No. 845,528. PATENTED FEB. 26, 1907.

W. COOPER & C. W. JOHNSON.

CONTROLLER.

APPLICATION FILED OCT. 13, 1903.

3 SHEETS—SHEET 1.

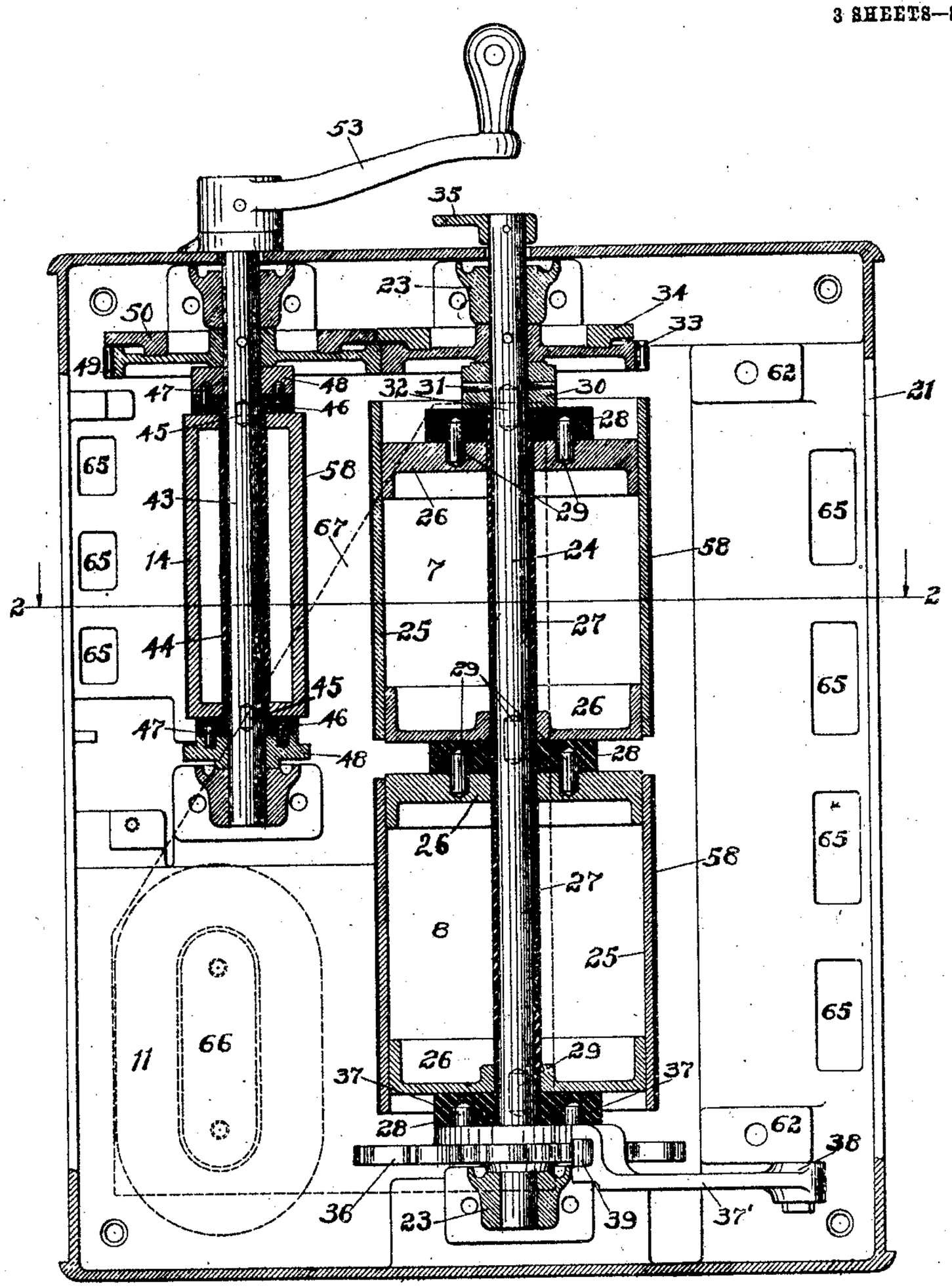

Fig. 1.

Witnesses

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3 SHEETS—SHEET 2.

