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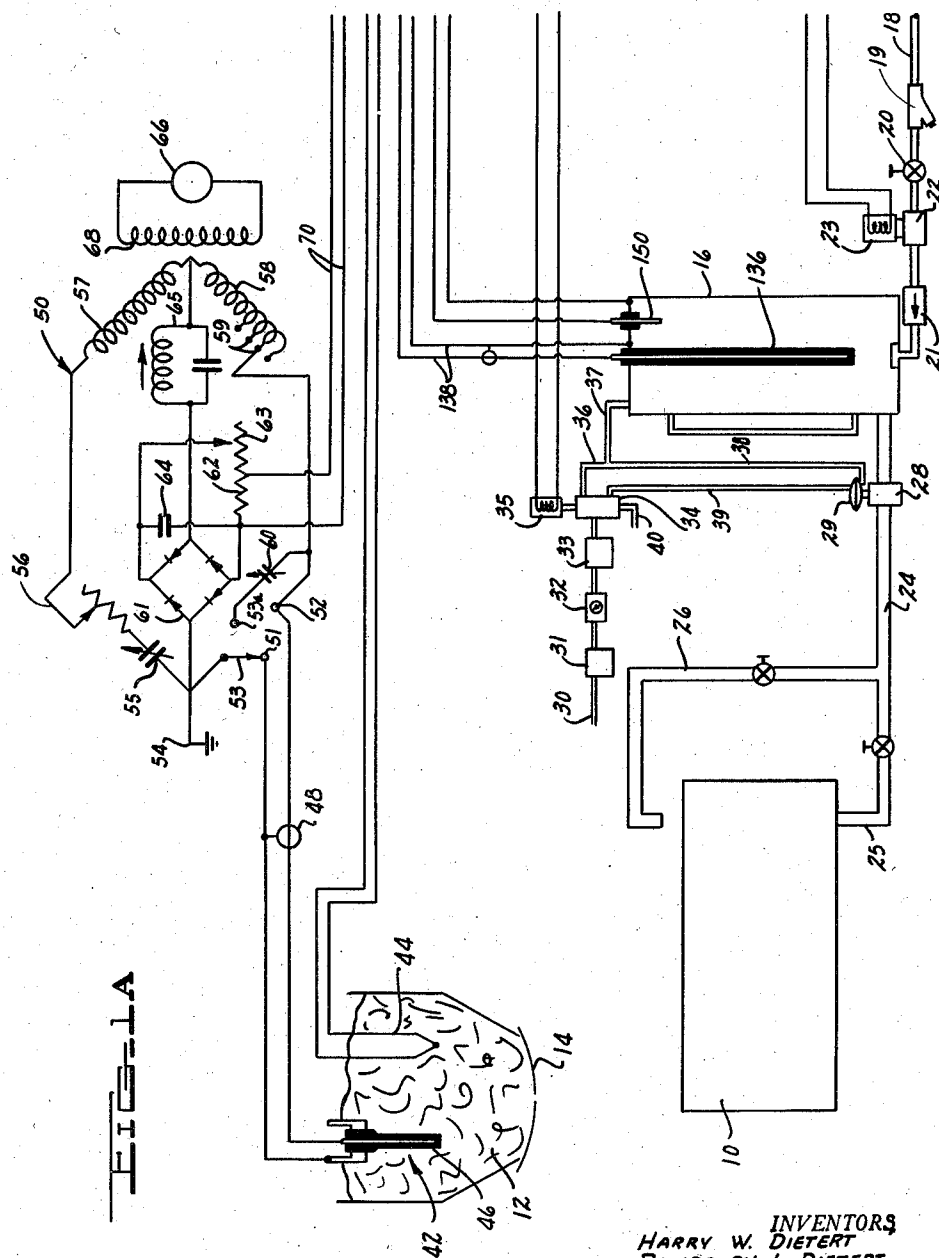
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AUTOMATIC SAND TEMPERING UNIT

