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METHODS AND APPARATUS FOR CONTROLLABLY DISPENSING
MOISTURE BEARING INGREDIENTS

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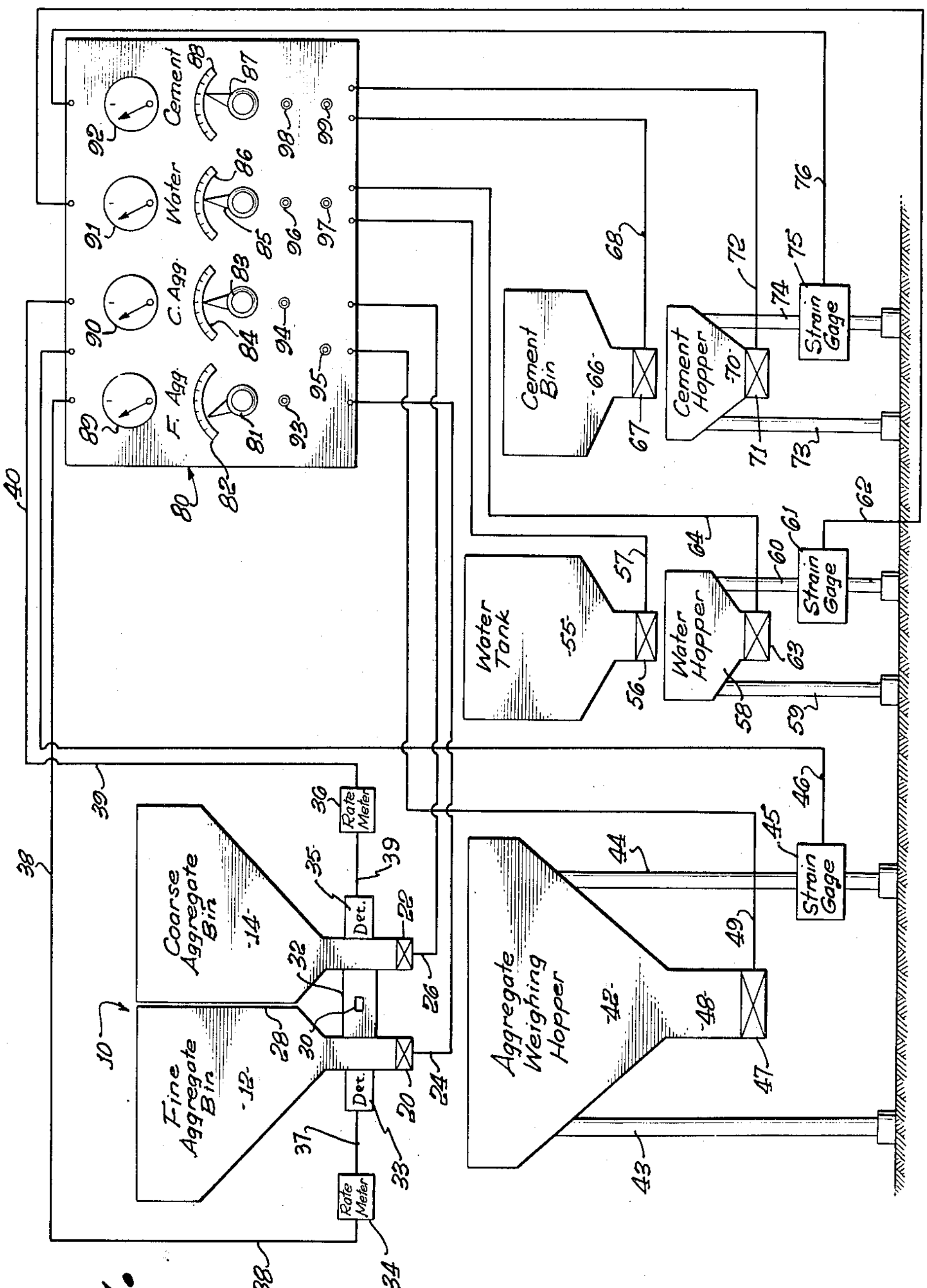

Fig. 1.

