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MOTOR CONTROL

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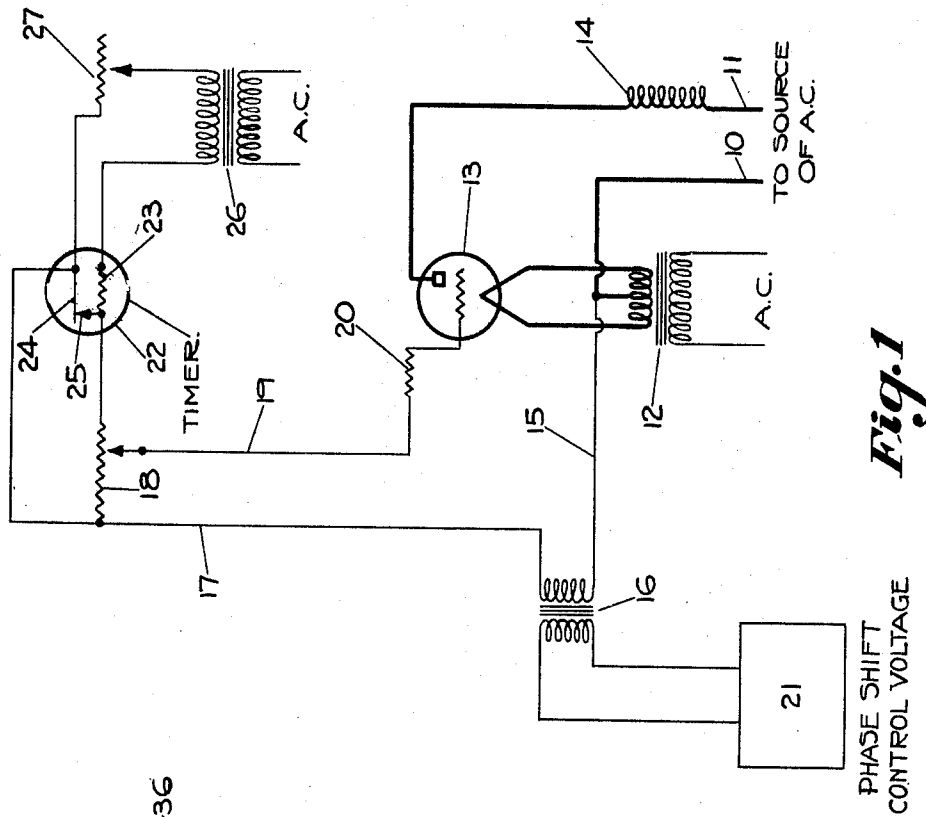


Fig. 1

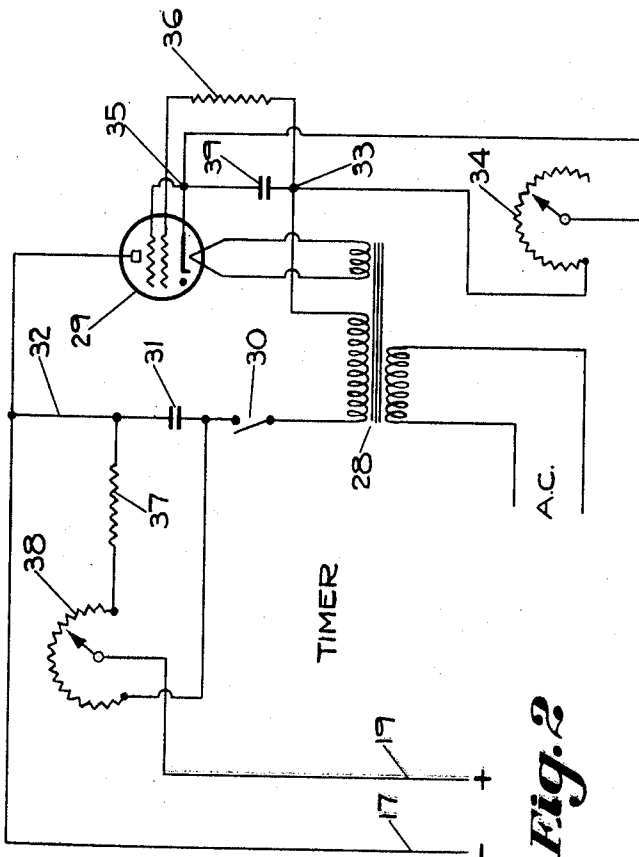


Fig. 2

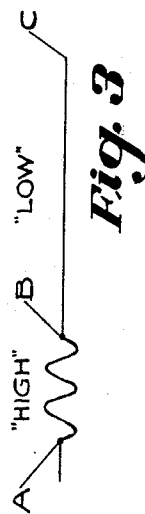


Fig. 3

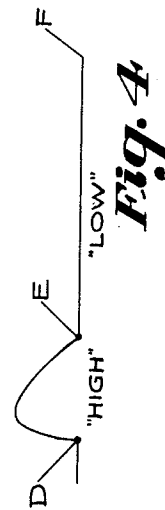


Fig. 4

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MOTOR CONTROL

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2 Claims. (Cl. 198—220)