Filed Nov. 28, 1955

4 Sheets-Sheet 1



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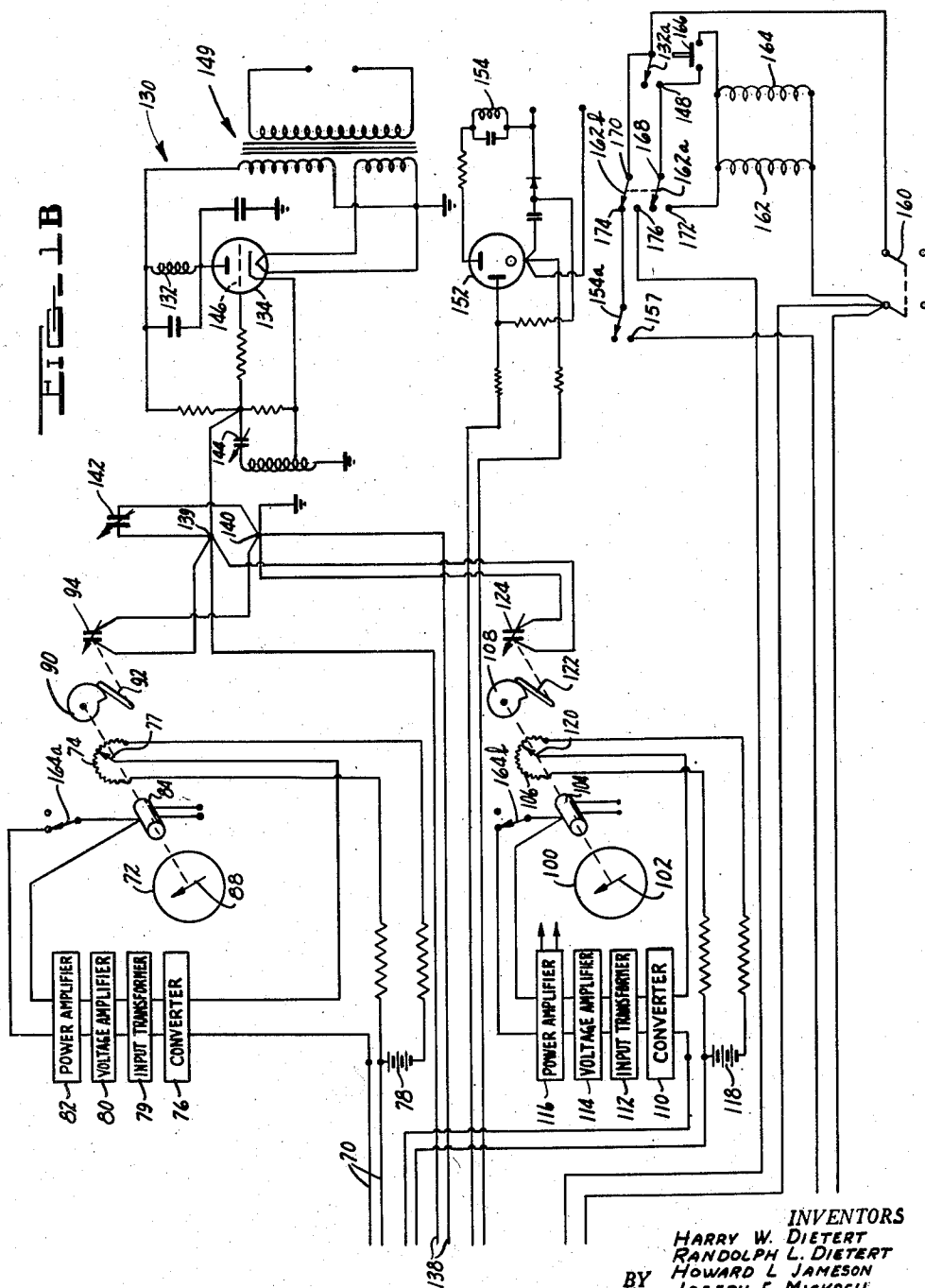
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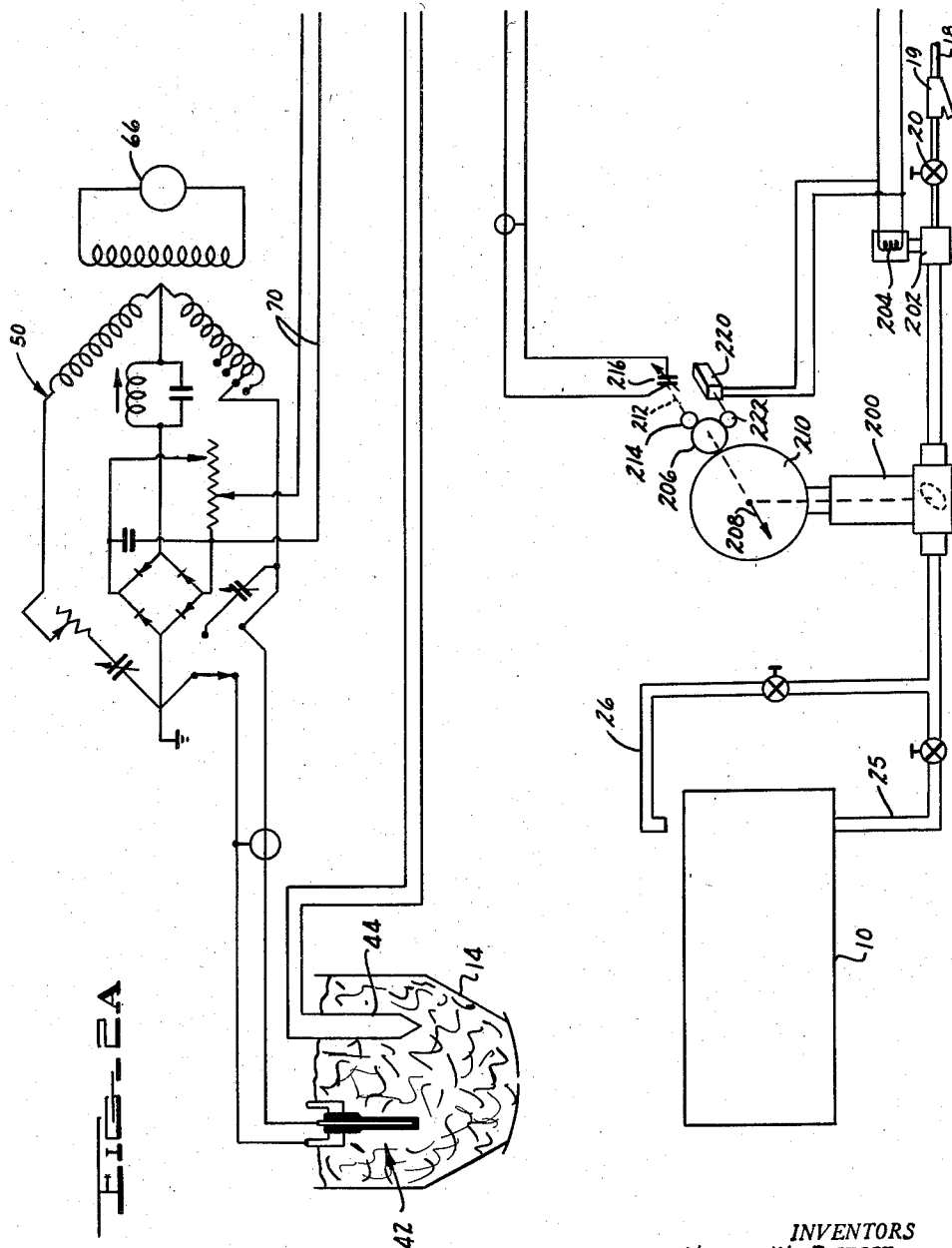
