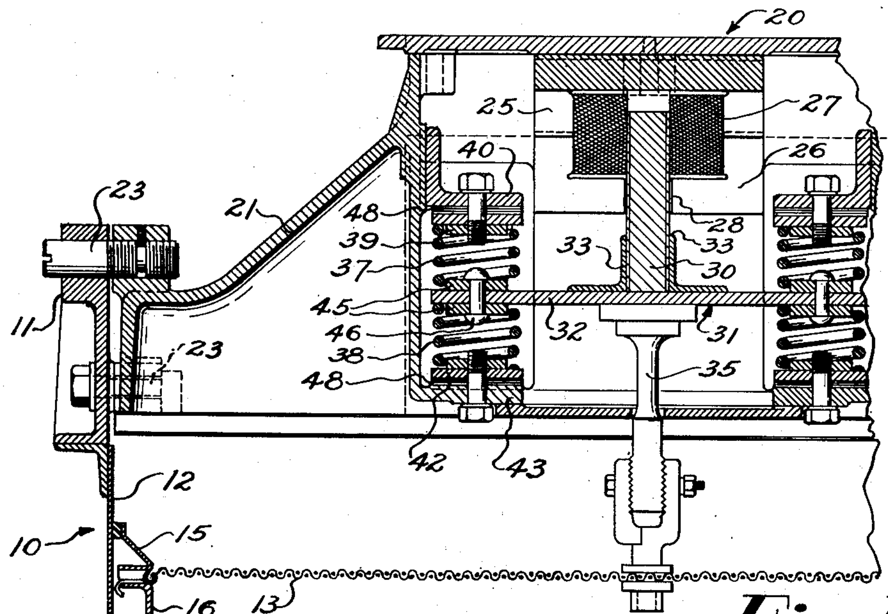

Fig. 1

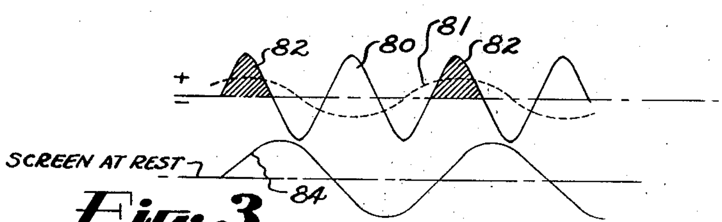

Fig. 3

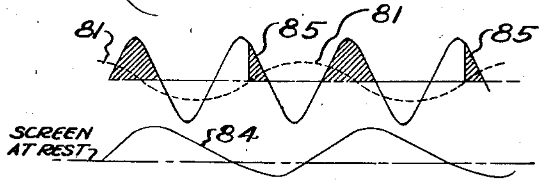

Fig. 4

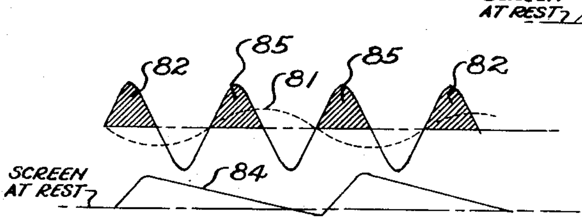

Fig. 5

INVENTORS.
HUGH E. BROWN
BY & STEWART M. GRANT
Fay, Golrick & Fay
ATTORNEYS

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METHOD AND APPARATUS FOR CONTROLLING MAGNETICALLY VIBRATED SCREENS

Filed Dec. 16, 1947 2 Sheets-Sheet 2

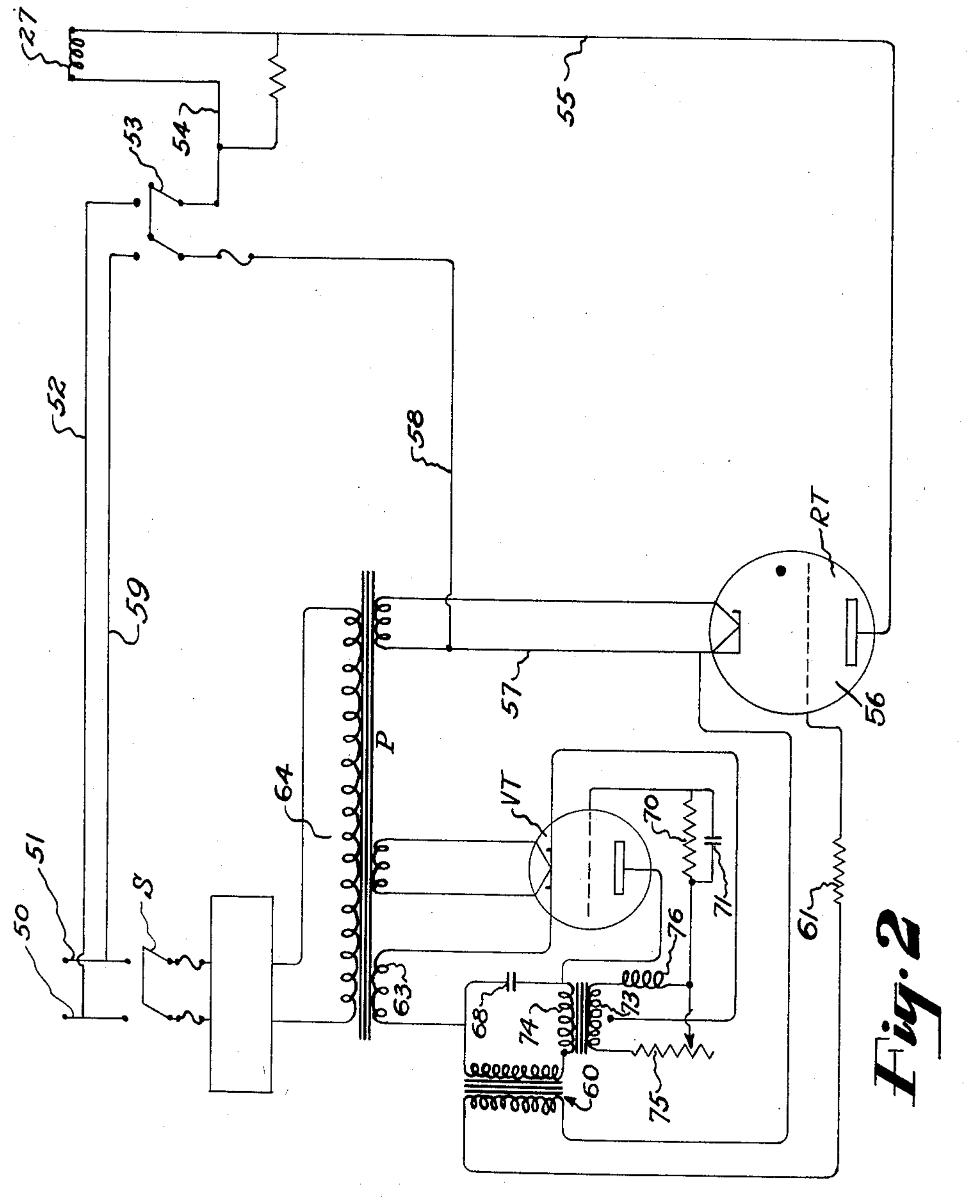

Fig. 2

INVENTORS.
HUGH E. BROWN
& STEWART M. GRANT
BY Fay, Golrick & Fay
ATTORNEYS

Patented Jan. 23, 1951

2,538,760

UNITED STATES PATENT OFFICE

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METHOD AND APPARATUS FOR CONTROLLING MAGNETICALLY VIBRATED SCREENS

Hugh E. Brown, Cleveland Heights, and Stewart M. Grant, Bay Village, Ohio, assignors to The W. S. Tyler Company, Cleveland, Ohio, a corporation of Ohio

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9 Claims. (Cl. 318—132)

1

The present invention relates to a magnetically operated vibrator for a screening machine and a method of control therefor.

Heretofore screens for screening materials have been vibrated by devices consisting of an electro-magnet and an armature attached directly or indirectly to the screen, the magnet being supplied with a pulsating or alternating current to impart oscillation to the armature and screen. In some instances resilient means were provided for causing the armature and the parts of the screen integral therewith to oscillate at a frequency the same as that of the current pulsations. The amplitudes of vibration were controlled by increasing or decreasing the voltage or current supplied to the magnet proportional to the amplitude desired. When the amplitude was relatively large, these vibrators were more or less satisfactory, but for smaller amplitudes, the reduction in current merely weakened the screen action so that a "soft" motion would result and the screen would readily clog. To overcome this disadvantage, some screens were designed so that at one end of the vibrator stroke the armature or its associated structure would strike a stop member and thus impart a jarring action to the screen which would effectively shake material from the interstices of the screen.

