increasing the hazards and the expense of operation in addition to providing for a highly inefficient transfer of heat.

The shortcomings of prior systems which pass an electrical current through the pipe line to maintain the material being transported in a flowable state involves the basic problem of confining the electrical circuit to the pipe line, particularly while the metal is being poured from the pipe line into the casting box. In general, these prior proposed systems fail to show how the electrical current can be specifically limited to flow through desired straight and curved sections of pipe without grounding and with consequent proper balance and uniform distribution of current throughout the pipe line circuit.

It has been suggested that the particular problem of grounding of the electrical current which occurs through the discharging stream of molten metal could be overcome by shutting down the heating system while the molten metal is being poured This proposal, however, results in inefficient heating and additional time-consuming operations in addition to the possibility of having the metal solidify within the pipe while the pouring operation is being consummated. Moreover, these prior systems in attempting to confine the current path to the pipe line itself in order to achieve a commercially useful system, have developed undependable, complicated apparatus leading to inordinate initial expense and troublesome maintenance requiring the services of skilled and expensive maintenance personnel. Thus, these systems have been found to be totally unsuitable for normal commercial and industrial use.

Another serious problem with the proposed prior systems which utilize the pipe line wall as the electric heating unit, is the large capacity required to heat a metal to maintain it in a liquid state. This problem is magnified by the influence of the required high operating temperatures upon the electrical resistance of the current-carrying pipe line. It will be appreciated, with respect hereto, that the electrical resistance of a conduit increases substantially in direct proportion to temperature increases. This significant increase in the resistance of the circuit due to increasing conduit temperature has been previously overcome by initially providing equipment of adequate capacity to handle both the heating of the material and to provide for sufficient power to overcome the resistance offered by the conduit at the elevated operating temperature. Thus, the transformer size employed to develop the required low voltage-high current power for heating the pipe is consequently proportionately heavier thereby increasing the cost and over-all physical size of the unit. As a consequence, it will be appreciated from the foregoing, that the systems which have been proposed are consequently costly and operatively uneconomic for commercial uses, thus precluding the plant designer from availing himself of the more efficient and less costly disposition of the metal casting stations or other stations of usage at a location which is substantially remote from the melting furnace or pot.

Although the construction embodying the principles of the present invention is shown and described in its application for heating and transporting molten type metal, the present invention further contemplates the utilization of the novel heating and transporting system hereinafter described generally in heating and transporting any fluid capable of being heated and transported through a pipe line. For example, the principles of the present invention may be applied with respect to heating and transporting all metals in their molten state such as, for example, aluminum. The invention may also be applied to the heating and transportation of liquids such as water, oil or molasses and is particularly adapted for heating and transporting fluids irrespective of their electrical conductivity.

Accordingly, the present invention has as its purpose and primary object the provision of a novel and thoroughly workable and practical heating and transporting system for the transportation of a fluid wherein the fluid is conveyed through a pipe line which is heated by passing a controlled electrical current therethrough. This is accomplished in accordance with the present invention by connecting the pipe line to be heated to the secondary winding of a transformer to establish a special load circuit and connecting different pre-selected numbers of primary coil turns across a voltage source in circuit interrupting sequence by means of a novel control circuit so that the voltage induced in the load circuit is capable of being controlled relative to the voltage across the primary coil. The control circuit for controlling the voltage induced in the transformer secondary winding is responsive to variations in the electrical resistance of the pipe line effected by changes in pipe line temperature and functions to re-establish and restore a selected power input to the pipe line, which is lost when the pipe line electrical resistance increases with a rise in pipe line temperature, which increase in resistance effectuates a fall in the magnitude of current flowing in the secondary load circuit.

Accordingly, it is a further object of the present invention to provide a novel heating and transporting system wherein a pipe line is heated by passing an electrical current therethrough and wherein increases in electrical circuit resistance effected by increases in pipe line temperature is compensated for by controlling the voltage induced into the electrical circuit which includes the pipe line.

A further object of the present invention is to provide in a novel heating and transporting system wherein a pipe line is heated by passing an electrical current therethrough by means of a transformer, a novel control circuit for controlling the voltage induced into the secondary winding of the transformer relative to the voltage across the primary winding of the transformer in response to predetermined variations of pipe line electrical resistance effectuated by variation in pipe line temperature.

Still a further object of the present invention is to provide in a novel heating and transporting system wherein a pipe line is heated by passing an electrical current therethrough by means of a transformer having its secondary winding connected to the pipe line, a novel control circuit for selecting different predetermined numbers of transformer primary turns to be connected across a voltage source in circuit interrupting sequence, which control circuit includes time delay means for providing a predetermined period of time in which the secondary winding of the transformer cannot be energized following de-energization thereof to permit the current in the secondary winding to collapse completely before inducing a further voltage therein.

Still another object of the present invention is to provide in a novel heating and transporting system wherein a pipe line is heated by passing an electrical current therethrough by means of a transformer having its secondary winding connected to the pipe line, a novel load circuit which includes the pipe line and the secondary winding wherein the flow of current therein is confined to the load circuit to electrically isolate the pipe line from associated apparatus utilizing the fluid heated and transported by the pipe line.

A further object of the present invention is to provide a novel heating and transporting system for the efficient, dependable and speedy handling of a fluid through a pipe line which is heated by passing an electrical current therethrough in a safe and efficient manner to maintain the fluid therein in a heated and flowable condition.

