March 29, 1932. E. S. FLARSHEIM 1,851,504

ELECTRICAL APPARATUS

Filed Aug. 26, 1927 4 Sheets-Sheet 1

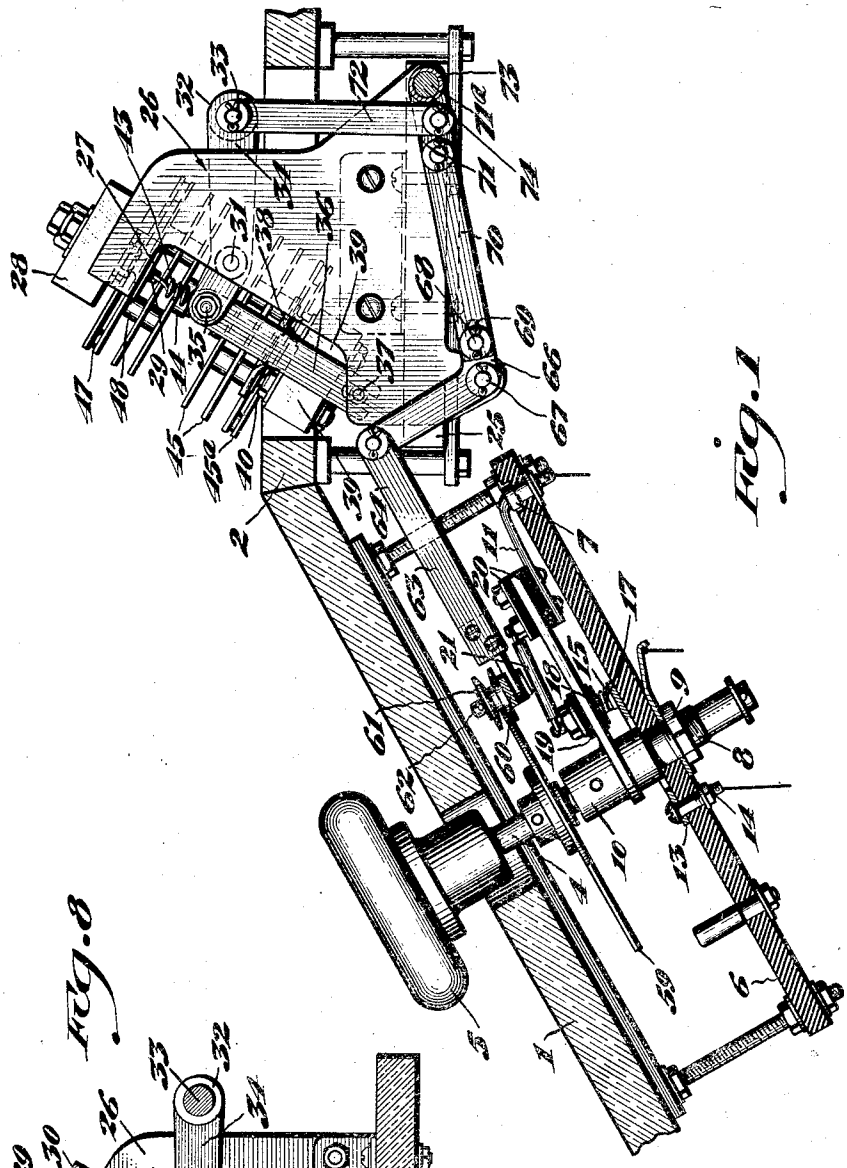

Fig. 1

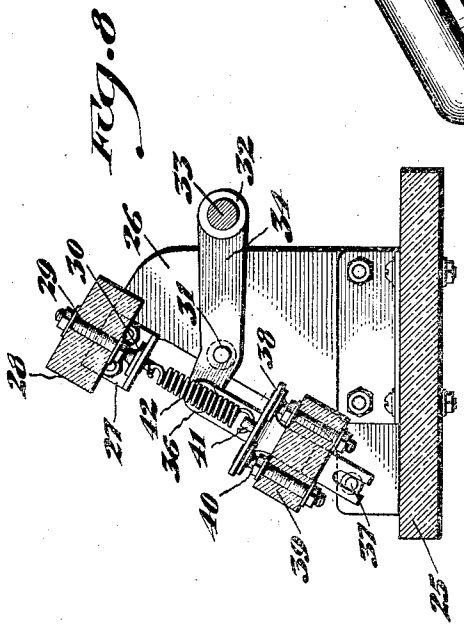

Fig. 8

Inventor

Edwin S. Flarsheim

By Wm. Wood

Attorneys

March 29, 1932. E. S. FLARSHEIM 1,851,504

ELECTRICAL APPARATUS

Filed Aug. 26, 1927 4 Sheets-Sheet 2

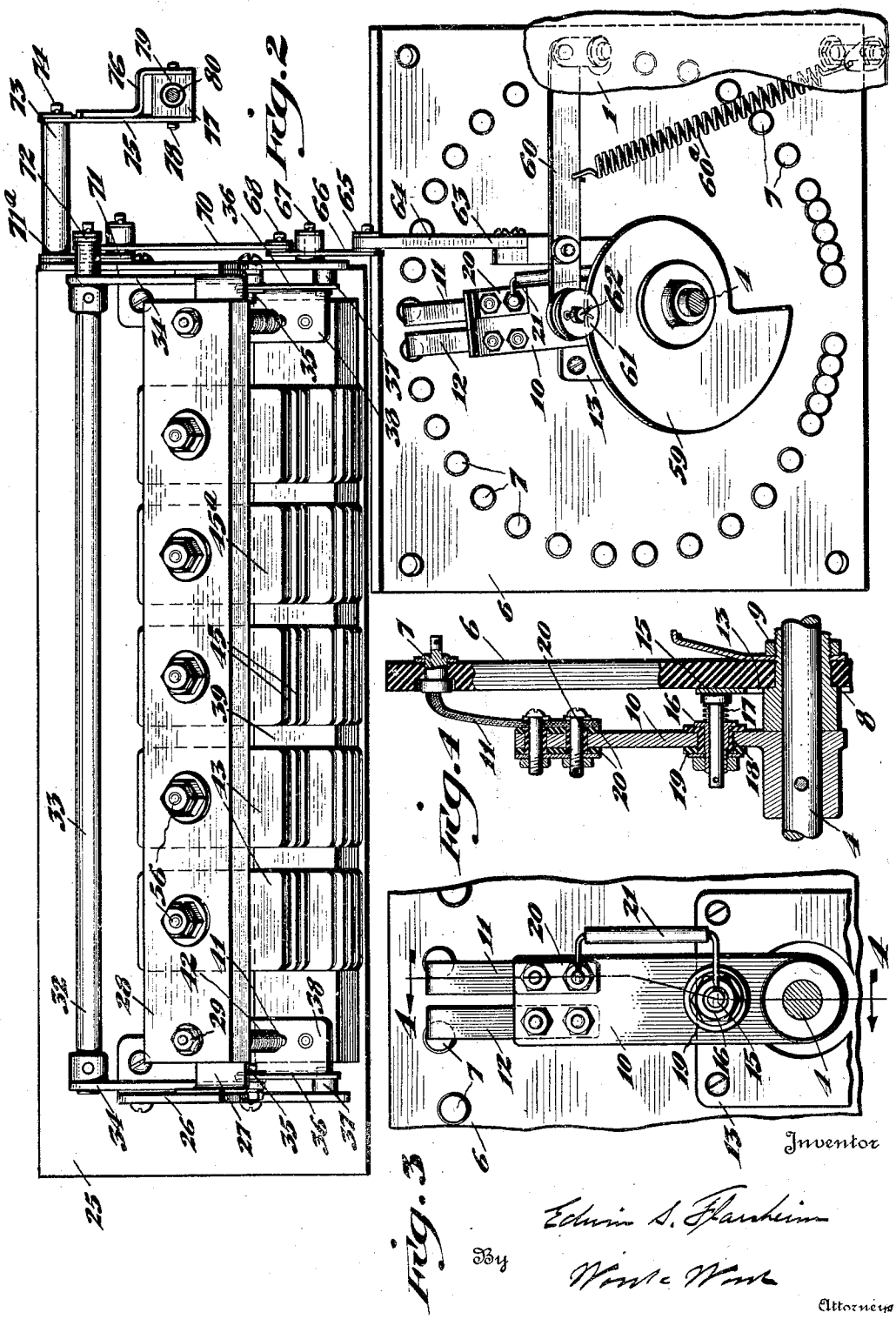

Fig. 2

Fig. 4

Fig. 3

Inventor

Edwin S. Flarsheim

By Wood & Wood

Attorneys

March 29, 1932. E. S. FLARSHEIM 1,851,504

ELECTRICAL APPARATUS

Filed Aug. 26, 1927 4 Sheets-Sheet 3

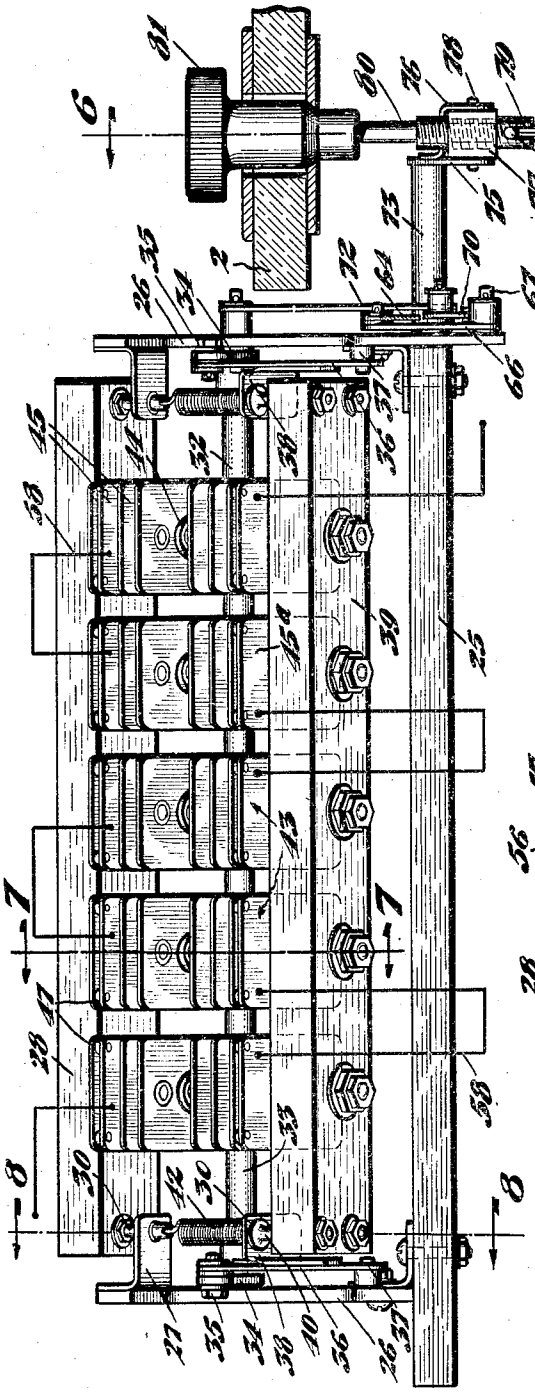

Fig. 5

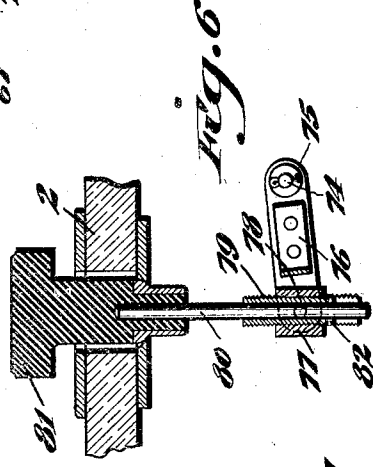

Fig. 6

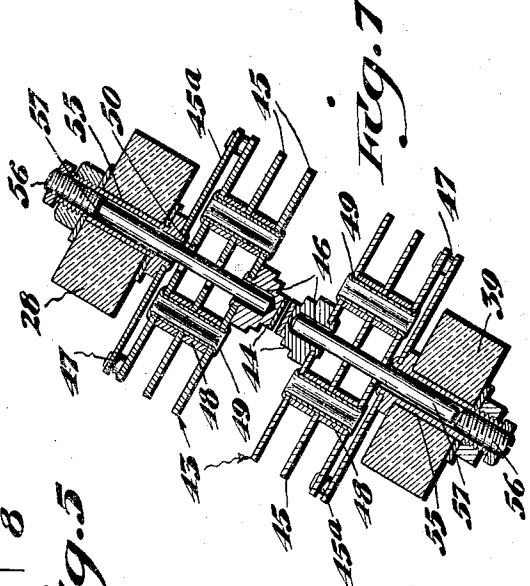

Fig. 7

Inventor

Edwin S. Flarsheim

By Woodcock Washburn

Attorneys

March 29, 1932. E. S. FLARSHEIM 1,851,504

ELECTRICAL APPARATUS

