June 19, 1956 V. S. BUCCICONE 2,751,150

MAGNETIC SWITCHING APPARATUS

Filed June 6, 1952

3 Sheets-Sheet 1

FIG. 1.

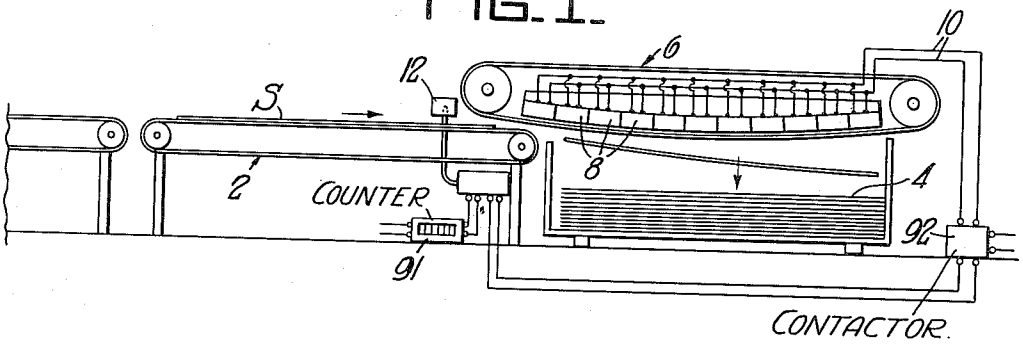


FIG. 2.

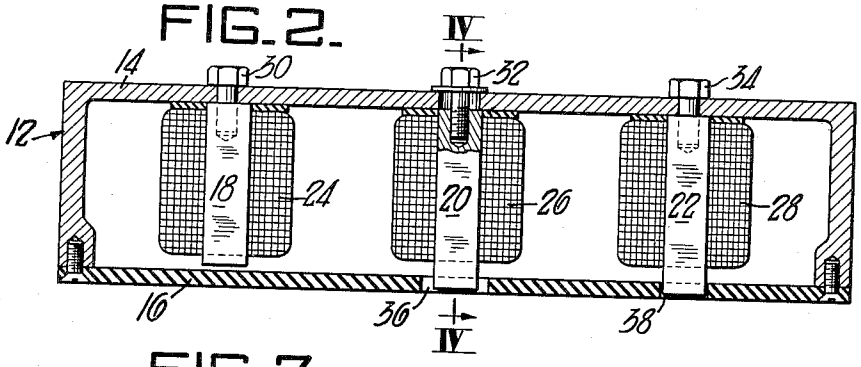
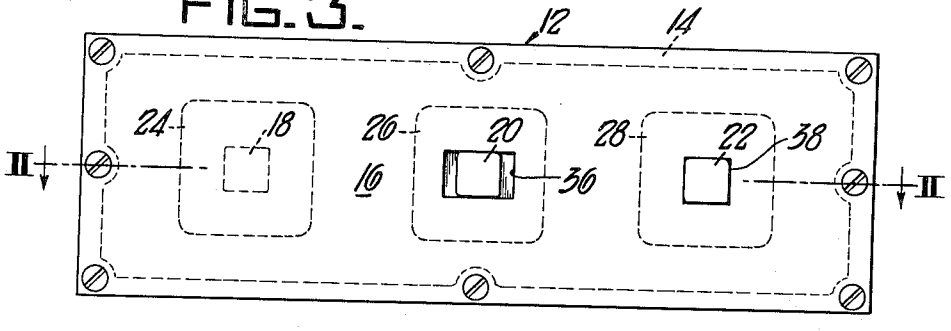


FIG. 3.



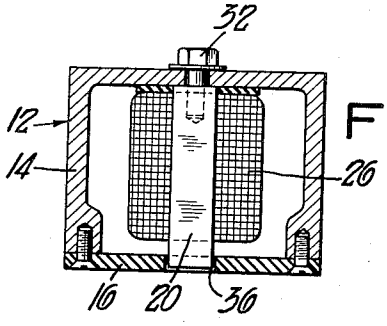


FIG. 4.

Inventor:
VELIO S. BUCCICONE,
by: Robert U. Geib, Jr.
his Attorney.