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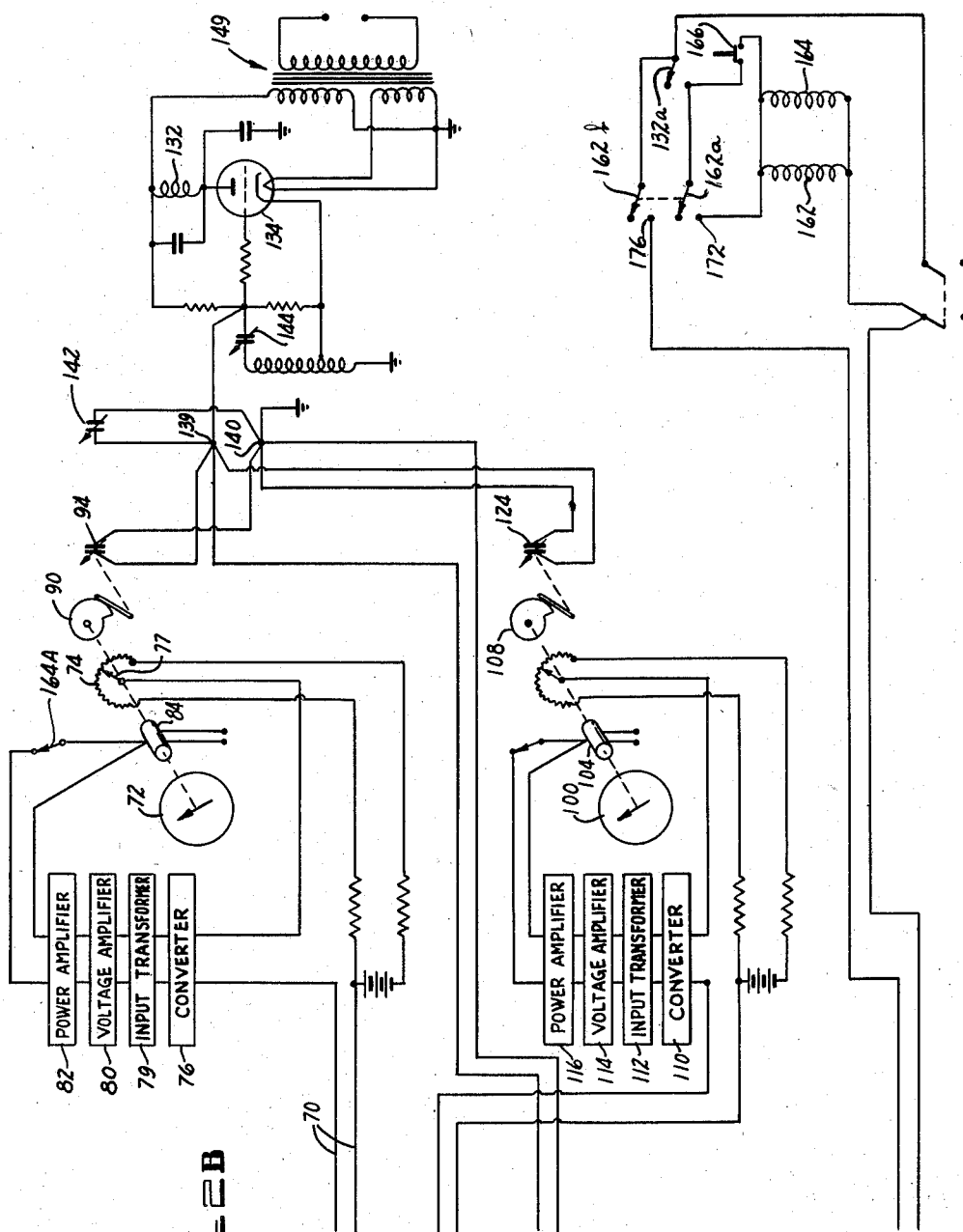
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AUTOMATIC SAND TEMPERING UNIT