This structure was objectionable in that it was extremely noisy and there was considerable wear and strain on various parts thereof. Also, adjustments were necessary to maintain efficient operation for various amplitudes and the exercise of skill was necessary in making the proper adjustments.

The object of the present invention is to provide a control circuit for a magnetic vibrator for a screening machine in which the vibrating element is mechanically freely floating but which is acted upon by the magnet to impart a quick reversal of movement of the screen throughout all ranges of amplitudes so that the screen will not clog due to lack of vigorous agitation of the screen.

Another object of the invention is to provide a method of controlling a magnetically operated vibrator for a screening machine which will impart a jarring action to the screen during relatively small amplitudes of movement of the screen solely by the action of the magnet.

Other objects and advantages of the invention will be apparent from the following description of a preferred form of the invention, reference being made to the accompanying drawings wherein:

2

Fig. 1 is a fragmentary cross sectional view of a screening machine;

Fig. 2 is a wiring diagram of a control circuit for the screening machine; and

Figs. 3, 4 and 5 are wave diagrams indicating the relationship of certain currents in the control circuit and the corresponding motion of the screen.

Although the invention may be incorporated in various types of material handling or treating devices wherein rapid oscillation of certain parts is required, for the purpose of illustrating our invention we have shown a section of a screening machine indicated generally at 10 for screening or sorting materials according to particle size. The screen structure of the screening machine may be of any suitable conventional design and it is, therefore, not shown in detail. In the present embodiment of the invention the machine comprises a rectangular frame indicated at 11 to which is attached a skirt portion 12 which depends from the lower side of the frame. The frame 11 is adapted to be supported by any suitable structure, not shown, and the skirt portion 12 is adapted to support a wire screen 13 which extends transversely of the lower open side of the skirt throughout the length thereof. The periphery of the screen 13 is secured between brackets 15 and 16 which are attached to skirt 12 so that the screen is relatively taut.

The screen is adapted to be oscillated vertically by a vibrating mechanism indicated at 20. The mechanism 20 is enclosed in a housing 21 which bridges the central portion of the frame 11 and which is attached to the frame by bolts 23. An electro-magnet 25 is attached to the upper wall of the housing structure and it comprises a core 26 and coil 37. The core has an opening 28 therein which is in alignment with the central opening of the coil 27 for receiving an armature 30 of a vibrating element. The vibrating element is indicated generally at 31 and this element comprises a rigid plate 32 having the armature 30 attached integral therewith by brackets 33, the connection between the brackets and plate and armature being effected by riveting. A downwardly projecting post 35 is attached to the plate 32 and the lower end of the post is connected to the central portion of screen 13 so that when the plate 32 is oscillated vertically the screen will be vibrated by the post.

The plate 32 is resiliently mounted by two sets of coiled springs one at each end of the plate and each set comprises upper springs 37 and lower springs 38. The springs 37 abut against a centering member 39 which is attached to brackets 40 on the housing structure 21. The lower springs 38 abut a centering member 42 which is attached to flanges 43 formed on the housing structure. The coiled springs are centered on the plate 32 by disks 45 which are attached to the plate by rivets 46 and which fit within the ends of the springs. The springs are adapted to impart a vibration frequency to the plate 32 which frequency will be the same as that of the current suppplied to the coil 27 of the magnet. This frequency of vibration may be determined by the dimensions, tension and material of the springs. The tension of springs 37 and 38 may be adjusted by interposing a suitable number of shims, indicated at 48, between the seating members 39 and 42 and their respective supporting brackets 40 and flange 43. The plate 32 will vibrate at the natural frequency, or a harmonic thereof, of the loaded springs. It will be seen that when the coil 27 is energized armature 30 will be drawn upwardly compressing the springs 37 and when the flow of current to the magnet ceases armature 30 will move downwardly and its momentum will compress spring 38 causing this spring to return the plate upwardly. By proper timing of the energization of the coil 27, oscillation of the plate and its associated structure is maintained.