Filed Aug. 26, 1927 4 Sheets-Sheet 4

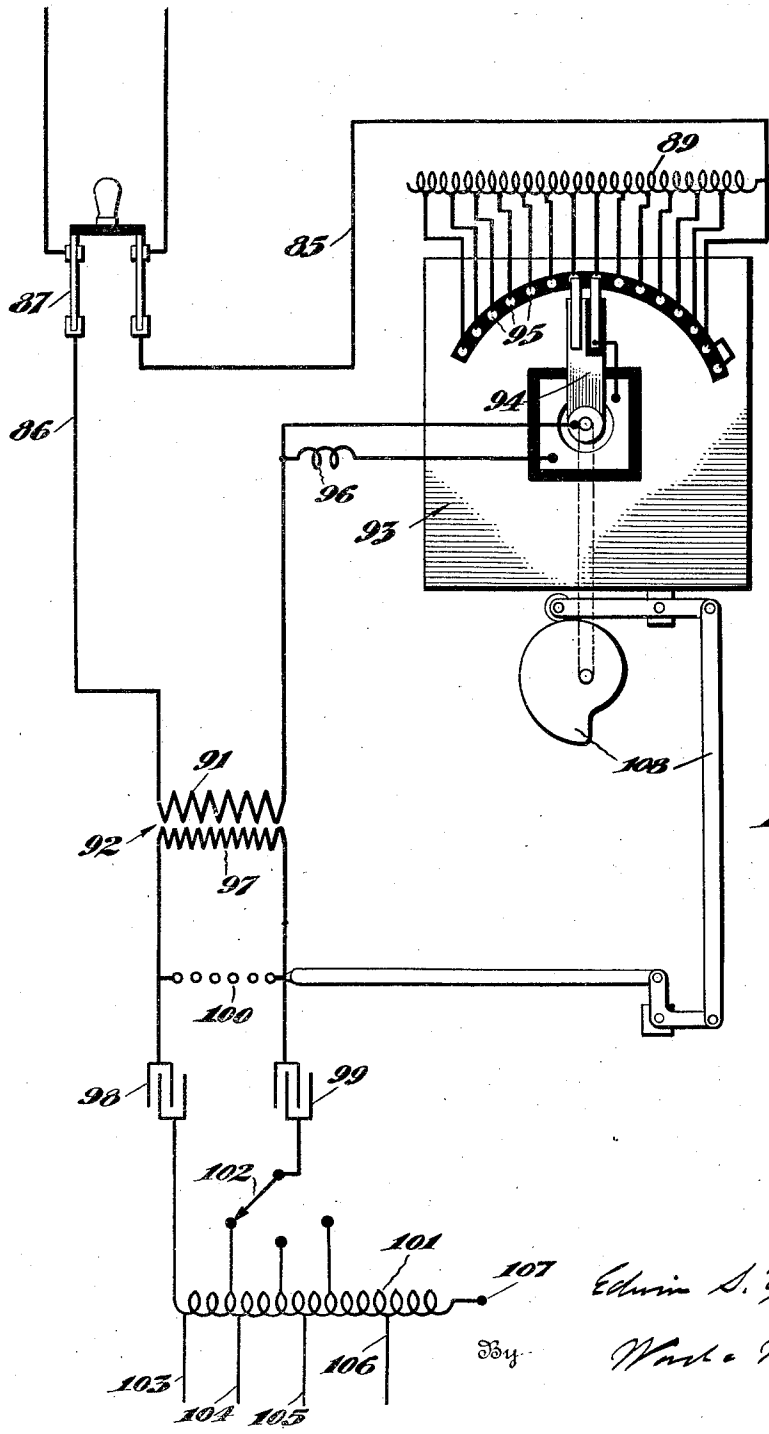

Fig. 9

Inventor

Edwin S. Flarsheim

By Wm. C. Wm.

Attorneys

Patented Mar. 29, 1932 1,851,504

UNITED STATES PATENT OFFICE

EDWIN S. FLARSHEIM, OF CINCINNATI, OHIO, ASSIGNOR TO THE LIEBEL-FLARSHEIM COMPANY, OF CINCINNATI, OHIO, A CORPORATION OF OHIO

ELECTRICAL APPARATUS

Application filed August 26, 1927. Serial No. 215,541.

This invention relates to electrical apparatus involving a plurality of separate but functionally related circuit controlling elements. The particular mechanism disclosed was developed as one solution to a problem heretofore existing in machines for the therapeutic application of high frequency currents. However, the disclosed mechanism will, to the skilled in the art, obviously admit of introduction into other environments presenting pertinently analagous circuit conditions.