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Application November 28, 1955, Serial No. 549,323

22 Claims. (Cl. 22—89)

The present invention relates to an automatic sand tempering unit.

It is an object of the present invention to provide a fully automatic unit for controlling the addition of water to a batch of foundry sand in accordance with specific requirements.

More specifically, it is an object of the present invention to provide an automatic sand tempering unit including a sand mill or mixer and a water tank in position to discharge water into the mixer, means for maintaining the water tank filled to a predetermined level, means for determining the water requirements of a batch of sand, and automatic means responsive to the requirements and to the delivery of water from the tank to the mixer for terminating delivery of water to the mixer.

Still more specifically, it is an object of the present invention to provide in an automatic sand tempering unit temperature and moisture measuring means for effecting an automatic control of the addition of water to the sand, in conjunction with lock-out means to prevent a change in reading of temperature and/or moisture content during delivery of water to the sand.

Other objects and features of the invention will become apparent as the description proceeds, especially when taken in conjunction with the accompanying drawings, wherein:

Figures 1A and 1B together are a combined wiring and mechanical diagram showing the automatic sand tempering unit.

Figures 2A and 2B together are a similar wiring and mechanical diagram showing a modified sand tempering unit.

There has long been a problem of properly mixing foundry sand with the required amount of water to produce moist sand having optimum physical properties. Historically, the preparation of foundry sand for producing molds was considered a matter of individual skill. More recently, it has been recognized that any given character of sand could be brought to its optimum molding condition by the addition of a predetermined quantity of water dependent upon the temperature of the sand and the moisture content of the sand before the addition of water.

Some of the applicants herein have previously made application for patents on sand tempering equipment in which the temperature and moisture content of the sand were measured either directly or indirectly and the necessary water was added to the sand and mixed therewith. In these prior applications, various approaches were made, such for example as continuously measuring the moisture content of the sand in the mixer as the water was added thereto. In another prior application a water tank was provided and a measured quantity of water was admitted to the tank in accordance with temperature and moisture conditions of a batch of sand, after which all of the water in the tank was discharged into a mixer with the sand.

The present invention is an improvement over the

prior inventions as will appear from the detailed description which follows.

Referring first to Figures 1A and 1B, the automatic sand tempering unit comprises a sand mill or mixer 10 and a sand hopper 12 located in position to empty a batch of sand into the mixer. The hopper as illustrated, is provided with gates 14 which may be opened to discharge a predetermined batch of sand into the mixer. Also adjacent the mixer is a water tank 16 having an inlet or supply pipe 18 provided with a filter 19, a manual shut-off valve 20, a check valve 21, and a solenoid controlled inlet or supply valve 22. The coil of the solenoid controlled supply valve 22 is indicated at 23 and is controlled by circuit connections later to be described. Intermediate the tank 16 and the mixer 10 is a discharge pipe 24 having branches 25 and 26 for selectively controlling admission of water into the mixer from the top or bottom thereof as desired. The pipe 24 is provided with a diaphragm actuated valve 28 having an actuating diaphragm indicated diagrammatically at 29 adapted when air is supplied thereto as will subsequently be described, to open the discharge valve 28.

An air supply line 30 is provided connecting through a filter 31, pressure regulator 32, and lubricator 33 to a four-way solenoid actuated air valve 34, the coil of the solenoid being indicated at 35 and actuated by a circuit which will subsequently be described. The four-way air valve 34 includes a line 36 having a first branch 37 leading to the water tank 16 and adapted to pressurize the tank for rapid discharge of water therefrom. Line 36 includes a second branch line 38 leading to the diaphragm 29 and adapted when air is admitted through the branch 38 to open the valve 28. Accordingly, when air is admitted through the air valve 34 to the air line 36, the discharge valve 28 is opened and simultaneously the tank is pressurized to produce a rapid discharge of water from the tank to the mixer. The four-way air valve is provided with a second outlet line 39 and an exhaust connection 40.

The automatic control system for the valves in general includes means for predetermining the quantity of water added to the mixer in accordance with the temperature of a batch of sand and the moisture content thereof before the addition of water thereto. Preferably, these measurements are taken of the sand while it is in the hopper 12 and for this purpose the hopper is provided with a moisture probe 42 and a thermocouple 44.

Referring first to the moisture probe and the circuit associated therewith, the probe comprises a metallic probe element as illustrated, completely surrounded by insulation as indicated at 46. Connected to the moisture probe 42 is a coaxial cable indicated at 48. The moisture probe is a capacitance moisture probe and as the moisture content of the sand surrounding the probe changes, a corresponding change in the electrostatic field surrounding the probe also takes place. This change in the electrostatic field is due to the change of the dielectric constant of the sand. For instance, dry sand has a dielectric constant of two or three, whereas water has a high value of dielectric constant of eighty. Therefore, as the moisture in the sand increases the dielectric constant of the sand increases. The change in dielectric constant of the sand surrounding the probe will cause a change in capacitance of the probe. This capacitance is introduced into a capacitance induction bridge indicated generally at 50, by connection to terminals 51 and 52.

The moisture capacitance bridge 50 between the terminals 51 and 52 comprises a standardizing switch 53 alternately connected to contact 51 or a second contact 53a, a ground connection 54, a manually adjustable capaci-

55, a manually adjustable rheostat 56, a fixed pick up coil 57, and a variable voltage pick up coil 58 having a plurality of selectively connectable taps 59. The standardizing switch 53 when connected to contact 53a introduces a manually adjustable condenser 60 into the bridge circuit instead of the capacitance introduced by the moisture probe. The bridge includes a connection from opposite sides thereof comprising a full wave rectifier 61 connected adjacent the ground connection 54, a fixed resistor 62, and a calibration control variable resistor 63. The condenser 64 is connected across the full wave rectifier as illustrated. A rejector indicated generally at 65 is provided in the cross connection which connects to the opposite side of the bridge circuit between the fixed voltage pick up coil 57 and the variable voltage pick up coil 58.

The moisture capacitance bridge 50 is energized from a high frequency oscillator 66 having a primary coil 68 coupling it to coils 57 and 58.

The current flow in the bridge when unbalanced is rectified and produces a direct current millivolt drop across the fixed resistor 62. The millivolt signal is fed by lines 70 to a millivolt indicating instrument and comprises a bridge circuit and includes an indicator 72 calibrated to read directly in percent moisture of the sand.

When the moisture indicating instrument reads the correct value of moisture content of the batch of sand, the bridge is balanced. When however, the moisture indicating instrument does not read the correct moisture content of the sand, a difference between the potential across the fixed resistor 62 and a balancing slide wire 74 will appear across the converter 76 as a direct current unbalance whose polarity will depend upon the relative values of opposing potentials. The potential across the balancing slide wire 74 is determined by the position of the movable contact 77 and the value of the direct current potential source 78. The direct current unbalance is converted by the converter to an alternating voltage which is supplied through the input transformer 79, voltage amplifier 80, and power amplifier 82 to the balancing motor 84 which drives the motor in the proper direction to adjust the movable contact 77 of the balancing slide wire in the proper direction to balance the measuring circuit. The polarity of the direct current signal at the converter determines the phase of the alternating current signal at the voltage amplifier. The direction of rotation of the balancing motor is determined by the phase of the amplified signal.

