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W. C. BIRTWELL ET AL
FEED CONTROLLING APPARATUS

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2 Sheets-Sheet 1

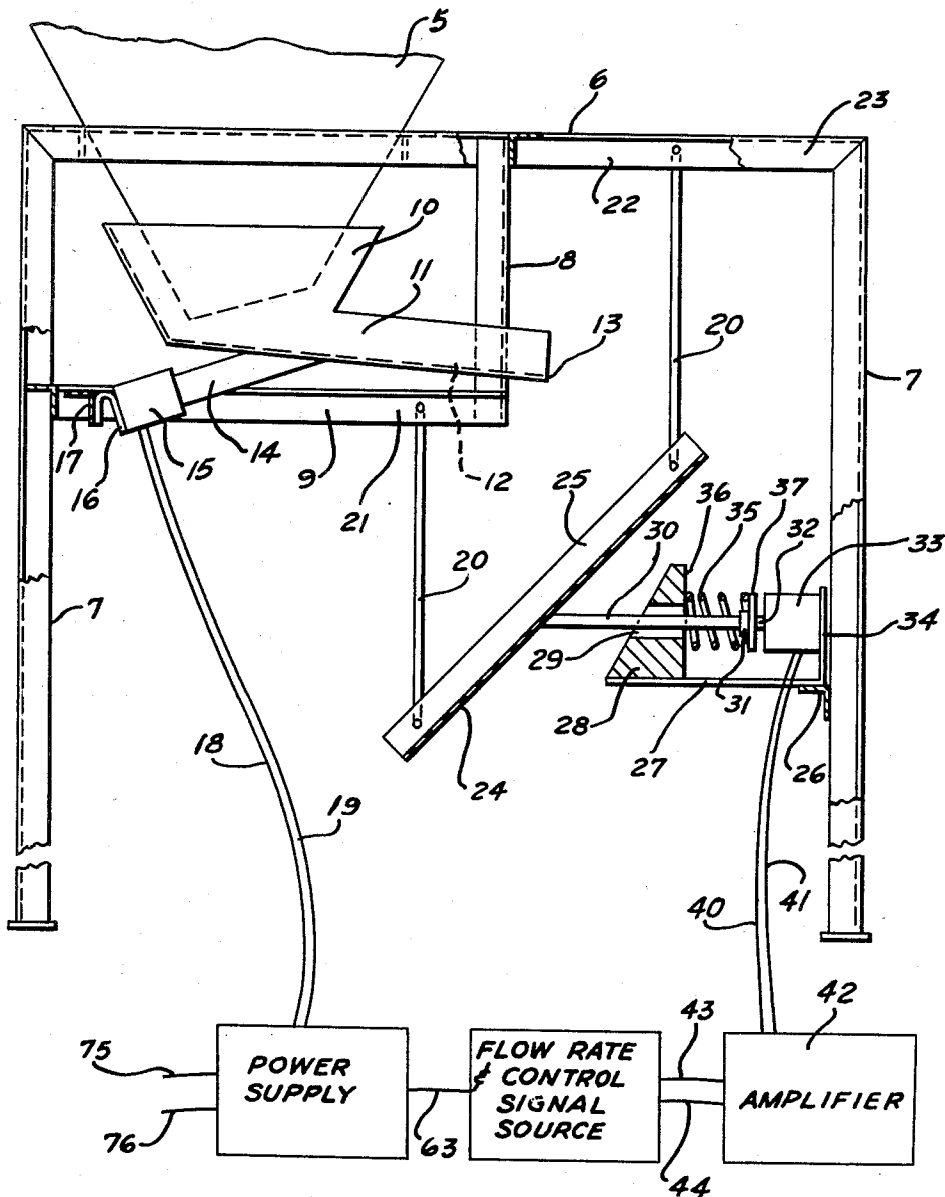


Fig. 1

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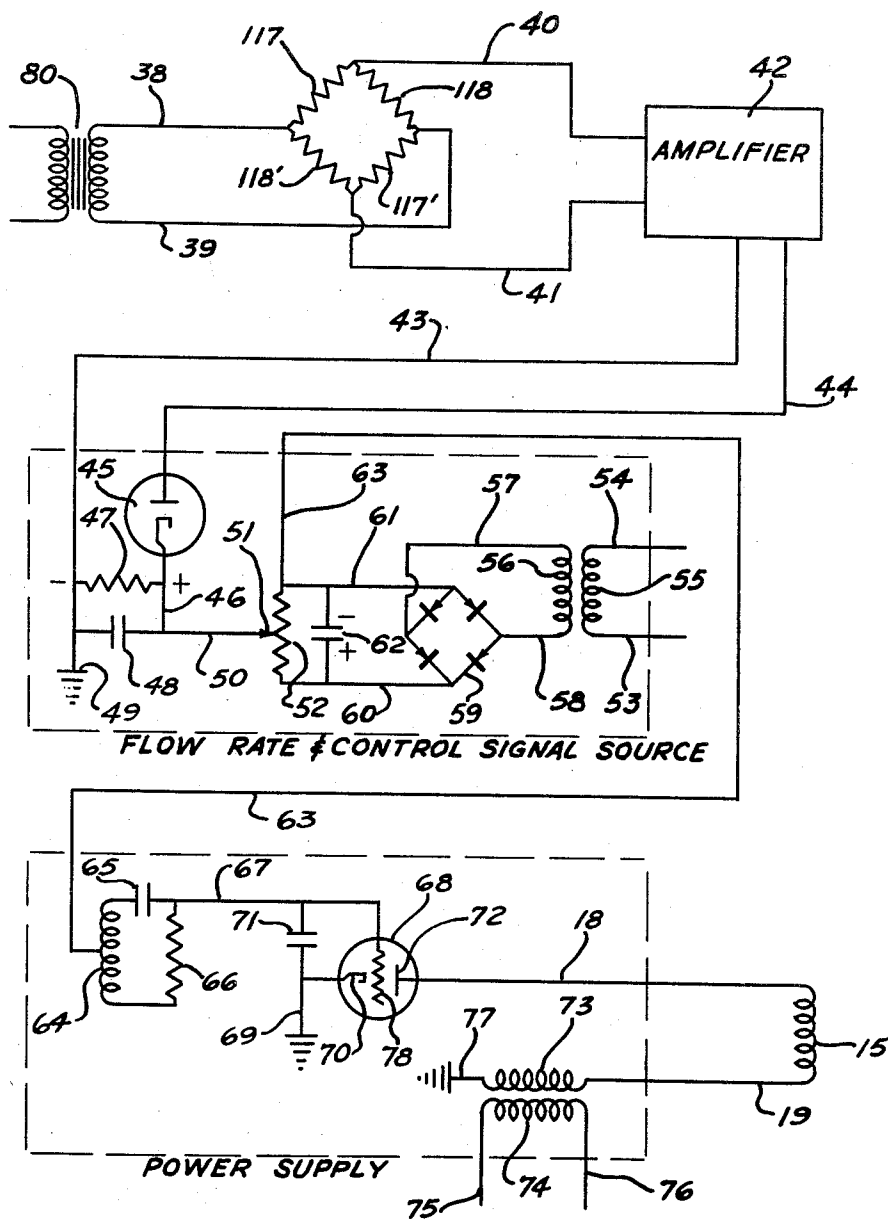


Fig. 2

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FEED CONTROLLING APPARATUS

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17 Claims. (Cl. 222—55)

Our invention relates to feed controlling apparatus, and more particularly to an apparatus for controlling the rate of feed of a feeding device by electronic means that controls the rate of operation of the feeding means.

It is a purpose of our invention to control the rate of feed of a feeding means, that discharges a stream of material in such a manner that it falls by gravity from the feeding means to any suitable or desired apparatus, by interposing in the falling stream means acted on by the impact of the stream thereagainst to control said feeding means. The material discharged may be either a liquid or a dry material.

It is a further purposes of our invention to provide feed controlling means that comprises means interposed in a falling stream of material to be responsive to the impact of the material in said stream thereagainst, for measuring the flow of the stream, in which the difficulty is avoided that the weight of the material on the member interposed in the stream would affect the accuracy of the results obtained by our apparatus.

More particularly our invention comprises electronically controlled feeding means so constructed and arranged as to discharge a stream of material into engagement with suitable sensing means in the form of a deflecting member, or members, interposed in the stream so that all of the stream will engage the deflecting means and the particles of the stream engaging said deflecting member, or members, will have fallen through a constant predetermined height upon engagement with the sensing means, and thus all the particles will be accelerated to a predetermined velocity at the time of such engagement, said sensing means being of the general character shown in the co-pending application of Lyndus E. Harper, Serial No. 573,740, filed March 26, 1956, on Feed Measuring and Controlling Apparatus.