Referring now to Fig. 2, we have shown the supply and control circuit for supplying a pulsating current to the coil 27 of the magnet. The power supply circuit includes the two lines 50 and 51 connected with the usual 50 or 60 cycle commercial current and the line 50 is adapted to be connected to one side of coil 27 through line 52, switch 53 and line 54. The opposite side of the coil 27 is connected by line 55 to the anode of a grid controlled gas filled rectifier tube RT and the cathode of the rectifier tube 56 is connected to power line 51 by lines 57, 58, switch 53 and line 59. The filament of the tube RT is energized by the secondary of a power transformer P, as indicated in Fig. 2, the transformer being connected to the lines 50 and 51 through a switch S. It will be seen that the rectifier tube is capable of permitting current impulses to flow through the coil 27 at the rate of the frequency of the alternating current supply, for example, 60 per second, providing the grid of the tube is not negatively biased.

The grid circuit for the tube RT is adapted to be controlled by a tuned oscillator circuit adapted to provide an alternating current of a frequency one-half that of the power supply. An important feature of the oscillator circuit is that the phase of the current cycles thereof may be shifted relative to that of the power current by manual adjustment. This oscillator circuit includes a transformer 60, one side of the secondary of which is connected to line 57 and the opposite side of which is connected to the grid of tube RT through a suitable resistance 61. The primary of transformer 60 is energized by a secondary 63 of transformer P and the flow of power to the primary is controlled by a vacuum tube VT, one cathode of which is connected to one side of the secondary 63 and the anode of which is connected to one side of the primary of transformer 60 through a primary winding of a center tapped transformer 74. The opposite side of the primary of transformer 60 is connected directly to one side of secondary coil 63 and a condenser 68 is connected in shunt with the primaries of transformers 60 and 74. The grid of the vacuum tube VT is connected in a circuit which includes

a resistor 70 having a condenser 71 in shunt therewith and the resistor is attached to a circuit which includes the secondary 73 of the center tapped transformer 74. The secondary circuit 73 consists of a manually variable resistor 75 and an inductor 76 connected in series. The center tap of secondary 73 is connected to the cathode of tube VT. The oscillator circuit is adapted to provide the grid of tube RT with an alternating current of 30 cycles, assuming that the power circuit is 60 cycles, so that the grid will be negatively impressed thirty times per second. By adjusting the resistor 75 the wave phase of the oscillator circuit can be shifted and when adjusted to one position the grid will be negatively biased during alternate positive waves of the current in the power circuit and the current passing through the tube 56 will have an impulse frequency of 30 cycles per second. This condition is indicated in Fig. 3 wherein line 80 indicates the phase of the 60 cycle alternating power current, line 81 indicates the phase of the oscillator current and the shaded areas 82 indicate current passing through the tube RT and consequently the current through the coil 27. When this condition prevails the vibrator element will oscillate at its maximum amplitude which is illustrated graphically by line 84, as near as can be ascertained. If it is desired to reduce the amplitude of the screen for screening finer materials, for example, a current impulse is interposed between the normal impulses illustrated at 82 and this is accomplished by adjusting the variable resistor 75 to cause shifting of the phase of the oscillator current so that the grid of tube RT will be positive during all or a portion of the positive phase of the power waves intermediate the normal waves 82, and thereby permit passage of current through the coil. This phase shifting is illustrated in Fig. 4 wherein the shaded area 85 indicates current flowing to the coil 27 intermediate the normal impulses or waves 82. This additional flow of current apparently restrains the normal downward movement of the screen between the normal 30 cycle current impulses so that the armature will more quickly respond to the succeeding normal current impulses whereby a more sudden reversal in the direction of the screen is effected. This not only reduces the amplitude of the screen but at the same time it increases the speed at which the screen reverses direction so that a substantial jarring action occurs in the screen. The lines 84 in Figs. 3, 4 and 5 illustrate the vertical movement of the screen as plotted against the time of the current frequencies, as near as can be determined, and it will be seen that as the degree of phase shifting of the oscillator current is increased the current of the intermediate impulses are increased thereby further reducing the amplitude of the screen and increasing the vigor of its action. As the phase of grid current is shifted it will not remain positive throughout the normal waves 82, but once current starts to pass through rectifier tube VT it will continue for that wave phase although in the meantime the grid shifts to a negative bias. Thus, it is necessary to have the grid of the tube positive only at the initiation of the normal power cycles. We have found that as the amplitude is reduced in the manner described, the screen action becomes sharper so that the screen will not clog due to its violent motion. By our control instead of reducing the current to reduce the amplitude, the current used is actually increased and this increase results in more power being applied to the effective vibration of the screen.