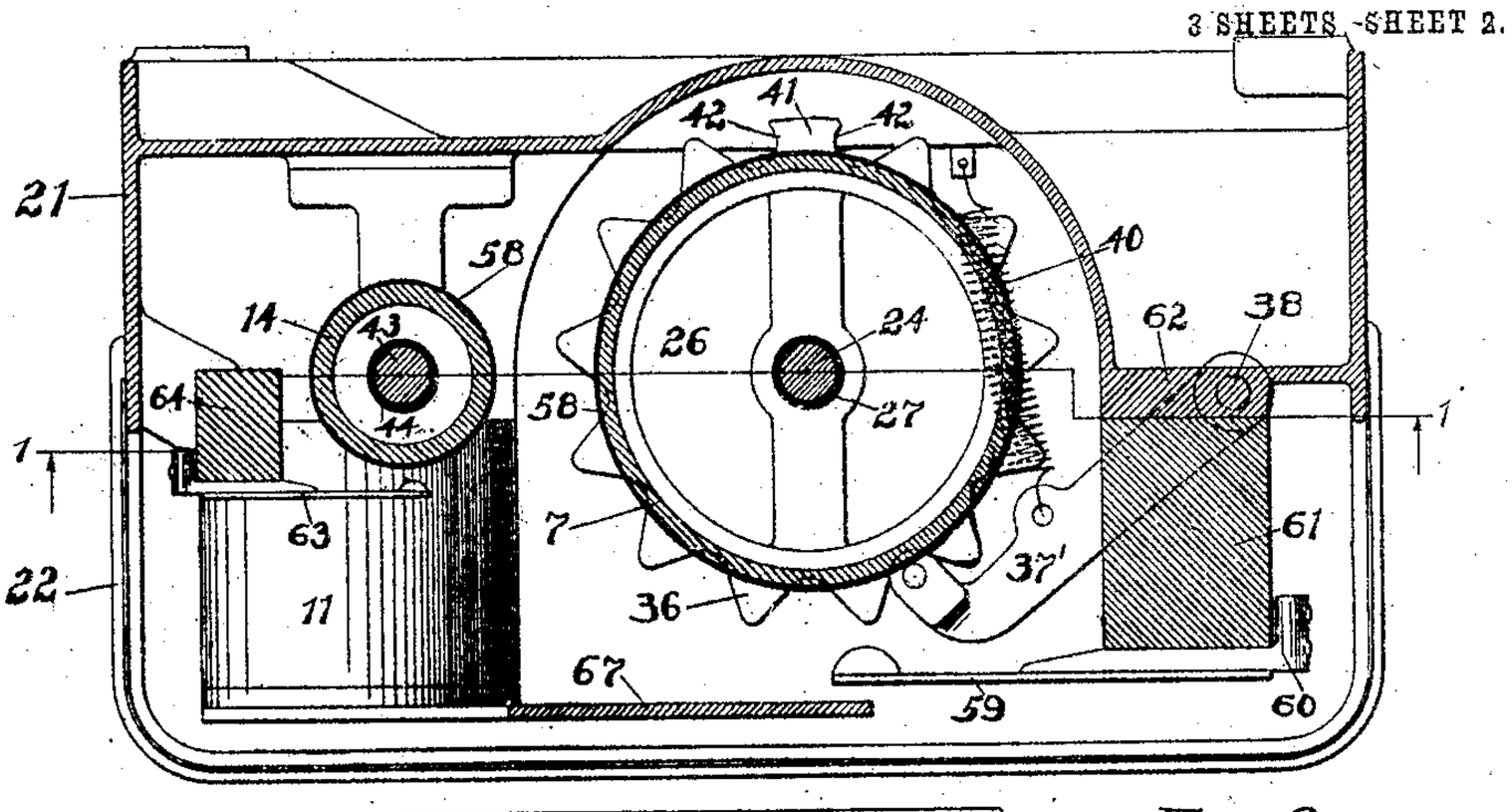

Fig. 2.

