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Ahrenberg

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[54] **APPARATUS FOR MOISTENING MIXABLE MATERIALS**

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[21] Appl. No.: **338,956**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 876,461, Nov. 13, 1969, Pat. No. 3,727,894.

[30] **Foreign Application Priority Data**

Nov. 15, 1968 Germany 1808998

[52] **U.S. Cl.** ..... **259/154,** 259/168, 259/174, 259/177 R

[51] **Int. Cl.** **B28c 7/04**

[58] **Field of Search** ..... 259/149, 154, 161, 164, 259/165, 166, 168, 175, 178 A, 179, 15, 84, 85, 104; 68/12 R; 73/59; 137/92; 23/188

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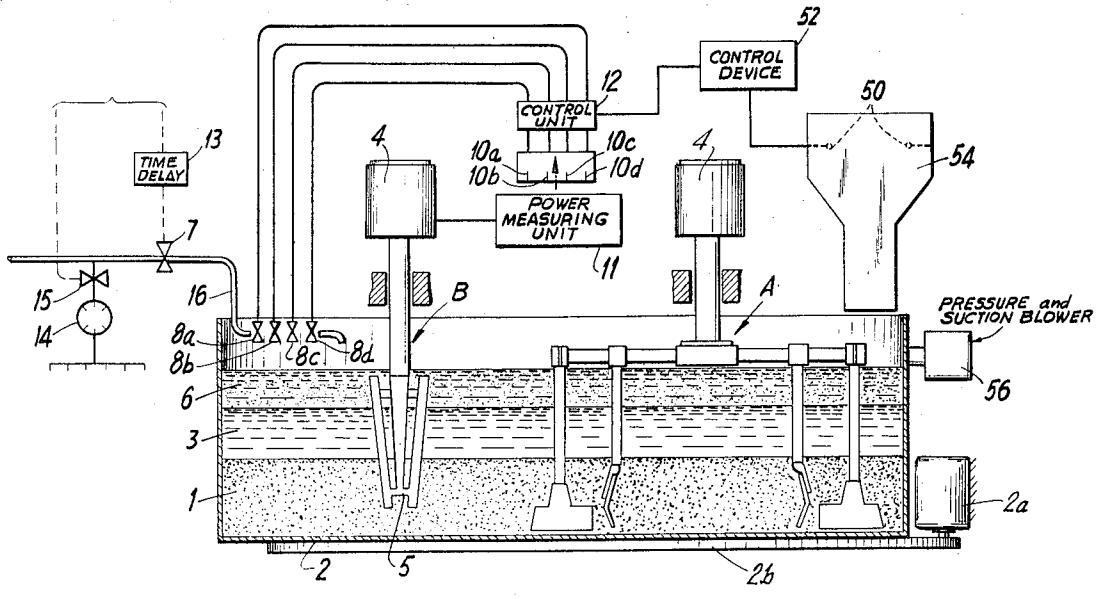
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[57] **ABSTRACT**

For controlling the moistening of mixable materials, particularly the moistening of foundry casting sand with water, a high-speed low-inertia auxiliary mixing tool is rotated in the sand and the quantity of water added is determined in dependence on the resistance of the sand to rotation of the tool as measured by the power consumption of an electric motor driving the tool. Since the materials used are required to be at a certain starting temperature, the temperature of the material is automatically adjusted prior to commencing the moistening operation.

3 Claims, 7 Drawing Figures



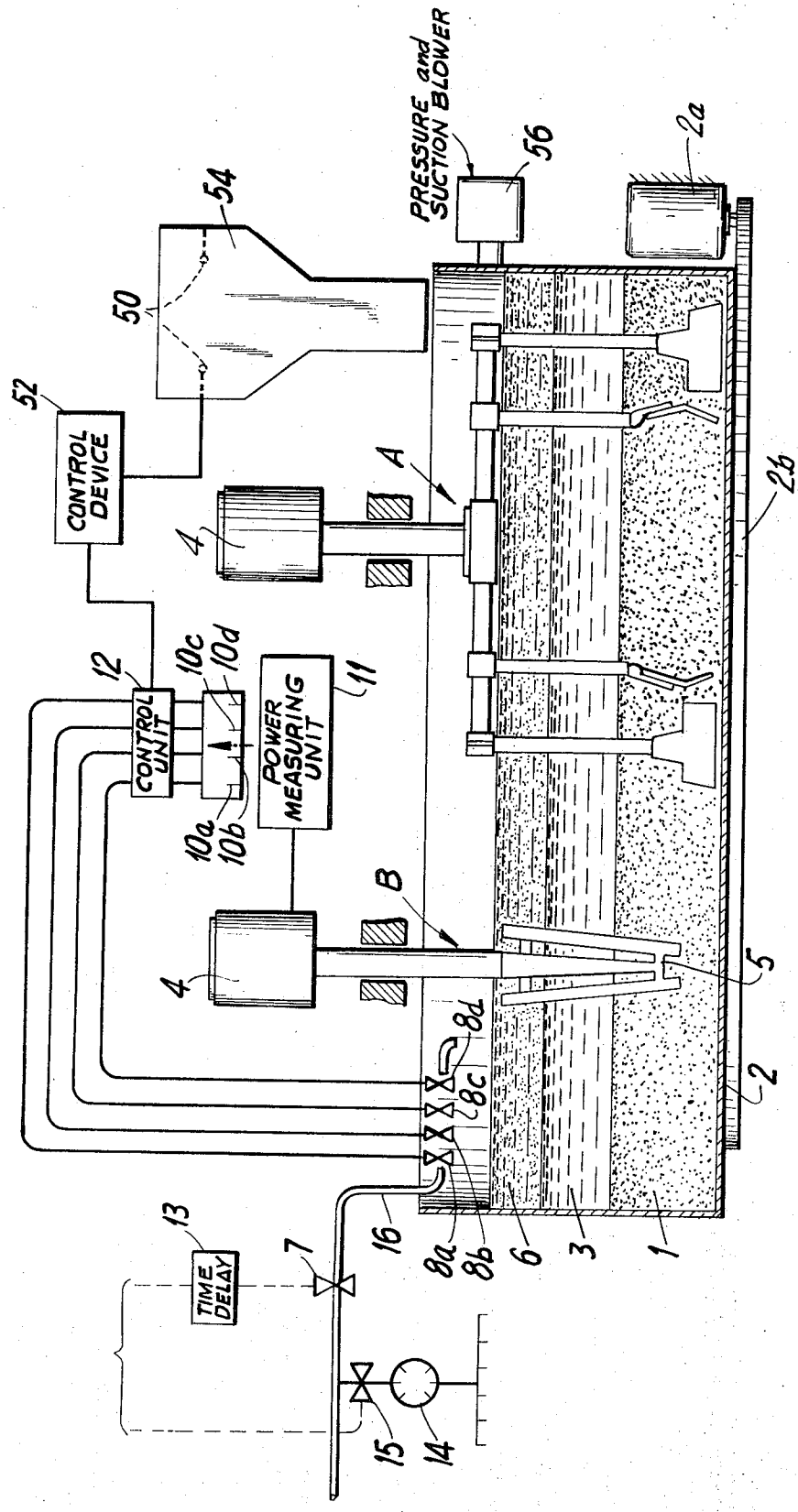

PRESSURE and SUCTION BLOWER
56
2a
54
50
52
CONTROL DEVICE
A
4
2b
12
10c
10d
CONTROL UNIT
POWER MEASURING UNIT
11
10a
10b
B
4
5
8d
8c
2
13
TIME DELAY
7
16
8a
8b
6
3
1
15
14