More specifically the sensing means utilized in our invention comprises deflecting means interposed in the freely falling stream of material discharged from the feeding means, which is constrained against vertical movement by suitable suspending means so that any material adhering to said deflecting means will be supported solely by the pivotal mounting of said suspending means, and a movable member that has a position determined by the position of the deflecting means that acts upon an output voltage controlling means, which may be a strain responsive apparatus of such a character that the resistance thereof varies in accordance with the strain imposed thereon, said apparatus being of the general character disclosed in the patent to Ruge, 2,322,319, June 22, 1943, on Strain Responsive Apparatus. The particular apparatus of this character that has been found suitable for utilization in our apparatus is one in which the member provided with the resistance filaments is subjected to compression.

It is a further purpose of our invention to provide in combination with a feeding device that is of such a character that the rate of feed thereof varies with the

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electrical voltage applied thereto, means for controlling the rate of feed thereof, comprising electronic discharge means for controlling the voltage of the operating circuit of said feeding means, which electronic discharge means varies the voltage of said operating circuit responsive to the variable potential applied to the grid thereof, and means for varying the potential applied to said electronic controlling means comprising output voltage varying means that is responsive to the position of the movable member that is an element of the sensing means interposed in the falling stream of material that is discharged from the feeding means, referred to hereinbefore, so as to increase said output voltage as rate of feed increases.

More particularly our invention comprises impact responsive means mounted in a stream of freely falling material discharged from a feeding means, and means for controlling the feed of said feeding means in response to said impact comprising a strain responsive device of the character above referred to, that is acted on by the impact responsive means to vary the voltage in an electrical circuit and amplifying means for amplifying the voltage variations in said circuit, the output circuit of the amplifying means including rectifying means, that impresses positive voltage impulses on the negatively biased control circuit of an electronic controlling device for controlling the energy supplied to electrical means for operating the feeding means, said electronic device being an electron discharge tube having a grid for controlling the flow of electrical energy therethrough, on which a variable negative biasing voltage is impressed due to the effect of said amplified positive voltage impulses on said control circuit. The electron discharge tube that is utilized for so controlling the feeding means is preferably a thyratron tube, which is interposed in the secondary of a power transformer supplying electrical energy to the means for operating the feeding device with the grid thereof interposed between the plate and cathode of said tube.

It is a further purpose of our invention to provide means for adjusting the rate of feed manually, comprising means for negatively biasing said control circuit comprising a resistance connected across a bridge rectifier which is the source of the negative biasing voltage, variable portions of which resistance may be included serially with the means for supplying the positive amplified rectified voltage impulses under the control of said impact responsive means to said controlling circuit. By adjusting the portion of said resistance serially included in the output circuit from the impact responsive means the negative grid voltage that is added to said positive voltage impulses is varied, thus varying the negative bias of the grid of said control tube to adjust the average rate of feed.

Other objects and advantages of our invention will appear as the description of the drawings proceeds. We desire to have it understood, however, that we do not intend to limit ourselves to the particular details shown or described, except as defined in the claims.

In the drawings:

Fig. 1 is a view partly in elevation and partly in section, and partly broken away, of a feeding device, showing our improved feed controlling means applied thereto, diagrammatically showing the electrical controlling means utilized in conjunction therewith, and

Fig. 2 is a circuit diagram of the means for controlling the rate of feed.

Referring in detail to the drawings, in Fig. 1 is shown a fragmentary portion of a hopper 5, which is mounted on a suitable framework 6 having vertical frame members 7, and vertical frame members 8 and horizontal frame members 9 constituting a portion thereof. The hopper

5 feeds material into a hopper portion of a vibratory feeder 11, which has an inclined bottom wall 12 and which feeds material from the discharge end 13 thereof in proportion to the rate of vibration of the member 11, the vibrating means 14 comprising a coil or winding 15 of an electro-magnetic operating means therefor, which is mounted in a suitable manner on a bracket 16 on the cross member 17 extending between a pair of the frame members 9. The conductors 18 and 19 lead to the winding 15.

