LOW VOLTAGE ELECTRO-THERAPY GENERATOR

Filed April 18, 1952 2 Sheets-Sheet 1

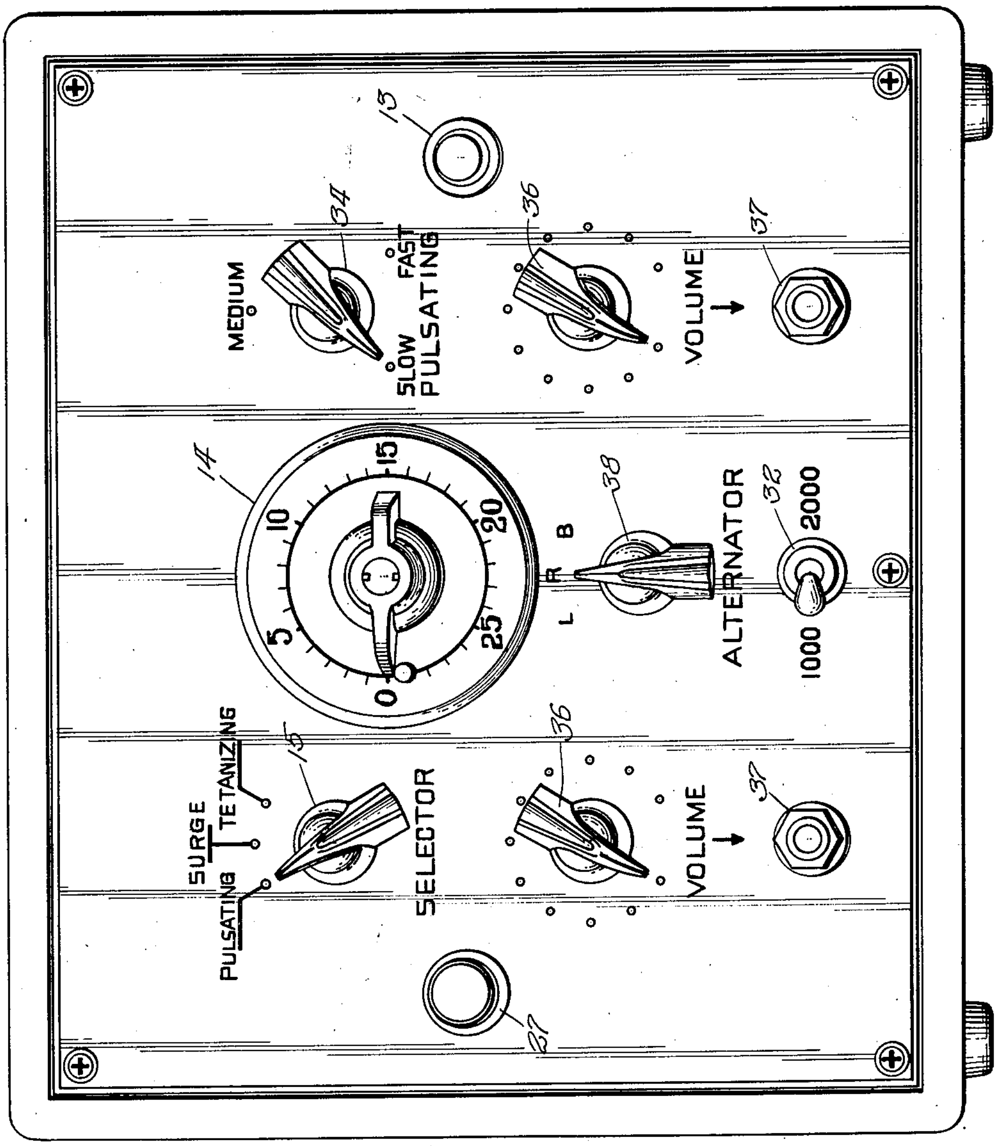


Fig. 1.