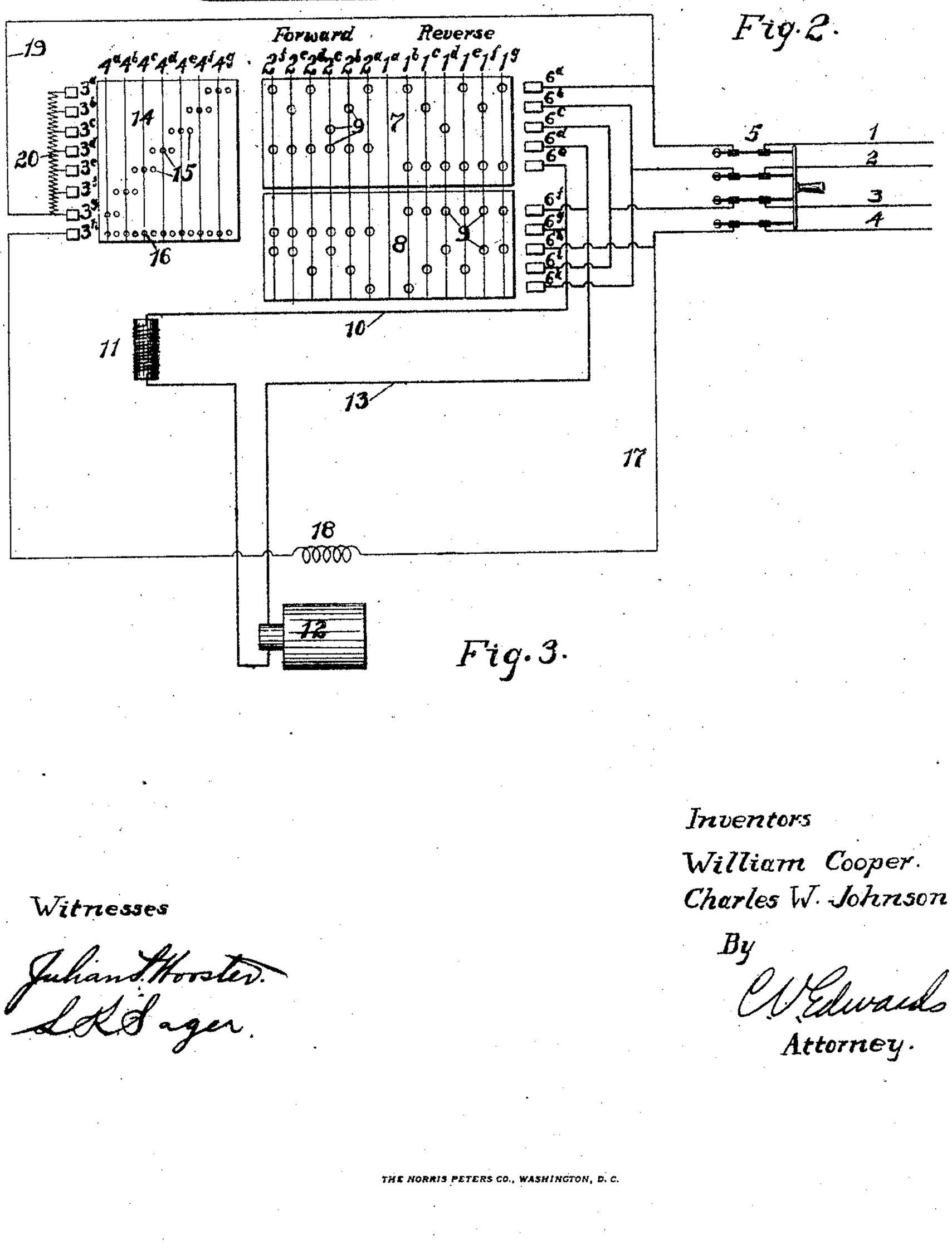

Fig. 3.

Witnesses

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3 SHEETS—SHEET 3.