Therapeutic machines of the class indicated, comprise, a primary circuit wherein a multiple contact switch varies the power input, and a high frequency circuit wherein spark gaps having electrodes adjustably spaced vary the power of the high frequency circuit.

Therefore, to vary the power of the applied current it is necessary to change the spark gap electrode spacing which in turn necessitates or makes advisable a corresponding change in primary circuit power. This coordinated two circuit adjustment necessary for efficient and satisfactory operation of the machine is an operation which requires skill of a variety foreign to the knowledge and training of the average physician. If the adjustment of spark gap opening to power input is not reasonably proportioned it can cause the high frequency output current to become irregular and faradic in character, producing very undesirable muscular contraction.

The object of this invention is therefore to provide a therapeutic machine wherein one control handle adjusts the power of the current to be applied to the patient.

Another object of the invention is to provide mechanism for controlling simultaneously two separate but functionally related circuits or circuit controlling elements.

In relation to a therapeutic machine, the invention comprises a connection between the power input varying means such as a variometer or a multiple contact switch of the primary circuit and the spark gap of the secondary circuit whereby the primary current is increased as the gaps are opened to provide adequate but not excessive primary circuit power. Likewise, this connection prevents spark electrode spacing too great for the primary power, a condition which provides a current unsuitable for therapeutic treatments.