FIG.1

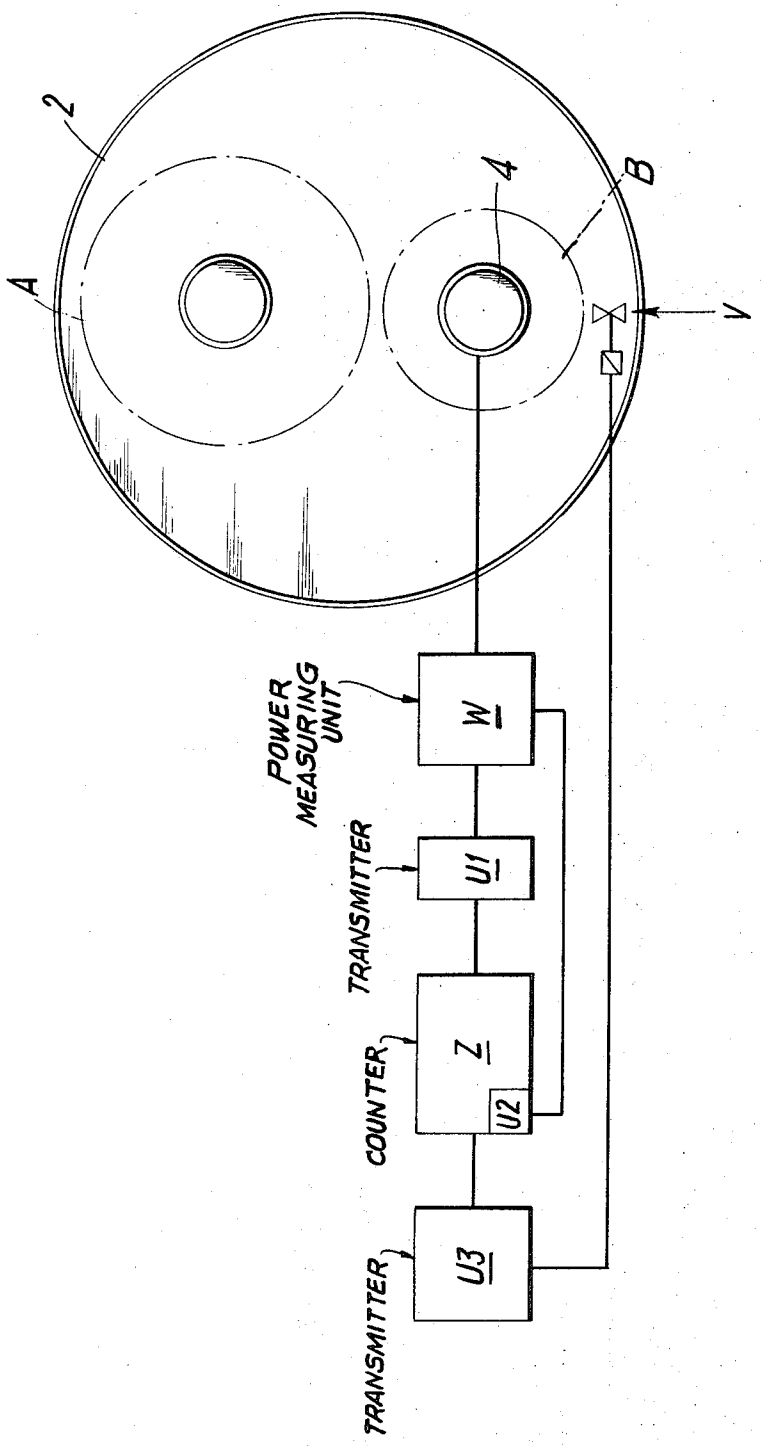

2
A
4
B
V
POWER MEASURING UNIT
W
TRANSMITTER
U1
COUNTER
Z
U2
TRANSMITTER
U3

FIG.2

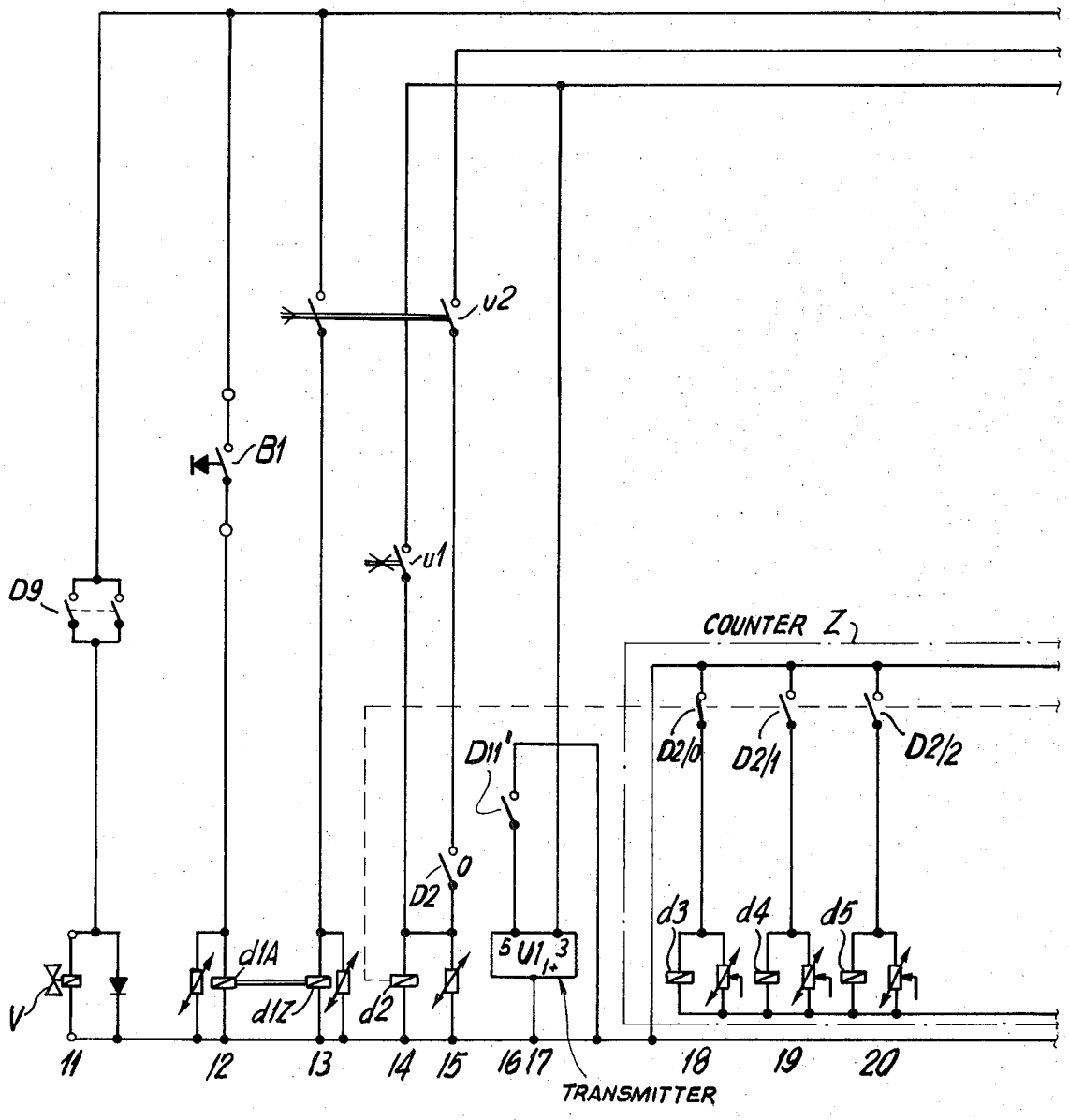

u2
B1
u1
D9
COUNTER Z
D11'
D2/0
D2/1
D2/2
D2
d3
d4
d5
d1A
d1Z
d2
U1
V
11
12
13
14
15
16
17
18
19
20
TRANSMITTER