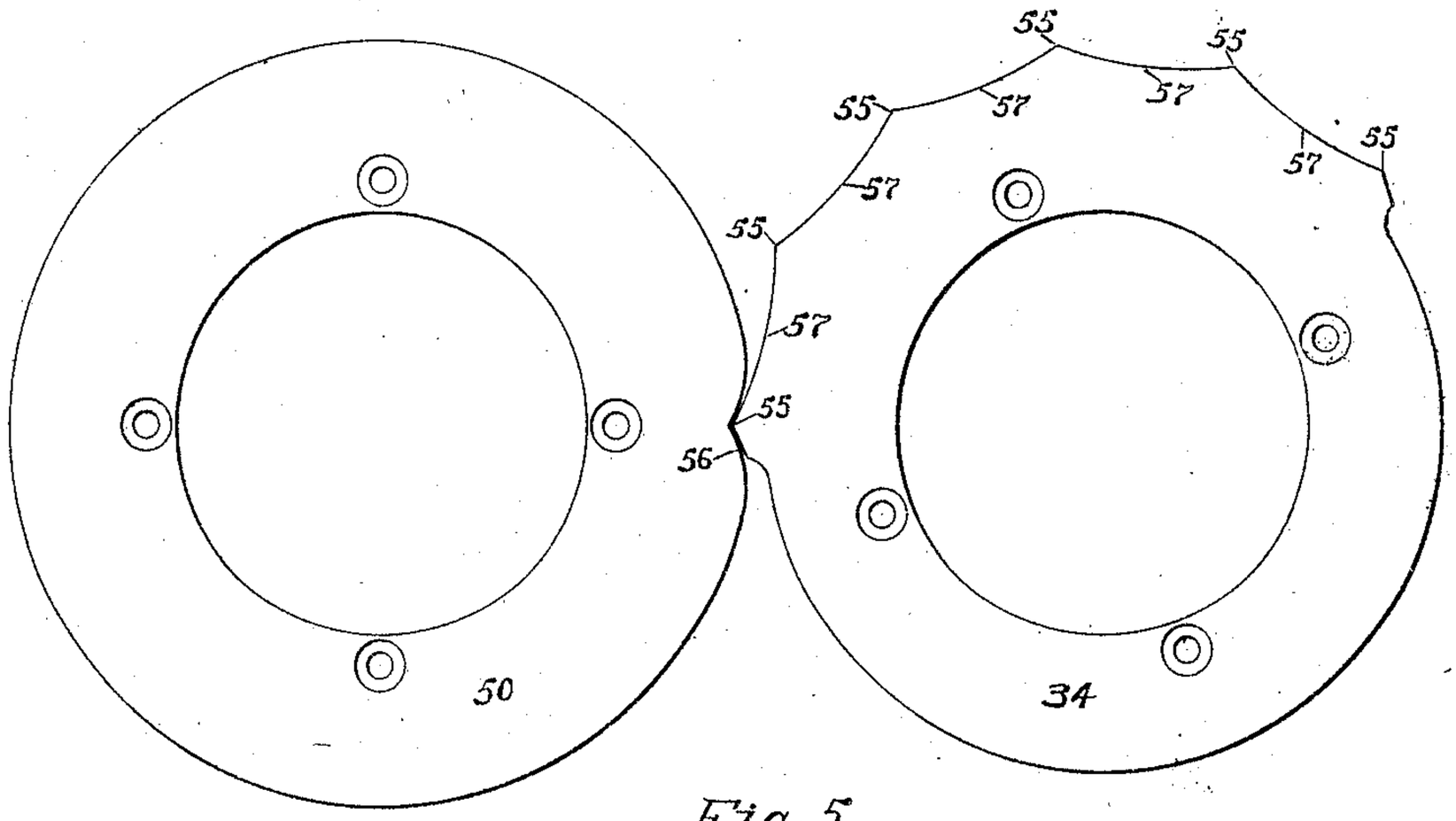

Fig. 5.

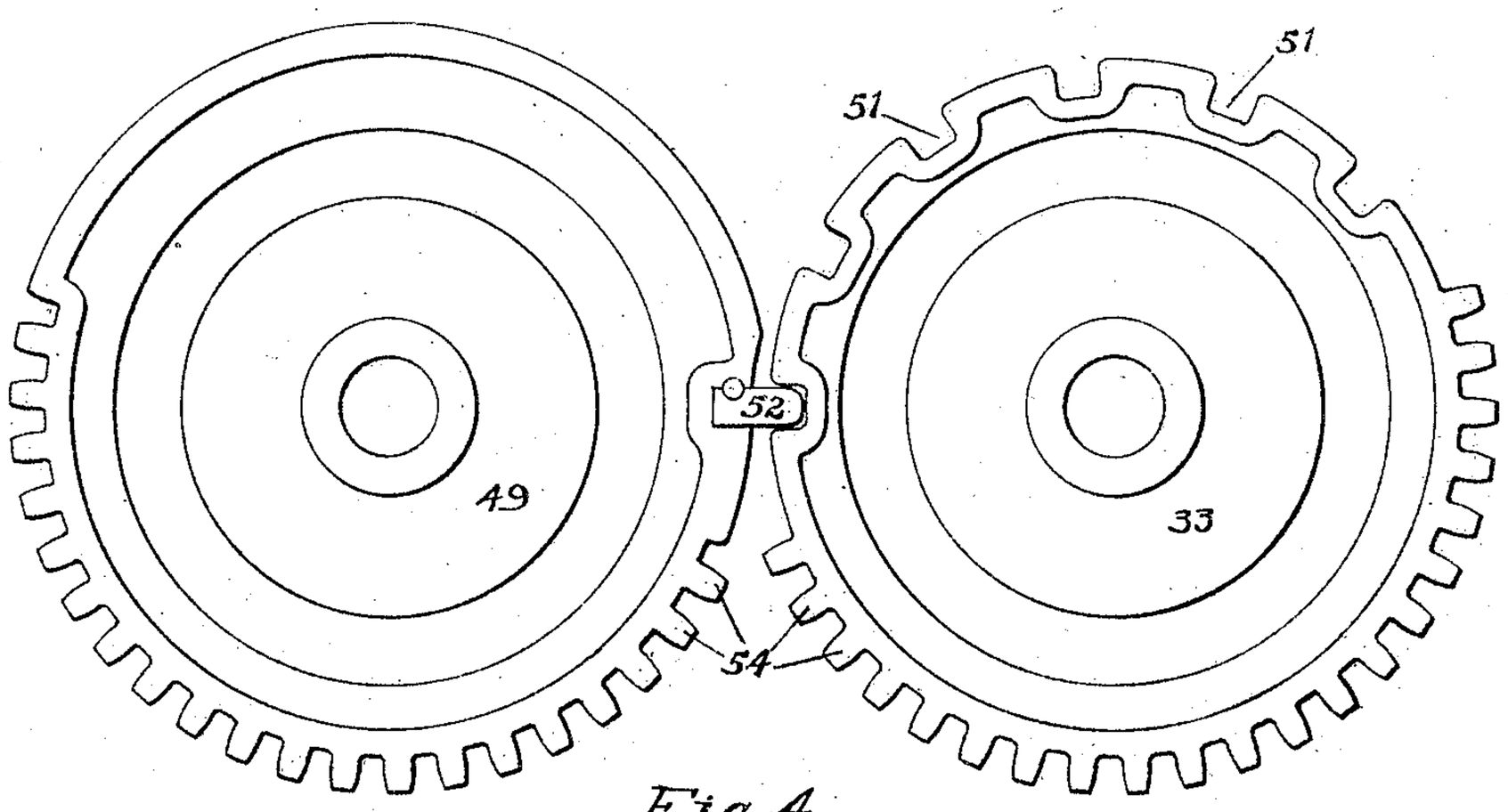

Fig. 4.

Witnesses

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UNITED STATES PATENT OFFICE.

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CONTROLLER.

No. 845,528. Specification of Letters Patent. Patented Feb. 26, 1907.