The mechanism developed and selected to constitute this connection, comprises, an arcuately movable switch arm adapted to effect a plurality of circuit completing contacts selectively, a shaft rotated with the arcuate movement of said switch arm, a cam mounted on said shaft, and lever mechanism operated by the rotation of said cam, said lever mechanism connected to said spark gap to vary the electrode spacing by its actuation.

The other objects, advantages and details of the invention will best be understood with reference to the accompanying drawings, in which:

Figure 1 is a sectional view taken through a portion of a therapeutic machine cabinet, showing the switch device for altering the power in the primary circuit, the spark gap device, and the connection between these two devices.

Figure 2 is a plan view of the spark gap device and the switch, shown in Figure 1, the cabinet in which these devices are mounted being removed for the purpose of illustrating the mechanisms of the various devices.

Figure 3 is a detail view of the switch arm.

Figure 4 is a sectional view taken on line 4—4, Figure 3.

Figure 5 is a front view of the spark gap device illustrating at one end thereof, the independent control for the spark gap device.

Figure 6 is a sectional view taken on line 6—6, Figure 5, detailing the independent spark control device.

Figure 7 is a sectional view taken on line 7—7, Figure 5, showing in detail one set of the plurality of sets of spark gap electrodes used in the device.

Figure 8 is a sectional view taken on line 8—8, Figure 5, detailing the arrangement for unitarily varying the spacing of the sets of spark gap electrodes.

Figure 9 is a wiring diagram illustrating the electrical circuits concerned in this invention and showing, schematically, the me-

chanical movements employed for coordinating the movements of the switch and the spark gap device.

This invention comprises three devices in combination, (A) a device for altering the power in the primary circuit, (B) a spark gap device in a high frequency circuit, (C) a connection device between said power varying device and the spark gap to coordinate their adjustments.

The spark gap device and the switch device as well as the multiple control for the spark gap are all the subject matter of separate patent applications.

Switch device

For the purposes of illustration a portion of the cabinet is shown. This portion of the cabinet comprises two faces 1, 2, joining each other on a slight angle. Below the faces 1, 2, is mounted the uni-control mechanism. Through face 1 extends a shaft or rod 4 on the outer end of which is a knob or handle 5 of hard rubber or other insulating material.

Below this face 1 of the cabinet is mounted a switch plate 6. Inserted in the switch plate are a plurality of contacts 7 with connections for primary circuit wires extending from the lower face of the switch plate. Each contact comprises a headed member countersunk in the switch plate with the portion for connecting wires extending on the opposite side of the plate, said contact member riveted over a washer on the connection side of the plate to hold the contact in position. These contact members are disposed throughout an arc or circle concentric with the rod 4.

The shaft 4 rotates in a shouldered bushing 8 centrally mounted in the switch plate with respect to the arc or circle of contacts, which bushing is held in place by a retaining nut 9 threaded upon the side of the switch plate opposite to that upon which the shoulder bears.

The shaft is held against axial movement in this bushing by means of a cotter pin and washer on the shaft on the lower side of the bushing and a switch arm 10 riveted to the shaft on the upper side of the bushing. At the outer end of the switch arm 10 are secured to contact brushes 11, 12, adapted to make electrical connection with the arcuately disposed contacts. These brushes are secured to the switch arm by means of bolts, nuts and washers. Bolted to the switch plate 6 on the same side as the switch arm is a square contact plate 13 encircling the rotatable shaft 4 and insulated therefrom. One of the bolts which holds this square contact plate in position extends downwardly from the underside of the switch plate and constitutes a terminal 14 for electrical connection.

A spring pressed contact 15 extends downwardly from the switch arm to this square contact plate 13. This spring contact 15 comprises a headed member, said head being adapted to contact the square plate. The headed member is slidably mounted in a guide sleeve 16 flanged on its lower end and threaded upon its upper end. A coiled spring 17 under compression is positioned between the member head and the guide sleeve flange to maintain the head in contact with the plate. This guide sleeve passes through an insulating bushing 18 flanged to withhold the guide sleeve flange from contact with the switch arm. An insulating washer 19 is disposed on the upper surface of the switch arm about the guide sleeve and the parts secured together by means of a washer and a nut threaded upon the guide sleeve above this insulating washer 19. The brush 11 at the outer end of the switch arm is insulated from said switch arm by means of insulating plates 20. This brush 11 is electrically connected with the upper end of the headed member of the plate engaging contact 15 by means of a flexible wire connection 21.