FIG.3

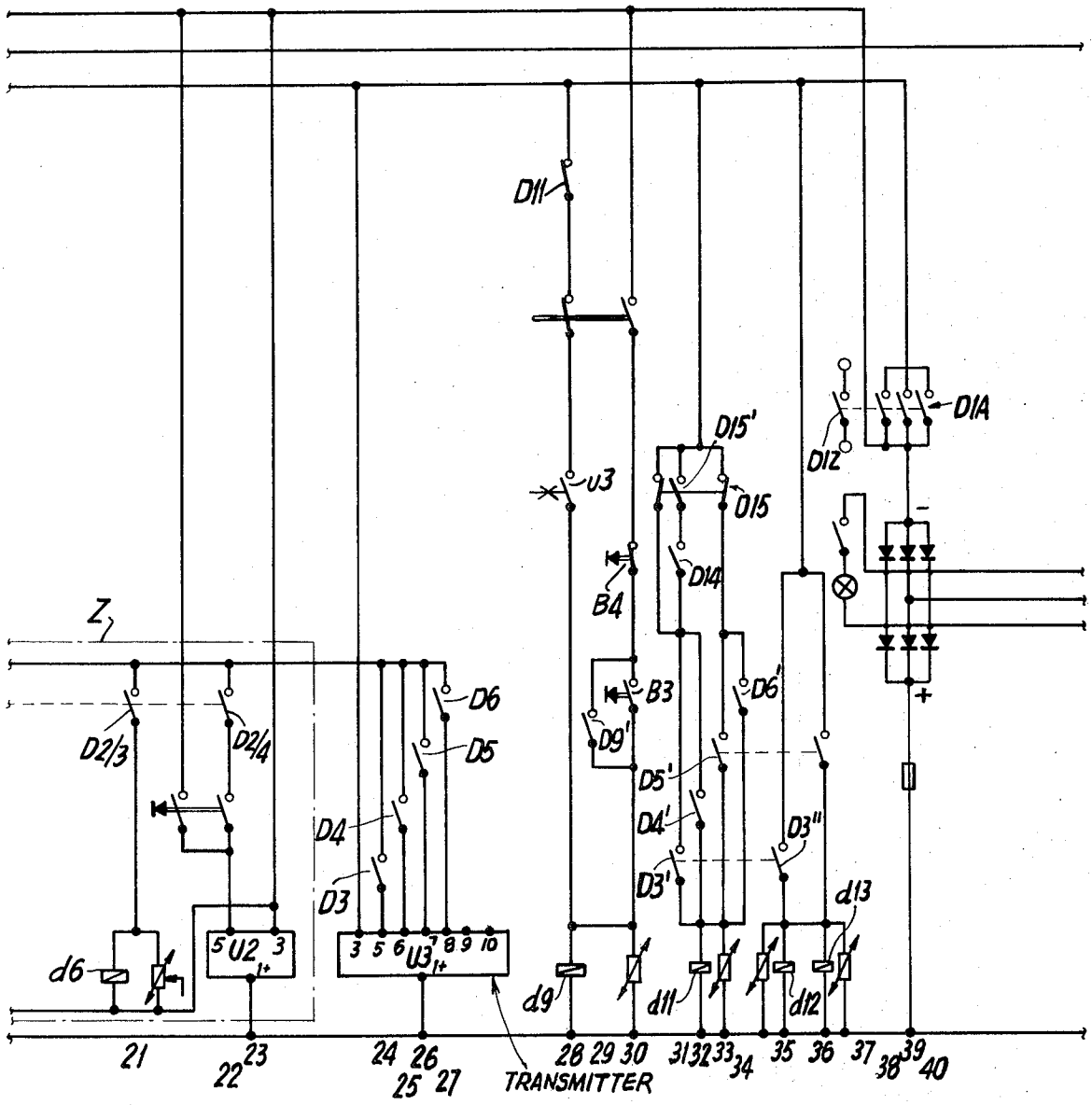

D11
U3
D15'
D15
D14
B4
B3
D9'
D6'
D5'
D4'
D3'
D3"
D12
D1A
Z
D2/3
D2/4
D6
D5
D4
D3
d6
d9
d11
d12
d13
5 U2 3
3 5 6 U3 7 8 9 10
21
22 23
24 26
25 27
TRANSMITTER
28 29 30
31 32 33 34
35 36 37
38 39 40