June 19, 1956

V. S. BUCCICONE

2,751,150

MAGNETIC SWITCHING APPARATUS

Filed June 6, 1952

3 Sheets-Sheet 2

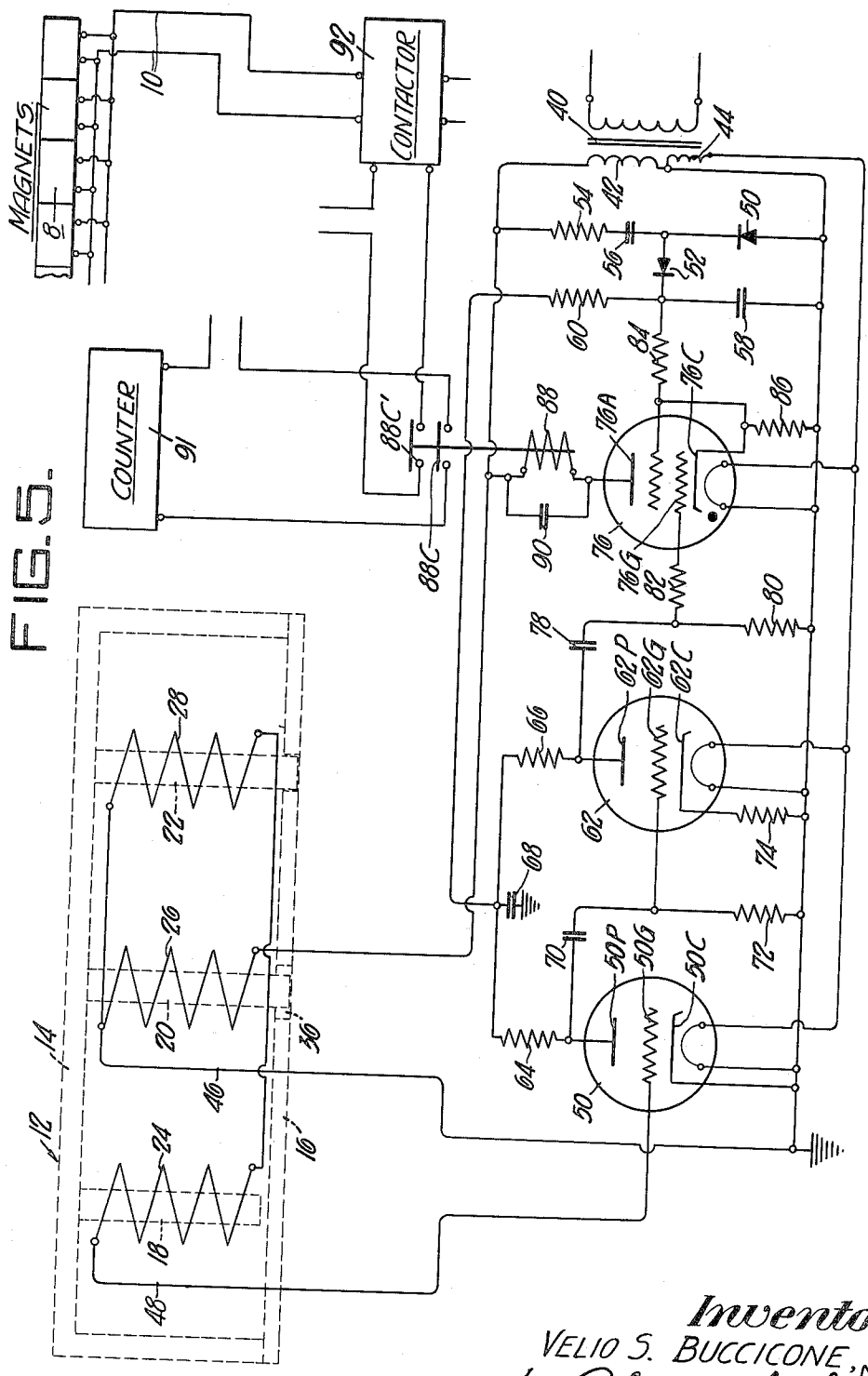


FIG. 5.

Inventor:
VELIO S. BUCCICONE,
by: Robert U. Geib, Jr.
his Attorney.

June 19, 1956 V. S. BUCCICONE 2,751,150

MAGNETIC SWITCHING APPARATUS

Filed June 6, 1952 3 Sheets-Sheet 3

FIG. 6.

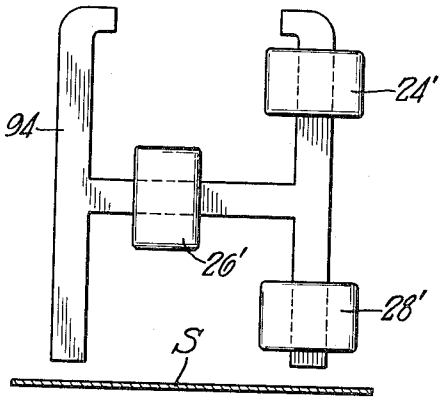


FIG. 7.