Links 20 are mounted on suitable frictionless pivots on the depending flanges 21 and 22 of the horizontal frame members 9 and 23. The links 20 suspend an inclined plate-like member 24 by being mounted in frictionless pivots on said links 20, as by passing through suitable openings in the side flanges 25 on said plate-like member 24. It is, of course, to be understood that there is a pair of flanges 25 on the plate-like member 24 and that there is a pair of links 20 at the upper end and a pair of links 20 at the lower end of the plate-like member 24, the mounting of the plate-like member 24 being similar to that of the mounting for the plate-like members disclosed in the application of Lyndus E. Harper, Serial No. 573,740, filed March 26, 1956, on Feed Measuring and Controlling Apparatus.

Mounted on a cross member 26 extending between a pair of the vertical frame members 7 is a bracket 27 on which is mounted an abutment block 28 that has an opening 29 therethrough, through which a rod 30 extends that is fixed to the plate 24 in any suitable manner. A head 31 may be provided on said rod-like member 30. A projecting button 32 is provided on the load cell 33 mounted on the upstanding portion 34 of said bracket 27.

The load cell 33 comprises a device of the general character shown in the patent to Ruge, 2,322,319, June 22, 1943, on Strain Responsive Apparatus. The projecting button 32 is mounted on one end of a member that is put under compression and the compression is measured by the change in the resistance of the resistance elements that are bonded to said member and which are of such a character that the electrical resistance thereof varies in accordance with the strain exerted thereon, as disclosed in said patent to Ruge, said resistances 117, 117', 118 and 118' as shown in Fig. 2 of our drawings corresponding to the similarly numbered resistances in the disclosure of said patent. A compression coil spring 35 is mounted between the face 36 of the abutment 28 and a disk-like member 37 mounted on the button 32. The head 31 on the rod-like member 30 engages the disk 37 and the force of the impact of the stream on the plate 24 is transferred through the rod 30, head 31 thereon and the disk 37 to the button 32 and thus to the member that is put under compression in the load cell 33, to which the resistance elements above referred to are bonded. The spring 35 is provided to put an initial constant compression strain on said cell and the plate 24 puts an additional variable compression strain thereon.

The general character of such a load cell is shown diagrammatically in Fig. 2 of the drawings, the conductors 38 and 39 leading from the secondary of a step down transformer connected with an alternating current source to the points between the arms of the Wheatstone bridge arrangement of resistance elements, as shown in said diagram, and the output from said cell being determined by the variation in the resistance created in the resistance elements shown in said diagram by the strain placed on the element on which these resistances are mounted in a manner as described in said patent to Ruge. The conductors 40 and 41 lead from the other two corners of the Wheatstone bridge and are portions of the output circuit of said strain responsive resistance device.

The conductors 40 and 41 lead to suitable amplifying means 42 of a standard character and the amplifier produces an amplified alternating current in the conductors

43 and 44 leading from the amplifier. The variations in the resistance produced in the input circuit to the amplifier including the conductors 40 and 41, cause voltage variations in the circuit proportional to the resistance variations, and the voltage variations in the output circuit, of which the conductors 43 and 44 are a part, correspond to the voltage variations in the input circuit of said amplifier, but are of greater magnitude and of higher voltage. The amplifier serves to bring the power level up high enough to be usable at the very high levels required for the thyratron tube which controls the current flow through the winding 15 of the vibratory feeding means.

In order to utilize the positive impulses in the output circuit of the amplifier 42, the rectifier tube 45 is provided, the conductor 44 leading to the plate of said tube 45, and the conductor 46 extending from the filament of said tube. A high resistance 47 is bridged across the conductors 43 and 46 and a condenser 48 is also bridged across said conductors, the conductor 43 having a ground connection at 49. As a result of this arrangement, only positive current impulses flow through the conductor 50, which is provided with a movable contact 51, which may be a slide, engaging a resistance element 52.

The conductors 53 and 54 lead from a 110 volt alternating current source to the primary winding 55 of a transformer that has the secondary winding 56 from which the conductors 57 and 58 extend to the full wave rectifier 59 from which the conductors 60 and 61 extend to the opposite terminals of the resistance 52, a condenser 62 being bridged across the conductors 60 and 61. The condenser 62 is a filter condenser. The resistance 52 and slide 51 constitute a potentiometer. The condenser is polarized as shown.