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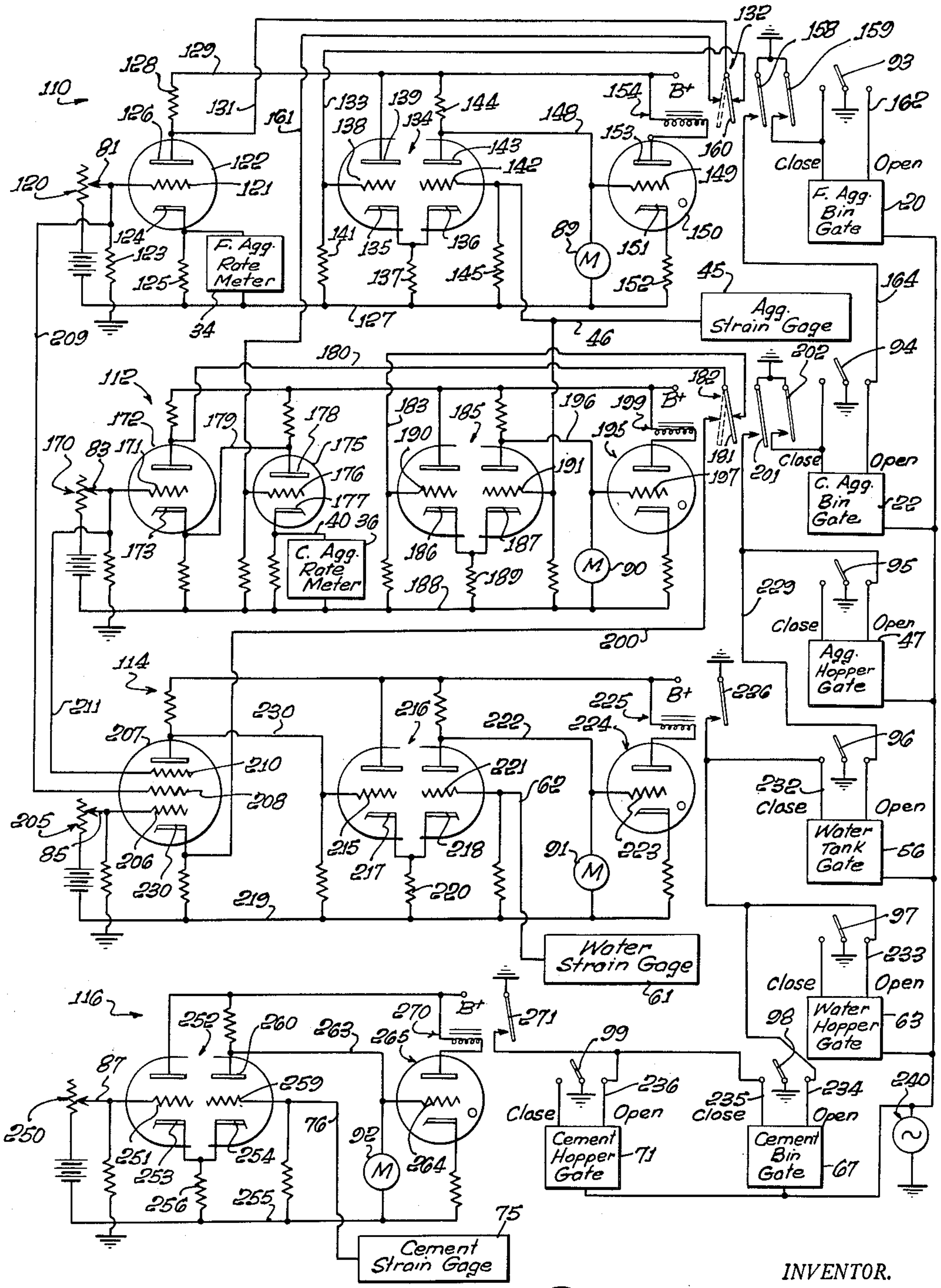

Fig. 2.

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METHODS AND APPARATUS FOR CONTROLLABLY DISPENSING MOISTURE BEARING INGREDIENTS

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6 Claims. (Cl. 249—14)

This invention relates generally to control of proportions in concrete mixing and particularly discloses novel and useful means and techniques by which desired proportions of component ingredients in mixing concrete may be maintained virtually constant despite substantial variations in the moisture content of certain of the ingredients.

As is well known, concrete is made up of cement, aggregate and water. The aggregate normally includes a fine component such as sand and a coarse component, typically gravel. The ratios of the several materials to one another vary somewhat dependent upon structural requirements of the finished concrete, ambient temperature and humidity during curing and other factors, and such ratios or proportions among the ingredients must of course be controllable by the operating in charge of mixing. In particular, the amount of water in a given mix in proportion to other ingredients is relatively critical and must be accurately controlled in order to produce uniformly satisfactory mixes.

Accurate control of the proportions of ingredients to be used, especially water, is made difficult by the fact that the aggregate is rarely if ever wholly dry. Water accompanying the aggregate may adhere to the surfaces thereof or otherwise be held in association with the aggregate in bins or other storage containers, and this is especially true of the fine aggregate or sand. The amount of such accompanying water is extremely variable: an apparent weight of 2,000 pounds of fine aggregate as stored may, in one instance, include ten pounds of water and 1,990 pounds of dry fine aggregate. In another instance such a total apparent weight of fine aggregate may include three hundred pounds of water and, consequently, only 1,700 pounds of dry fine aggregate. If no corrective action were taken, such a variation in actual content of ingredients would produce concrete of widely divergent physical characteristics. Hence, for accurate control of such physical characteristics it is necessary to measure the moisture content of ingredients and effect compensating corrections in the weights of ingredients introduced into the mixing receptacle.