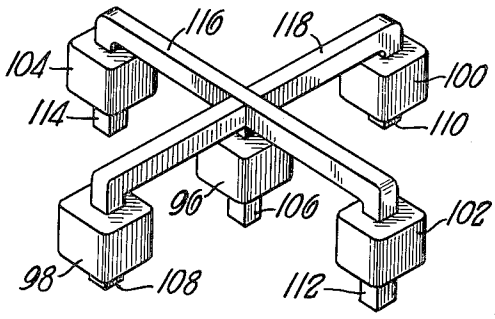


FIG. 8.

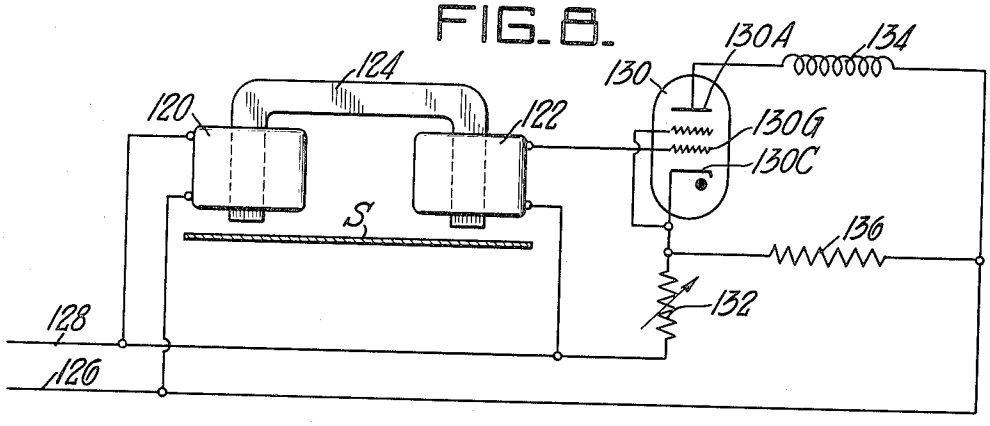
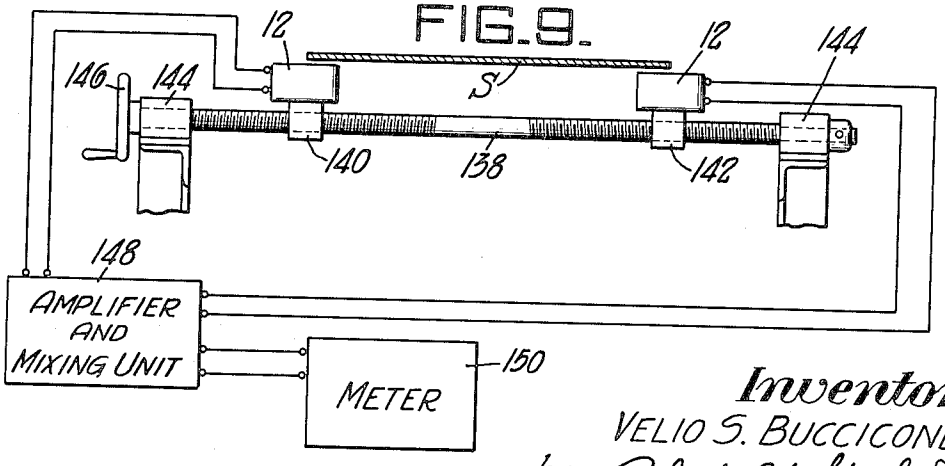


FIG. 9.



Inventor:
VELIO S. BUCCICONE,
by: Robert U. Geib, Jr.
his Attorney.

United States Patent Office 2,751,150 Patented June 19, 1956

2,751,150

MAGNETIC SWITCHING APPARATUS

Velio S. Buccicone, Gary, Ind.

Application June 6, 1952, Serial No. 292,033

16 Claims. (Cl. 235—98)

This invention relates to magnetic switching apparatus and more particularly to such apparatus for detecting relatively large magnetic objects such as steel sheets. In some magnetic conveyors and sheet pilers the magnets of the piler or conveyor must be deenergized at a particular point by the steel sheets being conveyed. Sometimes a lever type switch is used, but these are unsatisfactory for use at high speeds since the edge and/or surface of the sheets are damaged by the switch lever. Photo-electric devices have also been used, but the arrangement of the equipment is not always suitable for mounting the necessary light source and photocells. Another disadvantage is the danger of the light source burning out and/or being damaged by dirt and dust. Magnetic switches of various types have also been proposed, but they are objectionable because they require the use of high frequency and complicated circuits which are too delicate to maintain for industrial use and accurate performance. Apparatus similar to that discussed above are also used to count steel sheets.