Spark gap device

The spark gap device is mounted below the upper face 2 of the cabinet and extends upwardly therethrough. This spark gap device comprises a base 25 secured to the cabinet and side standards or supports 26 mounted at either end of the base. At the top of each standard is bolted an inwardly extending bracket 27 to which bracket is attached a stationary gap bar 28 preferably of marble, porcelain or some other insulating material. The connection between the gap bar 28 and brackets 27 is made by means of shoulder screws 29 extending through the bar and through the brackets, the bar being positioned on the shoulder screws by means of nuts and washers on either side of the bar, the shoulders 30 of said screws which rest upon the brackets, being riveted to the brackets on the sides opposite to the shoulders, and provided with eyelets at their ends on the other sides of said brackets. Pivoted to the inner faces of said side standards by means of studs 31 projecting from said faces is a yoke 32. This yoke consists of a rod 33 extending substantially the distance of the standard spacing and arms 34 extending from the ends of the rod 33. It is these arms which are pivoted to the side standards, the pivot points being located near the ends of the arms. Pivoted to the ends of the arms by means of studs 35 extending inwardly from the arm ends are slide bars 36 held in position on the studs by cotter pins. The opposite ends of these slide bars 36 are slotted and the slots are entered by studs 37 extending inwardly from the side standards. By this construction the swinging of the yoke upon its pivots back and forth reciprocates the slide bars 36 in substantially a straight

line. On the inner faces of the slide bars 36 are riveted brackets 38 to which a movable gap bar 39 is secured by means of shoulder screws 40 such as used on the stationary gap bar. A stud 41 is provided at each end of the bar 39 having an eyelet disposed in alignment with the eyelet 29 extending below the opposing face of the stationary gap bar retaining brackets. A coiled spring 42 under tension is anchored at each end in these eyelets in order to draw the gap bars together.

These gap bars 28 and 39 carry a plurality of opposing sets of spark electrodes 43, five sets as disclosed. Each set of opposing spark electrodes comprises opposing spark electrodes proper 44, each connected to its carrying gap bar by way of a plurality of radiator plates 45 of which one or more are flexible. These spark electrodes 44 are preferably tipped with tungsten or some other substance suitable for spark gap purposes. They are recessed as at 46 on the side opposite to the active face, said recesses extending almost to said active face and leaving but a thin partition of metal between the recess and the active face. The radiator plate 45[a] adjacent the spark electrode is apertured and the electrode riveted to the plate through said aperture.

As disclosed, four radiator plates 45 are used in connection with each spark electrode. The radiator plate 45[a] adjacent to the gap bar is riveted to the third radiator plate at the corners by means of shouldered studs 47. This fourth radiator plate is of thinner material than the others to provide spring action. The three radiator plates nearest to the spark electrode are held together by means of spacing washers 48 with an eyelet 49 running through and spread on each end. These spacing washers and eyelets are disposed relatively near the centers of said radiator plates. Due to the disposition of the mounting studs of the radiator plates the three inner plates 45 are substantially rigidly secured together, moving as a unit in relation to or under the flexing of the spring radiator plate 45[b]. All of the radiator plates are provided with apertures 50 aligned with the spark electrode recesses.

In the gap bar behind and in alignment with the apertures is mounted a sleeve 55 flanged on the inner side of the gap bar, threaded on the outer side of the gap bar and secured thereto by means of a nut and washer. In the outer end of this sleeve 55 is a set screw or adjustable abutment 56 for a spacer rod 57 which extends through said sleeve through the apertures in said radiator plates into the far end of the recess of the spark electrode. Therefore, by screwing in or out this set screw the spacer rod 57 is moved longitudinally and the distance of the spark electrode from the gap bar carrying it correspondingly adjusted. The requisite amount of motion is permitted by the flexible radiator plate adjacent to the gap bar. It is therefore possible by adjusting this set screw to adjust each spark electrode individually in relation to the gap bar and bring them into proper alignment. The spacer rod is preferably of invar or some other material having a substantially zero coefficient of thermal expansion within the range encountered in service. The radiator plates protect this invar spacer rod from the heat generated by the spark and what little expansion there might be is compensated for by the very slight expansion of the sleeve 55 extending through the gap bar. These spark electrodes are so adjusted that the flexible radiator plate is under tension greater than can be relieved by expansion of the radiator plates and the electrode is thus held firmly against the spacing member so that only the expansion of this spacing member in relation to its adjustable abutment changes or alters the position of the spark electrode in relation to its carrying bar. Therefore a spark gap comprising two of these spark electrodes so mounted is not subject to change or alteration of gap distance as the temperature varies as a result of the heat generated by the spark.

These individual sets of spark electrodes are connected in series by means of flexible connectors 58 (indicated diagrammatically in Figure 5) extending between and secured to the radiator plates.