Further objects of the present invention will presently appear as the description proceeds in connection with the appended claims and the annexed drawings wherein:

Figure 1 is a top plan view of a heating and transportation system embodying the principles of the present invention according to a preferred embodiment thereof and schematically illustrating the system controls;

Figure 2 is a left end elevation of the system of Figure 1 as indicated by line **2—2** in Figure 1;

Figure 3 is a side elevation of the system of Figure 1 as indicated by line **3—3** in Figure 1 and illustrating the metal melting pot in section;

Figure 4 is a section substantially along line **4—4** of Figure 1 illustrating the pipe hangers and insulation;

Figure 5 is a schematic view illustrating the secondary electrical load circuit of the system of Figure 1;

Figure 6 illustrates the schematic wiring diagram for a control system for the system of Figure 1;

Figure 7 is a side elevation view of a transportation system according to a further preferred embodiment of the invention illustrating the melting and reservoir pots storing the molten melt in section;

Figure 8 is a schematic view illustrating the secondary load circuit of the system of Figure 7; and

Figure 9 is an enlarged view of the insulating flange illustrated in Figure 2.

Referring now to the drawings and more particularly to Figures 1–4 wherein the construction embodying the principles of the invention are shown, reference numeral **20** generally designates a hot-lead system such as that utilized in newsprinting plants for producing the plates in printing newspapers. This system **20** comprises a type-metal plate melting pot **22** which is mounted on the floor by suitable structural forms **23** and a casting box **24** enclosing a metal shell mold for forming the type-metal plates. This melting pot is heated by any suitable means (not shown) to approximately a temperature of 700° F. for melting the type-metal and to maintain the metal in a molten state.

To deliver the metal in its molten state at an unchilled temperature to the casting box **24**, a pipe line **26** is provided and comprises a supply branch **28** and a return branch **30**. These branches **28** and **30** are suitably interconnected at their corresponding casting box ends by a three-way plug type valve **32** which is arranged to be positioned over the pouring spout of the casting plate mold. At the melting pot end of the pipe line **26**, the supply branch **28** terminates below the normally maintained level of molten metal as indicated at **34** in a pump intake housing **36**. This housing **36** contains a suitable pump impeller (not shown) which is connected to an upstanding pump shaft **38**. Shaft **38** is coupled at **40** to a suitable motor **42** or other suitable prime mover which is mounted on suitable structural forms generally indicated at **44** over the melting pot **22**. The return branch **30** is spaced apart from the supply branch **28** and terminates over the melting pot and near the level of the molten metal as indicated at **45**.

The supply and return branches **28** and **39** are illustrated to be substantially in parallel spaced-apart relation and are substantially of the same linear length for a purpose as will hereinafter become apparent. All of the pipes and fittings are preferably made of steel or iron having threaded, flanged or welded joints in accordance with the temperature and pressure of the service. The pipes are covered with a suitable thermal and electrical insulation material **46** over which a canvas jacket **48** is sewn. Suitable hangers **50** are provided to support each branch **28** and **30** individually from the building, by suitable hanger rods **52** connected thereto. Rods **52** are electrically insulated from the pipes by providing a union **54** composed of electrically insulating material which will not conduct electrical current. The insulation and pipe support hangers have been omitted from all the figures with the exception of Figure 4 for clarity.

Both the supply and return pipe branches **28** and **30** are anchored to the building against undue movement by electrically insulated anchors **56** which are individual to each branch near the corresponding ends thereof. Each of the anchors **56** comprises a nipple or short length of pipe **58** welded or otherwise suitably secured to its associated branch at one end and is coupled at its other end to a rigidly secured anchor pipe **60** by an insulating coupling **62** which serves to electrically insulate the anchor pipe **60** from the pipe line **26**. The coupling **62** as shown in Figure 9 comprises a flange **64** secured to the end of pipe **60** and a flange **66** secured to the adjacent end of pipe **58** by screw threads, welding or other suitable means. An insulating annulus **68** and bolt **70** insulated from the flange secure the coupling together. Any other structure which electrically insulates the two flanges of the coupling may be alternatively used in place of the structure shown.

In order to pass a current through the pipe line **26** for heating and raising the temperature of the pipe line **26** to liberate heat to the molten metal therein, a transformer **80** is provided having a variable tap primary winding **82** and a secondary winding **84**. The fixed terminals **86** and **88** of the secondary winding **84** are connected to the supply and return branches **28** and **30** by suitable conductors **90** and **92** respectively. These conductors **90** and **92** are suitably secured to their respective pipe branches by terminal lug clips **94** and **96** which are welded to the pipe branches.

Under actual working conditions, the melting pot end of the supply branch **28** is immersed and consequently electrically grounded in the molten metal stored in the melting pot **22**, which metal provides an electrical path through the metal walls of the melting pot, the structural support **23** to earth. It further will be appreciated that when the plug valve **32** is opened to pour molten metal into the casting box **24**, another electrical ground will be established since the discharging metal will provide an electrical path to interconnect the pipe line **26** with the casting box. Moreover, the pipe line may be permanently electrically connected to the casting box **24** by a shrouding (not shown) which is employed to shield against the splashing and splattering of molten metal as it enters the casting box. Consequently, the particular electrical circuit established between the transformer secondary winding **84** and the pipe line **26** will be the determining factor in whether or not continuity between the above two grounds will be established.

It will be appreciated that when continuity between the pipe line grounds is established through the casting apparatus in conforming the heating system to actual working conditions, that there will be a flow of current through the melting pot and casting box apparatus. This condition, it will be appreciated, is extremely hazardous in that the operators in handling the casting apparatus are subject to severe electrical shock, the magnitude of which is dependent upon the voltage induced in the pipe line and other surrounding conditions such as wet or damp floors. Also where continuity between pipe line grounds is established, electrical sparks will be produced as the molten metal is discharged from the valve **32** and strikes the casting box **24**.