FIG.4

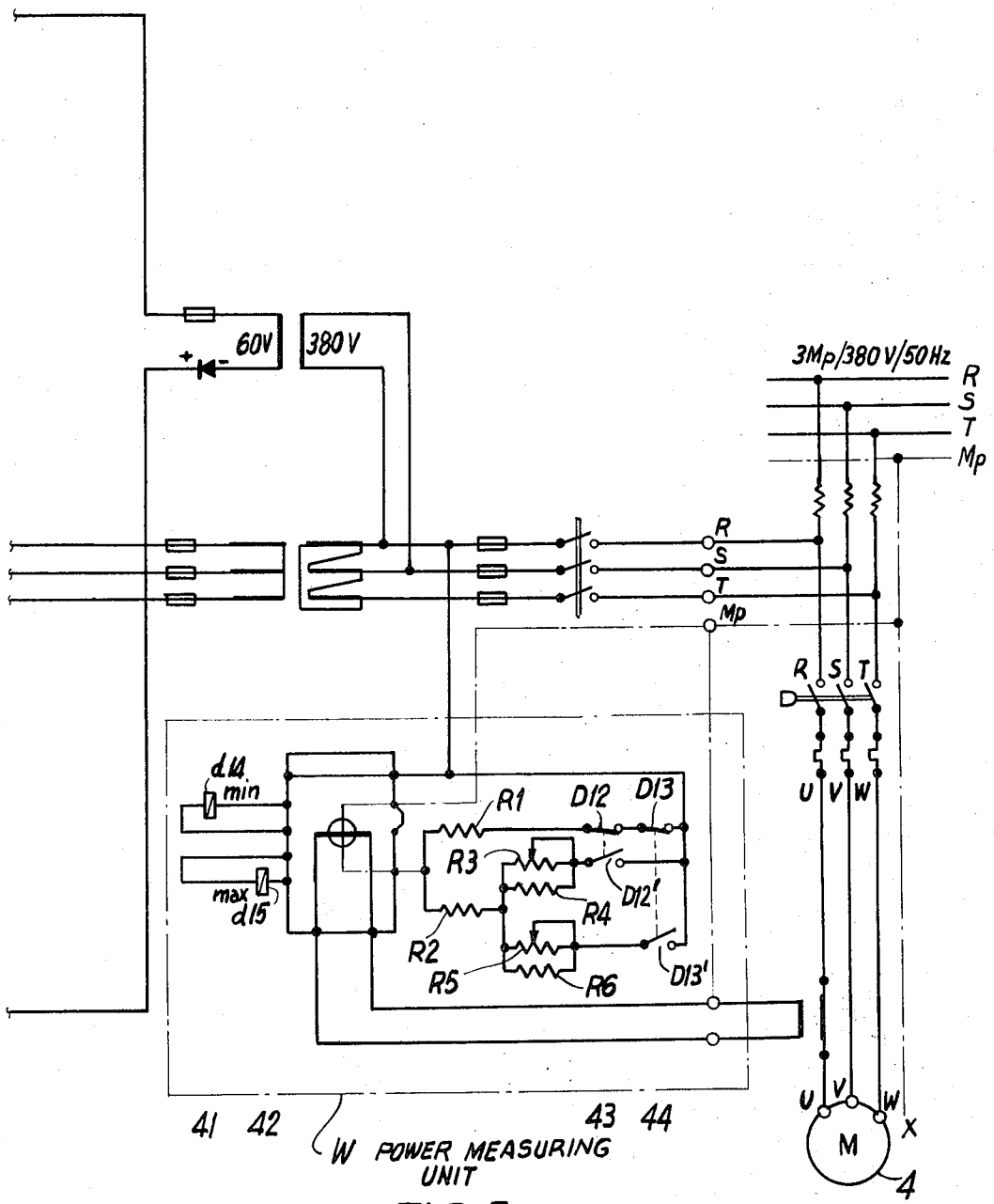

60V
380V
3Mp/380V/50Hz
R
S
T
Mp
d14 min
max d15
R1
D12
D13
R3
D12'
R4
R2
R5
R6
D13'
U V W
M
X
4
41 42
43 44
W POWER MEASURING UNIT