Connection device

The spacing of the gap bars 28 and 39 and the spark electrodes carried thereby is controlled from the handle 5 of the primary circuit switch. The connection between the two is as follows:

On the rotatable switch shaft preferably between the switch plate and the cabinet is disposed a cam 59. A lever 60 is pivoted on the undersurface of the cabinet face 1 in which the control handle is mounted, and this lever is provided at its end with a roller 61 mounted on a stud 62 to which the roller is held by means of a washer and cotter pin. This roller is held against the cam edge by means of a spring 60[a] and is adapted to be swung by the cam engagement. Pivoted to the lever 60 intermediate its pivot and the roller is a connecting rod 63. The end of the connecting rod 63 pivoted to the lever is of brass. The main length 64 of the rod is of insulating material such as formica, this portion being screwed to the brass at one end and at the opposite end is provided with a brass bushing 65 which is inserted over one arm of a bell crank lever 66 which bell crank lever in turn is pivotally mounted on a stud 67 extending outwardly from the side standard of the spark gap. The bell crank lever 66 is held on the stud 67 by means of a washer and cotter pin. The other arm of the bell crank lever is shorter than said first

mentioned arm and is provided with an outwardly extending stud 68 which makes slidable connection in a slot 69 in another lever 70 fulcrumed near its opposite end to an arm 71 pivotally mounted as at 71ª to the side standard. These fulcrum points and pivots unless otherwise specified, comprise studs, washers and cotter pins.

On the end of the lever 70, opposite to the end which has sliding connection with the bell crank lever is pivoted a link 72, the other end of which is pivoted to the outer end of the spark gap yoke 32. Motion is therefore transmitted from the uni-control handle to the movable spark gap bar via reduced motion mechanism comprising three levers, namely, the lever which carries the cam roller, the bell crank lever, and the lever engaged by the bell crank lever. The adjustment of the spark gap by the uni-control handle is therefore very delicate.

In order to provide spark gap adjustment independent of the switch handle and to permit the opening of the gaps for cleaning purposes, the arm 71 to which the lever 70 adjacent to the link 72 joining the yoke is pivoted is attached to a sleeve 73 pivoted to the side standard of the gap by means of a long stud 74 extending through the sleeve. On the outer end of this sleeve 73 is a second arm 75 extending radially therefrom and to this arm is bolted a bracket 76 forming a forked end on the arm. In this fork a block 77 is pivoted on studs 78 mounted in the fork, the block being provided with a centrally extending threaded aperture. Through this threaded aperture extends a sleeve 79 and through the sleeve slidably extends a rod 80 on the upper end of which is a knob 81 of insulating material projecting through the upper surface 2 of the cabinet. The rod 80 is rotatably connected to the threaded sleeve 79 by means of a pin 82 extending from each side of the rod and engaged in a slot in the lower end of the sleeve. The turning of this knob raises or lowers the block through the sleeve, this raising or lowering the arm of the sleeve to which is pivoted the lever intermediate the bell crank lever and the link connected to the yoke. This provides adjustment for the spark gap independent of that provided by turning the switch handle. The knob projecting from the top of the cabinet is not axially secured and therefore, raising or lifting this knob lifts the block which in turn lifts the yoke via a connecting link which lowers the movable gap bar which separates the spark electrodes for examination, adjustment or cleaning. The pin and slot connection is provided between the rod and sleeve so that the operator cannot force the gaps together when they are held apart for cleaning. The pin drops below the slot and free of the sleeve when the handle or knob is released and the rotative connection is therefore broken preventing screwing down of the block and closing of the gaps when they are otherwise held apart.

The spark gap mechanism therefore is provided with four controls, (1) the spacing of each individual electrode from its carrying bar, (2) the delicate control through the switch handle, (3) the independent control of the gap as a unit through the handle in the top of the cabinet, (4) the rapid opening of the gaps by lifting this last specified handle.

It is to be noted that differential motion between the primary circuit control handle and the spark electrode movement is effected primarily by the use of the cam. This differential is a function of the cam curvature and can be either constant or varied.

Another spark gap mechanism non-subject to temperature change applicable to this type of machine is that described and claimed in my co-pending application, Serial No. 161,931, filed January 18, 1927, patented December 18, 1928, No. 1,696,157.

Circuit

The inbound supply wires 85, 86, connect to switch 87, then one of them 85 runs to one end of choke coil 89 the other inbound wire 86 runs to the primary 91 of step-up transformer 92 then to the central point of the primary circuit regulating switch 93. The regulating switch 93 has a variable contact switch arm 94 which connects to the buttons 95 of said switch whereby turning this switch arm to the right cuts into circuit less of the turns of choke coil 89, and turning it to the left cuts in more turns on said choke coil winding. The switch arm 94 is equipped with a double set of contacts, and across these contacts is floated a separate small inductance coil 96 to prevent a short circuit of adjacent buttons, which would be the case if there were no means of generating a counter electro-motive force when both contacts on the lever arm 94 are resting on adjacent contact buttons. The coil 96 is so proportioned, however, that in order to generate the required counter electro-motive force a comparatively high flux density is necessary, thereby allowing an appreciable current flow in this coil, with the result that two adjustments of power setting are secured for each button on switch 93, or it may be said for each step of inductance on choke coil 89 two degrees of regulation are secured.