In accordance with the present invention the above hazards are eliminated without necessitating any change or alteration in working conditions or the process of producing the final castings. This is accomplished by electrically connecting the separated corresponding melting pot ends of the supply and return branches **28** and **30** together with a jumper wire **98** or other suitable means to establish and complete a continuous or looped load circuit **100**. This load circuit **100** may be traced from the supply branch **28**, through the plug valve **32**, the return branch **30**, the jumper **98** and back to the supply branch **28**. Referring to Figure 5, the circuit **100** is provided with two positive electrical grounds **101** and **101a** to earth so that the electrical impedances between the grounds are equal. Where the supply and return branches **28** and **30** are substantially of equal length, the ground **101** is connected to the plug valve **32** or to the pipe line **26** substantially in the region of the plug valve. This ground **101** may also be established by electrically connecting the plug valve **32** to the casting box **24**. The other ground **101a** is connected to the end of the supply branch **28** which is immersed in the molten metal stored in the melting pot **22** or other parts of the pipe line **26** immersed in the molten metal such as the pump housing **36**.

As best shown in Figure 5, the secondary winding terminal clip lugs **94** and **96** are connected respectively to the supply and return branches **28** and **30** at the electrical impedance midpoints between the grounds **101** and **101a**. Consequently, the electrical impedances in the continuous load circuit **100** between ground **101** and secondary terminal clip **94**, between ground **101a** and clip **94**, between ground **101** and terminal clip **96**, and between ground **101a** and clip **96** are all equal.

Thus, with continued reference to Figure 5, when the terminals of the primary winding 82 are connected across a source of voltage 102, the potential induced across the terminals of the secondary winding 84 causes substantially equal magnitudes of current to flow through two parallel circuits of substantially equal impedance. The first of these circuits includes conductor 90 connected to terminal 86 of secondary winding 84, the portion 104 of the supply branch 28, the plug valve 32, the portion 106 of the return branch 30 and conductor 92 which is connected to the other terminal 88 of the secondary winding. The other circuit initiates from the terminal 86 of the secondary winding 84, and passes through conductor 90, through the portion 108 of supply branch 28, through jumper 98 which connects the corresponding melting pot ends of the supply and return branches, through the portion 110 of return branch 30 to conductor 92 which connects with the other terminal 88 of the secondary winding.

Therefore, in the above-described parallel circuit paths of equal impedance, there is no continuity between the grounds 101 and 101*a* and consequently there is no current flow through the casting and melting pot apparatus. The operation of the making the castings is carried on in the same manner as before the application of the molten metal heating and transporting system embodying the principles of the present invention. Operators may handle the melting and casting apparatus without experiencing electrical shock and no electrical sparks are produced by the pouring of the molten metal into the casting box 24 since the pipe line is effectively electrically isolated from the casting box 24 and the melting pot 22 to confine the flow of current to the load circuit 100.

Since the current flowing throughout the pipe line 26 is equal, it will be appreciated that the pipe line will be heated uniformly. This advantage eliminates the development of hot and cold sections of the pipe line and assures uniform heating of the molten metal therein.

Referring now to Figure 6, and in accordance with the present invention, a control system 120 is provided in a suitable control panel 122 to automatically maintain the pipe line temperature within an operating predetermined range and to utilize substantially full transformer capacity throughout the entire temperature range of heating. Thus, with continued reference to Figure 6, the voltage source 102 is connected across the primary winding 82 of transformer 80 to establish a power circuit which includes a three-position relay type selector switch 124. This relay type selector switch 124 includes two switch blades 126 and 128. Blade 126 is engageable with a pair of contacts 130 and 131 and blade 128 is engageable with the pair of contacts 132 and 133. These blades 126 and 128 are operated by armatures 134 and 136 which are mechanically interlocked by linkage 138 which prevents the switch blades 126 and 128 from engaging their respective sets of contacts at the same time and further provides for the breaking of one set of contacts before the other set can be made. This is accomplished by providing for an arm 140 which is centrally pivoted at 142. Pivotally connected to opposed ends of the arm 140 are links 144 and 146 one on each side of the pivot at 142. These links 144 and 146 respectively are connected to the armatures 134 and 136. The pivot arm 140 is biased by means not shown to a neutral contact disengaging position by a clockwise rotation which disengages the blades 126 and 128 from their respective contacts.

In addition to the mechanical interlock, a conventional electrical interlock (not shown) may also be provided to prevent both switch blades 126 and 128 from completing their associated circuits at the same time.

The relay type selector switch 124 also includes separately energized armature windings 148 and 149 which operate armatures 134 and 136 respectively to alternately move switch blades 126 and 128 into engagement with their associated sets of contacts. Contacts 131 and

133 are contacted in series circuit relation with an ammeter 156 to the power source conductor 158.

The contacts 130 and 132 respectively are arranged in series circuit relationship with taps 160 and 162 of primary winding 82. These taps 160 and 162 are spaced apart on the primary winding so that a preselected different number of primary turns are provided for between terminal 164 and the taps 160 and 162 respectively, which terminal 164 is connected directly to power source conductor 166. Thus, energization of winding 148 makes contacts 130 and 131 to arrange the maximum number of primary turns N_1 across the voltage source 102 while alternate energization of winding 149 makes contacts 132 and 133 to arrange a smaller preselected number of primary turns N_2 across the voltage source. It will be appreciated that this variance in the number of primary turns across the voltage source will raise and lower the voltage induced in the secondary winding in inverse proportion to the number of turns across the primary voltage source.