FIG.5

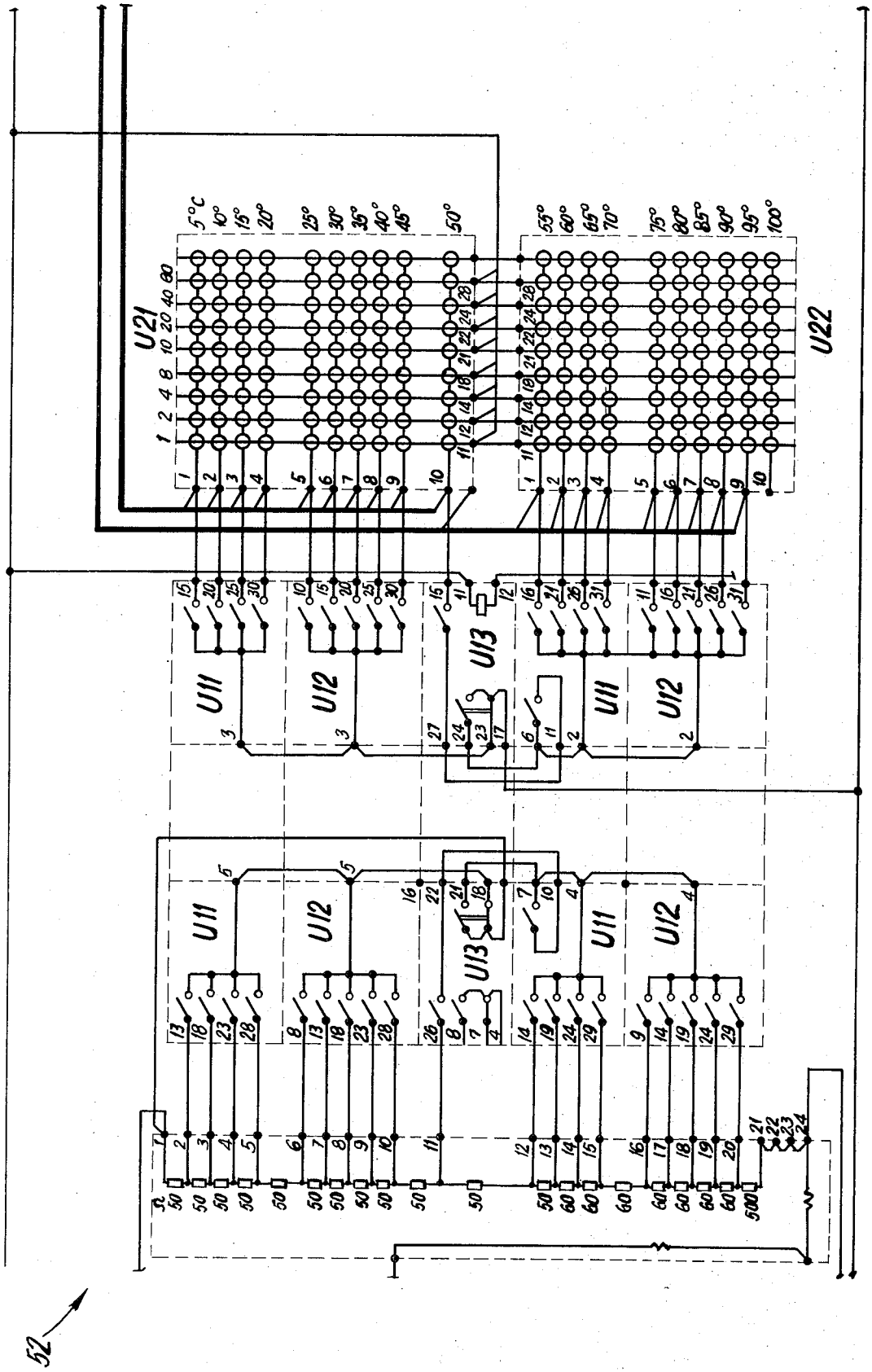


FIG.6

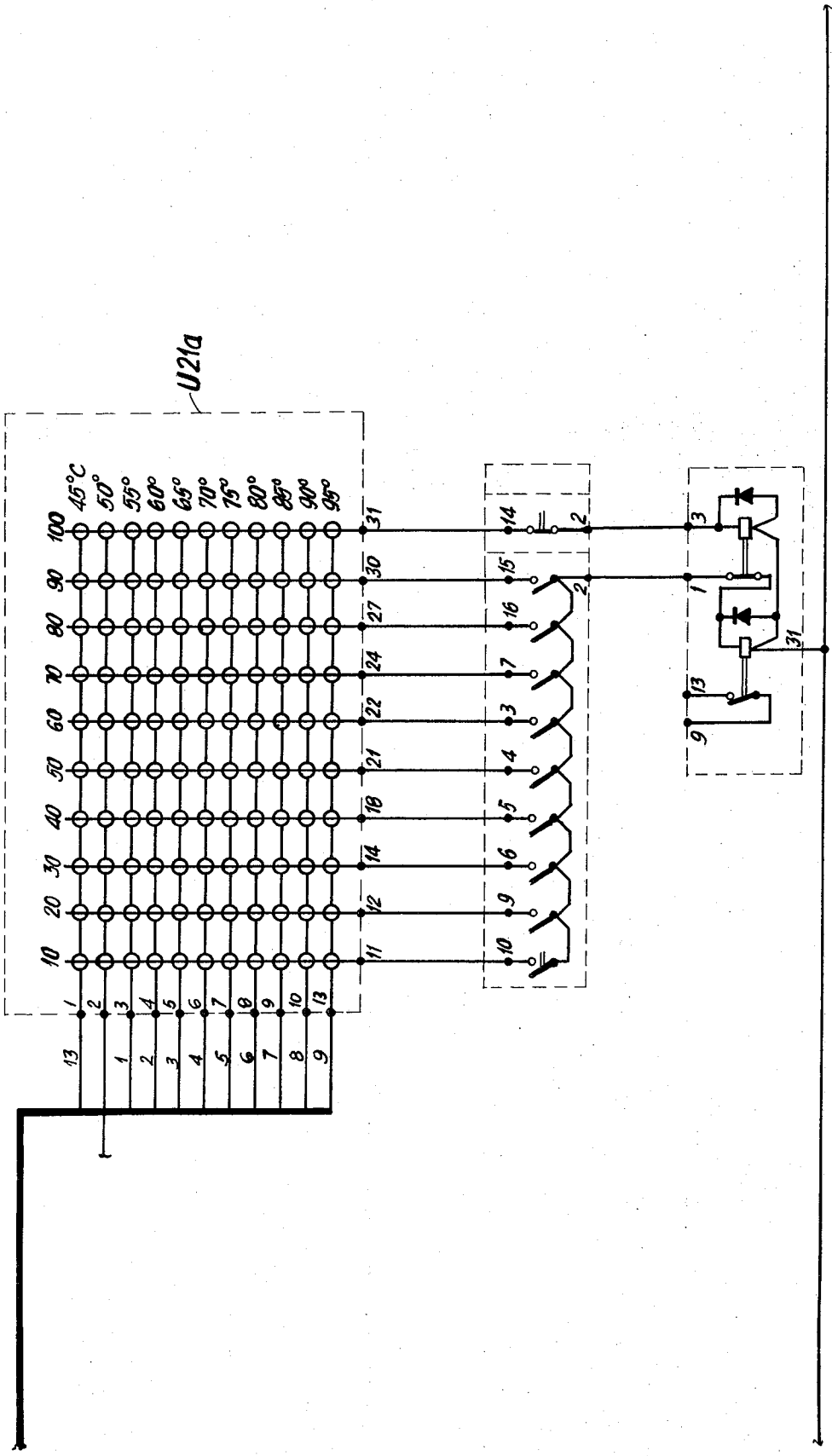

U21a
45°C
50°
55°
60°
65°
70°
75°
80°
85°
90°
95°
100
90
80
70
60
50
40
30
20
10
31
30
27
24
22
21
18
14
12
11
14
15
16
7
3
4
5
6
9
10
2
2
3
1
31
13
9

FIG.7

APPARATUS FOR MOISTENING MIXABLE MATERIALS

This is a continuation-in-part application of my copending application Ser. No. 876,461 filed Nov. 13, 1969 now U.S. Pat. No. 3,727,894 issued Apr. 17, 1973.

BACKGROUND OF THE INVENTION

For the purpose of determining the moisture content of moulding sands for casting, it is known to use measuring capacitors, or to pass a test amount of the sand over a plate provided with slots of different widths, the moisture content being determined in dependence on the amount of sand which falls through the slots, relative to the amount remaining on the plate. Finally, it is known to determine the moisture content of the sand by a cone test.

The above-mentioned known methods suffer either from the disadvantage that it is not possible to impart a predetermined consistency to the sand, or that test samples must frequently be taken from the sand, which interrupts the treatment.

SUMMARY OF THE INVENTION

One object of the present invention is to provide an improved method and apparatus for controlling the moistening of mixable materials such as foundry moulding sand.

Another object is to provide such apparatus in which the quantity of moistening liquid added is determined in dependence on the resistance of the material to an auxiliary mixing tool.

Another object is to provide such an apparatus in which the auxiliary mixing tool is a high-speed low-inertia rotary mixing tool.

Still another object is to determine the temperature of the starting materials for automatically adjusting the temperature to a predetermined level.

According to one aspect of the present invention a method of moistening a mixable material comprises rotating in the material a high-speed low-inertia auxiliary mixing tool and then adding a quantity of moistening liquid to the material determined in dependence on the resistance of the material to the auxiliary mixing tool as measured by the power consumption of the auxiliary mixing tool.

According to another aspect of the present invention apparatus for moistening a mixable material, comprises a container for the material, a main mixing tool for mixing the material, a high-speed low-inertia auxiliary mixing tool, driving means to rotate the auxiliary tool in the material, and means to add a quantity of moistening liquid to the material determined in dependence on the power consumption of said driving means.

Preferably the auxiliary mixing tool rotates at a speed which is higher by a multiple than the main mixing tool, for example at a peripheral speed of from **10** to **70** metres per second.

With the method of the invention the following advantages may be obtained.

Because the resistance of the material to a tool which rotates at high speed is comparatively large, the power consumption of the driving means for the auxiliary mixing tool is large, thus permitting an accurate comparison between the actual and required values, that is, between the actual and required consistency of the material.

Controlling the consistency of the material by automatic moistening of the material may be carried out with greater precision, and the apparatus required for that purpose is simplified.

The temperature of the material may, if desired, be taken into consideration at the same time. Normally used sand is employed in the preparation of molding sand. The used sand stripped from castings must be processed so that it has uniform qualitative properties when utilized in the mixing container. In addition to its residual moisture content, the temperature of the used sand varies within wide limits and must be cooled to a predetermined starting temperature for the proper automated mixing of the molding sand. The temperature of the sand is carefully checked prior to its introduction into the mixing container and then, based on its temperature, a control device admits the requisite amount of water into the sand so that its temperature can be brought to the desired level by evaporation.

Depending on the consistency of the material, which can for example comprise moulding sand, ceramic material, concrete, lime sandstone materials, granulated materials, and pressing and ramming materials, the resistance to mixing and the power consumption may be in widely different ranges. It is therefore advantageous for the driving means for the auxiliary mixing tool to be a variable speed electric motor, preferably a pole-changing motor. In this way, depending on the consistency of the material or the nature of individual components of the material, the most favorable treatment for each particular case can be achieved.

Finally, care should be taken that the moisture introduced into the mixing material to achieve a predetermined consistency does not exceed its desired value unless additional apparatus is provided for removing moisture. It is therefore important that the moisture be distributed rapidly in the material; as otherwise, under certain circumstances, an excessively lower power consumption may momentarily be indicated and an incorrect control order be transmitted to the regulating apparatus, resulting in the further excessive addition of moisture. A regulating signal corresponding to the power consumption of the motor must preferably therefore be derived when almost unvarying conditions are obtaining in the apparatus, that is, in particular, when the tool is rotating at a speed which is uniform and therefore free from acceleration, and the material is sufficiently homogenised for continuation of the mixing operation not to vary the power consumption of the motor.

In order to ensure that the further addition of moisture is only derived from the power consumption signal after a substantially unvarying condition of the above-mentioned nature has been achieved, the apparatus for carrying out a two-stage method in which a given amount of moisture is firstly introduced into the material and, subsequently, further moistening is controlled in dependence on the power consumption of the motor, can with advantage be embodied with a regulating apparatus which has an adjustable time delay operable after the first supply of moisture. This time delay can be made correspondingly larger when the time constants in the control circuit affect the measurement, so that the measured values of the power consumption are in fact taken as consistency values measured in the sub-

stantially unvarying condition of the material, and are transmitted to the regulating apparatus for the purposes of further controlling the moistening operation.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this disclosure. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which there are illustrated and described preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Two embodiments in accordance with the invention will now be described by way of example with reference to the accompanying drawings, in which:

FIG. 1 shows the first embodiment in diagrammatic form;

FIG. 2 shows the second embodiment in block form;

FIGS. 3 to 5 show the electric circuit of the second embodiment, the circuit being completed by placing FIG. 4 to the right of FIG. 3, and FIG. 5 to the right of FIG. 4; and

FIGS. 6 and 7 show the control diagram for a control device for regulating the temperature of the materials changed into the second embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, a counter-flow mixer comprises a clockwise-rotating mixing container 2 in which operates a relatively low-speed anti-clockwise-rotating main mixing tool A having a plurality of mixing blades, and a high-speed low-inertia auxiliary mixing tool B. The container 2 is rotated by a gear motor 2a which drives a ring gear 2b secured to the container. The axes of rotation of both tools A and B are eccentric relative to the axis of rotation of the container 2, and the tool B lies outside the working area of the tool A.