Application filed October 13, 1903. Serial No. 176,821.

To all whom it may concern:

Be it known that we, WILLIAM COOPER and CHARLES W. JOHNSON, citizens of the United States, residing the former at Cincinnati and the latter at Norwood, in the county of Hamilton and State of Ohio, have invented certain new and useful Improvements in Controllers, of which the following is a full, clear, and exact specification.

Our invention relates to controllers for electric motors, and more particularly to controllers adapted to vary the speed of a motor by changing the voltage applied thereto and operated from a multiple-voltage system.

In the most modern shops of all descriptions it has become the practice to use independent electric motors for driving the various machine-tools or other driven mechanisms. In connection with this class of work a wide variation of speed control is very desirable; and the object of our invention is to obtain a large range of speeds, at any one of which the motor may be continuously operated at high efficiency.

By our invention certain changes of speed are obtained by using a motor in conjunction with multiple-voltage mains and varying the voltage applied to the armature, and other changes in speed are secured by changing the field strength. The lowest speed may be obtained by applying a low voltage to the armature with a strong field. The speed may then be increased by weakening the field step by step. The field may then be increased and a higher speed obtained by increasing the voltage applied to the armature, which more than offsets the strengthened field. Further increase in speed is then obtained by gradually weakening the field, as before, and this series of changes may be repeated until the motor is operated on the highest voltage available with the field weak. In obtaining the above speed control we have developed a controller which is simple in construction and easily operated.

Our invention will be understood from the following description, read in connection with the accompanying drawings, which show the preferred form of construction, and the novelty thereof will be specifically set forth in the appended claims.

Figure 1 is a longitudinal sectional view through the axis of the controller-drums on line 1 1 of Fig. 2 with star-wheel and pawl in elevation. Fig. 2 is a sectional view on the line 2 2 of Fig. 1. Fig. 3 is a diagram of the circuit connections and development of drum-contacts. Fig. 4 is an enlarged plan of the intermeshing gears on the two drums, and Fig. 5 is an enlarged plan of the interlocking cams.

Referring first to Fig. 3, the multiple-voltage mains are indicated at 1 2 3 4, and there may be three or more, as desired, the greater the number the greater being the number of different voltages available. In the present instance six different voltages are available, and their difference may be arranged to suit requirements of speed. It has been found in practice that the following combination of voltages give very good results: between mains 1 and 2, sixty volts; between 2 and 3, eighty volts; between 3 and 4, one hundred and ten volts; between 1 and 3, one hundred and forty volts; between 2 and 4, one hundred and ninety volts, and between 1 and 4, two hundred and fifty volts.

The mains are run throughout the factory or shop to which the system is applied to a number of motors arranged at different points. The connections for only one motor are shown, as the connections to the other motors are similar. The mains are connected, through a switch 5, to the fingers 6^a 6^b–6^k, as shown, which engage with contacts on the two drums 7 and 8, which are insulated from each other. The contacts carried by the drums are indicated at 9 and consist of small cylindrical metal pieces screwed into the drums and having the outer ends adapted to make contact with the fingers at the different positions of the drums, as indicated at 1^a 1^b–1^g and 2^a 2^b–2^f. Connection is made from fingers 6^e and 6^g by the lead 10 through the magnetic blow-out coil 11 to the armature 12 of the motor to be driven and thence by lead 13 to fingers 6^d and 6^f.

An additional drum 14 is used, which may be designated as the "field-drum." This carries contacts 15, arranged in groups, and a row of contacts 16 near the bottom of the drum. These contacts are similar to contacts 9 on the main drums. Their outer ends make contact with the fingers 3^a 3^b–3^h as the drum is turned through the different positions indicated at 4^a 4^b–4^g. Connection is

made by lead 17 from the main 4 through the field-coil 18 of the motor to finger 3^h. A lead 19 connects main 1 to finger 3^g. Between fingers 3^a and 3^g a resistance 20 is connected, and this is subdivided by taps which connect to fingers 3^b, 3^c, 3^d, 3^e, and 3^f, as shown.

The controller is inclosed by a cast frame 21 and a removable front cover 22. In the upper and lower bearings 23 is mounted the shaft 24 of the two main drums 7 8. The drums are made up of the iron cylinders 25, secured to the end heads 26. These are insulated from the shaft by the micanite sleeve 27 and at the ends by the insulators 28, being secured thereto by the pins 29. Above the upper insulator 28 is the collar 30, fixed to the shaft by the taper pin 31 and to the insulator 28 by pins 32. Above the collar 30 and also fixed to the shaft is the gear 33, on which is secured the cam 34. A pointer 35 is attached to the top of the shaft outside of the frame for the purpose of indicating its position with reference to a dial below the pointer. Beneath the lower insulator 28 is a star-wheel 36, fixed to the shaft and secured to insulator 28 by pins 37. A pawl 37′, pivoted to the frame at 38, carries a roller 39, which engages the star-wheel. The pawl is pressed against the star-wheel by the spring 40, secured at one end to the pawl and at the other to the frame. This arrangement tends to keep the drums in certain positions for the different speeds and to prevent stopping at intermediate points. The star-wheel is provided with the projection 41, having the concave sides 42. When the pawl engages the projection on either side, it prevents further movement of the drums in that direction.