It is an object of my invention to provide apparatus for detecting magnetic objects without the use of moving parts or high frequencies.

Another object is to provide magnetic switching apparatus for counting sheets.

Still another object is to provide magnetic switching apparatus for use with magnetic conveyors and similar devices.

These and other objects will be more apparent after referring to the following specification and attached drawings, in which:

Figure 1 is a schematic vertical elevation of my invention as applied to a sheet piler and counter;

Figure 2 is a sectional view of the sensitive unit of my invention;

Figure 3 is a bottom plan view of Figure 2;

Figure 4 is a sectional view taken on the line IV—IV of Figure 2;

Figure 5 is a schematic wiring diagram of the electrical circuit of my invention;

Figure 6 is a view of a second type of sensitive unit;

Figure 7 is a view of a third type of sensitive unit;

Figure 8 is a view of a fourth type of sensitive unit connected to a modified electrical circuit; and

Figure 9 is a schematic vertical elevation of my invention as applied to a strip width gauge.

Referring more particularly to Figure 1 of the drawing, the reference numeral 2 indicates a belt conveyor for conveying sheets S to a piler 4. Directly above the piler 4 is a magnetic conveyor 6 having electro-magnets 8 which are provided with power from the lines 10. The entry end of conveyor 6 extends over the exit end of conveyor 2. The sensitive unit 12 of my invention is mounted above conveyor 2 adjacent the conveyor 6. If desired the unit 12 may be mounted below the top run of the conveyor 2. As shown in Figures 2, 3 and 4 the sensitive unit 12 consists of a case or box 14 made of steel or other magnetic material open at its lower end. A

plate 16 made of non-magnetic material encloses the lower end of box 14. Three poles or cores 18, 20 and 22, made of iron or soft steel, are mounted in the case 14 and are surrounded by coils 24, 26 and 28, respectively. The coils 24, 26 and 28 are shown as identical, but core 18 is shorter than cores 20 and 22. For increased sensitivity coil 26 can be provided with a relatively small number of turns and coils 24 and 28 identical and with a large number of turns. Cores 18, 20 and 22 are held in place by means of bolts 30, 32 and 34, respectively, extending through holes in the bottom of box 14 into tapped holes in the cores. The hole for core 20 in case 14 is elongated so as to permit adjustment thereof with respect to cores 18 and 22. The plate 16 is provided with a slotted hole 36 for receiving the core 20 and a hole 38 for receiving the core 22. The coil 26 is continuously energized with 120 volts alternating current from a transformer 40 and induces voltages in coils 24 and 28. Transformer 40 is a constant voltage transformer having one winding 42 which supplies 120 volts A. C. and another winding 44 which supplied 6.3 volts A. C. The coils 24 and 28 are identical and are placed in the same physical direction so that when the leads of one coil are reversed from the other the terminal voltage of the coils will be of opposite polarity. When the coils 24 and 28 are connected in series and opposite in polarity as shown the combined output will always be the difference between their outputs. The main purpose of coil 24 is to compensate for line voltage fluctuations which tend to alter the magnitude of the magnetic field of coil 26 and consequently the terminal voltages of coils 24 and 28. However, the effect of line voltage variations will not appear in the combined output of coils 24 and 28 because of the manner in which they are connected. The position of coil 26 and its core 20 is adjusted so that equal voltages appear at the terminals of coils 24 and 28 and a resultant voltage of zero from the two coils when there is no steel under the coils. Because the core 18 is shorter than core 22 the voltage induced in coil 28 will be greater than that induced in coil 24 when a sheet covers all three poles.

Line 46 from coils 26 and 28 is connected to ground and line 48 from coil 24 is connected to grid 50G of an amplifying tube 50. A voltage doubling rectifying circuit is connected to the winding 42 and consists of two selenium rectifiers 50 and 52 which receive current through a protective resistance 54 and a capacitor 56. A filter condenser or capacitor 58 is also part of the rectifying circuit. Approximately 250 volts direct current from this circuit is supplied through a decoupling resistor 60 to the plate 50P and also to plate 62P of a second amplifying tube 62. Resistances 64 and 66 are inserted in the plate circuits of tubes 50 and 62, respectively. A de-coupling condenser 68 in these plate circuits provides a low impedance path for the alternating currents. The plate output voltage of tube 50 is coupled to grid 62G through a coupling condenser 70 and grid resistor 72. A resistor 74 provided in the cathode circuit of tube 62 aids the general stability of the circuit. The values of the resistors and condensers are selected so that the output of tube 62 as it appears from plate to ground will be in phase with the voltage originally impressed on the grid 50G. This is so because each tube 50 and 62 will shift the phase of the impressed signal approximately 180 degrees.