Devices and techniques heretofore used to accomplish the above have been so time-consuminf in practice as to unduly delay operations in concrete batching, and the present invention meets this problem by providing methods and apparatus for measuring moisture content in ingredients used for making concrete and controlling the dispensing of ingredients in accordance with such measurements.

An object of the invention is to thus disclose a novel system for controlling proportions of component materials used in mixing concrete.

Another object is to provide such a system which is to a large extent automatic and which does not require continuous supervision by skilled personnel.

A further object is to disclose a method of controlling the amount of water added to cement and aggregate in

making concrete as a function of the moisture content of the aggregate as dispensed.

Another object is to provide a system of the above character using a neutron source and neutron detecting means for determining the moisture content of aggregate.

Yet another object is to provide a system of the above character wherein the weight of aggregate dispensed is controlled by its moisture content as dispensed.

A further object is to disclose such a system including means providing manual stand-by control of the dispensing operation in the event of failure of the automatic features.

These and other and allied objects and purposes will become clear from a study of the following description of a preferred embodiment of the invention, taken in connection with the accompanying drawings in which:

Fig. 1 represents schematically a preferred embodiment of a system for practicing the invention.

Fig. 2 is a detailed circuit diagram of the circuitry associated with the system of Fig. 1.

The invention will be described particularly with reference to its use in supplying to transit mix trucks or other suitable receptacles at concrete batching plants measured amounts of aggregate, cement and water for mixing concrete of desired physical properties, although it will be understood that the invention may be adapted for use in connection with control of proportions of other ingredients where moisture content of one or more ingredients must be compensated.

It is known that a flux of neutrons passing through a target material interacts with hydrogen in the material to produce certain measurable phenomena. Important for present purposes is the fact that the neutron flux is attenuated by the hydrogen nuclei present, and that gamma rays are produced incident to such attenuation. Quantitatively, both the attenuation and gamma ray production are functions of the amount of hydrogen in the flux path, and either may thus be used as a measure of the amount of hydrogen. The attenuation of neutron flux is made use of in the typical installation herein shown and described, although it will be readily seen that appropriate changes in instrumentation enables the present invention to utilize the production of gamma rays as the measured phenomenon if desired.

Of the ingredients used in mixing concrete batches, cement is uniformly moisture-free and hence no measurement of its moisture content is necessary. In the case of coarse aggregate—typically gravel—the moisture content as stored is normally small and in many instances may be disregarded, although the present embodiment of the invention includes means for measuring such moisture content and accomplishing the necessary corrections. Fine aggregate, or sand, presents the principal problem. Compensation for the effect of moisture content of the sand is two-fold: (1) when moist sand is dispensed by weight, it is necessary to increase the weight of dispensed moist sand over the weight of dry sand desired by an amount equal to the weight of moisture therein; (2) when water is dispensed by weight, it is necessary to decrease that weight from the total amount desired in the mix by an amount equal to the weight of water accompanying the aggregate. The present invention accomplishes these objectives rapidly and automatically and, as previously stated, includes means for similarly compensating the weight of dispensed coarse aggregate and dispensed water when extremely moist coarse aggregate is used or where extreme accuracy of proportions is required.

Referring now to the drawings and particularly to Fig. 1 thereof, a pair of storage bins is indicated generally at **10** and includes a fine aggregate bin **12** and a coarse aggregate bin **14**. Desirably, the bins include in their lower portions separated throats 16 and 18, terminating in gates 20 and 22 respectively. The gates 20 and 22 preferably include suitable electrically powered means such as solenoids, motors or the like by which either one or both of the gates may be opened or closed depending upon electric signals brought thereto by cables 24 and 26. As will be later understood from the description of Fig. 2, each of the cables may include a plurality of conductors.

Desirably, the two bins 12 and 14 may have a common central wall or partition 28, and between the separated throat portions of the bins and spaced somewhat above the gate mechanisms 20 and 22 there is disposed a neutron source indicated generally at 30. The neutron source 30, may be, for example, radium-beryllium or any other known source of neutron. Surrounding the neutron source 30 there is provided a suitable moderator 32 in order to obtain thermal neutrons. As is well known, such moderators may be of paraffin, graphite or other known materials of similar characteristics.

Means are provided for detecting and measuring the strength of neutron flux emitted by the source 30. Such means include detectors 33 and 35 and rate meters 34 and 36 respectively connected to the detectors. The detectors are desirably but not necessarily disposed so that the paths of neutron flux thereto from the source 30 are substantially normal to the direction of flow of respective aggregates during discharge. The detector 33 is sensitive to neutron flux which has traversed a portion of the fine aggregate in throat 16 while the detector 35 is sensitive to neutron flux which has traversed a portion of coarse aggregate in throat 18. The detectors 33 and 35 may be of any desired type capable of detecting neutrons. Each of the rate meters 34 and 36 is connected to its respective detector by suitable leads indicated schematically at 37 and 39 and is adapted to produce in its output lead 38 and 40 a signal having a value which is a function of the strength of neutron flux impinging the detectors 33 and 35.