The field-drum 14 is mounted on shaft 43 to one side of the main drum. The drum, which is of metal, has the end heads cast integral with the cylindrical portion and is insulated from the shaft by the micanite sleeve 44. The drum is secured at the end by pins 45 to insulators 46, and these are secured by pins 47 to collars 48, which are fixed to the shaft 43. Above the upper collar 48 is a gear 49, fixed to the shaft, and secured to this gear is a cam 50. The gears 49 and 33 mesh with each other, and their outline is shown in Fig. 4. The gears are the same in diameter, and one half of each is toothed in the usual manner. The other half of gear 33 is provided with the six indentations 51, which are engaged by the tooth 52, carried by gear 49. When shaft 43 is turned by the operating-handle 53 in a right-handed direction for forward speeds, it is evident that it will make one complete revolution between each movement of shaft 24 of one notch by engagement of tooth 52, and six complete revolutions of shaft 43 may be made for one-half a revolution of shaft 24. When the shaft 43 is moved left-handed for reverse speeds, the teeth 54 intermesh and both shafts make a half-revolution simultaneously. The cams 50 and 34 interlock, as shown in Fig. 5, and for forward speeds permit shaft 24 to be moved step by step, at which times the projections 55 successively engage the indentation 56; but between steps the circular periphery of the cam 50 engages the curved portions 57 and locks the drums in position.

The outside of drums 7, 8, and 14 are covered with micanite 58 to protect the surfaces from sparking. The contacts 9 and 15 are not shown on the drums in Figs. 1 and 2 for the purpose of avoiding confusion; but it will be understood that they are placed thereon in positions to correspond with those shown in Fig. 3. The fingers 6^a to 6^k are, as shown at 59, secured to terminals 60, which are mounted upon the wooden strip 61, made of maple soaked in paraffin. This strip is secured at top and bottom to the frame, as shown at 62. The fingers 3^a to 3^h for the field-drum (shown at 63) are similarly mounted on a wooden strip 64, which is secured to the frame. Openings 65 are provided in the back of the frame for the leads which connect to the fingers.

Below the drum 14 is the blow-out coil 11, the core 66 of which projects forward from the back of the frame. An iron plate 67 (shown in dotted lines in Fig. 1) is attached to the core 66 and extends over all the contacts 6^a to 6^k. The rear portion of the frame is curved and closely envelops the contacts, as shown in Fig. 2. The contacts are made of brass, with an iron sleeve upon each. There is therefore a path of comparatively low magnetic reluctance from the core of the blow-out coil through the plate 67, across the fingers 59 to the drums 7 and 8, through the drum-contacts, and from the drum through the contacts at the rear to the frame, and then to the core of the blow-out coil. The magnetic flux across the points when the fingers engage the contacts minimize the sparking by blowing out the arc, as is well understood.

The various connections made by the controller will be understood by reference to Fig. 3. The field is always excited when switch 5 is closed and is always connected to the highest potential difference available, which is that between mains 1 and 4. The contacts on the field-drum on the same horizontal line are equivalent to a single contact-strip, as they are so close together that the fingers may make contact with two adjacent contacts at the same time. The off position of drums 7 and 8 is indicated by the line 1^a, and no contacts being thereon no current flows through the armature. The corresponding position of the field-drum is with line 4^g under the fingers 3^a to 3^h. The field-current then flows from main 1 by lead 19, through resistance 20 to finger 3^a to the

drum, out by finger 3^h, through field-winding 18, lead 17, to main 4. The shunt-field at that time has all resistance 20 in series with it, which reduces the current in the coil, and the field is then its weakest.