In order to automatically control the three-position switch 124, a conventional thermostat 168 is provided which includes a bulb 170 suitably strapped to the supply branch 28 to sense the pipe line temperature, and a capillary tube 172 interconnecting the bulb 170 with a bellows 174. The bellows 174 is connected by linkage 175 to a movable switch blade 176 of two-position switch 178 which is included in the control circuit 120. The bulb, capillary tube and bellows are filled with gas so that the bellows responds to the pressure of the gas which in turn is responsive to the pipe line temperature. Thus the switch blade 176 is movable upon rise or fall in the temperature of the pipe line 26 and is biased by means not shown to engage contact 180. Upon a preselected temperature rise in the pipe line 26, the blade 176 is moved by expansion of the bellows to engage contact 182. Upon a preselected fall in pipe line temperature the blade 176 disengages from contact 182 and moves into engagement with contact 180

Engagement of the switch blade 176 with contact 180 energizes relay 184. Engagement of the switch blade with contact 182 alternatively energizes relay 186. Both relays 184 and 186 are of the type having a long pull-in time and may be one of several conventional relays having the characteristic of slow make and fast break. For example, relays 184 and 186 may be of the type having a dash pot or a slugged core to provide the long pull-in time.

The relay 184 includes a winding 188, a movable switch blade 190 and stationary contacts 192 and 194. This relay 184 is shown to be in de-energized condition wherein the movable switch blade 190 is biased, by means not shown, to be out of engagement with contacts 192 and 194. Upon energization of relay 184 the switch blade 190 moves into engagement with the stationary contacts 192 and 194 after a preselected time delay.

Similarly, the relay 186 is shown to be in de-energized condition and includes a winding 196, a movable switch blade 198 and stationary contacts 200 and 202. The switch blade 198 is biased by means not shown to be out of engagement with contacts 200 and 202. Upon energization of relay 186, switch blade 198 moves into engagement with the stationary contacts 200 and 202 after a preselected time delay.

Since contacts 192 and 194 are in series relationship with winding 148 of the three-position switch 124 across the voltage source, engagement of relay switch blade 190 with its associated contacts will energize the winding 148 to activate the three-position switch to one of its circuit engaging positions. When switch blade 198 alternately engages its associated contacts 200 and 202, the three-position switch winding 149 being in series circuit relation with these contacts is energized to activate the three-postion switch 124 to its alternate circuit making position.

The reference numeral 204 designates an operating temperature thermostat having a thermostatic bulb **206** strapped to the supply branch **28** to sense the temperature of pipe line **26** and a capillary tube **208** which interconnects the bulb with a bellows **210**. The bellows **210** is connected by linkage **212** to a movable switch blade **214** of switch **216** which is included in the control circuit **120**. The bulb **206**, capillary tube **208** and bellows **210** are filled with gas so that the bellows responds to the pressure of the gas which in turn is responsive to the pipe line temperature similar to thermostat **168**. This thermostat **204** indicates the need for heat to maintain the pipe line **26** at a preselected operating temperature and is operable upon a preselected fall and rise in pipe line temperature to move the switch blade **214** into and out of engagement respectively with an associated switch contact **218** of switch **216**. Energized by actuation of thermostat **204** is relay **184** or **186** depending upon the position of switch blade **176** of the two-position switch **178**.

Also included in the electrical network are indicator lamps **220**, **222**, **224** and **226**. The indicator light **220** is connected across the voltage source to indicate application of voltage across the power source conductors **158** and **166**. Indicator light **222** which is in series circuit relation with contact **227** of switch **216** indicates the de-energization of the control circuit by thermostat **204** when the demand for heat is satisfied and switch blade **214** is in engagement with contact **227**. Indicator light **224** serves to indicate that relay **186** is energized while indicator light **226** serves to indicate that relay **184** is energized.

Also included in the electrical network is a conventional manual disconnect switch **228** enclosed within a suitable switch box **230** for connecting the voltage source to power conductors **158** and **166** and across the terminals **164** and a selected tap of the primary winding **82**. The circuit further is provided with conventional fuses **232** and **234** to prevent the circuit from being overloaded.

The apparatus of the present invention is shown in the standby de-energized condition wherein the pipe line **26** is at ambient room temperature and the voltage source **102** is disconnected from the control circuit **120** and the transformer **80** by line switch **228**. The thermostat **204**, for purpose of this embodiment, moves the blade **214** into and out of engagement with contact **218** at 600° F. and 700° F. respectively, this temperature range being the operating range for the system in order to maintain molten type metal in a flowable and unchilled state. Consequently, in the standby condition, switch blade **214** is in engagement with contact **218** indicating the need for operation of the transformer. At temperatures up to 325° F., switch blade **176** of switch **178** is in engagement contact **180**, the force exerted by bellows **174** not being sufficient to overcome the bias against blade **176**. Since none of the relay windings are energized, the three-position switch **124** is biased to its neutral circuit disengaging position as shown.

To set the system in operation for heating the pipe line **26**, the line switch **228** is closed to connect the control circuit power conductors **158** and **166** across the voltage source **102** and to illuminate indicator light **220** indicating the application of power to the control circuit. With blade **214** engaging contact **218** and blade **176** engaging contact **180** an energizing circuit is completed to the time delay control relay **184** from the power conductor **158**, through switches **216** and **178**, relay winding **188** to the other power input conductor **166**. At the same time indicator light **226** which is in parallel circuit relation with winding **188** is illuminated.

