The present invention relates to sand conditioning equipment.

This application is a continuation-in-part of our prior copending application Serial No. 567,020 filed February 27, 1956.

It is an object of the present invention to provide sand conditioning equipment for controlling the addition of water to foundry sand and for mixing the sand to bring it to the proper condition for use in a foundry.

More specifically, it is an object of the present invention to provide means for mixing sand and water, means for effecting controlled addition of water to the sand, means for measuring the moisture content of the sand and the temperature of the sand, and means for terminating the addition of water when the sand and water mixture has reached the proper moisture content in accordance with its temperature.

Still more specifically, it is an object of the present invention to provide a container in which sand and water are mixed, means for providing continued addition of water to the sand, moisture measuring means including a sensing element disposed at the inner surface of the container, the mixing means comprising means for alternately compressing a specimen of sand against the sensing element, and means for thereafter removing the compressed sample from the sensing element.

It is a further object of the present invention to provide apparatus as described in the preceding paragraph in which the means for compressing the specimen against the sensing element comprises a roller, and the means for removing the compressed specimen from the sensing element comprises a scraper.

It is a further object of the present invention to provide sand conditioning apparatus including an improved moisture sensing element characterized by its ability to prevent a moist sand sample from sticking thereto.

It is a further object of the present invention to provide an improved sand moisture sensing element comprising an insulated stainless steel probe having a surface substantially flush with the interior of a sand container.

It is a further object of the present invention to provide a probe for sensing the moisture content of sand in a container comprising an insulated conducting element having a surface substantially flush with the inner surface of a sand container, and means for effecting heating of the probe to prevent a false response due to accumulation of moisture in the vicinity of the probe.

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

Figure 1 is a circuit diagram showing the complete system including means for sensing temperature and moisture content of the sand, and means for controlling the addition of moisture to the sand.

Figure 2 is a diagrammatic plan view of a sand container constructed in accordance with the present invention.

Figure 3 is a transverse sectional view of the structure shown in Figure 2.

Figure 4 is a diagrammatic plan view of a sand container forming a second embodiment of the present invention.

Figure 5 is a partly diagrammatic sectional view on the line 5—5, Figure 4.

Figure 6 is a diagrammatic elevational view partly in section, of structure comprising a third embodiment of the present invention.

Figure 7 is a side elevational view of the structure shown in Figure 6.

Figure 8 is an axial section through a moisture determining probe employed in the present invention.

Referring first to Figure 1, there is illustrated a sand mill or mixer 10 comprising an open topped chamber or container into which foundry sand is dumped. It is a function of the apparatus to temper the sand for use in preparing foundry castings. In foundry operation the foundry sand may be returned for re-use and may be mixed with different proportions of unused sand. Inasmuch as the sand returned for re-use may still be relatively hot, it will be apparent that the temperature of the sand in the mixer may vary between wide limits.

It has been found that for satisfactory foundry use, the sand must have an accurately controlled moisture content. This moisture content as determined at the mixer, must be varied in accordance with the temperature of the sand. One factor which requires variation in the moisture content of the sand in accordance with temperature is the loss of more moisture from relatively hot sand during the time elapsing between its discharge from the mixer to its actual use in preparing the mold.

The sand within the mixer 10 is continuously mixed by suitable means such as for example as the paddles or rollers disclosed in subsequently described figures.

A quantity of sand is dumped into the mixer and water is added through a water line 14 having a manual shut-off valve 16, a solenoid controlled valve 18, and branch lines 20 and 22 respectively controlled by manual valves 24 and 26. It will be observed that with the valve 24 open and the valve 26 closed, water is admitted into the top of the mixer 10. With the valves 24 and 26 reversed, water is admitted into the bottom of the mixer.

Preferably, a second water line 30 having a solenoid controlled valve 32 is provided. While this water line is illustrated as adapted to permit water only to the top of the mixer 10, it will be appreciated that it may if desired be provided with a branch line for admitting water to the bottom of the mixer.

In accordance with the present invention it is desired to provide apparatus which may condition any desired amount of sand without requiring measurement of the quantity of sand. Accordingly, the addition of water is of the type referred to hereinafter as end point control, which means that the actual moisture content of the sand in the mixer is continuously measured and this measurement is employed as a means for controlling the addition of water directly to the mixer. This is to be contrasted with prior known types of sand tempering apparatus in which a measured quantity of sand was placed in the mixer and a measured quantity of water was provided in a tank and thereafter dumped into the mixer.