The output of tube 62 is coupled to grid 76G of a Thyratron tube 76 by means of a coupling condenser 78, grid resistor 80 and isolating resistor 82. The D. C. voltage from the rectifier circuit is also used to supply a fixed bias to the cathode 76C through voltage dropping resistors 84 and 86 connected in series. The value of resistor 84 is large compared with resistor 86. The anode 76A is connected to the winding 42 through a D. C. relay

coil 88 which is shunted by a condenser 90. The voltage impressed on grid 76G will be approximately in phase with the anode voltage. When the voltage on grid 76G exceeds the firing voltage as determined by the fixed bias the tube 76 will fire on the positive half cycle of the impressed grid voltage and will extinguish itself at the end of each half cycle. Condenser 90 is large enough to prevent relay chatter and small enough to cause no appreciable time delay in relay operation. Relay coil 88 is provided with normally open contacts 88C and 88C'. Contacts 88C are connected in a circuit to a sheet counter 91 and contacts 88C' are connected in a circuit to contactor 92 which when closed will supply current to the leads 10. The winding 44 supplies current for the heaters of tubes 50, 62 and 76. When less sensitivity is required the amplifiers 50 and 62 can be omitted and the output of the coils 24 and 28 connected to Thyratron tube 76.

The operation of the device is as follows: When there is a sheet S under the sensitive element 12 a voltage will appear between the grid and cathode of tube 50 causing it to conduct and an amplified voltage will appear from the plate to cathode of tube 50. This voltage which is approximately 180 degrees out of phase with the voltage impressed on grid 50G is impressed on grid 62G causing tube 62 to conduct and an amplified voltage will appear from the plate to cathode of tube 62. This voltage is impressed on the grid 76G causing tube 76 to conduct on the positive half cycle of the impressed grid voltage. This will energize coil 88 which will remain energized (because of condenser 90) as long as a sheet S is under the sensitive element 12. Energization of coil 88 will close contacts 88C and 88C', thus causing counter 90 to operate and also magnetizing the electro-magnets 8. When the tail end of the sheet passes from under the sensitive element 12 the tubes 50, 62 and 76 will all cease to conduct and relay coil 88 will be deenergized thus opening contacts 88C and 88C'. Opening of contacts 88C readies counter 91 for counting an additional sheet and opening of contacts 88C' deenergizes electro-magnets 8. The sheet S which was supported by the magnets 8 will then fall into the piler 4. Instead of operating a relay coil the solenoid of a counter could be placed directly in the anode circuit. The tube 76 could be replaced by an electronic detector circuit to operate a meter or other indicating device.

While it is preferred to place the sensitive element in the box 14, both to shield it from external magnetic fields and to prevent dirt from damaging it, the box may be omitted when the sensitive element is used in places where such protection is not necessary. In that case the end of the cores away from the article to be detected will be connected by a bar having magnetic characteristics similar to the cores and a cross section approximately the same as the cores as shown in Figure 8. In Figure 6 the coils 24', 26' and 28' are mounted on an H-shaped core 94. Another arrangement is shown in Figure 7 in which five coils 96, 98, 100, 102 and 104 are mounted on cores 106, 108, 110, 112 and 114, respectively. In this embodiment coil 96 is the exciting coil corresponding to coil 26, coils 98 and 100 are the balancing coils corresponding to coil 24, cores 108 and 110 are short compared to the other cores, and coils 102 and 104 are the pick up coils corresponding to coil 28. The cores 112 and 114 are connected by means of an iron bar 116 and cores 108 and 110 are connected by an iron bar 118. The entire unit may be housed in a round steel shell.