Means are provided for retaining and weighing aggregate dispensed from bins 12 and 14 through gates 20 and 22. In the present illustration an exemplary form of such means is shown as including a weighing hopper indicated generally at 42 provided with suitable supporting members 43 and 44. In one of the supporting members, as 44, is a weighing device in the form of a strain gage 45 adapted to produce in its output lead 46 an electric signal which is a function of the weight of aggregate in the hopper 42. Means are provided for controllably discharging or dispensing aggregate from hopper 42 including a gate 47 disposed in throat 48 of the hopper. Gate 47, similar to gates 20 and 22 in the storage bins, is desirably electrically operable to open or closed position by signals carried thereto by cable 49. Preferably weighing hopper 42 is supported high enough above ground level to permit transit-mix trucks or other mixing receptacles to be positioned beneath gate 47 when being filled.

Means are provided for supplying controllable weights of water to mixing receptacles such as transit-mix trucks or the like. In Fig. 1 these means include a water supply such as water tank 55 having an outlet valve or gate 56 electrically actuable to either open or closed positions in accordance with signals fed thereto by conductors of cable 57. A water hopper 58 is disposed to receive water discharged through gate 56 and is supported on suitable member 60, including a weighing device in the form of strain gage 61 and also provided with an outlet valve or gate 63 electrically actuable to either open or closed positions in accordance with signals fed thereto by conductors of cable 64. Similarly to strain gage 45 previously referred to, the strain gage 61 is adapted to produce in its output lead 62 a signal which is a function of the weight of water in the hopper 58.

Means are provided for dispensing measured weights of dry cement, such means including a cement storage bin 66 having an outlet gate 67 electrically actuable to either open or closed positions in accordance with electric signals fed thereto by the conductors of cable 68. A cement weighing hopper 70 is arranged to receive dry cement discharged through outlet gate 67, and the hopper 70 includes an outlet gate 71 operable to either open or closed positions in accordance with electric signals fed thereto through the conductors of cable 72. The cement weighing hopper 70 is supported upon suitable members 73 and 74 and a weighing device which may take the form of a strain gage 75 is located in the supporting member 74, the strain gage 75 being adapted to produce in the outlet lead 76 an electric signal which is a function of the weight of dry cement in the weighing hopper 70.

A control panel indicated generally at 80 is adapted for use by operating personnel. On the control panel there are provided a series of control knobs and associated dials, each control knob having an indicating arm which may be set to a desired reading on its dial. These elements include a fine aggregate control knob and indicator arm 81 with its associated dial 82; coarse aggregate control knob and indicating arm 85 and its associated dial 86 and cement control knob and indicating arm 87 and its associated dial 88. The function and operation of these elements will be later understood by reference to the description of Fig. 2.

An indicating meter is provided for each of the four component ingredients, the meters being identified as 89, 90, 91 and 92 respectively. A number of control switches are provided on the control panel 80, the control switches being indicated at 93, 94 and 95 for control of the several gates associated with the fine and coarse aggregates; switches 96 and 97 associated with the control of water gates; and 98 and 99 associated with the cement control gates. The functions of these switches will also be understood by reference to the circuit diagram of Fig. 2, but it may be said at this point that the several control members on the panel 80, including the knobs and switches thereon, allow an operator to select any desired proportion of the several ingredients for concrete mixing and to control the supply of such ingredients to mixing receptacles such as transit mix trucks which may be positioned beneath the hopper outlet gates 47, 63 and 71. It will be noted that all electrical leads and cables heretofore referred to are connected to control panel 80, the internal circuitry being set forth in detail in Fig. 2 and described in connection therewith.

In Fig. 2 is shown a typical electronic circuit suitable for accomplishing the purposes set forth above. In general, the uppermost series or bank of electron tubes and associated circuitry indicated generally at 110 constitutes the fine aggregate control means. The second bank of tubes indicated generally at 112 constitutes the control means for coarse aggregate. The third bank indicated generally at 114 constitutes control means for the water supply. The fourth bank indicated generally at 116 constitutes the control means for the cement.

With particular reference to the uppermost bank of tubes indicated generally at 110 and constituting the fine aggregate control means, a potentiometer is indicated generally at 120, the selectively adjustable terminal of which is indicated at 81 and corresponds to the fine aggregate control knob shown in Fig. 1. By means of adjustment of the member 81 a controllable electric potential is applied to the grid 121 of an electron tube 122. Associated with the tube 122 is a conventional grid resistor 123, a cathode 124, a cathode resistor 125 and a plate or anode 126. As is conventional, the cathode and grid resistors are grounded through conductor 127 and the anode 126 is connected through plate resistor 128 to a source of high positive potential existing in conductor 129.