When relay **184** becomes energized, the switch blade **190** will be moved into engagement with contacts **192** and **194** after a predetermined time delay. This completes an energizing circuit to winding **148** of the three-position switch mechanism **124** which is in series circuit relation with contacts **192** and **194** across the power input conductors **158** and **166**.

When winding **148** is energized, the switch blade **126** will move into engagement with contacts **130** and **131** to complete an energizing circuit to the transformer primary winding **82** to energize the maximum predetermined number of turns N_1 in the primary winding. This circuit to the primary winding **82** may be traced from the power input conductor **166**, through conductor **240** which electrically interconnects input conductor **166** with the primary winding terminal **164**, through the turns N_1 of primary winding **82** to tap **160**, through conductor **242** to contact **130**, through switch blade **126** and contact **131**, through conductor **244** connected to contact **131** and through the ammeter **156** to the other power input conductor **158**.

When current flows through N_1 turns in the primary winding **82**, a corresponding voltage is induced in the secondary winding **84** of transformer **80** to cause current to flow through the pipe line **26** in the load circuit **100** to uniformly heat the pipe line as hereinbefore described. As the temperature of the pipe line gradually increases from an initial ambient temperature it will be appreciated that the resistance of the metal of which the pipe line is composed will increase appreciably with temperature. Consequently, the magnitude of electric current and therefore the transformer power (I^2R) delivered to the load circuit **100** will fall as the temperature of the pipe line is increased from an ambient temperature which is generally 70° F. to the normal maximum operating temperature of 700° F. for keeping the molten type metal of the present embodiment in a flowable and unchilled state.

In accordance with the present invention, the initial electric current passed through the pipe line and the corresponding transformer power (I^2R or VI for the transformer secondary) for initially preheating the pipe line from ambient temperature are the rated current and rated output respectively. As the temperature increases with a corresponding increase in electrical resistance to cause the current to fall to decrease the heat input into the pipe line, thermostat **168** responds to a selected temperature of the pipe line **26** to operate switch **178** and move switch blade **176** out of engagement with contact **182**. This temperature for operating switch **178** is, in accordance with the present embodiment, selected in the preheating temperature range of the pipe line intermediate the ambient and operating pipe line temperatures and is preferably 325° F. to provide a final operating electrical current of adequate magnitude to properly heat the molten metal.

Disengagement of the switch blade **176** with contact **180**, de-energizes relay **184** to disconnect the relay blade **190** from contacts **192** and **194** to thereby de-energize winding **148** which in turn disconnects switch blade **126** from contacts **130** and **131** to allow the switch **124** to assume a neutral circuit de-energizing position. This action interrupts the energizing circuit for the transformer primary coil **82** to de-energize the primary coil.

Upon disengagement of contact **180** the switch blade **176** is moved to connect with contact **182**. This completes an energizing circuit to winding **196** of time delay relay **186** which is connected across the contact **182** and power conductor **166**. At the same time, indicator light **224** which is in parallel circuit relationship with winding **196** is illuminated. When relay **186** becomes energized, the switch blade **198** is moved into engagement with contacts **200** and **202** after a predetermined time delay. This completes an energizing circuit to winding **149** of the three-position switch mechanism **124** which is in series circuit relationship with contacts **200** and **202** across the power input conductors **158** and **166**.

When winding **148** is energized, the switch blade **128** connects contacts **132** and **133** to complete an energizing circuit to the transformer primary winding **82** to energize a preselected number of turns N_2 in the winding which is less than the maximum number N_1. The mechanical interlock 138 hereinbefore described functions to insure disconnection of contacts 130 and 131 when the armature 136 moves switch blade 128 into engagement with contacts 132 and 133.

The circuit now made through the selected coil portion N_2 of the primary winding 82 may be traced from the power input conductor 166 through the conductor 240 which electrically interconnects input conductor 166 with the primary winding terminal 164, through the turns N_2 of the primary winding 82 to tap 162, through conductor 250 to contact 132, through the switch blade 128 to contact 133, through conductor 244 connected to contact 133 and through the ammeter 156 to the other power input conductor 158.

Consequently, the voltage impressed across the secondary winding 84 by energization of N_2 turns in the primary coil 82, will be greater than the voltage impressed by energization of the N_1 turns of the primary winding by a magnitude which is in direct proportion to the fraction of N_2/N_1 coils. This increase in impressed secondary voltage restores a corresponding magnitude of electric current in the load circuit 100, which current has been steadily dropping due to the increase in circuit resistance caused by the temperature rise of the pipe line. Consequently, a corresponding power input to the pipe line is also restored so as to re-establish the heat input into the pipe line to raise the temperature thereof to the operating range and to provide for adequate liberation of heat to the molten metal when the metal is passed through the pipe line to keep it flowable and in an unchilled state.

The magnitude of power delivered to the pipe line which is restored, is preferably the rated value of the transformer so as to facilitate maximum usage of the equipment. Thus, as the temperature of the pipe line 26 is increased with its corresponding increase in electrical resistance and the load circuit current with its corresponding power (I^2R) falls with a resulting drop in heat input to the pipe line, the control circuit 120 functions to restore and re-establish the rated kva. of the transformer. This particular feature of the present invention eliminates the necessity of providing for a larger conventional transformer wherein power outputs cannot be selectively varied to meet operational requirements. Consequently, substantial savings in initial cost of equipment are achieved in addition to the advantage of permitting the utilization of equipment which is of smaller size and more easily handled. The efficiency of the transformer also is increased since substantially maximum rated power outputs are facilitated throughout the range of temperatures to which the pipe line is subjected.