The embodiment of my invention shown in Figure 5 is preferred for most purposes because of its sensitivity. In the simpler form of my invention shown in Figure 8, coils 120 and 122 are mounted on a U-shaped core 124. The coil 120 is the exciting coil and is connected to an A. C. voltage source 126, 128. The coil 122 is the pick up coil and has one lead connected to grid 130G of a Thyratron tube 130 and its other lead connected to cathode 130C through a variable resistor 132. The line

126 is connected to anode 130A through a solenoid or relay coil 134. A resistor 136 is provided in the anode-cathode circuit of the Thyratron tube 130. Proper bias for tube 130 is obtained by means of resistors 132 and 136. When there is no sheet S under the iron core 124 the induced voltage in coil 122 will not be sufficient to fire the Thyratron tube 130. As soon as a sheet S passes under the core 124 the induced voltage will be sufficient to fire the tube 130 and the solenoid coil 134 will be energized. If necessary for increased sensitivity amplifying tubes 50 and 62 may be inserted between the coil 122 and Thyratron tube 130 as in Figure 5.

My device can also be used to measure strip width or strip gauge, to operate a loud speaker, horn, bell or other alarm device, and to operate a control for controlling sheet tension or sheet position.

Figure 9 shows how my device may be used to measure strip width. A pair of sensitive units 12 are mounted on opposite ends of a right and left hand screw 138 by means of left hand nut 140 and right hand nut 142. The screw 138 is supported in suitable bearings 144 and is provided with a hand wheel 146. The leads from the sensitive elements 12 are connected to an amplifier and mixing circuit 148, the output of which is applied to a meter 150.

In operation, the screw 138 is turned until a strip S of desired width will cover half of each sensitive unit 12. As the strip width varies the voltage output from each unit 12 varies. The voltage outputs are amplified and algebraically added in the device 148 so that as the strip width varies the output of device 148 will vary. This output will be applied to meter 150 so that the correct strip width will be indicated thereon.

While several embodiments of my invention have been shown and described it will be apparent that other adaptations and modifications may be made without departing from the scope of the following claims.

I claim:

1. Apparatus for detecting magnetic objects comprising three cores, the center core being equally spaced from the end cores and of the same length as one of said end cores, the other end core being shorter than the center core, a coil surrounding the center core, identical coils surrounding each of said end cores, means connecting the center coil to a source of alternating current, said center coil when energized inducing a voltage in said identical coils, means connecting the end coils in series and opposite in polarity, and magnetic means connecting one end of the center core to the adjacent ends of the other cores.

2. Apparatus for detecting magnetic objects according to claim 1 including a pair of tubes each having a plate, cathode and grid, a connection between the grid of the first of said tubes and the coil surrounding the short core, a connection between the other coils and the cathode of said first tube, a connection between the cathodes of said tubes, a connection between the plates of said tubes, a connection between the plate of said first tube and the grid and cathode of the second tube, and a connection between a source of power and the plates of each of said tubes.

3. Apparatus for detecting magnetic objects according to claim 2 including a Thyratron tube, a connection between the plate of said second tube and the grid and cathode of the Thyratron tube, means for supplying a fixed bias on the cathode of the Thyratron tube, a connection between a source of power and the anode of said Thyratron tube, and a coil in said connection.

4. Apparatus for detecting magnetic objects according to claim 1 including a Thyratron tube connected to the output of the end coils.

5. Apparatus for detecting magnetic objects according to claim 1 including an amplifying circuit connected to the output of the end coils, and a Thyratron tube connected to the output of the amplifying circuit.

6. Apparatus for detecting magnetic objects comprising

a core, an exciting coil surrounding said core, a second core, a balancing coil surrounding the second core, a third core of greater length than the second core, a pick-up coil surrounding the third core, said exciting coil when energized inducing a voltage in said balancing and pick up coils, means connecting the balancing and pick-up coils in series and opposite in polarity, and means connecting the first core to a source of alternating current, more voltage being induced in said pick-up coil than in said balancing coil when the magnetic object is positioned adjacent both of the coils.

7. Apparatus for detecting magnetic objects comprising a box made of magnetic material, a cover for said box made of non-magnetic material, three cores in said box extending from the base of said box to said cover, the center core being equally spaced from the end cores and of the same length as one of said end cores, the other end core being shorter than the center core, a coil surrounding the center core, identical coils surrounding each of said end cores, said center coil when energized inducing a voltage in said identical coils, means connecting the center coil to a source of alternating current, and means connecting the end coils in series and opposite in polarity.

8. Apparatus for detecting magnetic objects according to claim 7 including a pair of tubes each having a plate, cathode and grid, a connection between the grid of the first of said tubes and the coil surrounding the short core, a connection between the other coils and the cathode of said first tube, a connection between the cathodes of said tubes, a connection between the plates of said tubes, a connection between the plate of said first tube and the grid and cathode of the second tube, and a connection between a source of power and the plates of each of said tubes.