Means are provided for impressing upon the cathode 124 a potential which is a function of the moisture content of the fine aggregate in the bin 12 of Fig. 1. As previously explained, the fine aggregate rate meter 34 is adapted to produce an output signal having a value which is a function of the amount of neutron flux impinging detector 33. In turn, the intensity of such impinging neutron flux is a function of the moisture content of fine aggregate in the throat 16 of bin 12. If no moisture were present in the fine aggregate, the output voltage of rate meter 34 would be maximum, and the amount by which the output of the rate meter falls below such maximum is a measure of the moisture content of the fine aggregate. The output voltage of rate meter 34 is applied through conductor 38 (compare Fig. 1) to the cathode 124. It will thus be seen that the circuitry associated with tube 122 constitutes a voltage summing circuit, the polarities of the voltages applied respectively to the cathode and the control grid being opposed. Hence the output voltage existing in conductor 131 connected to the anode 126 is a function of the weight of dry fine aggregate desired (as introduced into the circuit by the setting of potentiometer control 81) and the quantity of moisture in the actual fine aggregate used. The potential existing in conductor 131 is impressed on a solenoid-actuated switch indicated generally at 132, the connections of such switch being such that when the solenoid is not energized, conductor 131 is connected to conductor 133.

A voltage difference measuring circuit is provided and includes a duplex triode indicated generally at 134 having cathodes 135 and 136 connected together and to ground through cathode resistor 137. The left hand portions of tube 134 includes a control grid 138 connected to the conductor 133 and an anode 139 connected to high positive potential in conductor 129. The control grid 138 is grounded through grid resistor 141.

The duplex tube 134 constitutes a voltage difference measuring means, the right hand section of the tube including a control grid 142 and an anode 143, the anode being connected through resistor 144 to positive potential in conductor 129. The control grid 142 is connected to ground through resistor 145 and the potential impressed upon grid 142 through conductor 46 is the output potential of the aggregate strain gage 45.

The output voltage of the right hand anode 143 of duplex tube 134 is fed through conductor 148 to the control grid 149 of a gas filled triode indicated generally at 150, said tube being typically a thyratron. Thyratron 150 includes a cathode 151 connected to ground through resistor 152 and an anode 153 connected to high potential through solenoid winding 154. In order to facilitate manual control of the mechanism of the present invention there is provided an indicating meter 89 between the control grid 149 and ground. The thyratron tube 150 is adapted to be triggered into conductive condition, as is conventional, and when conductive the tube supplies current through the solenoid winding 154 which in turn controls the switch 132 heretofore referred to as well as normally open switches 158 and 159. These last named switches are adapted to be closed upon energization of solenoid winding 154 and, simultaneously, movable switch arm 160 of switch 132 is moved away from its contact with conductor 131 into its dotted position in contact with the conductor 161.

The circuitry and tubes in the second bank, indicated generally at 112, are similar in certain aspects to the circuitry heretofore described, the bank 112 being adapted to control the coarse aggregate mixture. A potentiometer indicated generally at 170 includes a movable contact member 83 corresponding to the control knob shown in Fig. 1. It will be seen that adjustment of member 83 controls the potential impressed upon the grid 171 of tube 172. Means are provided for impressing upon cathode 173 of tube 172 a potential which is a function of the weight of dispensed fine aggregate including its accompanying moisture plus the weight of moisture accompanying the coarse aggregate. Such means include electron tube 175 having a control grid 176, cathode 177 and anode 178. It will be recalled that energization of solenoid 154 causes switch arm 160 of switch 132 to move into contact with conductor 161, and this conductor is connected to the control grid 176 of tube 175. Thus the output voltage of tube 122 is impressed on grid 176, this voltage being a function of the weight of fine aggregate plus its accompanying moisture. The output signal of coarse aggregate rate meter 36 is a function of the moisture content of coarse aggregate, and this voltage is impressed upon the cathode 177 of the tube 175 through conductor 40, the connections being made with reverse polarity as previously described in the case of fine aggregate rate meter 34 and tube 122. The output voltage of tube 175 is impressed through conductor 179 upon cathode 173 of tube 172.

The output voltage of tube 172 is fed through conductor 180 to movable switch arm 181 of switch 182 and, when the switch arm 181 is in its position shown in solid lines, thence to conductor 183.

A voltage difference measuring circuit is provided and includes duplex triode 185 corresponding generally to the duplex triode 134 heretofore described in the fine aggregate control circuit. The two cathodes 186 and 187 are connected together and to grounded conductor 188 through common cathode resistor 189. The left hand control grid 190 is maintained at the output potential of tube 172 by means of conductor 183 above referred to, and the right hand control grid is connected through conductor 46 to the output of aggregate strain gage 45.