In operation, a known amount 1 of material to be mixed and moistened is put into the container 2 and treated with an amount 3 of fluid. Hereinafter the material will be assumed to be casting sand and the fluid water. In a first mixing stage, which is not necessarily regulated, the amount of water is metered by a meter 14 controlling a valve 15 in such a way that, together with the usual initial water content of the sand, the sand is still definitely below the desired final water content necessary to achieve the desired consistency or plasticity. This first stage prepares for the subsequent stage of finely regulating the water content, and also brings the water content to a value at which the electric current or power used by an electric motor 4 driving the tool B can be satisfactorily measured.

The sand is then homogenised by the tools A and B, during which step many materials have a tendency to increase in volume up to an expansion level 6. For clarity, the levels 3 and 6 are shown in exaggerated form. Further high-speed tools, combined with stationary tool systems, can also be used instead of the tools A and B. The uniform distribution of the water can be achieved in a short period of, for example, 10 to 20 seconds, after which time a magnetic valve 7 controlled by a time relay 13 opens, so that valves 8*a* to 8*d* are acted upon by water pressure.

The power used by the motor 4 in driving the tool B is then measured by a power measuring means having contacts 10*a* to 10*d*. There is normally connected between the motor 4 and the power measuring means a measured value treatment unit 11 by means of which the measured value is transformed and smoothed. When the sand is homogeneous the power used by the motor 4 is a direct, generally non-linear, function of the consistency of the sand. As the motor 4 is driven by a constant network voltage, the reading of the power measuring means is proportional to the current used and causes one or more of the contacts 10*a* to 10*d* to be tripped so that the measured value which is obtained in analog form is quantised in four steps. Depending on the number of contacts 10*a* to 10*d* tripped, a control unit 12 acts on the magnetic valves 8*a* to 8*d* in such a way that any of the contacts 10*a* to 10*d* tripped cause the corresponding valves 8*a* to 8*d* to be opened.

The amount of water allowed into the sand during this second stage depends on the condition of the valves 8*a* to 8*d*, the common supply pipe 16 to which is throttled after a predetermined period by the magnetic valve 7. In this way, the amount of water added depends on the number of valves 8*a* to 8*d* open, and this is determined by the consistency of the sand following the first stage. Following the addition of the water in the second stage the sand is again homogenised and subsequently discharged. All the control and regulating elements are then returned to their initial conditions.

The above described method and the apparatus can be modified in various ways without going outside the scope of the invention. Thus the valves 8*a* to 8*d* could be closed by flow measuring means instead of the time relay 13. Depending on the specific use to which the apparatus is put, the valves 8*a* to 8*d* can also be formed as regulating valves, regulating cocks, snap valves or restrictor valves with a large flow cross-section if thick or viscous fluids are used for moistening. The valve control can be effected by potentiometers which fully open the valves initially and then successively close them in dependence on the power used by the motor 4.

If the motor 4 is a three-phase motor, the above-mentioned power measuring means will desirably be used, while with a direct-current motor a contact ammeter is preferable. When hydraulic motors are used to drive the tools A and B, they are combined with known regulating and measuring devices.

The invention permits reliable control of the moistening operation and rapid homogenisation of the sand. By using a constant weight of said, supplied from a charging container 2A, a high degree of measuring precision can be achieved because of the possibility of reproducing the values of power used relative to a given water content, and hence calibrating the power measuring means. Also, a high-speed low-inertia auxiliary tool has a sensitive reaction to variations in water content of the sand, so that the range of power used is extended and differentiation between different water contents increased. The sensitivity and precision of the regulation is still further increased if the motor 4 is connected directly, that is without the interpolation of gears, to the tool B. Additionally, it has been found advantageous if the motor 4 maintains its speed of rota-

tion substantially constant within the measuring range. As different measuring ranges are found desirable for different materials, it is of advantage for the motor **4** to be pole-changing.

It has been found preferably for the tool B to be in the form of a H-shaped spinner **5**, the bars of which diverge upwardly in a V-shape. However other tools suited to the specific properties of the material can also be used.

In the apparatus shown in FIGS. **2** to **5**, two limit contacts are associated with the power measuring means W coupled to the motor **4** for the auxiliary tool B. With the two limit contacts in this embodiment, a four-stage mode of operation is achieved by means of a suitable circuit connected to the power measuring means W and in this way the required water content can be approached in steps.

In order to make the cycle time of the mixer as short as possible, the apparatus should be set very rapidly and automatically to the water content which is still missing from the material. The amount of water in the old sand which is found for example in foundries, can however vary within wide limits. If for example the water content in the sand which has not yet been treated is in the vicinity of the required value, the first stage, which generally adds a large amount of water, and possibly even the second stage, are omitted so that then only the third and fourth stages are operative, with correspondingly smaller amounts of water added. The sequence in time of the additions of water and the amounts of water to be added can therefore be adjusted as desired as will now be described.

In FIG. **2**, the container **2** is shown diagrammatically with a main mixing tool A and a spinner or auxiliary tool B, the motor **4** of which is coupled to the power measuring means W. The power measuring means W transmits a signal to a pulse transmitted U1 which actuates the counting circuit Z. The counting circuit Z is connected to a transmitter U3 which actuates a magnetic valve V for the required water supply periods and intervals.

The magnetic valve V can be actuated in four modes by the transmitter U3 in the embodiment shown, the variation in the supply periods and intervals in each mode resulting in a variation in the amount of water added. With the shortest supply period and the longest interval, the through-put is 0.25 litres per minute, whilst with the longest supply period and the shortest interval, the throughput is 60 litres per minute.

The mode of operation of the metering control circuit with four-stage automatic operation will now be described with reference to FIGS. **3** to **5**. The metering operation is initiated when a switch B1 in the current path **12** is temporarily closed. This results in the relay d1A being energised, whereby the contacts D1A in the current path **39** are closed. This results in the control voltage for the metering apparatus being connected.

The relay d3 in the counting circuit Z is engaged by way of the rest contacts D2/0 in the current path **18**. The relay d3 closes inter alia the contact D3 in the current path **24** which supplies voltage to two potentiometers (not shown) of the transmitter U3, which serve to adjust the water supply period and interval of the first mixing stage. These two potentiometers are built into the transmitter U3 together with the interval potentiometers of the second, third and fourth mixing stages. Therefore, for each stage there is provided a potentiometer for adjusting the supply period of the valve V and a potentiometer for adjusting the interval. The transmitter U3 therefore acts as a pulse transmitter with variable supply periods and intervals. The intervals must be selected in such a way that the water which is added during the first supply period of the magnetic valve V mixes thoroughly with the sand. Only then does the power measuring means W indicate a rise in power consumption by the motor **4**, and only after the power rise has terminated should the second addition of water take place.