Movement of handle 53 to a slight extent in a right-handed direction brings line 2^a under the fingers 6^a to 6^k and line 4^a under fingers 3^a to 3^h. The armature-circuit is then as follows: main 1, finger 6^a, drum 7, finger 6^d, lead 13, armature 12, blow-out coil 11, lead 10, finger 6^g, drum 8, finger 6^k, to main 2. The lowest voltage or potential difference available is then applied to the armature. The field-circuit is from main 1, lead 19, finger 3^g, drum 14, finger 3^h, field 18, lead 17 to main 4. The field then has its greatest strength, as no resistance is in series with the field-coil, and this strong field, combined with the low voltage applied to the armature, gives the lowest speed to the motor. Further movement of drum 14 may then be made to position 4^b, while the drums 7 and 8 remain stationary by reason of the form of the gears 49 and 33. For position 4^b of the field-drum the current passes from main 1, through lead 19 and a part of resistance 20 to finger 3^f, then to the drum and out by finger 3^h through the field-coil to main 4. The insertion of a part of resistance 20 in series with the field-coil weakens the field, and therefore gives an increase in speed. In the same way further movement of drum 14 to the successive positions 4^c, 4^d, 4^e, 4^f, and 4^g inserts a greater and greater amount of resistance 20 in the field-circuit until it is all inserted at position 4^g and gradually increases the speed at each step. Seven different speeds are therefore obtained while the armature is connected to the mains giving the lowest potential difference. When the field resistance is increased step by step, one finger makes contact before the adjacent one breaks contact, and the circuit is therefore not broken. After one revolution of the field-drum the tooth 52 again engages the gear 33, and drums 7 and 8 are moved so that the fingers make contact on line 2^b. The armature-current is then as follows: main 2, finger 6^b, drum 7, finger 6^d, lead 13, armature 12, blow-out coil 11, lead 10, finger 6^g, drum 8, finger 6^i to main 3. The voltage of the mains 2 3, which is higher than that of mains 1 2, is therefore applied to the armature. At the same time the field-drum fingers contact on line 4^a, and all the resistance is cut out of the field-circuit, giving a strong field. The strengthening of the field is, however, more than offset by the increase in armature-potential, and an increased speed results. The field is weakened step by step for increased speeds by completing the second revolution of the field-drum. At the beginning of the third revolution drums 7 and 8 are turned another step. This connects the armature-circuit to mains 3 4, and although the field strength is increased at this step an increased speed results, due to the higher potential difference of mains 3 4 over that of mains 2 3. The field strength is now gradually weakened again for increased speeds. In the same way for each revolution of the field-drum the potential difference applied to the armature is increased by connecting the armature-circuit to mains of gradually-increasing potential. At each increase in armature-potential the field strength is also increased and then weakened step by step until the armature-potential is again increased. It will be evident by following out the circuits that for position 2^d the armature will be connected to mains 1 3 for position 2^e the armature will be connected to mains 2 4, and for position 2^f the armature will be connected to mains 1 4. There is therefore six different voltages applied to the armature, and as there are seven different field strengths for each voltage there are obtained forty-two speeds for forward operation. When the drums are in such a position as to give the highest speed, the pawl 37′ engages projection 41 on the star-wheel, and further movement of the drums in the same direction is prevented.

For reverse operation of the motor the handle 53 is turned from off position in a left-handed direction, and by reason of the teeth 54 the drums 7 8 and field-drum are moved simultaneously. For the first reverse speed line 1^b is brought under the fingers 6^a to 6^k and the armature-circuit is as follows: main 1, finger 6^a, drum 7, finger 6^e, lead 10, blow-out coil 11, armature, lead 13, finger 6^f, drum 8, finger 6^k to main 2. The lowest potential difference is therefore applied to the armature, and the current passes through the same in a reverse direction, while the polarity of the field remains unchanged, thus giving reverse operation of the motor. The corresponding position of the field-drum is line 4^f, and the field is therefore weak. The first reverse speed corresponds to the sixth forward speed. Further movement of handle 53 brings the fingers over lines 1^c and 4^e for the second reverse speed. The armature-circuit is then as follows: main 2, finger 6^b, drum 7, finger 6^e, blow-out coil, armature, finger 6^f, drum 8, finger 6^i to main 3. For remaining positions the armature will be connected to mains 3 4, then to mains 1 3, then to 2 4, and finally to mains 1 4 at position 1^g. For each of these connections the field will have a different strength and become stronger for each increase in voltage, until at the last position all the resistance 20 will be cut out and the field will have its full strength. After the highest reverse speed is obtained further movement of the drums is prevented by the pawl 37′ engaging the projection 41. Six reverse speeds are therefore obtained.

Evidently various modifications may be

made in the structure of our device and still be within the scope thereof as defined by the claims. Also the number of supply-mains and voltages available may vary without departing from the esssential features of our invention, and three mains with three different voltages, or four mains with six different voltages, or any greater number of mains may be used.

We claim as our invention—

1. The combination of multiple-voltage mains, a motor, a controlling-switch operated by a single handle and connections arranged to connect the armature to mains of gradually-increasing voltage and at each increase in voltage to strengthen the field by increasing the current in the field-circuit and between each increase in voltage to weaken the field by reducing the current in the field-circuit to gradually increase the speed of the motor, and means for obtaining a reverse rotation of said motor by movement of said handle.

2. The combination of multiple-voltage mains, a motor, a field resistance, a controlling-switch operated by a single handle and connections arranged to connect the armature to mains of gradually-increasing voltage and at each increase in voltage to cut out resistance from the field-circuit and between each increase of voltage to insert the resistance in the field-circuit to gradually increase the speed of the motor, and means for obtaining a reverse rotation of said motor by movement of said handle.

3. The combination of multiple-voltage mains, a motor, a controlling-switch, and connections arranged to connect the armature of the motor to low-voltage mains, then weaken the field by reducing the current in the field-circuit, then connect the armature to mains of higher voltage and again weaken the field by reducing the current in the field-circuit to gradually increase the speed of the motor, and means for obtaining a reverse rotation of said motor by movement of said handle.

4. The combination of multiple-voltage mains, a motor, a controlling-switch, a single handle for operating the same, and connections arranged to connect the armature of the motor to low-voltage mains, then weaken the field by reducing the current in the field-circuit, then connect the armature to mains of higher voltage and again weaken the field by reducing the current in the field-circuit to gradually increase the speed of the motor, and means for connecting the armature of said motor to the said mains of different voltage so as to obtain reverse rotation of said motor also by movement of said single handle.