Although the primary winding 82 is shown and described to have two sets of alternately selectable coil turns N_1 and N_2, the present invention further contemplates the utilization of the novel control circuit described herein to accommodate as many sets of coil turns as required to accomplish a particular operation. Thus, the primary winding 82 may be provided with additional taps between the terminal 164 and the taps 162 and 160 as required. For each additional tap provided for, an additional circuit energizing switch in the relay type switch mechanism 124 is required in addition to a time delay relay for actuating the additional switch.

The purpose of providing for the long pull in time of relays 184 and 186 is to allow for a complete collapse of current in the transformer secondary whenever the primary winding 82 is de-energized so that when the primary winding is re-energized, no current "bucking" is experienced.

It will be appreciated in this respect that when the temperature of the pipe line 26 reaches its intermediate value of 325° F. and thermostat 168 functions to cause the operation of the switching mechanism 124 to de-energize the turns of coils N_1 in the primary winding 82 and to energize the turns N_2 in circuit interrupting sequence, that as soon as the switch blade 176 breaks from contact 180, the magnetizing current and therefore the magnetic flux begins to collapse. Since the current collapse is not instantaneous due to a closed secondary circuit, the rate of flux drop increases the rate of cutting conductors of the transformer winding to induce a high pressure voltage into the primary winding 82. If line voltage is impressed across the primary at the time that the secondary is injecting this electrical pressure, the phenomenon generally referred to as "bucking" will occur.

The severity of the phenomenon referred to above is dependent upon the point of the pressure wave at which switching in occurs and results in arcing at the switch contacts and chattering of switch contacts which ultimately leads to considerable damage to the relays and switching mechanisms. Such arcing and chattering further produces trains of high frequency waves which impinge upon the transformer windings and represent a distinct menace to the insulation to ultimately cause dielectric breakdowns.

With the present invention, it will be appreciated that the problem of "bucking" resulting from the switching in and out of the transformer is eliminated since in switching from primary coil turns N_1 to N_2 in current interrupting sequence, the relay 186 provides an adequate time delay period before contacts 200 and 202 are made by switch blade 198 to energize winding 149 which in turn completes the energizing circuit to the coils N_2. Alternatively, under certain conditions where the pipe line temperature drops due to, for example, excessive flow of material through the pipe line, the thermostat functions to move the switch blade 176 out of engagement with contact 182 and into engagement with contact 180. This re-establishes the initial preheat circuit for energizing time delay relay 188 which facilitates the energization of primary coils N_1. Consequently, the relay 188 with its long pull in time does not permit the energization of coils N_1 for a predetermined time period to allow for a complete collapse in the current in coils N_2. Either relays 186 or 188 will function to prevent "bucking" whenever the disconnect switch 228 is rapidly switched in and out in the same manner as described above.

When the temperature of the pipe line reaches a preselected maximum which is approximately 700° F. in the present embodiment, the thermostat 204 functions to move the switch blade 214 of switch out of engagement with contact 218 and into engagement with contact 227. This interrupts the transformer energizing by de-energizing relay 186 which in turn de-energizes winding 149 to cause the three-way switching mechanism 124 to assume its neutral de-energized position thereby de-energizing the primary coil 82. Connection of the switch blade 214 to contact 227 illuminates the indicator light 222 to indicate that need for heat is satisfied.

When the temperature drops to a pre-selected value, which is 600° F. in the present embodiment, the thermostat functions to move the switch blade 214 back into engagement with contact 218 to facilitate re-energization of primary coil turns N_2 as hereinbefore described.

In place of the thermostat 168, which measures the pipe line temperature and consequently indicates the relative pipe line electrical resistance, an ammeter circuit may be provided to actuate switch 178 by measurement of the pipe line resistance directly.

Referring now to Figure 7 a central feeding system is there illustrated and generally designated at 260. This central feeding system 260 comprises a central reservoir and melting pot 262 suitably located in the basement or on the ground floor of the printing plant and a plurality of remote spaced-apart melting pots 22 (only one shown) as hereinbefore described. In the embodiment illustrated in Figure 7, the melting pots 22 now serve to maintain the molten metal delivered thereto in a flowable and unchilled state ready for use as needed. The melting pots 22 generally are located on the same floor level as the printing room (not shown) and above the central melting reservoir 262.

The central reservoir and melting pot 262 is heated by any suitable means (not shown) to approximately a temperature of 700° for melting down the type metal plate 264 as they are removed from the printing press (not shown) following a printing run. The dead plates are placed on any suitable and conventional conveyor 266 upon their removal from the press and are transferred directly to the melting reservoir 262 to be melted down.

To deliver the type metal in its molten state to each reservoir melting pot 22, a pipe line 268 is provided and comprises at least a supply pipe 270. At the central reservoir end of the pipe line 268 the supply pipe 270 terminates below the level of the molten metal as indicated at 272 in a pump intake housing 274. This housing 274 contains a suitable pump impeller (not shown) which is connected to an upstanding pump shaft 276. Shaft 276 is coupled by any suitable means to a conventional electric motor 278 or other suitable prime mover which is mounted on structural forms generally indicated at 280 over the reservoir 262.

As hereinbefore described, the pipes and fittings of pipe line 268 are preferably and conventionally made of steel or iron having threaded, flanged or welded joints in accordance with the temperature and pressure of the service. The pipe line is suitably covered with a thermal and electrical insulation material (not shown) and the hanger rods (not shown) for supporting the pipe line are the same as those illustrated in Figure 4.