9. Apparatus for detecting magnetic objects according to claim 8 including a Thyratron tube, a connection between the plate of said second tube and the grid and cathode of the Thyratron tube, means for supplying a fixed bias on the cathode of the Thyratron tube, a connection between a source of power and the anode of said Thyratron tube, and a coil in said connection.

10. Apparatus for detecting magnetic objects according to claim 7 including a pair of tubes each having a plate, cathode and grid, a connection between the grid of the first of said tubes and the coil surrounding the short core, a connection between the other coils and the cathode of said first tube, a connection between the cathodes of said tubes, a resistor in said last named connection, a connection between the plates of said tubes, a resistor in said last named connection, a connection between a source of power and the plates of each of said tubes, a condenser in the plate circuits of said tubes, a connection between the plate of said first tube and the grid of the second tube, a condenser in said last named connection, a connection between the plate of said first tube and the cathode of the second tube, a resistor in said last named connection, a Thyratron tube, a connection between the plate of said second tube and the grid of the Thyratron tube, a condenser and resistor in said last named connection, a connection between the plate of said second tube and the cathode of said Thyratron tube, a resistor in said last named connection, means for supplying a fixed bias on the cathode of the Thyratron tube, a connection between a source of power and the anode of said Thyratron tube, and a coil in said last named connection.

11. Apparatus for detecting magnetic objects comprising a box made of magnetic material, a cover for said box made of non-magnetic material, three cores in said box extending from the base of said box to said cover, the center core being equally spaced from the end cores and of the same length as one of said end cores, the other end core being shorter than the center core, a coil surrounding the center core, identical coils surrounding each of said end cores, means connecting the end coils in series, a source of alternating current, means connecting the center coil to said source of alternating current, a rectifier, a condenser, a resistor connected in series with said rectifier and condenser across said source of alternating current, an electrical connection between said rectifier and condenser, a second rectifier in said last named connection, a pair of tubes each having a plate, cathode and grid, a connection between the grid of the first of said tubes and the coil surrounding the short core, a connection between the other coils and the cathode of said first tube, a connection between the cathodes of said tubes, a resistor in said last named connection, a connection between the plates of said tubes, a resistor in said last named connection, a connection between said second rectifier and the plate of each of said tubes, a condenser in the plate circuits of said tubes, a connection between the plate of said first tube and the grid of the second tube, a condenser in said last named connection, a connection between the plate of said first tube and the cathode of the second tube, a resistor in said last named connection, a Thyratron tube, a connection between the plate of said second tube and the grid of the Thyratron tube, a condenser and resistor in said last named connection, a connection between the plate of said second tube and the cathode of said Thyratron tube, a resistor in said last named connection, means connected to said second rectifier for supplying a fixed bias on the cathode of the Thyratron tube, a connection between said source of power and the anode of said Thyratron tube, and a coil in said connection.

12. Apparatus for counting magnetic sheets moving over a conveyor comprising a box made of magnetic material and located adjacent said conveyor, a cover for said box made of non-magnetic material, three cores in said box extending from the base of said box to said cover, the center core being equally spaced from the end cores and of the same length as one of said end cores, the other end core being shorter than the center core, a coil surrounding the center core, identical coils surrounding each of said end cores, means connecting the center coil to a source of alternating current, said center coil when energized inducing a voltage in said identical coils, means connecting the end coils in series and opposite in polarity, and a counter operable by current induced in said end coils.

13. Apparatus for counting magnetic sheets moving over a conveyor comprising a box made of magnetic material and located adjacent said conveyor, a cover for said box made of non-magnetic material, three cores in said box extending from the base of said box to said cover, the center core being equally spaced from the end cores and of the same length as one of said end cores, the other end core being shorter than the center core, a coil surrounding the center core, identical coils surrounding each of said end cores, means connecting the center coil to a source of alternating current, said center coil when energized inducing a voltage in said identical coils, means connecting the end coils in series and opposite in polarity, a pair of tubes each having a plate, cathode and grid, a connection between the grid of the first of said tubes and the coil surrounding the short core, a connection between the other coils and the cathode of said first tube, a connection between the cathode of said tubes, a connection between the plates of said tubes, a connection between the plate of said first tube and the grid and cathode of the second tube, a connection between a source of power and the plates of each of said tubes, and a counter operable by the output from said second tube.