A gas filled tube or thyratron is indicated generally at 195, and the output of duplex triode 185 is connected through conductor 196 to the control grid 197 of the thyratron. The control grid 197 is grounded through meter 90. Thyratron 195 is adapted, when triggered, to energize a solenoid winding indicated generally at 199, energization of the solenoid being effective to actuate switch arm 181 so that the arm breaks contact with conductor 183 and moves to its position shown in dotted outline in contact with conductor 200. Simultaneously normally open switches 201 and 202 are closed when solenoid 199 is energized.

As previously mentioned, the third bank of tubes and associated circuitry indicated generally at 114 constitutes the control means for water in the present invention. A potentiometer indicated generally at 205 includes a selectively controllable member 85 corresponding to the similarly numbered control knob of Fig. 1. Thus the potential impressed upon the first control grid 206 of tube 207 is determined by the setting of the control knob 85. Tube 207 includes a second control grid 208 on which the potential of control grid 121 of tube 122 is impressed thruogh conductor 209. Tube 207 also includes a third control grid 210 on which is impressed the potential of control grid 171 of tube 172 through conductor 211. The cathode potential of tube 207 is, after actuation of switch 182, that of the output of tube 172, the path including conductor 180, switch arm 181 and conductor 200. As will be clarified later, the output signal of tube 207 is a measure of the total amount of water called for in a given mix minus the amount of water represented in the moisture content of the fine aggregate and coarse aggregate.

The output potential of tube 207 is impressed on the left hand control grid 215 of duplex triode 216 having twin cathodes 217 and 218 connected together and to grounded conductor 219 through common cathode resistor 220. The potential of the right hand control grid 221 is that of the output signal of water strain gage 61, as led to the grid by conductor 62.

The output voltage of the right hand section of duplex tube 216 is fed through conductor 222 to the control grid 223 of a gas filled tube or thyratron indicated generally at 224. A meter 91 is provided between the control grid 223 and ground. The output of thyratron 224, when triggered, is adapted to energize the solenoid winding indicated generally at 225 and thereby to close the normally open switch 226.

The lowermost bank 116 of tubes and associated circuitry in Fig. 2 is adapted to control the supply of dry cement to the mix being prepared. The circuitry includes a potentiometer indicated generally at 250 having a controllably movable member 87 corresponding to the control knob similarly numbered in Fig. 1. Thus a potential is impressed upon the left hand grid 251 of the duplex triode indicated generally at 252. The two cathodes 253 and 254 are connected together and to grounded conductor 255 through common cathode resistor 256. The potential of the right hand control grid 259 is controlled through conductor 76 by the output of the cement strain gage 75.

The potential of the right hand anode 260 of duplex triode 252 is adapted to be impressed through conductor 263 upon the control grid 264 of a gas filled tube or thyratron indicated generally at 265, and a meter 92 is connected between the control grid 264 and the grounded conductor 255. The output of the thyratron tube 265 is adapted, when the tube is triggered, to energize a solenoid winding indicated generally at 270 and thereby to close the normally open switch 271.

Operation

The operation of the control mechanism heretofore described is as follows. For a given desired mix of concrete the potentiometer control members 81, 83, 85 and 87 are adjusted to values specified by supervisory personnel. In the case of the fine aggregate, adjustment of member 81 impresses upon the grid 121 of tube 122 a potential proportional to the amount of dry fine aggregate called for in the mix. Similarly, adjustment of member 83 impresses a potential on the grid 171 proportional to the amount of dry coarse aggregate called for in a given mix. With particular attention to the fine aggregate control circuitry indicated generally at 110 it will be recalled that the cathode 124 is maintained at a potential determined by the output signal of the fine aggregate rate meter 34, the polarity of this potential being opposed to the polarity of the potential produced by potentiometer 120. Specifically the rate meter output is a function of the percentage of moisture in the fine aggregate contained in the bin 12, and the potential of the control grid 121 is a function of the amount of dry fine aggregate or sand desired. The tube 122 provides for summing these two potentials. The output of this circuit, the potential in conductor 131, is proportional to the sum of the weight of dry fine aggregate required plus the amount of water accompanying said aggregate in the bin. It will be seen that this potential, when solenoid winding 154 is not energized, is impressed upon the left grid of the voltage difference measuring circuit including duplex triode 134.

Flow of fine aggregate from bin 12 into weighing hopper 42 is initiated by opening the gate 20 of the fine aggregate bin. This may be done by the operator by actuating switch 93 to make contact with conductor 162, this conductor being included in the cable 24 as shown in Fig. 1. Gate 20 being opened, fine aggregate flowing into weighing hopper 42 causes the signal produced by strain gage 45 to gradually increase. When such signal, impressed upon control grid 142 of duplex triode 134, reaches a value equal to the potential on the left hand control grid 138, the output voltage of the right hand section of duplex triode 134 is sufficient to trigger the thyratron 150. In turn, current flowing through the thyratron energizes the solenoid winding 154, moving switch arm 160 to its dotted position in contact with conductor 161 and closing switches 158 and 159. Closing of switch 159 completes the electrical circuit associated with the gate 20 and is operative to close said gate. Closing of switch 158 energizes the opening circuit of the coarse aggregate bin gate 22 through conductor 164 so that coarse aggregate begins to flow from bin 14 into the weighing hopper 42.