Basically, the present invention comprises an electrical circuit adapted to operate the solenoid controlled valves, the electrical circuit being dependent upon an electrical capacity which represents the sum or difference of two electrical capacities, one of which is proportional to sand temperature and the other of which is proportional to the moisture content of the sand.
Referring first to the temperature measuring part of the system, a thermocouple indicated generally at 34 is provided in the mixer wall, the thermocouple being connected to conductors 40 and 41. The conductor 41 leads through a resistance 42 to one end of a slide wire 43, the other end of which is connected by a conductor 44 through a resistance 45 to a battery 46, the battery being connected by a conductor 47 to the conductor 41. A movable contact 48 of the slide wire 43 is connected by a conductor 49 to a converter. The conductor 40 previously referred to is connected between the thermocouple and the converter.

Direct current supplied to the converter is applied through a proportionately greater moisture transformer, the voltage amplifier, and the power amplifier designated in the figure to an electric motor 50 having an output shaft 52. The output shaft of the motor is connected to a pointer 53 movable over a dial 54 to indicate the temperature of the moist sand within the mixer 10. Also connected to the shaft 52 is the movable contact 48 of the slide wire. Finally, the shaft 52 also carries a cam 55 which bears against an arm 56 connected to a shaft 57 which in turn controls the setting of a variable condenser 58.

When the temperature is sensed by the thermocouple 34 is different from that indicated by the pointer 53, a differential is established by the thermocouple and the slide wire 43 will appear across the converter as a direct current unbalance whose potential will depend upon the relative values of opposed potentials. The potential across the balancing slide wire 43 is of course determined by the position of the movable contact 48 and the value of the direct current potential source 46. The direct current unbalance is converted by the converter to an alternating voltage which is supplied through the input transformer, voltage amplifier, and power amplifier to the balancing motor 50 which drives the motor in the proper direction to adjust the movable contact 48 of the balancing slide wire 43 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 amplifier signal. Since rotation of the motor 50 also rotates the cam 55, it follows that the setting of the variable condenser 58 is determined by the temperature of the moist sand in the container 10.

Also received in a wall of the container 10 is a probe 60 measuring the actual moisture content of the sand. The probe 60 is shown in detail in Figure 8 and comprises a tube 62 preferably formed of stainless steel and fixed in an opening 64 in a plate 66 adapted to be exposed at the inner surface of a wall of the container 10. Located within the tube 62 is a metal ring 68 fixed in position by pin 70. An insulating bushing 72 is provided having an opening 74 through which extends a stainless steel probe element 76 of the outer end of which is conically formed as illustrated and has a surface substantially flush with the inner surface of the container wall 66. At the opposite side of the ring 68 is a second insulating member 84 having a reduced portion 80 which carries a washer 82 preferably formed of metal such as example for brass. Slidably supported in the tube 62 is a third insulating member 84 having a reduced portion 86 carrying a washer 88 preferably formed of metal such as example for brass. Extending between the washers 82 and 88 is a compression spring 90. Located within the spring 90 and engaging the intermediate portion of the probe element 76 is an insulating sleeve 92.

The outer end of the probe element 76 is threaded as indicated at 94 and carries a nut 96 bearing against a washer 98 which in turn bears against the outer end of the insulating member 84. Accordingly, the spring 90 urges the probe element 76 outwardly and maintains its head in firm contact in the conically formed seat provided in the insulating member 72. By adjusting the nut 96, the effectiveness of the spring 90 may be adjusted to insure a positive seal between bushing 72 and element 76 at all times despite cold flow of the material of the bushing. Bushings 72, 78 and 84 may be formed of a suitable inert plastic material such as polyethylene, di- fluoro ethylene, and the like.

It has been found that unacceptable large errors in a determination of moisture content result if the moisture probe is at a temperature less than that of the sand. This is apparently for the reason that the cold probe tends to condense moisture from the sand and accordingly, in such case the moisture probe indicates a substantially lower reading for the sand than is actually present. In accordance with the present invention means are provided for insuring that the moisture probe is maintained at a temperature above that of the sand.

An electrical heating element indicated diagrammatically at 100 is provided. The heating element may surround a collapsible plate 104 and if desired insulation may be provided, as indicated at 103, to surround the tube 62.