It will be seen that there are no rubbing or striking of parts of the vibrating mechanism so that the screen is not only practically noiseless in its operation, but there is no part subject to wear or unusual stresses. The range of amplitude of vibration is wide and the only adjustment necessary is that of the variable resistor 75 which can be controlled by merely turning a knob.

Although we have described but one form of the invention, it is to be understood that other forms might be adopted, all falling within the scope of the claims which follow.

We claim:

1. A control circuit for a magnetic vibrator which comprises, a grid controlled gas tube rectifier; a circuit for supplying alternating current of a predetermined frequency to the rectifier; and control means for said grid consisting of a tuned oscillator circuit, said circuit being adapted to supply an alternating current to said grid and having a frequency which is a sub multiple of the first mentioned current, and a phase shifting circuit associated with said oscillator circuit for shifting the phase of the current in the oscillator circuit relative to that of the first mentioned current.

2. A control circuit for a magnetic vibrator which comprises, a grid controlled gas tube rectifier; a circuit for supplying alternating current of a predetermined frequency to the rectifier; and control means for said grid consisting of a tuned oscillator circuit, said circuit being adapted to supply an alternating current to said grid and having a frequency of one-half that of the first mentioned current, and a phase shifting circuit associated with said oscillator circuit for shifting the phase of the current in the oscillator circuit relative to that of the first mentioned current whereby said rectifier is operative to pass one phase of alternate waves of the alternating current and fractional portions of one phase of the waves intermediate said alternate waves.

3. The method of controlling a magnetically operated material handling screen having a substantially predetermined vibration frequency, which method comprises supplying pulsating current to the magnet having a frequency substantially the same as the predetermined vibrating frequency of the screen, and introducing a pulsating current to the magnet which latter pulsating current is out of phase with the pulsations of the first mentioned current pulsations.

4. The method of controlling a magnetically operated material handling screen having a substantially predetermined vibration frequency, which method comprises supplying pulsating current to the magnet having a frequency the same as the vibrating frequency of the screen, and reducing the amplitude of vibration of the screen by introducing an additional current to the magnet at the same frequency but out of phase with said screen.

5. A control circuit for an electro-magnetically vibrated screening mechanism comprising, a circuit including a source of alternating current for the magnet; a gas filled grid controlled tube in said circuit for controlling the flow of current to the magnet; and a control circuit for the grid comprising an oscillator for producing an alternating current on the grid having a frequency one half that of said alternating current, said control circuit having means for shifting the phase of the alternating current on the grid relative to the first mentioned alternating current.

6. The method of controlling a magnetically operated material handling screen having a substantially predetermined vibration frequency, which method comprises supplying to the magnet pulsating current at a frequency equivalent to the vibrating frequency of the screen, and reducing the amplitude of vibration of the screen by introducing current to the magnet at the same frequency of said predetermined frequency of vibration of the screen but intermediate to said first mentioned pulsating current and out of phase with said pulsating current, said alternate intermediate impulses being of a lesser value than said first mentioned pulsation whereby said intermediate impulses diminish the negative amplitude to accelerate the screen action.

7. An electromagnetic vibrator for vibrating a material handling screening machine, comprising a coil, an armature, a resilient means for mounting the armature relative to the magnet for oscillating motion, means interconnecting the armature and screen, and a control circuit for said magnetic vibrator comprising, a grid controlled gas tube rectifier; a circuit for supplying alternating current of a predetermined frequency to the rectifier and coil, control means for said grid consisting of a tuned oscillator circuit being adapted to supply an alternating current to said grid and having a frequency which is a sub multiple of the first mentioned current, and a phase shifting circuit associated with said oscillator circuit for shifting the phase of the current in the oscillator circuit relative to that of the first mentioned current.

8. A magnetic vibrator of the character defined in claim 7 in which the oscillator circuit for controlling the grid of said rectifier is adapted to supply a pulsating current of one half the frequency of that of the alternating current supply.

9. In an electromagnetic vibrator having a coil and armature, rectifier tube, source of alternating current, and circuit including all of these elements, means to control amplitude of vibration of the armature comprising a phase shifting circuit and an oscillator adjusted to introduce to the rectifier a pulsating current intermediate the pulses of the alternating current supply to check the impressed reciprocating movement of the armature and thereby accelerate the movement of the vibrated element.

HUGH E. BROWN.
STEWART M. GRANT.

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