5. The combination of multiple-voltage mains, a motor, a field resistance, a controlling-switch, and connections arranged to connect the armature of the motor to low-voltage mains, then weaken the field by inserting resistance in the field-circuit, then connect the armature to mains of higher voltage and also strengthen the field by cutting the resistance out of the field-circuit, then weaken the field by again inserting the resistance in the field-circuit to gradually increase the speed of the motor, and means for connecting the armature of said motor to the said mains of different voltage so as to obtain reverse rotation of said motor also by movement of said single handle.

6. The combination of multiple-voltage mains, a motor, a field resistance, a controlling-switch, a single handle for operating the same, and connections arranged so that when the handle is turned in one direction the armature of the motor is connected to low-voltage mains, the field then weakened by inserting resistance in the field-circuit, the armature then connected to mains of higher potential and the field resistance cut out of the field-circuit, the field again weakened by inserting the resistance in the field-circuit to gradually increase the speed of the motor, and connections arranged so that when the said handle is turned in the opposite direction a reverse rotation of the motor is obtained.

7. The combination of multiple-voltage mains, a motor, a field resistance, a controlling-switch, a handle for operating the same, and connections arranged so that when the handle is turned in one direction the armature of the motor is connected to low-potential mains, the field then weakened by inserting resistance in the field-circuit, and the armature then connected to mains of higher potential to gradually increase the speed of the motor, and connections arranged so that when the said handle is turned in the opposite direction a reverse rotation of the motor is obtained at different speeds by connecting the armature to said mains of different potential.

8. The combination of multiple-voltage mains, a motor, a controlling-switch, a handle for the same, a field resistance, and connections arranged so that turning the handle in one direction for forward speeds first connects the motor-armature to mains of low voltage, then inserts resistance in the field-circuit, then connects the armature to mains of higher potential and cuts out the field resistance to give a gradually-increasing speed, and turning the handle in the opposite direction reverses the direction of rotation of the motor and connects the motor-armature to mains of gradually-increasing voltage to give gradually-increasing speeds in the opposite direction.

9. The combination of multiple-voltage mains, a motor, a controlling-switch, a handle for the same, a field resistance and connections arranged so that turning the handle in one direction for forward speeds connects

the motor-armature to mains of gradually-increasing voltage and also strengthens the field and between each increase in voltage weakens the field to gradually increase the speed of the motor, and turning the handle in the opposite direction reverses the direction of rotation of the motor and connects the armature to mains of gradually-increasing voltage to give gradually-increasing speeds in the opposite direction.

10. The combination of multiple-voltage mains, a motor, a field resistance, a controlling-switch and connections, said controlling-switch comprising a shaft carrying contacts adapted to vary the voltage applied to the motor-armature, a second shaft carrying contacts adapted to vary the resistance in the field-circuit, gearing connecting said shafts, interlocking cams on said shafts and a handle on one of said shafts for operating the same.

11. The combination of multiple-voltage mains, a motor, a field resistance, a controlling-switch and connections, said controlling-switch comprising a contact-drum, a second contact-drum out of alinement with the axis of said first drum, and means controlled by a single device for actuating both of said drums.

12. The combination of multiple-voltage mains, a motor, a field resistance, a controlling-switch and connections, said controlling-switch comprising a contact-drum having contacts for varying said field resistance, a second contact-drum out of alinement with the axis of said first drum and having contacts for varying the voltage applied to the circuit of the motor-armature, and means controlled by a single device for actuating both of said drums.

13. The combination of multiple-voltage mains, a motor, a field resistance, a controlling-switch and connections, said controlling-switch comprising a contact-drum having contacts for varying said field resistance, a second contact-drum out of alinement with the axis of said first drum and having contacts for varying the voltage applied to the circuit of the motor-armature, and means controlled by a single device for imparting a continuous movement to said first drum and an intermittent movement to said second drum.

14. The combination of multiple-voltage mains, a motor, a field resistance, a controlling-switch and connections, said controlling-switch comprising a contact-drum having contacts for varying said field resistance, a second contact-drum out of alinement with the axis of said first drum and having contacts for varying the voltage applied to the circuit of the motor-armature, and means controlled by a single device for actuating said first drum and for exerting a force at intervals tending to move said second drum when said device is moved continuously.

15. The combination of multiple-voltage mains, a motor, a field resistance, a controlling-switch and connections, said controlling-switch comprising a contact-drum having contacts for varying said field resistance, a second contact-drum out of alinement with the axis of said first drum and having contacts for varying the voltage applied to the circuit of the motor-armature, and means controlled by a single device for actuating said second drum one step per each revolution of said first drum, both of said drums being actuated by the movement of said device.

In testimony whereof we affix our signatures in presence of two witnesses.

WILLIAM COOPER.
CHARLES W. JOHNSON.

Witnesses:
L. K. SAGER,
SANFORD KLEIN.