A float level control (not shown) operates motor 278 to deliver molten metal to the pot 22 when the level of the molten metal therein falls to a preselected level by withdrawal of molten metal therefrom for delivery as required to the casting boxes 24 (see Figure 1). This may be accomplished in the present embodiment in accordance with the embodiment illustrated in Figure 1. Where it is not required to space the casting boxes 24 from the pot 22, the casting box 24 may be located immediately adjacent to the pots 22 in a conventional manner with a communicating passage therebetween for conveying the molten metal from the pot to the casting box.

With continued reference to Figure 7, the control circuit 120 and transformer 80 shown therein is substantially identical with that shown in Figures 1-6 and described in connection therewith, with the exception of the load circuit 282 which is connected to the terminals 86 and 88 of the secondary transformer winding 84. As best shown in Figure 8, the terminal 86 in the secondary winding 84 is connected to the opposite ends of the pipe 270 by separate suitable electrical conductors 284 and 286 which terminate in conventional clip lugs 288 and 290. These clip lugs 288 and 290 are preferably welded to the ends of pipe 270 to assure good electrical connections. The other terminal 88 of the secondary winding 84, is connected to the electrical impedance midpoint of the pipe 270 by a suitable conductor 296 which similarly terminates in a lug clip 298, which lug clip is also preferably welded to the pipe. The ends of the pipe 270 are immersed in the molten metal to provide electrical grounds to earth. The pipe 270 also is positively grounded to earth by electrical grounds 300 and 302 where the conductors 284 and 286 are connected to the pipe to assure zero potential at these points.

Consequently, two parallel electrical circuits having an equal electrical impedance are provided through the pipe 270. The first of these circuits may be traced from terminals 86, through the conductor 284, through the portion 306 of pipe 270, and through conductor 290 to the other secondary winding terminal 88. The other parallel circuit may be traced from secondary winding terminal 86 through electrical conductor 286, through the portion 308 of the pipe 270, and through the conductor 290 to the other terminal 88 of the secondary winding 84.

Therefore, in the above-described parallel circuit paths of equal impedances, there is no continuity between the grounds 306 and 308 and consequently there will be no current flow through these grounds and the associated melting and reservoir pots 22 and 262. Thus, with this embodiment wherein current is passed through the single pipe 270 to heat the latter so as to liberate heat to the molten metal flowing therethrough, the operation of making castings is carried on in the same manner as before the application of the molten metal heating and transporting system embodying the principles of the present invention and the same result is achieved as with the embodiment of Figures 1–6. Operators may therefore handle all of the melting, casting apparatus without experiencing electrical shock since the pipe line 268 is effectively electrically isolated from the melting and reservoir pots 22 and 262 so as to confine the flow of current to the load circuit 282.

Since the current flowing throughout the pipe line 268 is equal it will be appreciated that the pipe line will be heated uniformly. This advantage as hereinbefore described eliminates the development of hot and cold sections in the pipe line and insures a uniform heating of the molten metal therein.

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

What is claimed and desired to be secured by United States Letters Patent is:

1. In a system for use in heating and transporting a fluid between two spaced-apart stations, a supply pipe line having an electrical resistance which increases as its temperature increases and adapted to interconnect said stations for conveying the fluid therethrough, electrical heating means for raising the temperature of said pipe line by passing an electrical current therethrough to heat the fluid therein comprising a transformer capable of supplying a plurality of different secondary voltages and including a primary winding and a secondary winding, said secondary winding having two terminals connected to said pipe line to establish a load circuit, a source of input voltage arranged to be connected across said primary winding to establish a power circuit, selecting means for connecting different predetermined numbers of primary turns to be connected across said source in sequence whereby the voltage induced in said load circuit is controlled relative to the voltage across said primary winding, and control circuit means for operating said selecting means to decrease the number of primary turns across said source in response to a predetermined increase in the electrical resistance of said pipe line effected by the temperature rise to increase the voltage in the secondary winding and to approximately re-establish and restore initial power input to said pipe line.

2. The system as defined in claim 1 wherein said control means includes time delay means for rendering said selecting means inoperative to connect said primary winding across said source for a predetermined period of time following de-energization of said primary winding to provide for a substantially complete collapse of current in said load circuit before said primary winding is re-energized.

3. The system as defined in claim 1 wherein said selecting means comprises switching means having at least two separate circuit making positions and a neutral circuit de-energizing position between said circuit making positions, each of said circuit making positions being ar-

ranged in said power circuit to be associated with different predetermined numbers of turns on said primary winding.

4. The system as defined in claim 3 wherein said control circuit means comprises a thermostatically operated two-position switch having a movable contact responsive to the temperature of said pipe line, first and second control circuit relay means having switch contacts and individual energizing circuits connected in energizing circuit relationship to said two-position switch to be energized in sequence by said movable contact, said first and second relay means each having time delay means providing a long pull-in time for closing said switch contacts on said relay means, switch actuating means individual to each of said circuit making positions of said switching means and arranged in circuit energizing relationship with each of said time delay relay means switch contacts for selectively actuating said switching means from said neutral position to complete said power circuit associated with said circuit making positions and energize said primary winding a predetermined selected time period after associated ones of said first and second relay means are energized.

5. The system as defined in claim 4 wherein said control circuit means includes a thermostatically operated switch responsive to the temperature of the material being conveyed through said pipe line to de-energize said first and second relay means irrespective of the position of said two-position switch, and means for biasing said three-position switching means to said neutral position when said relay means are de-energized thereby de-energizing said primary winding at a predetermined temperature of the material.