The probe element 76 is connected to a conductor 106 of a coaxial cable indicated diagrammatically at 108. Referring again to Figure 8, the electrical capacity across the moisture probe 60 is connected between ground as indicated at 110 and a contact point 112. At the same time, the electrical capacity existing across the variable condenser 58 is applied between ground as indicated at 114, and the same electrical contact point 112. Also connected in parallel with the variable condenser 58 are a pair of variable condensers 116 and 118, the electrical capacity of which may be manually set to obtain the desired operation. From the foregoing it will be observed that the electrical capacity of the probe 60 and of the variable condensers 58, 116 and 118 are all connected in parallel and that these parallel circuits are connected between ground and the common contact point 112.

The common contact point 112 is included in a Hartley oscillator circuit including the vacuum tube 120 and having a relay coil 122 in the plate circuit of the vacuum tube. When the sum of the electrical capacities connected to the contact 112 reach the proper value as determined by the circuit constants, the value of the current in the relay coil 122 will change so as to effect operation of normally closed contacts 122a and 122b. As illustrated in the figure, the contacts 122a are normally closed contacts in a 110-volt line connected to the windings of solenoid valves 18 which may be interconnected so that when the solenoid is de-energized the valves close, thus terminating admission of water through line 14. Contacts 122a when opened by energization of coil 122, latch open and remain latched open until manually released.

In the preferred form of the invention a second water line 30 is provided with the solenoid valve 32 previously referred to. In this case the second manually adjustable condenser 118 is provided and is adapted to be connected in parallel with the condenser 116 so long as normally closed contacts 122b remain closed. In this case condensers 116 and 118 are set at a value such that the current through relay coil 122 will operate to open the normally closed contacts 122a and 122b when the moisture content of the sand within the container 10 approaches the required value for the particular temperature of the sand. Thus for example, the relay 122 may operate when the moisture content is 90% of the desired content. In this case the water line 30 continues in operation to add a relatively small flow of water to the sand within the mixer until the moisture content reaches the exact value desired. This may be determined by the setting of the condenser 118 whose capacity is
additive to that of the condenser 116 so long as normally closed contact 122b remains closed. Thus, the subtraction of the capacity of the condenser 118 upon the first operation of the relay 123 requires a further increase in the capacity as determined by the moisture probe 60.

Contacts 122a and 122b are of the type including manually releasable latch means which operate to maintain them in open position after they have been opened by relay coil 122 until manually released. The circuit to the solenoid of the valve 32 is controlled by normally closed contacts 122c, adapted to be opened when the coil 122 is energized.

From the foregoing it will be observed that initially the capacitance applied to the contact point 112 of the oscillator circuit and to the control grid of the vacuum tube 120 includes the sum of the capacities of the condensers 116 and 118 as well as the capacity of the condenser 58 and the capacity across the moisture probe. When the sum of these capacities reaches a predetermined amount as determined by the circuit constants, the current passing through the relay coil 122 opens all normally closed contacts 122a, 122b, and 122c. The contacts 122a and 122b, being provided with the manually releasable latch means, remain open until manually released following the cycle. Opening of contacts 122b removes the capacity of the condenser 118 from the sum of the capacities applied to the point 112 and thus requires a further addition of capacity by increase in the moisture content of the sand to again bring the current in the coil 122 up to the actuating value. Thus, upon opening of the normally closed contacts 122b, relay 122 is in effect de-energized and normally closed contact 122c again closes and remains closed until the sum of the capacities applied to the contact point 112 reaches the value required by the constants of the oscillator circuit. At this time solenoid valve 32 is closed and the sand in the mixer or container 10 is of the actually required moisture content for its particular temperature.

The circuit disclosed herein may if desired be operated as a high level or as a low level control circuit. In the case of a high level control circuit as moisture is added the electrical capacity of the probe increases and the system oscillates to increase the grid bias voltage. When the grid bias voltage reaches a predetermined value, the plate current of the tube decreases, de-energizing the relay coil 122. If employed as a low level circuit, as moisture is added the electrical capacity of the probe increases and the plate current of the oscillator system decreases until the oscillation cannot be sustained. This reduces the grid bias voltage and results in an increase in plate current, thereby energizing the relay coil 122.

It will of course be appreciated that appropriate changes in the solenoid valve control circuits and the control contacts thereof will be made dependent upon whether the control circuit operates as a high level or low level control circuit. In the specifically illustrated and described circuit it is assumed that the coil 122 is rendered operative to activate contacts 122a, 122b and 122c when moisture content reaches the required amount.

The foregoing operation is particularly useful when it will be recalled that its accuracy is entirely independent of the quantity of sand in the mixer.