14. Apparatus for counting magnetic sheets moving over a conveyor comprising a box made of magnetic material and located adjacent said conveyor, a cover for said box made of non-magnetic material, three cores in said box extending from the base of said box to said cover, the center core being equally spaced from the end cores and of the same length as one of said end cores, the other end core being shorter than the center core, a coil surrounding the center core, identical coils surrounding each of said end cores, means connecting the center coil to a source of alternating current, said center coil when ener-

gized inducing a voltage in said identical coils, means connecting the end coils in series and opposite in polarity, a pair of tubes each having a plate, cathode and grid, a connection between the grid of the first of said tubes and the coil surrounding the short core, a connection between the other coils and the cathode of said first tube, a connection between the cathodes of said tubes, a connection between the plates of said tubes, a connection between the plate of said first tube and the grid and cathode of the second tube, a connection between a source of power and the plates of each of said tubes, a Thyratron tube, a connection between the plate of said second tube and the grid and cathode of the Thyratron tube, means for supplying a fixed bias on the cathode of the Thyratron tube, a connection between a source of power and the anode of said Thyratron tube, a coil in said last named connection, and a counter operable by current flowing in said coil.

15. Apparatus for counting magnetic sheets moving over a conveyor comprising a box made of magnetic material and located adjacent said conveyor, a cover for said box made of non-magnetic material, three cores in said box extending from the base of said box to said cover, the center core being equally spaced from the end cores and of the same length as one of said end cores, the other end core being shorter than the center core, a coil surrounding the center core, identical coils surrounding each of said end cores, means connecting the center coil to a source of alternating current, said center coil when energized inducing a voltage in said identical coils, means connecting the end coils in series and opposite in polarity, a pair of tubes each having a plate, cathode and grid, a connection between the grid of the first of said tubes and the coil surrounding the short core, a connection between the other coils and the cathode of said first tube, a connection between the cathodes of said tubes, a resistor in said last named connection, a connection between the plates of said tubes, a resistor in said last named connection, a connection between a source of power and the plates of each of said tubes, a condenser in plate circuits of said tubes, a connection between the plate of said first tube and the grid of the second tube, a condenser in said last named connection, a connection between the plate of said first tube and the cathode of the second tube, a resistor in said last named connection, a Thyratron tube, a connection between the plate of said second tube and the grid of the Thyratron tube, a condenser and resistor in said last named connection, a connection between the plate of said second tube and the cathode of said Thyratron tube, a resistor in said last named connection, means for supplying a fixed bias on the cathode of the Thyratron tube, a connection between a source of power and the anode of said Thyratron tube, a coil in said connection, and a counter operable by current flowing in said coil.

16. Apparatus for counting magnetic sheets moving

over a conveyor comprising a box made of magnetic material and located adjacent said conveyor, a cover for said box made of non-magnetic material, three cores in said box extending from the base of said box to said cover, the center core being equally spaced from the end cores and of the same length as one of said end cores, the other end core being shorter than the center core, a coil surround said center core, identical coils surrounding each of said end cores, means connecting the end coils in series and opposite in polarity, a source of alternating current, means connecting the center coil to said source of alternating current, said center coil when energized inducing a voltage in said identical coils, a rectifier, a condenser, a resistor connected in series with said rectifier and condenser across said source of alternating current, an electrical connection between said rectifier and condenser, a second rectifier in said connection, a pair of tubes each having a plate, cathode and grid, a connection between the grid of the first of said tubes and the coil surrounding the short core, a connection between the other coils and the cathode of said first tube, a connection between the cathodes of said tubes, a resistor in said last named connection, a connection between the plates of said tubes, a resistor in said last named connection, a connection between said second rectifier and the plates of each of said tubes, a condenser in the plate circuits of said tubes, a connection between the plate of said first tube and the grid of the second tube, a condenser in said last named connection, a connection between the plate of said first tube and the cathode of the second tube, a resistor in said last named connection, a Thyratron tube, a connection between the plate of said second tube and the grid of the Thyratron tube, a condenser and resistor in said last named connection, a connection between the plate of said second tube and the cathode of said Thyratron tube, a resistor in said last named connection, means connected to said second rectifier for supplying a fixed bias on the cathode of the Thyratron tube, a connection between said source of power and the anode of said Thyratron tube, a coil in said connection, and a counter operable by current flowing in said coil.

References Cited in the file of this patent

UNITED STATES PATENTS

1,957,222	Mershon	May 1, 1934
1,980,816	McDill	Nov. 13, 1934
2,045,769	Geffcken et al.	June 30, 1936
2,064,882	Brainerd	Dec. 22, 1936
2,201,146	Barker	May 21, 1940
2,337,132	Shaw	Dec. 21, 1943
2,540,063	Vectoreen	Jan. 30, 1951
2,580,934	Love et al.	Jan. 1, 1952