6. In a system for transporting an electrically conductive fluid between a supply station and a receiver station, a pipe line interconnecting said supply station with said receiver station including a supply branch for withdrawing fluid from said supply station and terminating in fluid discharge means at said receiver station and a recirculating return branch substantially equal in length to said supply branch and connected to said discharge means for recirculating undispensed fluid back to said supply station, means electrically connecting together said supply and return branches at their corresponding ends to establish a continuous circuit of electrical resistance, means electrically grounding said continuous circuit at two separate spaced apart points near said supply station and said receiver station respectively to provide substantially equal electrical impedances between said points in either direction along said circuit, electrical means for passing an electrical current through said pipe line to heat the fluid therein comprising a transformer having a primary winding and a secondary winding, said secondary winding having two terminals respectively connected to said continuous circuit at spaced-apart points providing substantially equal electrical impedances between said terminals and adjacent electrical grounding means in said continuous circuit whereby flow of electrical current is confined to said continuous circuit and said secondary winding to electrically isolate said pipe line from said stations irrespective of flow of electrically conductive fluid therebetween.

7. The system as defined in claim 6 wherein pumping means are provided to circulate said fluid through said pipe line under pressure.

8. In a system for use in heating and transporting a fluid between spaced-apart supply and receiving stations, a supply pipe line having an electrical resistance which varies directly with the temperature thereof and adapted to interconnect said stations for conveying said fluid therethrough, electrical power supply means having a predetermined power output for passing an electrical current through said pipe line to heat and raise the temperature of said pipe line from an ambient temperature to an elevated operating temperature comprising means electrically connected to said pipe line to form a load circuit, selector means for inducing different selected substantially constant voltages in said load circuit to effectuate current flow therein and means responsive to a predetermined drop in magnitude of current flow in said load circuit as effectuated by the rise in temperature of said pipe line for controlling said selector means to increase the voltage induced in said load circuit by a selected magnitude and thereby re-establish and restore approximately the initial magnitude of power input to said pipe line to increase the current flow in said load circuit.

9. In a system for use in heating and transporting a fluid between spaced-apart supply and receiver stations, a supply pipe line having an electrical resistance which varies directly with the temperature thereof and adapted to interconnect said stations for conveying said fluid therethrough, electrical power supply means for passing an electrical current through said pipe line to heat and raise the temperature of said pipe line comprising a transformer having a primary winding and a secondary winding, said secondary winding having at least two terminals connected to said pipe line to establish a load circuit, said primary winding having at least three spaced-apart taps and a preselected number of coil turns between said taps, a source of input voltage arranged to be connected to a selected pair of said taps to establish a power circuit, selecting means for changing the taps connected to said source in circuit interrupting sequence whereby the number of primary coil turns connected across said source is varied by a preselected magnitude to control the voltage in said load circuit and the power applied to said pipe line relative to the voltage across said primary winding and control means responsive to a predetermined increase in the pipe line electrical resistance effectuated by the rise in temperature of said pipe line for automatically operating said selecting means to decrease the number of primary turns across said source by a preselected magnitude to approximately re-establish the initial power input across the pipe.

10. The system as defined in claim 9 wherein said control means includes timing delay means to render said selecting means inoperative to energize said primary winding for a predetermined time period following de-energization of said primary winding to provide a complete collapse of the current in said load circuit prior to re-energization of said primary winding.

11. The system as defined in claim 10 wherein said selecting means comprises three-position switchng means having at least two separate circuit making positions and a neutral circuit de-energizing position between said circuit making positions, each of said circuit making positions being arranged in said power circuit to be associated with said different predetermined numbers of primary turns in series circuit relation across said source, said timing delay means being electrically interconnected with said switching means to render said switching means inoperative in said neutral circuit de-energizing position.

12. In a system for use in transporting a fluid between separated stations of usage, a pipe line interconnecting said stations for conveying said fluid therebetween and having an electrical resistance which varies directly with the temperature thereof, electrical means for passing an electrical current through said pipe line to heat and raise the temperature of said pipe line comprising a transformer having a primary winding and a secondary winding, said secondary winding having two terminals connected to said pipe line to establish a load circuit, a source of input voltage arranged to be connected across said primary winding to establish a power circuit and means included in said power circuit for selecting different predetermined numbers of primary turns to be connected across said source in circuit interrupting sequence whereby the voltage in said load circuit and the power input thereto is controlled relative to the voltage across said primary winding comprising three-position switching means having at least two separate circuit mak-

ing positions and a neutral circuit de-energizing position between said circuit making positions, each of said circuit making positions being arranged in said power circuit to be associated with one of said different predetermined numbers of primary turns in series circuit relation across said source, control circuit means for automatically operating said three-position switch to decrease the number of primary turns in response to a predetermined increase in the electrical resistance of said pipe line effectuated by the rise in temperature of said pipe line to re-establish a selected power output of said transformer and time delay means for rendering said three-position switching means inoperative in said neutral position so that said primary winding remains de-energized for a predetermined time delay following each de-energization of said primary winding to provide for a substantially complete collapse of current in said load circuit before said primary winding is re-energized.

13. In the system defined in claim 12 wherein said fluid is electrically conductive and said pipe line is electrically connected to said stations and wherein said load circuit includes means for confining the flow of current through said pipe line and said secondary winding to electrically isolate said pipe line from said stations.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,981,818 April 25, 1961

William J. Trabilcy

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 5, line 37, for "39" read -- 30 --; column 16, line 39, after "pipe" insert -- line --; line 47, for "switchng" read -- switching --.

Signed and sealed this 26th day of September 1961.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

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Commissioner of Patents

USCOMM-DC

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