The motor 84 drives the pointer 83 movable over the dial of the indicator 72 and also drives the movable contact 77 of the balancing slide wire. In addition, the motor 84 drives a moisture cam 90 which in turn through a cam follower 92, effects an adjustment of a variable condenser 94 which is a part of a water measuring capacitance relay as will subsequently be described.

The second electronic circuit is referred to as the temperature measuring circuit and consists of the thermocouple 44 and a temperature indicating instrument including an indicator 100 including a movable pointer 102 movable over a dial calibrated to read directly in degrees Fahrenheit. The thermocouple produces a millivolt signal similar to the signal across the fixed resistor 62 and this signal is employed to operate the motor 104 so as to effect adjustment of the balancing voltage across the balancing slide wire 106 and to effect corresponding adjustment of a temperature cam 108. The circuit includes the converter 110, input transformer 112, voltage amplifier 114 and the power amplifier 116, all corresponding precisely to similar elements in the moisture indicator. A source of uniform direct current voltage 118 is connected to the ends of the slide wire 106 and operation of the motor 104 effects movement of the movable contact 120 over the slide wire as well as movement of the pointer 102 over the dial of the indicator 100 and adjustment of the cam 108. The cam 108

through a cam follower 122, effects adjustment of an adjustable condenser 124.

A water measuring capacitance relay indicated generally at 130 is provided including a relay coil 132 connected in the plate circuit of a vacuum tube 134. The vacuum tube functions as an oscillator operating at high frequency and the circuit used is a modified Hartley oscillator having circuit constants selected such that the relay coil 132 is sensitive to small changes in water level in the tank. Within the water tank 16 is provided a water measuring probe 136 connected through a shielded coaxial cable 138 to contacts 139 and 140. Across these contacts are also connected the moisture condenser 94 and the temperature condenser 124, as well as a calibrating condenser 142. The quantity of water in the tank affects the value of the capacitance introduced into the circuit by the coaxial cable 138. The water measuring capacitance relay includes an adjustable zero setting capacitor 144. When the values of the four capacitances connected across the contacts 139 and 140 are at the proper value, oscillation in the tank circuit including the adjustable capacitor 144 reduces the bias voltage on the vacuum tube grid 146 to a value such that the plate current drops to a low level and the relay becomes de-energized. This condition occurs when the required quantity of water has been admitted to the mixer to bring the value of capacitance as determined by the water measuring probe 136 to the proper value dependent upon the values of the capacitances of the condensers 94, 124 and 142.

The relay coil 132 controls the position of the movable contact 132a which is movable into and out of engagement with a fixed contact 148 to control current flow to the winding 35 of the four-way air valve 34.

The water measuring capacitance relay 130 is energized through a transformer indicated generally at 149 from a usual 110 volt, 60 cycles circuit, and preferably this circuit remains energized continuously whether or not the unit is in use.

It is an important feature of the present invention that the water tank is always maintained filled to a constant predetermined level except when water is actually being discharged therefrom. The advantages of this will subsequently be pointed out in detail. However, in order to accomplish this, the tank is provided adjacent its top with a full level probe 150 which is connected to an electronic conductive relay employing a three element cold cathode gas filled tube 152. When water makes contact with the full tank level probe the tube extinguishes and the relay coil 154 is de-energized. The relay coil 154 controls a contact 154a into and out of engagement with a fixed contact 157 so as to make and break a circuit to the coil 23 of the solenoid water inlet or supply valve 22.

The circuit including the tube 152 is connected to a 110 volt, 60 cycles source and this circuit also is preferably left on continuously whether or not the unit is in operation.

A power circuit is provided including a disconnect switch 160 having one pole connected through parallel relays 162 and 164 through a momentary contact water discharge switch 166 which connects to the stationary contact 148 previously described, and a second stationary contact 168. Adjacent the contact 168 is a second stationary contact 170. Movable contacts 162a and 162b are respectively connected to stationary contacts 168 and 170 and are interconnected for actuation by relay 162. Contact 162a is movable into and out of contact with a fixed contact 172 and movable contact 162b is movable between fixed contacts 174 and 176.

Relay 164 controls movable contacts 164a and 164b adapted to control the circuit to the motors 84 and 104 respectively for a purpose which will presently appear.

From the foregoing detailed description it will be apparent that the automatic sand tempering unit is essen-

tially an electronic unit composed of three electronic circuits coupled together to automatically compute the volume of water necessary to raise the moisture content of a given batch of sand to any predetermined value, and to automatically control the addition of water to the batch of sand when operation of the unit is initiated by momentary closure of the switch 166.

The first of the three circuits is the sand moisture measuring circuit including the moisture probe 42. This probe is connected to the moisture capacitance bridge 50 which operates as will now be described. The bridge is initially adjusted so that the moisture indicator 72 indicates at the zero index mark when the hopper 12 is empty. The zero index mark is not the same as zero percent moisture because of the difference in dielectric constant of air and dry sand. The zero adjustment is accomplished by adjusting the zero adjust capacitor 55 until the moisture indicator indicates at the zero index. Sand of a known moisture content is then dumped into the hopper and the bridge becomes unbalanced due to a change in the capacitance of the moisture probe. The variable resistor 63 is then adjusted until the moisture indicator indicates the known moisture content of the sand in the hopper. The standardize switch 53 is moved into engagement with fixed contact 53a and connects the variable condenser 60 into the bridge circuit. Capacitor 60 is then adjusted until the moisture indicator again indicates the moisture content of the sand in the hopper. This serves as a reference value of capacitance to which the bridged circuit can be re-adjusted at any time it is desired so that the moisture indicator may be recalibrated or standardized to the original conditions. This permits minimum error due to such factors as changes in line voltage, tube aging, changes in component tolerances, etc. After the above adjustments have been made the moisture indicator will indicate the correct moisture of the sand in the hopper.