The conductor 60 is a positive lead extending to one terminal of the resistance 52 and the conductor 61 a negative lead extending to the other terminal thereof. Accordingly the nearer the movable contact 51 is to the terminal of the resistance 52 connected with the conductor 60 the more negative will be the conductor 63 with respect to the conductor 50, and similarly the greater amount of the resistance 52 that is being imposed between the contact 51 and the conductor 63 the greater will be the reduction in the potential of the positive impulses produced in the conductor 50 by the amplified and rectified impulses produced as a result of the strain responsive resistance means provided in the load cell 33.

The conductor 63 leads to a phase shifting network comprising the impedance 64, condenser 65 and resistance 66 from which the conductor 67 leads to the grid 78 of the thyratron tube 68, a ground connection 69 being provided from the cathode 70 of said thyratron tube and a condenser 71 being bridged across the conductors 67 and 69. The plate 72 of said tube is connected with the conductor 18 that leads to one end of the winding 15 of the electro-magnetic vibratory feeding means and the conductor 19 extends from one end of the secondary 73 of the transformer having the primary winding 74 having its terminals connected with the conductors 75 and 76 leading from a 110 volt alternating current source. The opposite end of the secondary winding 73 is connected with the ground by a conductor 77. The control grid 78, which is interposed between the cathode 70 and the plate 72, is variably negatively biased due to the amplified and rectified positive voltage impulses impressed on the grid control circuit due to the load cell 33, and the uniform negative potential additional thereto impressed on said grid control circuit by the source of direct current flowing through the conductors 60 and 61, which potential may be manually adjusted by means of the movable contact 51 of the potentiometer that has the resistance element 52. movement thereof toward the terminal thereof connected with the conductor 63 increasing the negative bias of the grid 78.

As the variations in the potential of the grid 78 will cause variations in the flow of electrical energy through the circuit comprising the conductors 69, 18, 19, 77, secondary 73 and electro-magnet winding 15, the rate of feed of the feeding device is adjusted by means of the impact produced by the falling material over the edge 13 of the feeder onto the deflector plate 24.

The greater the negative bias of the control grid 78 the greater will be the voltage across the winding 15. Accordingly the greater the impact of the material on the plate 24, the lower will be the resistance as the compression load on the cell increases in the controlling circuit in which the load cell 33 is located and the higher the output voltage thereof and the higher the positive voltage impulses impressed on the grid control circuit. This will reduce the negative bias of the control grid 78 and reduce the voltage of the circuit in which the vibratory winding 15 is located, thus reducing the amplitude of the vibrations and the rate of feed. Similarly, the desired normal rate of feed can be varied by adjusting manually the contact 51, as the nearer the contact 51 is moved to the end of the resistance 52 connected with the conductor 60 the higher will be the negative potential applied to the control grid 78 from the direct current source 59 and the greater will be the amplitude of the vibrations of the vibratory feeder member 11.

In Fig. 1 the conductors 40 and 41 are shown as leading to the amplifier 42 and the conductors 43 and 44 leading to the flow rate and control signal source, which comprises the rectifying means for the output current of the amplifier and the direct current source for the bias control voltage impressed on the thyatron tube of the power supply, the conductor 63 being shown as extending from the flow rate and control signal source to the power supply, into which the conductors 75 and 76 lead from the alternating current 110 volt source, each group of apparatus being shown diagrammatically in Fig. 1 and the electrical elements thereof being shown diagrammatically in Fig. 2.

What we claim is:

1. The combination with feeding means discharging a freely falling stream of material therefrom of means for controlling the rate of feed thereof, comprising deflecting means, means mounting said deflecting means in said stream to be engaged by all the particles thereof upon reaching a predetermined velocity, said mounting means comprising suspending means for constraining said deflecting means against vertical movement by engagement of said particles therewith, electronic means controlling the rate of said feeding means and a voltage responsive controlling circuit for said electronic means comprising means responsive to the horizontal displacement of said deflecting means for varying the voltage in said controlling circuit.

2. The combination with feeding means discharging a freely falling stream of material therefrom of means for controlling the rate of feed thereof, comprising deflecting means, means mounting said deflecting means in said stream to be engaged by all the particles thereof upon reaching a predetermined velocity, said mounting means comprising suspending means for constraining said deflecting means against vertical movement by engagement of said particles therewith, electronic means controlling the rate of said feeding means and a voltage responsive controlling circuit for said electronic means comprising means responsive to the horizontal displacement of said deflecting means for varying the voltage in said controlling circuit, and manually adjustable means for varying the voltage in said controlling circuit.