In the control circuit for coarse aggregate indicated generally at 112, it was previously pointed out that the output signal of the coarse aggregate rate meter 36 is impressed upon the cathode 177 of tube 175. This output signal is a function of the moisture content of the coarse aggregate in bin 14. Tube 175 operates to add the output signal of the coarse aggregate rate meter to the signal impressed upon the control grid 176 of the tube. This latter signal, after actuation of switch 132, is the output signal of tube 122 and is a signal therefore which is a function of the weight of fine aggregate plus its accompanying moisture which has previously been dumped into the weighing hopper 42. The output signal of tube 175 is then impressed upon the cathode of tube 172, the latter tube likewise constituting a summing circuit for the potentials impressed upon its cathode and control grid. Thus the output signal of tube 172 is a function of the signal impressed upon its cathode plus the potential of control grid 171, the latter being a function of the weight of dry coarse aggregate called for in the given mix.

When switch 181 of switch 182 is in its position shown in solid lines in Fig. 2, the potential just described is compared with the output signal of the aggregate strain gage 45, such comparison being effected in duplex triode 185. Flow of coarse aggregate into weighing hopper 42 causes the output signal of aggregate strain gage 45 to gradually increased. When such a signal, appearing upon right hand control grid 191 of tube 185, becomes equal to the potential of grid 190, the output voltage of the right hand section of tube 185 is sufficient to trigger the thyratron 195 and thus to energize solenoid winding 199. In this way switch arm 181 is moved to its dotted position as shown and normally open switches 201 and 202 are moved to closed positions. Closing of the switch 202 is operative to energize the closing mechanism of the coarse aggregate bin gate 22, thus stopping the flow of coarse aggregate into weighing hopper 42. Simultaneously, closure of switch 201 is operative to open the gate 47 in the aggregate weighing hopper 42, thus dumping into a suitable receptacle (not shown) beneath gate 47 the total amount of aggregate theretofore held in the hopper 42. Closure of switch 201, through conductor 229 operates to open the gate 56 of the water supply 55 and thus to start water flow from the tank into water hopper 58.

Control of the weight of water dispensed for a given mix is effected by the circuitry indicated generally at 114. The voltage impressed upon the first control grid 206 of tube 207 is a function of the total amount of water called for in the given mix. It will be understood that the amount of water actually dispensed by water hopper 58 must be somewhat less than the amount called for by the control knob 85 in an amount equal to the water already present in the fine and coarse aggregates. When switch 181 of switch 182 is moved to its dotted position, a potential is impressed through conductor 200 upon the cathode 230 of tube 207 which is a function of the total weight of dispensed aggregate including the moisture content of such aggregate. The second and third control grids 208 and 210 of tube 207 are maintained at potentials equal to the potentials of control grids 121 and 171 respectively. These potentials, it will be recalled, are functions of the desired weights of dry fine aggregate and dry coarse aggregate respectively.

Tube 207 sums the potentials above described, such that the output of tube 207 is proportional to the net amount of water necessary to be added to the mix in order that the total weight of water therein be equal to the weight called for. This output signal is compared, in duplex triode 216, with the output signal of the water strain gage 61. The latter signal gradually increases as water is dispensed into water hopper 58, and when the signals on the two grids 215 and 221 are equal, the output voltage of the right hand section, applied to the grid 223 of thyratron 224, triggers the thyratron. In turn, thyratron current in solenoid winding 225 closes normally open switch 226, thus closing the water tank gate 56 (through conductor 232), opening water hopper gate 63 (through conductor 223) and opening cement bin gate 67 (through conductor 234).

As mentioned previously, no correction is necessary in dispensing cement in the desired amount, since it is dry as stored in bin 66. Hence the potential of the left hand grid 251 of duplex 252 is exactly that produced by the setting of movable contact member 87 of potentiometer 250, and this potential is compared with the output signal of cement strain gage 75. As cement flows into its weighing hopper 70, the output of the cement strain gage 75 increases and when it is equal to the potential on the left hand grid 251, the output voltage of the right hand section of duplex triode 252 triggers thyratron 265. As a result, normally open switch 271 is closed, thus closing the cement bin gate 67 (through conductor 235) and opening cement hopper gate 71 (through conductor 236).

Each of the several gates may be electrically actuated to open or closed positions by means of conventional apparatus well known in the art, such apparatus being energized by a suitable source of power indicated generally at 240. The details of the gate actuating mechanisms are not shown herein, since such details form no part of the present invention.