The range of capacitance covered by the moisture capacitance bridge is determined by which one of the taps 59 is connected. When the capacitance change is large, due to long probes or high moisture sands, the tap is set to give the minimum number of turns in the pick up coil 58. When the capacitance change is small the cap is set to move the maximum number of turns in the coil. The high frequency voltage is supplied to the bridge by the coupling of the primary coil 53 with the two voltage pick-up coils 57 and 58.

The cam 90, which is driven by the motor 84 into a position in accordance with the moisture content of the sand in the hopper 12, rotates the variable condenser 94, which is preferably a variable plate condenser, so as to introduce a predetermined value of capacitance across the contacts 139 and 140.

When the sand in the hopper is at room temperature and at the correct moisture content, no water will be required at the mixer. Because there is "zero" water required, this condition is referred to as the "zero" condition. With the moisture indicator and temperature indicator set at the "zero" condition, the water tank filled to the bottom of the full level probe and the calibrating condenser 142 set half-way, the "zero" set variable capacitor 144 on the water measuring capacitance relay 130 is adjusted until the relay de-energizes. When the relay is de-energized no water can be discharged from the tank when the water discharge switch 166 is momentarily depressed.

If the moisture indicator is moved to a lower moisture reading, the capacitance of the moisture condenser 94 will be increased. The increase in capacitance will cause the relay 132 in the water measuring capacitance relay 130 to energize. Now, when the water discharge switch 166 is momentarily depressed, relays 162 and 164 are energized, which in turn energize the four-way air solenoid valve 34 which causes air to enter at the top of the tank and causes air to enter the bottom of the diaphragm

29 of the discharge valve 28. The discharge valve opens and water is discharged under air pressure into the mixer 10. As the water level drops, the capacitance of the water measuring probe decreases. When the decrease in the capacitance is equal to the increase in the capacitance of the moisture condenser 94, the relay 132 will de-energize, the water discharge valve will close, and the air supply to the tank 16 will be cut off. At the same time, water inlet valve 22 will open and refill the tank to the full level.

It will be observed at this time that the water inlet valve 22 will remain closed so long as the discharge valve 28 is open since the coil 23 of the solenoid of the water inlet valve 22 is in series with movable contact 162b and this contact will be removed from stationary contact 174 so long as relay 162 is energized.

When the water discharge switch 166 is temporarily closed, relays 162 and 164 are locked in through contacts 162a and 132a if relay 132 is energized. When relay 132 becomes de-energized when the required amount of water has been discharged from the tank, movable contact 132a moves to the position illustrated in the figure, thus breaking the circuit to relays 162 and 164.

It will be observed that so long as relay 164 is energized, contacts 164a and 164b will be moved to a position to break the circuit to the motors 84 and 104 respectively. This serves a very important function in that it renders the temperature and moisture responsive mechanism insensitive to any changes in moisture or temperature which may occur after an initial reading is taken. While the moisture probe responds more or less instantaneously to moisture content of the sand, the thermocouple responds slowly and its rate of response decreases as it approaches the temperature of the sand. By providing means for terminating the measurement after a desired interval, it is possible to employ a predetermined fractional response of the thermocouple as the controlling factor, and thus by proper calibration, to effect a true correction of sand moisture for its actual temperature.

Another important reason for locking out the condition responsive instruments is that under certain conditions the responses change. Thus for example, vibration of sand in the hopper or skip hoist for example, if such were employed, would cause the sand to set or become more compact, with a substantial change in apparent moisture content.

It will be appreciated that the moisture condenser and temperature condenser together with the calibrating condenser and the capacitance of the water measuring probe are connected in parallel so that their capacitances add. Thereafter, the amount of water that will be discharged from the tank will be a direct function of the capacitances of the moisture and temperature condensers. The calibrating condenser may be used to add or subtract a given quantity of water from the total which is added to the mixer. For example, if it is desired to increase the final moisture content of the sand in the mixer, the capacitance of the calibrating condenser 142 is increased in value. The calibrating condenser may be provided with a dial calibrated to read percent moisture or gallons.

The water measuring capacitance relay 130 operates as follows: With the moisture indicator 72 and the temperature indicator 100 adjusted at the "zero" condition, the "zero" set capacitor 144 is adjusted so that sufficient positive feed-back is generated to sustain the tube 134 in an oscillating condition. The oscillation develops a grid-bias voltage which reduces the plate current of the tube to a low level and the relay 132 does not energize. When the moisture indicator moves to a lower moisture, or when the temperature indicator moves to a higher temperature, the capacitance to ground increases. This causes a reduction in the positive feed-back to a value where the oscillations cannot be sustained and a reduction in the grid-bias voltage results. The plate current of the tube increases sufficiently to energize the relay. As stated pre-

viously, the components of the circuit have been selected so that a very small change in capacitance will cause the relay to energize.