Thus, it has been found that for the necessary degree of accuracy, the sand whose moisture content is measured by the moisture probe 60 should be compacted against the surface of the probe uniformly since variation in the pressure with which the specimen of sand is compacted leads to variations in moisture indication. In accordance with the present invention, means are provided in the mixer for repeatedly compressing a specimen of moist sand against the surface of the probe and for thereafter removing the specimen prior to compressing a second test specimen thereagainst.

Referring now to Figures 2 and 3 there is shown a mixer 130 having a vertical drive shaft 132 carrying a cross shaft 134 provided with rollers 136 at opposite ends thereof. Also connected to the vertical shaft 132 is an arm 138 carrying a scraper 140 adapted to move over the bottom wall of the container 130. An inner scraper, indicated generally at 142, is also provided. In this case a moisture probe 144 is provided in the bottom wall of the container 130 in position beneath the path of travel of the rollers 136. Thus, during operation of the mixer rotation of the shaft 132 causes the rollers 136 to pass over the probe 144 and to compress the sand against the exposed surface of the moisture probe with a predetermined pressure. After the passage of the roller 136, which precedes the scraper 140, the compacted specimen of sand is removed. The system operates only upon attainment of a predetermined value of the sum of the various capacitances, so that the control circuit is operated only when the moisture content reaches the value required first to shut off the moisture supply through the water line 14 and thereafter when it reaches the second higher value required to shut off the supply of water through the water line 30. It will of course be appreciated that a thermocouple or other temperature responsive means is associated with the container 130.

Referring now to Figures 4 and 5 there is illustrated a somewhat different embodiment of the invention. In this case the container 150 has associated therewith a vertical drive shaft 152 including a plate 154 having rollers 156 adjacent its periphery. Depending from the plate 154 are vanes 155 the lower edges of which are connected to a plate 158 at the outer edges of the plate 154 and in the horizontal plane of the rollers 156 are provided scrapers 162. The mixer also includes plows 164. Water may be admitted to the container 150 through water lines corresponding to the lines 14 and 30, controlled by solenoid valves corresponding respectively to the valves 18 and 32. One such water line is indicated at 166 and a solenoid controlled valve indicated at 168.

Means are provided for measuring the temperature of the sand in the container 150 and this means may take the form of a thermocouple indicated diagrammatically at 170. A moisture probe which may be identical with that shown in Figure 8 is diagrammatically indicated at 172. It will be appreciated that as the shaft 152 rotates, the rollers 156 compress a specimen of moist sand against the exposed surface of the moisture probe. If the moisture content reaches a maximum reading. Theretofre, the moist specimen is removed by the scraper 162 which follows each of the rollers 156. Accordingly, a series of independent readings of moisture content are taken each of which includes the step of compressing a new specimen of moist sand against the operating surface of the moisture probe at a constant pressure.

Referring now to Figures 6 and 7, there is illustrated an application of the present invention to a sand controller which includes means for advancing tempered sand to a point of use. In this case sand in a hopper 180 is fed continuously to a conveyor 182 which advances it to a trough 184. Water is supplied to the sand in the trough 184 through a water line 186 having a regulating valve 188 therein which is regulated by a diaphragm control unit indicated at 190 connected to a variable pressure oil line 192. Water passing the valve 188 is sprayed through a fixture 194 onto the sand at the entry end of the trough 184.

Extending longitudinally of the trough are a pair of rotary shafts 196 and 198 each containing a multiplicity of blades 200. The blades are provided in generally coplanar sets of three, two blades of each set being pitched to feed the sand to the discharge end of the trough and the other blade being reversely pitched to improve the mixing action. Thus, as the sand and water are fed to the trough they are intimately mixed and are advanced
to the discharge end of the trough where the mixture falls upon a conveyor 204 for conveying the tempered sand to the point of use.

Located adjacent the entry end of the trough is a temperature responsive device diagrammatically indicated at 206 and a moisture probe diagrammatically indicated at 208. It will be observed that the moisture probe 208 is in the plane of one set of three blades 200. The operation of these blades during rotation is to press a specimen of moist sand against the exposed surface of the moisture probe as the blade passes. Thus, the passage of each blade provides a substantially uniform compression of the moist specimen of sand against the exposed surface of the moisture probe. At the same time, the sand is continually moved past an operating surface of the probe so that a succession of uniformly compressed specimens of moist sand are provided.