When energy is fed to the primary 91 of transformer 92 a high voltage is generated by secondary coil 97 which charges condensers 98 and 99. After a sufficient charge has built up on these condensers they discharge in an oscillatory manner across spark gap 100 through the condensers and through the primary portion of resonator winding 101.

Switch 102 is connected so that a selection of different numbers of primary turns of resonator 101 can be included in the primary oscillatory circuit and thereby controlling the frequency range of said circuit.

Different output taps 103, 104, 105, 106 are provided on resonator 101 to give different output voltages. A further extended tap 107 is sometimes used for securing a high voltage uni-polar current, but this tap can be used also bi-polarly in connection with any of the preceding taps, namely, 103, 104, 105, or 106.

The previously described mechanism coordinating the movements of the switch lever and the spark gap electrodes is shown schematically at 108.

Thus is provided a machine for therapeutic application of high frequency current, said machine characterized by many novel features of construction, including, the connection between the power varying means in the primary and high frequency circuits to which feature is directed the following claims by which alone I desire to be limited.

Having described my invention, I claim:

1. In a machine for the therapeutic application of high frequency current, a primary circuit, means for controlling the power in said circuit, a high frequency circuit, a plurality of spark gaps in said high frequency circuit, and mechanical connection between said means and said spark gaps whereby the increase of the power in the primary circuit increases the electrode spacing of the spark gaps collectively.

2. In a machine for the therapeutic application of high frequency current, a primary circuit, means for controlling the power in said circuit, a high frequency circuit, a spark gap in a said high frequency circuit, a cam adapted to be rotated by the movement of said means, and lever mechanism connected to said spark gap and adapted to be operated by said cam to increase the electrode spacing as the power in the primary circuit is increased.

3. In a machine for the therapeutic application of high frequency current, a primary circuit, a switch arm, a rotatable shaft from which the switch arm extends radially, said switch arm adapted to make a plurality of circuit completing contacts selectively to vary the power in said primary circuit, a cam mounted on said rotatable shaft, a high frequency circuit, a spark gap in said high frequency circuit, and a mechanism to be actuated by said cam, said mechanism connected to said spark gap to increase the spacing of the electrodes as the power is increased in the primary circuit.

4. In a machine for the therapeutic application of high frequency current, means for adjusting simultaneously yet differentially a plurality of circuit controlling elements, said means comprising a rotatable shaft, a circuit controlling mechanism connected directly to said shaft and adapted to be adjusted by the rotation thereof, a cam mounted on said shaft, a member adapted to be actuated by said cam, and a second circuit controlling mechanism connected with said member and adapted to be adjusted thereby differentially in respect to said first circuit controlling mechanism, said differential being a function of the cam curvature.

5. In a machine for the therapeutic application of high frequency current, a primary circuit including a power varying means, a high frequency circuit, and a spark gap in said high frequency circuit, the spacing of the gap electrodes being non-subject to temperature changes, and mechanical connection between said gap and said power varying means whereby the gap is opened as the primary circuit power is increased.

6. In a machine for the therapeutic application of high frequency current, a primary circuit, a switch for controlling the power in said circuit, a high frequency circuit, a plurality of spark gaps in said high frequency circuit, and mechanical connection between said switch and said spark gaps whereby the increase of the power in the primary circuit increases the electrode spacing of the spark gaps collectively.

7. In a machine for the therapeutic application of high frequency current, a primary circuit, a switch for controlling the power in said circuit, a spark gap in said high frequency circuit, a cam adapted to be rotated by the movement of the switch, and lever mechanism connected to said spark gap and adapted to be operated by said cam to increase the electrode spacing as the power in the primary circuit is increased.

8. In a machine for the therapeutic application of high frequency current, a primary circuit, means for controlling the power in said circuit, a high frequency circuit, a spark gap in said high frequency circuit, a cam adapted to be rotated by the movement of said means, and reduced motion lever mechanism, whereby the increasing of the power in the primary circuit increases the electrode spacing of the spark gap.

9. In a machine for the therapeutic application of high frequency current, a primary circuit, means for controlling the power in said circuit, a high frequency circuit, a spark gap in said high frequency circuit, sad spark gap comprising, a plurality of spaced electrodes, and mechanical connection between said means and said spark gap whereby the variation of the power in the primary circuit unitarily varies the spacing of the plurality of spaced electrodes.

In witness whereof, I hereunto subscribe my name.

EDWIN S. FLARSHEIM.