Referring now to Figures 2A and 2B, the unit is substantially the same and will not be described in detail except to point out the differences resulting from substitution of a movable water meter for the valve controlling discharge of water from a tank. In this embodiment of the invention the water supply line 18 connects through a flow meter 200. The flow of water to the mixer is controlled by a solenoid valve 202 which corresponds in type to the inlet or supply valve 22 of Figure 1A, but which has a solenoid 204 controlled by movement of the movable switch contact 162b into engagement with the fixed contact 176. In this case the flow meter includes drive mechanism adapted to rotate a gear 206 and also to actuate an indicator point 208 over a dial 210. The gear 206 drives a shaft 212 through a gear 214 which actuates a variable condenser 216. The variable condenser is connected to the contacts 139 and 140 and thus set a value of capacity into the water measuring capacitance relay in the same manner as the variable capacitance is set in by the water measuring probe 138 in the embodiment illustrated in Figures 1A and 1B.

In order to reset the water meter between alternate charges of water to the mixer, there is provided reset mechanism 220 connected across the solenoid coil 204 and connected by a pinion 222 to the gear 206. The reset mechanism is cocked when the solenoid 204 of the valve 202 is energized. When the solenoid is deenergized the reset mechanism is released and causes the pointer 208 to return to zero and the variable condenser 216 also to return to zero position (not zero value of capacitance).

It will of course be appreciated that in this embodiment of the invention the mechanism for refilling the tank is omitted. Otherwise, the significant remaining parts of the circuit are identical with that previously described and like reference numerals have been applied thereto.

The present system has substantial advantages over the prior system as will now be pointed out:

(1) The water tank (in the embodiment of the invention shown in Figures 1A and 1B) can be filled during the mixing cycle without sand being in the batch hopper. This permits preparation of the unit for rapid sand tempering and avoids the necessity for delay which is inherent in a system in which water is measured into the tank.

(2) The moisture measurement and temperature measurement information is sampled at the moment the water is discharged. Therefore, if the sand is permitted to set in the hopper for long periods, any change in moisture or temperature reading will affect the amount of water discharged. Previously, water was in some cases metered into the tank in accordance with information gathered when the sand was placed in the hopper. In this system, if conditions changed no compensation was made and an incorrect amount of water was added to the sand.

(3) The lock-in of the moisture and temperature dial is also particularly advantageous in applications where vibrations are present, such for example as in skip hoist applications where vibration causes the sand to compact and both temperature and moisture readings change. With the present system, the relays 164 may be separately energized at any desired point in the cycle so that constant results or readings are attained.

The present unit maintains the tank filled at all times. Obviously, the capacity of the tank is such that the tank will never be completely empty. As a result of this there is never a situation in which air pressure is exhausted into the room through an empty tank. In other words, air is admitted to the tank only during discharge of water therefrom, and accordingly, a substantially lower volume of compressed air will be required.

The drawings and the foregoing specification constitute a description of the improved automatic sand tempering

unit in such full, clear, concise and exact terms as to enable any person skilled in the art to practice the invention, the scope of which is indicated by the appended claims.

What we claim as our invention is:

1. An automatic sand tempering unit comprising a sand mixer, a water tank adjacent said mixer, a discharge pipe leading from said tank to said mixer, a discharge valve in said discharge pipe, a supply pipe leading to said tank, a supply valve in said supply pipe, means for measuring the temperature and moisture content of a batch of sand supplied to said mixer, valve control means for maintaining said tank filled except when water is supplied to said mixer, and discharge control means responsive to the measured temperature and moisture content of the sand for controlling said discharge valve to add a measured quantity of water to said mixer.

2. An automatic sand tempering unit comprising a sand mixer, a water tank adjacent said mixer, a discharge pipe leading from said tank to said mixer, a discharge valve in said discharge pipe, a supply pipe leading to said tank, a supply valve in said supply pipe, means for measuring the temperature and moisture content of a batch of sand supplied to said mixer, valve control means for maintaining said tank filled except when water is supplied to said mixer, and discharge control means responsive to the measured temperature and moisture content of the sand for controlling said discharge valve to add a measured quantity of water to said mixer, said discharge control means including air operated means for opening said discharge valve and means for simultaneously supplying compressed air to said air operated means and admitting compressed air to said tank.

3. An automatic sand tempering unit comprising a sand mixer, a water tank adjacent said mixer, a discharge pipe leading from said tank to said mixer, a discharge valve in said discharge pipe, a supply pipe leading to said tank, a supply valve in said supply pipe, means for measuring the temperature and moisture content of a batch of sand supplied to said mixer, valve control means for maintaining said tank filled except when water is supplied to said mixer, discharge control means responsive to the measured temperature and moisture content of the sand for controlling said discharge valve to add a measured quantity of water to said mixer, said discharge control means including means for simultaneously opening said discharge valve and admitting compressed air to said tank, and means for measuring water discharged from said tank operable to close said discharge valve when the proper amount of water has been discharged.

4. An automatic sand tempering unit comprising a sand mixer, a water tank, a supply valve controlling supply of water to said tank, a discharge valve controlling discharge of water from said tank to said mixer, temperature measuring means for measuring the temperature of sand supplied to said mixer, moisture measuring means for measuring the moisture content of sand supplied to said mixer, water discharge measuring means, means responsive jointly to sand temperature and moisture and the quantity of water discharged from said tank to said mixer for controlling said discharge valve, and supply valve control means operable as a result of termination of discharge to actuate said supply valve to refill said tank.

5. A unit as defined in claim 4 in which said discharge valve is air actuated, and said means for controlling said discharge valve is an air valve, and means for supplying air under pressure to said tank whenever air is supplied to said discharge valve to open the same.

6. An automatic sand tempering unit comprising a sand mixer, a water tank, a supply valve controlling supply of water to said tank, a discharge valve controlling discharge of water from said tank to said mixer, temperature measuring means for measuring the temperature of sand sup-

plied to said mixer, moisture measure means for measuring the moisture content of sand supplied to said mixer, means responsive jointly to sand temperature and moisture to control the addition of water to said mixer, and means for locking said temperature and moisture measuring means against change during the addition of water.