3. The combination with feeding means discharging a freely falling stream of material therefrom of means for controlling the rate of feed thereof, comprising deflecting means suspended in said stream to be engaged by all the particles thereof upon reaching a predetermined velocity, electronic means controlling the rate of said

feeding means and a voltage responsive controlling circuit for said electronic means comprising variable resistance means responsive to the horizontal displacement of said deflecting means, amplifying means including an input circuit in which said variable resistance is serially included to control the voltage output thereof and an output circuit including rectifying means impressing a positive voltage on said controlling circuit determined by said variable resistance means.

4. The combination with feeding means discharging a freely falling stream of material therefrom of means for controlling the rate of feed thereof, comprising deflecting means, means mounting said deflecting means in said stream to be engaged by all the particles thereof upon reaching a predetermined velocity, said mounting means comprising suspending means for constraining said deflecting means against vertical movement by engagement of said particles therewith, electronic means controlling the rate of said feeding means and a voltage responsive controlling circuit for said electronic means comprising means responsive to the horizontal displacement of said deflecting means for varying the voltage in said controlling circuit, and manually adjustable means for varying the voltage in said controlling circuit, said voltage varying means being in series.

5. The combination with feeding means discharging a freely falling stream of material therefrom of means for controlling the rate of feed thereof, comprising deflecting means suspended in said stream to be engaged by all the particles thereof upon reaching a predetermined velocity, electronic means controlling the rate of said feeding means and a voltage responsive controlling circuit for said electronic means comprising variable resistance means responsive to the horizontal displacement of said deflecting means, amplifying means including an input circuit in which said variable resistance is serially included to control the voltage output thereof and an output circuit including rectifying means impressing a positive voltage on said controlling circuit determined by said variable resistance means, and manually adjustable means for impressing a negative voltage on said controlling means.

6. The combination with feeding means discharging a freely falling stream of material therefrom of means for controlling the rate of feed thereof, comprising impact responsive means mounted in said stream in a position to be engaged by said falling material, electronic means controlling the rate of said feeding means and a voltage responsive controlling circuit for said electronic means comprising variable resistance means responsive to said impact responsive means, amplifying means including an input circuit in which said variable resistance is serially included to control the voltage output thereof and an output circuit including rectifying means impressing a positive voltage on said controlling circuit determined by said variable resistance means.

7. The combination with feeding means discharging a freely falling stream of material therefrom of means for controlling the rate of feed thereof, comprising impact responsive means mounted in said stream in a position to be engaged by said falling material, electronic means controlling the rate of said feeding means and a voltage responsive controlling circuit for said electronic means comprising variable resistance means responsive to said impact responsive means, amplifying means including an input circuit in which said variable resistance is serially included to control the voltage output thereof and an output circuit including rectifying means impressing a positive voltage on said controlling circuit determined by said variable resistance means, and manually adjustable means for impressing a negative voltage on said controlling means.

8. The combination with feeding means discharging a stream of material therefrom of means for controlling the rate of feed thereof, comprising sensing means

mounted in said stream to respond to the impact of said material thereagainst, an electron discharge tube controlling the rate of feed of said feeding means and means negatively biasing the grid of said tube comprising means for impressing a negative voltage on said grid and means for varying said voltage comprising manually adjustable voltage varying means, means for impressing a positive voltage on said grid and a variable resistance responsive to said impact responsive means determining said positive voltage.

9. The combination with feeding means discharging a stream of material therefrom of means for controlling the rate of feed thereof, comprising sensing means mounted in said stream to respond to the impact of said material thereagainst, an electron discharge tube controlling the rate of feed of said feeding means and means negatively biasing the grid of said tube comprising means for impressing a negative voltage on said grid and means for varying said voltage comprising means for impressing a positive voltage on said grid and a variable resistance responsive to said impact responsive means determining said positive voltage.