Owing to the relay d3 being energised, the contact D3'' in the current path **35** is also closed, energising the relay d**12**. As a result, the rest contact D**12** in the current path **43** is opened, which opens the circuit of the voltage path for the power measuring means W, which path includes the resistor R**1**. At the same time the working contact D**12**' in the current path **43** is closed, which closes the voltage path by way of the variable resistor R3 and the resistor R**2**. A voltage varied for example by 20 percent can be delivered to the power measuring means W by the resistor R**3**. By means of such an increase in voltage in the voltage path, the indication of the indicator (not shown) of the power measuring means W can be made to exceed the actual power consumption of the motor **4**.

As already mentioned, the closed contact D**3** in the current path **24** passes voltage to the two potentiometers for the first stage and by the contact *u***3** of the transmitter U**3**, the valve relay *d***9** in the current path **28** is energised and de-energised according to the supply periods and intervals set in the two potentiometers. Accordingly, the supply of water to the sand is effected by the valve V. For this purpose, the valve relay *d***9** switches the contacts D**9** in the current path **11** which includes the valve V.

Only after a certain interval does the sand react to this addition of water and put up a higher mechanical resistance to the tool B. This causes an increased power consumption by the motor **4** and the indicator of the power measuring means W leaves the minimum mark, whereupon the relay *d***14** in the current path **41** is energised. The contact D**14** in the current path **31**, which is supplied with voltage by way of the closed contacts D**15**' of the relay d**15**, energises the relay d**11** in by way of the contact D**3**' which is also closed by the relay d**11**. The rest contact D**11** in the current path **28** then opens and de-energises the valve relay **9**. The working contact D**11**' in the current path **16** is closed at the same time by the relay *d***11** and transmits voltage to the terminal **5** of the transmitter U**1**.

The transmitter U1 is also a pulse transmitter with variable working periods and interval. The working period of the pulse transmitter U1 is set to be very short as it acts to restrict the transmission of pulses, while the interval period acts as a response delay, so that the indicator of the power measuring means W is generally not quite at rest in operation of the metering apparatus, and so that its first maximum deflection should not initiate any stepping of the counting circuit Z. In other words, the supply of water to the sand should be stopped at that moment, but the pulse transmitter U1 should not yet step the counting circuit Z on to the next stage.

When the indicator of the power measuring means W has finally moved off the minimum mark, the contact u**1** of the transmitter U**1**, which contact *u***1** lies in the

current path **14**, closes temporarily, and the coil **42** of the counting circuit Z which also lies in the current path **14** is energised. As a result, the counting circuit Z is stepped on by one step. The result of this is that the rest contact D2/0 opens and the working contact D2/1 in the current path **19** closes. The contact D2/1 energises the relay *d*4 in the current path **19**, of which the working contact D4 which is in the current path **25** then closes and transmits voltage to the two potentiometers for the supply periods and intervals of the second stage. The transmitter U3 energises and de-energises the valve relay *d*9 according to the values set by way of the contact u3, and the water supply of the second stage takes place.

Owing to the relay d3 becoming de-energised, the relay d12 is also de-energised by way of the contact D3'', the contacts D12 and D12' of the relay *d*12, which lie in the current path **43**, switching the voltage path of the power measuring means W to normal voltage. As a result of this switch to normal voltage, the indicator of the power measuring means W returns to the minimum mark and the relay d14 becomes de-energised, the contact D14 opening. At the same time the contact D3' in the current path **31** opens and de-energises the relay d11. The rest contact D11 of the relay d11 which lies in the current path **28** prepares for the energising of the valve relay d9. The working contact D11' of the relay d3 simultaneously interrupts the control voltage for the transmitter U1 so that further stepping on of the counting circuit Z is prevented.

At this moment, the power measuring means W is operating without increased voltage. If now the power consumption of the motor **4** is again increased by the supply of water in the second stage, the indicator of the power measuring means W again moves off the minimum mark. The relay d14 is again energised and its working contact D14, which is in the current path **31**, energises the relay d11 by way of the contact D4' in the current path **32**, which contact has already been closed by the relay d4. The rest contact D11 of the relay d11 de-energises the valve relay d9. The working contact D11' is closed at the same time and transmits control voltage to the transmitter U1. The transmitter U1 steps the counting circuit Z by a further step, as already described above.

In that case, the relay d4 becomes de-energised and the relay d5 of the counting circuit Z is energised by way of the closed contact D2/2. The contact D4' in the current path **32** opens owing to the relay d4 becoming de-energised and de-energises the relay *d*11. The working contact D5 is closed by the relay *d*5 and transmits voltage to the two potentiometers in the transmitter U3 for the supply periods and intervals of the third stage. At the same time, the working contact D5' in the current path **36** is closed and transmits voltage to the relay *d*13 in the same current path. The relay *d*13 actuates the switching contact D13 and D13' in the current path **44**, which interrupts the voltage path of the power measuring means W by way of the resistor R1 and switches the latter to the variable resistor R5. Depending on the particular setting of the latter, an increased voltage is then again transmitted to the voltage path of the power measuring means W, which results in an increased power consumption indication. From this it is apparent that the voltage increase in the first and third stages can be adjusted separately.

The valve relay *d*9 which actuates the valve V is energised and de-energised, as already mentioned, by the transmitter U3. When the indicator of the power measuring means W finally reaches the maximum mark, the relay d15 in the current path **42** becomes de-energised. The rest contact D **15** of the relay *d*15, which lies in the current path **33**, closes and energises the relay d11 by way of the working contact D5' which is already closed. The relay d11 de-energises the valve relay d9 by way of the contact D11 and supplies voltage to the transmitter U1 by way of the contact D11', as already described above. As a result, the counting circuit Z is stepped on by one step. The relay d5 of the counting circuit becomes de-energised and the relay d6 becomes energised by virtue of the contact D2/3 being closed. Owing to the de-energisation of the relay *d*5, the relay **13** in the current path **36** is de-energised by way of the contact D5'. Also, the switching contact D13, D13' which lies in the current path **44** and which is actuated by the relay d13 switches the voltage path of the power measuring means W back to normal voltage. This condition is shown in FIG. **5**. The result of this is that the indicator of the power measuring means W again moves off the maximum mark so that the relay d15 is again energised.

The two potentiometers in the transmitter U3 for the supply periods and intervals of the fourth and last stage are energised by the relay *d*6. The transmitter U3 again accordingly actuates the valve relay d9. This results in a further supply of water to the sand and the indicator of the power measuring means W again returns to the maximum mark, owing to the rising power consumption of the motor **4**. As a result, the relay *d*15 is again de-energised and its rest contact D15 which is in the voltage path **33** energises the relay d11 by way of the working contact D6' in the current path **34**, which contact is already closed by the relay *d*6. The relay d11 de-energises the valve relay *d*9 and transmits voltage to the transmitter U1 by way of the contact D11'. The transmitter U1 thereupon steps the counting circuit Z by a further step. The working contact D2/4 of the counting circuit **2**, which contact lies in the current path **22**, transmits control voltage to the terminal **5** of the reset circuit U2 for resetting the counting circuit Z. The working contact *u*2 of the circuit U2 which lies in the current path **13**, energises the coil *d*1Z, whereby the control voltage for the entire apparatus is interrupted by way of the contact d1Z in current path **37**. The working contact u2 of the reset circuit U2, which contact lies in the current path **15**, transmits a half-wave rectified voltage by way of the zero-position contact D2 to the coil **42** which thereupon returns the counting circuit Z to its zero position. The pulse transmission of the reset circuit U2 lasts for about **1** second.