7. An automatic sand tempering unit comprising a sand mixer, a water tank, a supply valve controlling supply of water to said tank, a discharge valve controlling discharge of water from said tank to said mixer, temperature measuring means for measuring the temperature of sand supplied to said mixer, moisture measuring means for measuring the moisture content of sand supplied to said mixer, said temperature and moisture measuring means comprising electric motors, an electric circuit for controlling said discharge valve and motors, and means operable by actuation of said discharge valve to open position to break the circuit of said motors.

8. Automatic sand tempering unit comprising a hopper, a water tank, a sand mixer in position to receive sand from said hopper and water from said tank, means for measuring the temperature and moisture of sand in said hopper, automatic means for maintaining said tank filled except while discharging into said mixer, a valve controlling discharge of water from said tank to said mixer, operator controlled means for opening said valve, and means responsive jointly to sand temperature and moisture and the quantity of water discharged into said mixer for closing said valve.

9. Automatic sand tempering unit comprising a hopper, a water tank, a sand mixer in position to receive sand from said hopper and water from said tank, means for measuring the temperature and moisture of sand in said hopper, automatic means for maintaining said tank filled except while discharging into said mixer, a valve controlling discharge of water from said tank to said mixer, operator controlled means for opening said valve and simultaneously locking said temperature and moisture measuring means against change, and means responsive jointly to sand temperature and moisture and the quantity of water discharged into said mixer for closing said valve.

10. Automatic sand tempering unit comprising a hopper, a water tank, a sand mixer in position to receive sand from said hopper and water from said tank, means for measuring the temperature and moisture of sand in said hopper, automatic means for maintaining said tank filled except while discharging into said mixer, a valve controlling discharge of water from said tank to said mixer, operator controlled means for opening said valve, and means responsive jointly to sand temperature and moisture and the quantity of water discharged into said mixer for closing said valve, said last named means being effective to initiate operation of said automatic means for refilling said tank upon closure of said discharge valve.

11. Automatic sand tempering unit comprising a hopper, a water tank, a sand mixer in position to receive sand from said hopper and water from said tank, moisture responsive means comprising a moisture probe in said hopper for establishing a capacitance dependent on the moisture content of sand in said hopper, temperature responsive means for establishing a second capacitance dependent on the temperature of sand in said hopper, water measuring means comprising a probe in said tank for establishing a third capacitance dependent on the quantity of water delivered to said mixer, a relay-controlled valve controlling the delivery of water from said tank to said mixer, and a capacitance relay including said three capacitances for controlling said valve to close said valve when the required quantity of water has been delivered to said mixer.

12. A unit as defined in claim 11 in which said valve is air-actuated to open position, an air valve, and air lines from said air valve to said air-actuated valve and to said tank to pressurize said tank while said valve is open.

13. An automatic sand tempering unit comprising a sand mixer, a water tank, a supply valve controlling supply of water to said tank, a discharge valve controlling discharge of water from said tank to said mixer, temperature measuring means for measuring the temperature of sand supplied to said mixer, moisture measuring means for measuring the moisture content of sand supplied to said mixer, water discharge measuring means for measuring the water delivered to said mixer, control mechanism for said unit comprising operator controlled means for opening said discharge valve and for preventing opening of said supply valve so long as said discharge valve is open, means responsive jointly to sand temperature and moisture and water supplied to said mixer for closing said discharge valve and opening said supply valve, and means responsive to the level of water in said tank for closing said supply valve when said tank is filled to a predetermined level.

14. An automatic sand tempering unit comprising a sand hopper, a sand mixer positioned to receive sand from said hopper, a water tank, a supply valve controlling supply of water to said tank, a discharge valve controlling discharge of water from said tank to said mixer, temperature measuring means for measuring the temperature of sand supplied to said mixer, moisture measuring means for measuring the moisture content of sand supplied to said mixer, water discharge measuring means for measuring the water delivered to said mixer, control mechanism for said unit comprising operator controlled means for opening said discharge valve and for preventing opening of said supply valve so long as said discharge valve is open, means responsive jointly to sand temperature and moisture and water supplied to said mixer for closing said discharge valve and opening said supply valve, means for preventing a change in reading of said temperature and moisture measuring means during the time in which said discharge valve is open, and means responsive to the level of water in said tank for closing said supply valve when said tank is filled to a predetermined level.

15. A unit as defined in claim 14 in which said temperature measuring means is located in said hopper.

16. A unit as defined in claim 14 in which said moisture measuring means is in said hopper.

17. A unit as defined in claim 14 in which said water discharge measuring means is a probe in said tank.

18. A unit as defined in claim 14 in which said temperature measuring means is a thermocouple located in said hopper.

19. A unit as defined in claim 14 in which said moisture measuring means is a probe in said hopper.

20. A unit as defined in claim 14 in which said temperature measuring means is a thermocouple located in said hopper, said moisture measuring means is a probe in said hopper, and said water discharge measuring means is a probe in said tank.

21. An automatic sand tempering unit comprising a sand mixer, means for supplying water to said mixer including a valve, temperature measuring means for measuring the temperature of sand supplied to said mixer prior to any addition of water thereto, moisture measuring means for measuring the moisture content of sand supplied to said mixer prior to any addition of water thereto, means for measuring the quantity of water supplied to said mixer, means responsive jointly to sand temperature and moisture content and the quantity of water admitted to said mixer to control said valve to control the addition of water to said mixer, and means for locking said temperature and moisture content measuring means against change during the addition of water to said mixer.

22. A unit as defined in claim 21 in which the means for measuring the quantity of water added to said mixer comprises a flow meter.

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