The temperature and moisture content of the sand may be employed in a circuit similar to that shown in Figure 1 except that the output of the oscillator circuit, which will be dependent upon the moisture content of the sand, may be employed to regulate air pressure applied to the diaphragm control 190 of the valve 188; thus, the continually advancing sand is accurately tempered to the required moisture content.

Referring again to Figure 1 there is diagrammatically illustrated an improvement which increases the accuracy of temperature reading. As seen in this Figure, the container 10 is provided with a dump door 210 hinged as indicated at 212 and provided with an air cylinder 214 for opening and closing the door. Located within the container 10 and adjacent the exposed surface of the thermocouple 34 is an air conduit 216 connected to the exhaust line of the air cylinder 214. It will be appreciated that the air line 216 is disposed to extend along the inner surface of the container and that it therefore provides no interference with operation of paddles, rollers, plows or other moveable mixing members in the container. The open end of the air line 216 is directed toward the exposed surface of the thermocouple with the result that a blast of air cleans the exposed surface of the thermocouple every time the dump door is closed. Thus, when a new charge of sand is admitted to the container 10, there is no accumulation of old charge overlying the exposed surface of the thermocouple to interfere with a true reading of the temperature of the new charge of foundry sand.

It will of course be appreciated that a similar air blast may be provided for effecting a cleaning operation on the exposed surface of the moisture probe following each tempering cycle.

While the circuit of Figure 1 shows the probe and related elements as essentially electrical capacitors, those skilled in the art will recognize the possibility of employing circuitry involving resistances and/or inductances.

The drawings and the foregoing specification constitute a description of the improved sand conditioning equipment 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. Tempering equipment for granular material comprising a container for said material, moisture sensitive means at an inner wall of said container, means for measuring the temperature of material in the container, means for adding water to the material in the container, means for periodically compressing a moist specimen of material against said moisture sensitive means, means operable between successive specimen compressing operations to remove the compressed specimen from said moisture sensitive means, and control means responsive to the temperature and moisture content of the material for controlling the means for adding water to the material.

2. Equipment as defined in claim 1 in which said container comprises a fixed receptacle adapted to receive a batch of material to which water is added until it is sufficiently moist.

3. Equipment as defined in claim 1 in which said container comprises a trough through which granular material is continuously advanced, and said means for adding water comprises a spray positioned to moisten the material before it traverses said moisture sensitive means.

4. Equipment as defined in claim 3 which comprises spray regulating means under the control of said moisture sensitive means.

5. Tempering equipment for granular material comprising a container for said material moisture sensitive means at an inner wall of said container, means for continuously adding water to the material in the container, means for periodically compressing a moist specimen of the material against said moisture sensitive means, means operable between successive specimen compressing operations to remove the compressed specimen from said moisture sensitive means, and means controlled by said moisture sensitive means to terminate the addition of water when the moisture content of the material reaches the required amount.

6. Tempering equipment for granular material comprising a container for said material moisture sensitive means at an inner wall of said container, means for adding water to the material in the container, mixing means in said container to mix the water uniformly into the material said mixing means comprising a roller, means for revolving said roller in a path to roll across said moisture sensitive means, a scraper, and means for moving said scraper across said moisture sensitive means to remove the rolled material therefrom.

7. Tempering equipment for granular material comprising a container for said material moisture sensitive means at an inner wall of said container, means for adding water to the material in the container, mixing means in said container to mix the water uniformly into the material, said mixing means comprising a roller, means for revolving said roller in a path to roll across said moisture sensitive means, a scraper, means for moving said scraper across said moisture sensitive means to remove the rolled material therefrom, and means actuated by said moisture sensitive means to control the means for adding water.

8. Tempering apparatus for granular material comprising a container having an opening for discharging tempered material therefrom, a closure for said opening, a compressed air mechanism for actuating said closure, means responsive to moisture content of material in the container for adding water to material in said container including a member exposed at the inner surface of said container, and means for cleaning moist material from the exposed surface of said member following each tempering operation comprising an air line connected to said compressed air mechanism having an open end directed toward the exposed surface of said member to remove moist material adhered to said surface upon closure actuating operation of said mechanism.

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CERTIFICATE OF CORRECTION

Patent No. 2,863,191

Harry W. Dietert et al.

December 9, 1958

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

Column 4, line 48, for "normally" read — normally —; column 6, line 32, for "plate 150" read — plate 160 —; column 7, line 70, for "comprising" read — compressing —.

Signed and sealed this 2nd day of June 1959.

(SEAL)
Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents
UNITED STATES PATENT OFFICE
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