10. The combination with vibratory feeding means discharging a stream of material therefrom of means for controlling the rate of feed thereof, comprising sensing means mounted in said stream to respond to the impact of said material thereagainst, electro-magnetic means for vibrating said feeding means, a power supply circuit for said electro-magnetic means including an electron discharge tube controlling said circuit and means negatively biasing the grid of said tube comprising means for impressing a negative voltage on said grid and means for varying said negative voltage comprising means for impressing a positive voltage on said grid and voltage adjusting means responsive to said impact responsive means determining said positive voltage.

11. The combination with vibratory feeding means discharging a stream of material therefrom of means for controlling the rate of feed thereof, comprising sensing means mounted in said stream to respond to the impact of said material thereagainst, electro-magnetic means for vibrating said feeding means, a power supply circuit for said electro-magnetic means including an electron discharge tube controlling said circuit and means negatively biasing the grid of said tube comprising means for impressing a negative voltage on said grid and means for varying said voltage comprising manually adjustable means for varying said negative voltage, means for impressing a positive voltage on said grid and voltage adjusting means responsive to said impact responsive means determining said positive voltage.

12. The combination with feeding means discharging a stream of material therefrom of means for controlling the rate of feed thereof, comprising sensing means mounted in said stream to respond to the impact of said material thereagainst, an electron discharge tube controlling the rate of feed of said feeding means, means negatively biasing the grid of said tube and means for varying said bias comprising means for impressing a pulsating positive voltage on said grid, phase shifting means interposed between said voltage impressing means and said grid and means for varying said positive voltage impulses comprising a voltage adjusting means responsive to said impact responsive means.

13. The combination with feeding means discharging a stream of material therefrom of means for controlling the rate of feed thereof, comprising sensing means mounted in said stream to respond to the impact of said material thereagainst, an electron discharge tube controlling the rate of feed of said feeding means, means negatively biasing the grid of said tube and means for varying said bias comprising manually adjustable means and means for impressing a pulsating positive voltage on said

grid, phase shifting means interposed between said voltage impressing means and said grid and means for varying said positive voltage impulses comprising voltage adjusting means responsive to said impact responsive means.

14. The combination with vibratory feeding means discharging a stream of material therefrom of means for controlling the rate of feed thereof, comprising deflecting means mounted in said stream to be engaged by all the particles thereof, said deflecting means being mounted for movement responsive to the impact of said material thereagainst, electro-magnetic means for vibrating said feeding means, a power supply circuit for said electro-magnetic means including an electron discharge tube controlling said circuit and means negatively biasing the grid of said tube and means for varying said bias comprising means for impressing a positive voltage on said grid, and means for varying said voltage comprising strain responsive resistance varying means and means for transferring movements of said deflecting means to said strain responsive means.

15. The combination with vibratory feeding means discharging a stream of material therefrom of means for controlling the rate of feed thereof, comprising deflecting means mounted in said stream to be engaged by all the particles thereof, said deflecting means being mounted for movement responsive to the impact of said material thereagainst, electro-magnetic means for vibrating said feeding means, a power supply circuit for said electro-magnetic means including an electron discharge tube controlling said circuit, means negatively biasing the grid of said tube and means for varying said bias comprising manually adjustable voltage varying means, means for impressing a positive voltage on said grid and means for varying said voltage comprising strain responsive resistance varying means and means for transferring movements of said deflecting means to said strain responsive means.

16. The combination with feeding means discharging a freely falling stream of material therefrom of means for controlling the rate of feed thereof, comprising movable sensing means suspended in said stream to be engaged by all the particles thereof upon reaching a predetermined velocity, electronic means controlling the rate of said feeding means and a voltage responsive controlling circuit for said electronic means comprising variable resistance means responsive to the movement of said sensing means, amplifying means including an input circuit in which said variable resistance is serially included to control the voltage output thereof and an output circuit including rectifying means impressing a positive voltage on said controlling circuit determined by said variable resistance means.

17. The combination with feeding means discharging a freely falling stream of material therefrom of means for controlling the rate of feed thereof, comprising sensing means suspended in said stream to be engaged by all the particles thereof upon reaching a predetermined velocity, electronic means controlling the rate of said feeding means and a voltage responsive controlling circuit for said electronic means comprising variable resistance means responsive to the horizontal displacement of said sensing means, amplifying means including an input circuit in which said variable resistance is serially included to control the voltage output thereof and an output circuit including rectifying means impressing a positive voltage on said controlling circuit determined by said variable resistance means.

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