This invention relates to a system or circuit including a vibratory motor and more specific a vibratory electric or electromagnetic feeder circuit in which a desired average feed rate is obtained by successive periods of relatively high vibratory feeding followed by periods of relatively low or zero vibratory feeding.

An object of the invention, therefore, is to produce circuits of the type above described.

A further object of the invention is to provide an electrical system or circuit in which the variable feed rate is provided preferably but not necessarily without shutting off completely the vibratory feeder or motor by successively altering the amplitude of vibration of the motor or feeder from a conveying condition to an essentially non-conveying condition.

Other objects of the invention will appear hereinafter, the novel features and combinations being set forth in the appended claims.

In the accompanying drawing,

Fig. 1 is a wiring diagram of one form of the system or circuit comprising my invention;

Fig. 2 is a wiring diagram of a modified form of timer which may be substituted for the timer of Fig. 1;

Fig. 3 is a curve illustrating a typical condition of the timer voltage applied to the grid of the power tube of the system of Fig. 1; and

Fig. 4 is a curve illustrating another condition of the timer voltage applied to the grid of the power tube of the system of Fig. 1 when the timer of Fig. 2 is substituted for the timer of Fig. 1.

It has been found in practice that frequently a relatively low average feed rate is desired for a vibratory feeder which may be generally of the type disclosed in the patent to James A. Flint, No. 2,094,787, dated October 5, 1937. More specifically, however, it has been found that in vibratory electric or electromagnetic conveyors or feeders where a cooling or drying action is to be performed, it is desired that the material be conveyed at a low average feed rate so as to afford ample time for the cooling or drying function to be carried out. Flint patents, Nos. 2,094,785 and 2,094,786 are further illustrations of these vibratory coolers and dryers to which this invention pertains. These are only two illustrations of typical devices.

It has also been found that it is difficult to maintain vibratory feeding movement of the material at a satisfactory controllable rate where the average amplitude of vibration and consequently the average feed rate is low, if attempt

is made to maintain the feed rate or amplitude of vibration substantially uniform. This is believed to be because of the fact that granular material being conveyed on a conveyor, feeder, cooler or dryer, of the type generally illustrated in the above mentioned patents, tends to become substantially non-conveying at a rapid rate as the amplitude of vibration is decreased and consequently in such devices there is frequently vibration in the conveyor, feeder, cooler or dryer and there may or may not be any actual conveying of material, depending upon a very small change in the amplitude of vibration of the vibratory unit.

To overcome this difficulty and to insure that there will be a reasonably accurate average feed rate for granular material fed by one of these vibratory units, I have provided a novel control system or circuit in which the conveyor, feeder, cooler or dryer is vibrated at a relatively high conveying rate for a period of time which is preferably adjustable over a wide range, followed by a period during which the vibration of the vibratory unit is appreciably reduced, preferably so as to provide no conveying action whatever. These periods, which for shortness will be called feeding periods and non-feeding periods, are cyclically repeated, each following the other in succession.

Referring first to Fig. 1 of the drawing, 10 and 11 are the power conductors leading from a source of alternating current such as secondary terminals of a transformer and may have any desired voltage such as 220 volts. The conductor 10 leads to the center tap of the secondary of transformer 12 which is the heating transformer for the filament or cathode of a power tube 13 which is preferably a gaseous electronic discharge tube. The filament or cathode of the tube 13 is heated by the transformer 12, the primary of which is energized from any available source of alternating current. The plate of the power tube 13 is connected to power conductor 11 which includes a winding or field 14 of an electromagnetic motor which is in the preferred embodiment of my invention a part of a vibratory feeder, conveyor, cooler or dryer, having the construction of one of the three above specified patents to James A. Flint. The power tube 13 acts as a half-wave rectifier to provide electric impulses having a frequency the same as the frequency of the source of alternating current which energizes conductors 10 and 11. For example, if this frequency is 60 cycles per second, the vibratory device having field 14 will

vibrate at a frequency of 60 vibrations per second or 3600 vibrations per minute.