After the above switching operation has taken place, the supply of water is concluded and the apparatus is ready for a new metering operation.

If, by virtue of the power measurement, it turns out that there is initially a relatively large amount of water in the sand, the various stages are omitted until the power measuring means W indicates a value which shows that the addition of water is necessary. Manual release of the valve relay *d*9 for corresponding switching of the magnetic valve V is also possible by way of the manual switches B3 and B4 in the current path **30**.

Instead of the above described circuit with a power measuring means W, the principle upon which the invention is based can also be embodied by a control circuit having for example a current measuring means with an electronic coefficient forming means, or any other measuring device for supplying the necessary measured values.

If materials having widely varying starting temperatures are to be processed, additional temperature sensors **50** are employed in combination with a control device **52** to correct the influence of temperature on the amount of water contained in the material. The control device **52** is connected to the control unit **12.**

In preparing the materials to be mixed, the mixing container **2** must be charged with uniform size batches. A material supply hopper **54** is positioned above the mixing container **2** for introducing the uniform size batches into the container. The temperature sensing means **50** are located within the hopper **54** at several positions so that a reliable mean value of the temperature of the material, such as used foundry casting sand, to be introduced into the mixing container is obtained. The temperature of used sand can fluctuate from normal room temperature, approximately 20℃ to or above 100℃. For example, at the outset of a work week, after the weekend shutdown, the use casting sand is available at room temperature, however, during the work week the sand is hot if it is stripped from the molds as quickly as possible following the casting operation. If the temperature differences of the starting material is not taken into consideration it is not possible to automate the mixing process because the material at the commencement of mixing will not be at the required temperature for obtaining the needed consistency in processing each batch of material.

In FIGS. **6** and **7** the control diagram of the control device **52** is shown for dissipating any excess heat contained in the casting sand.

In FIGS. **6** and **7** a plug panel **U21, U22** is divided into temperature ranges of 5° intervals from 5° to 100℃. To cool the casting sand to the required starting temperature for the mixing operation, water is introduced into the sand and the temperature is reduced by evaporation. The amount of water added is based on the temperature of the starting material in the supply hopper **54.** To determine the amount of water needed to cool the sand, tests are run before the mixing container is placed in operation and the plugs are arranged in the panel to correspond to the amount of water required for each temperature range recorded. Along the upper edge of the plug panel U21 numbers **1, 2, 4, 8, 10, 20, 40** and **80** appear indicating liters. The size and gradations of the plug panel naturally depend on the size of the mixing container involved and the amount of water supplied also depends on the container.

As mentioned above, the dissipation of excess heat is attained basically through evaporation and the cooling time required for each batch of material introduced into the container depends upon the quantity of water to be evaporated. Another plug panel U21*a* establishes the cooling period exactly. The vertical coordinate of the plug panel U21a is divided into a temperature range from 45° to 95℃ and the horizontal coordinate has a scale ranging from 10 seconds to 100 seconds. The size of the plug panel U21*a* depends of course, upon the size of the mixing container and the operating conditions involved. The required cooling periods is determined by preliminary testing and is set forth in a table. The plugs are arranged in the panel before operation is commenced. Corrections necessitated by seasonal variations in the ambient temperature, can be made at any time by repositioning the plugs.

In providing the material at the proper starting temperature the above apparatus is operated as follows:

The temperature sensors **50** within the supply hopper **54** determine the temperature of the charge of material to be placed into the mixing container **2** and the sensors exert joint influence upon a counting relay (decimal counter) associated with the plug panels. At the same time, the temperature of the material may be read optically. The counting relay is also provided with an optical indicator so that the sand temperature can be checked to ascertain the correctness of the temperature readings.

Alongside the plug panels **U21, U22** a row of counting relays is arranged corresponding to the gradation of the temperature scale. For instance, if the temperature sensors indicate the temperature of the material to be 80℃, the relay **U12,** contact **16,** responds and through its connection to the plug panel **U22** determines the amount of water to be added. Further, the relay **U12,** contact **16,** also establishes the cooling period to be used in accordance with the values arranged in the plug panel U21*a.*

The plug panels **U21, U22** have a binary layout, that is, the decade has only four members, i.e. **1, 2, 4** and **8,** which can be used in making any desired addition of cooling water. The cooling period is divided in decimals so that each plugged-in value corresponds to the tabulated cooling period.

With the temperature of the material to be added having been determined, the material is directed automatically from the supply hopper **54** into the mixing chamber **2** and a dry mixing period is commenced. The dry mixing period is infinitely variable and generally amounts to only a few seconds. When the dry mixing period is completed, the control device **52** feeds the required amount of water into the container for cooling the material to be mixed. As the water is added a wet mixing period takes place which is also infinitely variable and during the wet mixing period the actual homogenisation of the material takes place. Concurrently with or immediately following the end of the wet mixing period the cooling period, determined from the plug panel U21a is effected. During the cooling period, a strong air current is directed through the mixing container **2** from pressure and suction blowers **56.** Normally, the blowers are in continuous operation. The start and end of the cooling period is controlled by opening and closing the suction side of the blowers.

At the completion of the cooling period, the material in the container is at the desired temperature and is thoroughly mixed. At this point the fine adjustment of the consistency of the material can be effected through the consumption of energy by the mixing tool B. There is no excess water in the material, since it has been evaporated during the prior cooling period. Accordingly, the mixing operation, as described above, is performed so that the material is in the proper consistency for use in carrying out the casting operations.

While specific embodiments of the invention have been shown and described in detail to illustrate the application of the inventive principles, it will be under-

stood that the invention may be embodied otherwise without departing from such principles.

What is claimed is:

1. Apparatus for moistening a mixable material by the multi-stage addition of a moistening liquid, comprising a container rotatable about a substantially vertical axis and arranged to hold the material to be mixed and moistened, a vertically arranged relatively low-speed rotatable main mixing tool located within said container for mixing the material, a vertically arranged high-speed low-inertia auxiliary mixing tool located within said container and spaced laterally from said mixing tool so that its path of rotation is outside the path of rotation of said main mixing tool, driving means for rotating said auxiliary tool in the material, means for a step-wise addition of moistening liquid to the material to bring its moisture content to a predetermined level, control means for regulating said means for a step-wise addition of moistening liquid to the material determined in dependence on the power consumption of said driving means for said auxiliary mixing tool, and said control means includes a means for affording an interval in which the moistening liquid thoroughly mixes with the material before the power consumption of said driving means is determined, wherein the improvement comprises a hopper for supplying measured quantities of material into said container, temperature sensing means positioned within said hopper for determining the temperature of the material to be supplied into said container, and said control means includes a control device connected to said temperature sensing means for regulating the admission of cooling water to said container and regulating the cooling period after the admission of the water based upon the temperature determined by said temperature sensing means for establishing a predetermined starting temperature for the material within said container prior to the multi-stage addition of the moistening liquid.

2. Apparatus, as set forth in claim 1, wherein said control device includes a plug panel arranged to regulate the amount of water to be added to the material in said container in accordance with the temperature determined by said temperature sensing means, and another plug panel arranged to regulate the time duration of the cooling period based on the temperature of the material as determined by said temperature sensing means.

3. Apparatus, as set forth in claim 2, wherein blowers are associated with said container for providing a flow of air through said container during the cooling period.

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