Accordingly it will be seen that I have provided a system for the overall control of proportions of ingredients to be mixed, where water is an ingredient and where other ingredients may contain greater or lesser quantities of water as stored. Although herein described as a wholly automatic system once the operator has set the controls and started the apparatus, nevertheless it will be understood that manual control may be exercised if desired, such control being available for stand-by purposes in case of failure of automatic control.

In each of the four principal control circuits as shown in Fig. 2 there is provided a meter 89, 90, 91 and 92 respectively, whose reading is displayed upon the control panel as shown in Fig. 1. Desirably these meters are not quantitatively calibrated, but include only a centrally disposed mark, the movable needle being adapted to indicate a voltage which is either less than, equal to or more than the predetermined voltage for which the meter is set. In this way an operator may observe the movement of the indicating needle of a meter and by means of manually actuated switches control the opening and closing of the several gates.

Obviously, the ingredients may be dumped in to the mixing receptacle in any sequence. Under some circumstances it may be desirable to supply water first to the receptacle, then aggregates and last cement. This is especially true when it is desired not to commence mixing the ingredients until some time after they have all been dumped into the mixing receptacle. This result can be easily achieved by maintaining the aggregate hopper gate closed until water has been dumped, and maintaining the cement hopper gate closed until after the aggregate has been dumped, such changes being accomplished by opening the respective electric control circuits for the several gates.

It will also be obvious that the positions of the several hopper gates shown in Fig. 1 are schematic only. Desirably all gates are so disposed as to feed their flow into a mixing receptacle held stationary while being filled.

It will be understood that the several weighing hoppers and associated strain gages herein shown and described are illustrative only of means for measuring the amount of the several ingredients dispensed from their respective storage containers in the practice of the present invention.

Modifications and changes from the specific embodiment of the invention illustratively shown and described herein may be made without departing from the spirit of the invention, and such modifications and changes are intended to be embraced within the scope of the appended claims.

I claim:

1. In a method of controlling the proportions of components of concrete mixes at batching plants wherein sand is periodically discharged from a source into a weighing device and thence into a receptacle, the steps of: constantly passing a flux of neutrons through a body of sand in said sand source, obtaining a response which is a function of the attenuation of said neutron flux resulting from the presence of hydrogen in said body of sand, and controlling the amount of sand discharged into the weighing device in accordance with said response.

2. In a method of controlling the proportions of component ingredients of concrete mixes at batching plants wherein moist aggregate is periodically discharged from a source into a weighing container and thence into a receptacle, the steps of: constantly passing a flux of neutrons through a body of aggregate in said aggregate source, obtaining a response which is a function of the proportion of the weight of water associated with said moist aggregate to the weight of the moist aggregate, and controlling the weight of aggregate discharged into the weighing device in accordance with said response.

3. The invention as stated in claim 2 including the steps of supplying water to said receptacle and controlling the weight of water so supplied in accordance with said response.

4. Apparatus for dispensing measured weights of ingredients, where one ingredient is water and a second ingredient is discrete in character and includes moisture associated therewith, including means for measuring the percentage of water in the discrete ingredient, said means having a source of neutrons arranged to traverse a predetermined path in the discrete ingredient and detecting means in said path and spaced from said source for yielding a response which is a function of said percentage; means for dispensing a controllable weight of the discrete ingredient; means for increasing the dispensed weight of said discrete ingredient in accordance with said response; means for dispensing a controllable weight of water; and means for decreasing the weight of water dispensed in accordance with said response.

5. In an apparatus for dispensing a discrete, granular moisture-bearing ingredient, a container for said ingredient having a discharge port and gate means for controllably opening and closing said port; a source of neutrons arranged to transmit neutrons through a predetermined path in the ingredient in said container adjacent said port; detecting means for receiving neutrons at the end of said path and producing a response which is a function of the percentage of weight of water in said ingredient; means for measuring the weight of moist ingredient discharged from said port and for continuously producing a second response correlated with the weight thus discharged; means for producing a signal of preselected value corresponding to weight of dry ingredient desired; means for continuously modulating said signal by said first response and continuously comparing the modulated signal with said second response; and means for actuating the gate closing means when the value of the second response attains a predetermined relationship with the modulated signal.

6. Apparatus for dispensing measured weights of ingredients, where one ingredient is discrete in character and is water and a second ingredient includes moisture associated therewith, including means for measuring the percentage of water in the discrete ingredient, said means having a source of neutron flux arranged to traverse a portion of discrete ingredient and detecting means, spaced from said source and receiving neutron flux therefrom, for yielding a response which is a function of said percentage; means for dispensing a controllable weight of the discrete ingredient; means for increasing the dis-

pensed weight of said discrete ingredient in accordance with said response; means for dispensing a controllable weight of water; and means for decreasing the weight of water dispensed in accordance with said response.

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