In the system of my invention, the amplitude of vibration of the vibratory motor, which may be generally referred to by the reference character 14, is controlled by what is known as phase shift mechanism, that is, the input or control voltage of the tube 13 is shifted with respect to the plate, output, or anode voltage of the tube 13 and this phase relation will determine the amplitude of vibration of the motor 14 in a manner well understood in this art.

To provide for automatic and periodic adjustment of the feed rate of the vibratory motor 14 I provide a control circuit for the tube 13 in which the phase relation between the input voltage and the output voltage is cyclically adjusted during succeeding periods in which the amplitude of vibration of the motor 14 is alternately relatively high and relatively low. I also provide means to adjust the actual time of each cycle of successive high and low periods as well as the ratio of the high periods to the low periods and consequently the time of the high period and of the low period of each cycle.

The input circuit of the tube 13 extends from its filament or cathode to the center tap of the secondary of transformer 12, thence by conductor 15 to the secondary of transformer 16, thence by conductor 17 to variable resistor 18 and from a variable tap thereof by way of conductor 19 through current limiting grid resistor 20 to the grid of tube 13. There is an electric network which provides for the adjustment of the phase relation of the grid voltage to the plate voltage of the tube 13 which includes a source of phase shift control voltage 21 energized from the same source which energizes conductors 10 and 11 and which energizes transformer 16. This phase shift control voltage 21 is so adjusted as to provide, without other influence, such a phase relation between the grid voltage and plate voltage of tube 13 as to give a normally desired amplitude of vibration of the motor 14. It may be stated at this point that this amplitude of vibration provided by the phase shift control 21, independently of the other control, may be either the so-called "high" vibration or the so-called "low" vibration and the selection of whether it is "high" or "low" will normally depend upon whether during each cycle of alternate "high" or "low" vibrations the proportion of "high" vibration is greater or less than the proportion of "low" vibration. For example, referring to Fig. 3 of the drawing, let it be assumed that the curve ABC represents a cycle of operation of successive "high" and "low" periods of vibration and for illustration we will assume that the time represented by curve ABC is ten seconds. In other words, every ten seconds there will be a cycle of successive "high" and "low" periods of vibration of the motor 14.

As illustrated in Fig. 3 of the drawing, the period from A to B is designated as "high" vibration and this period is approximately 25% of the complete cycle, the "low" period being approximately 75% of the cycle. Under such conditions the vibratory motor 14 will vibrate with a "high" vibration for $2\frac{1}{2}$ seconds, followed by a "low" vibration of $7\frac{1}{2}$ seconds and this will be repeated in cycles. Under these conditions the phase shift control 21, if alone in control, preferably would provide the "low" amplitude of vibration. It may be stated that the curve of Fig. 3 actually illustrates the voltage applied to conductors 17 and 19, which is the supplemental control voltage for tube 13.

Superposed by the timer mechanism, herein-after described, on the resistor 18, this "high" period may be adjusted to any portion of the cycle. In other words, the point B on the curve of Fig. 3 may approach the point A as one limit and the point C as the other limit. It is, of course, obvious that as the "high" period is adjusted, the ratio of the "high" to "low" is varied and the actual time of the "low" is also varied unless the overall time from A to C is also adjusted.

To provide the supplemental control for the tube 13 I provide a timer 22 which, as illustrated in Fig. 1 of the drawing, is in the form of a simple thermal flasher relay which controls a periodic application of an A. C. voltage to the resistor 18 followed in each instance by a short circuiting of said resistor 18. As illustrated, the timer 22 is provided with a heater 23 and bi-metallic strip 24 which controls a switch 25. The timer or relay 22 is energized from a transformer 26 through a variable resistor 27. The resistor 18 is connected across the terminals of the switch 25 and when said switch 25 has its contacts closed, the resistor 18 is short circuited.

Operation of the timer 22 is as follows: To start operation, the transformer 26 is energized and an obvious circuit is provided from the secondary thereof to the heater 23, normally closed switch 25, bi-metallic strip 24 and variable resistor 27. The heater 23 begins to heat under the influence of the electric current and after a predetermined time which may be adjusted by controlling the variable resistor 27, bi-metallic strip 24 deflects sufficient to open the contacts of switch 25. When this is done the circuit to the heater 23 is broken and the bi-metallic strip 24 starts to cool and after sufficient cooling time recloses the contacts of switch 25, repeating this cycle of operation. When the contacts of switch 25 are closed, period B—C of the curve of Fig. 3 maintains, and no control voltage is applied to conductors 17 and 19. Upon the opening of the contacts of switch 25, point A in the cycle of the curve of Fig. 3 is reached and a voltage is applied from the secondary of the transformer 26 through an obvious circuit to the resistor 18 including the heater 23 and resistor 27. The current flow at this time, however, is very small, due to the value of resistors 18 and 27 and consequently the heat generated in heater 23 under such circumstances is insufficient to maintain the switch 25 open.

It is obvious that by controlling the resistor 27, the time of the cycle A—B—C may be adjusted and this also adjusts the time that the switch 25 is closed which also adjusts the actual time of the period B—C. The time of the period A—B may be controlled by changing the bi-metallic strip 24 or by changing the adjustment of the contacts of switch 25.

As previously indicated, when the contacts of switch 25 open and remove the short circuit of resistor 18 an alternating current voltage is applied to resistor 18 and by it superposed on the normal phase shift voltage of the input circuit of tube 13, whereby a phase shift will take place so as to give a period of "high" vibration. The change in the vibration effected by this appearance of alternating current voltage on resistor 18 may be adjusted by adjusting the position of the variable contact associated therewith. Furthermore, as previously mentioned, if desired, the phase shift control apparatus 21 may be normally set so that when resistor 18 is short-circuited, the amplitude of vibration of the motor 14 will be "high" and when the particular phase

shift voltage appears on resistor 18, the amplitude of vibration of motor 14 may thereby be reduced.

Turning to Fig. 2 of the drawing, there is illustrated an electronic timer which may be substituted for the timer 22, resistor 18 and associated parts. In making this substitution it is to be understood that conductors 17 and 19 are merely connected to the timer of Fig. 2 as illustrated and everything above the conductors 17 and 19 of Fig. 1 is eliminated by the substitution. The mode of operation of the timer of Fig. 2 is slightly different from that of Fig. 1 and this difference is illustrated by comparing Figs. 3 and 4 of the drawing; since Fig. 4 is a curve of the supplemental control voltage applied to the grid or input circuit or network when the timer of Fig. 2 is employed with the system.

The timer of said Fig. 2 includes transformer 28 which is energized from a source of alternating current, preferably that which energizes conductors 10 and 11, as was the transformer 20 of the timer of Fig. 1. Transformer 28 has a double secondary winding, one winding of which energizes the filament of an electronic discharge tube 29, preferably of the gaseous type. The tube 29 has an indirectly heated cathode and may have two grids, one of which is a control grid, the other a stabilizing grid. Said tube 29 is connected as a relatively low frequency relaxation oscillator.

The plate or output circuit of the tube 29 extends from the left-hand terminal of the main secondary winding of transformer 28 by way of conductor 32 through a control switch 30 and condenser 31 which is connected to the plate or anode of said tube 29. The other or right-hand terminal of the main secondary winding of transformer 28 is connected to a terminal 33 and then through variable resistor 34 to a terminal 35 to which the indirectly heated cathode of tube 29 is directly connected. The stabilizing grid of the tube 29 is also connected to terminal 35. A condenser 36 is connected across the terminals 33 and 35. The control grid of the tube 29 is also connected to the terminal 33 through protecting resistor 38. It may also be mentioned that connected across the terminal of condenser 31 is a pair of resistors 37 and 39, the latter of which has a variable tap associated with it which is connected to conductor 19.

The operation of the timer of Fig. 2 will now be described. Assuming switch 30 is closed, a surge of current will flow in the plate circuit of the tube 29 the circuit being from the right-hand end of main secondary 28 to terminal 33, through resistor 34, terminal 35, through the cathode of tube 29 to the plate of tube 29 and thence through conductor 32, condenser 31 and switch 30 to the left-hand terminal of said winding. This surge of current will charge the condenser 31. When this occurs, voltage will appear between the terminals 33 and 35 which will charge condenser 36 connected between them. This voltage, acting through resistor 38 and the control grid of the tube 29, will immediately shut off the flow of current through said tube 29 by automatic action.

Referring now to Fig. 4 of the drawing, immediately upon the firing of the tube 29, or in other words, on the surge of current therethrough, the point D in the cycle is at hand and between the point D and the point E the condenser 31 has a charge which is indicated by this portion of the curve. This charge on condenser 31 is applied in an amount determined by the position of the variable contact associated with conductor 19 to said conductors 17 and 19, since the conductor 17 is connected by way of conductor 32

permanently to one terminal of condenser 31. Due to the fact that condenser 31 has a high resistant shunt permanently connected across its terminal, provided by resistors 37 and 39, it will discharge at a desired rate following its being charged, as above described.

After the voltage on condenser 31 has been substantially discharged, the point E of curve of Fig. 4 is reached. This time period D—E of said curve is indicated as representing the period of "high" vibration, though as previously indicated in discussing Fig. 1 it may be indicated as "low," depending upon the setting of the phase shift control device of Fig. 1.

From point E to point F of the curve is the "low" period in the illustration given, during which condenser 31 is substantially discharged and there is no supplemental voltage produced by the timer of Fig. 2 applied to the conductors 17 and 19. In other words, during this "low" period, the control of the amplitude of vibration of motor 14 is that determined by the phase shift control apparatus 21.

The effective height of the curve D and E may be controlled and thus the value of the "high" amplitude may be controlled, by adjusting the variable tap associated with conductor 19 and resistor 38. The time of the cycle from D to F may be variably controlled by controlling the discharge rate of the condenser 39, because this condenser 39 shuts off the current flow through tube 29 very shortly after it is initiated by placing a high negative bias on the control grid thereof and maintaining this bias until the condenser 39 has discharged. The time interval of this discharge of condenser 39 is controlled by controlling the effective value of variable resistor 34. It is, of course, evident that this time discharge of condenser 39 must be greater than the time of discharge of condenser 31 and as these two times approach each other the points E and F of the curve of Fig. 4 approach each other. The ratio of the "high" to the "low" period in the timer of Fig. 2 can, of course, be adjusted by adjusting the resistor 34.

It may be further pointed out that the timers of both Figs. 1 and 2 are extremely flexible as, for example, the "high" period of either can be almost as low as 1% or as high as 99% of each cycle and the same, of course, is true for the "low" period of each. Furthermore, the "high" period can be obtained by placing a supplemental voltage on conductors 17 and 19 or it may be obtained by removing the supplemental voltage from the conductors 17 and 19, depending upon whether the normal amplitude of vibration of the motor 14 is controlled by the phase shift control device 21 alone, as a "high" or as a "low" condition. It is thus obvious that each of the systems is extremely flexible.

To review briefly the operation of the system of Fig. 1, the phase shift control voltage device 21 will be set, for example, so that if it alone were influencing the input circuit of tube 13, the phase relation between the input and output voltage thereof would provide a "low" amplitude of vibration of the conveyor, feeder, cooler or dryer operated by the motor 14. This vibration may be insufficient to produce any conveying action whatever though it may produce some conveying action. It may be stated that the advantage of maintaining some vibration on the vibratory unit as against completely shutting it off is that some materials while being cooled or dried or merely conveyed tend to stick to the deck of the vibratory

device when said device is totally de-energized, or in other words when vibration is entirely limited. Periodically there will be successive periods of "high" and "low" vibration and the ratio of the two may be adjusted over an extremely wide range as above indicated. During the periods of "high" or working conveying vibration the material will be conveyed at a rather definite rate. As a consequence, in the operation of a conveyor, feeder, cooler or dryer, an operator can be assured that the material will be conveyed over a given distance in an approximate predetermined time, yet this time may be such that the average feed rate is appreciably below that which could be sustained by the vibratory unit, that is, the conveyor, feeder, cooler or dryer. I have therefore provided a system for conveying either alone or while conditioning granular material, one illustration of which is plastic material in granular form, in which the average rate of feed is below that at which the vibratory unit can dependably continuously convey material. The operation of the system of Fig. 1 when modified by substituting the timer of Fig. 2 is essentially the same, the difference being that the timer of Fig. 2 has a greater flexibility than the timer of Fig. 1.

Obviously those skilled in the art may make various changes in the details and arrangement of parts without departing from the spirit and scope of the invention as defined by the claims hereto

appended, and I wish therefore not to be restricted to the precise construction herein disclosed.

Having thus described and shown an embodiment of my invention, what I now desire to secure by Letters Patent of the United States is:

1. In combination, a feeder of the vibratory electric type, a source of current for energizing said feeder, a continuous circuit connecting said feeder and said source whereby said feeder is always energized, and automatically operable electrical control means connected to control the rate of current flow in said continuous circuit, said control means including mechanism operable to adjust cyclically the current flow in said continuous circuit to values successively below and above that at which said feeder will continue to feed material.

2. In combination, a feeder of the vibratory electric type, a source of current for energizing said feeder, a continuous circuit connecting said feeder and said source whereby said feeder is always energized, and automatically operable control means connected to control the rate of current flow in said continuous circuit, said control means including mechanism operable to adjust cyclically the current flow in said continuous circuit to values successively below and above that at which said feeder will continue to feed material.

JAMES ROBERT LINDSAY.