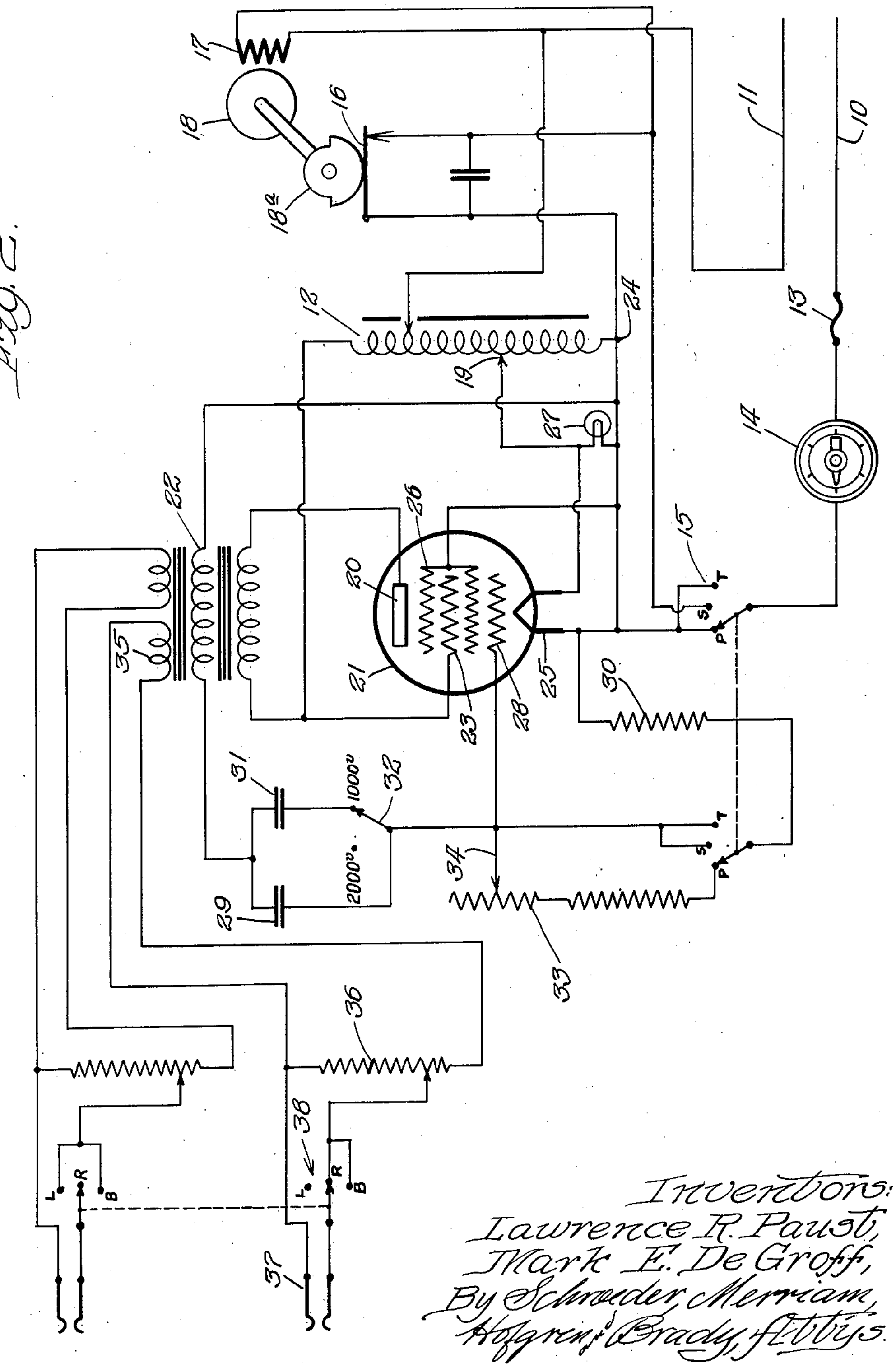
Inventors:
Lawrence R. Paust,
Mark E. DeGroff,
By Schroeder, Merriam,
Hofgren & Brady, Attys.

Sept. 25, 1956 L. R. PAUST ET AL 2,764,683

LOW VOLTAGE ELECTRO-THERAPY GENERATOR

Filed April 18, 1952 2 Sheets-Sheet 2

Fig. 2.



Inventors:
Lawrence R. Paust,
Mark E. De Groff,
By Schroeder, Merriam,
Hofgren & Brady, Attys.

United States Patent Office

2,764,683

Patented Sept. 25, 1956

2,764,683

LOW VOLTAGE ELECTRO-THERAPY GENERATOR

Lawrence R. Paust, Chicago, Ill., and Mark E. De Groff, Tulsa, Okla.; Leah M. Paust, administratrix of said Lawrence R. Paust, deceased, assignors to Physical Medicine Products Co., Kansas City, Mo., a partnership

Application April 18, 1952, Serial No. 283,082

7 Claims. (Cl. 250—36)

This invention relates to a low voltage electrotherapy generator.

In recent years, medical science has found it increasingly useful to employ electrical muscle stimulation in the treatment of strains, sprains, dislocations, fractures and the like. Depending on the nature and extent of the injury, different forms of electro-therapy currents are applied to the muscles controlling the injured joints. The application of these currents serves to counteract atrophy of the muscles due to disuse and nutritional reflex; aids in removing exudates; and minimizes the formation of adhesions. The current from an electro-therapy generator is usually applied through pads placed on the skin, these pads being connected to an outlet in the generator. Three types of electro-therapy currents are generally employed—pulsating current having instantaneous rectified pulsations with rest periods between each pulsation to cause twitch contraction of normally innervated muscles, tetanizing current wherein audio oscillations are superimposed on rectified electrical half waves to produce constant tetanic muscle contraction, and a surge form of current which is obtained by turning the tetanizing current off and on at predetermined periodic time intervals so as to effect graduated muscle contractions.

It is often advantageous in electro-therapy treatment to alternately and repeatedly stimulate first one group of muscles and then another group located in different areas of the body as for example first applying electro-therapy current to the flexor muscles, and then applying it to the opposing extensor muscles and repeating the cycle. To accomplish this with prior types of electro-therapy generators was cumbersome and not very satisfactory, requiring moving the pads to different positions each time that the extensor or corresponding flexor muscles were to be stimulated. In addition, it is oftentimes advantageous to treat different groups of muscles simultaneously.

We have developed and are here disclosing and claiming a low voltage electro-therapy generator arrangement which overcomes the disadvantages and objections mentioned above, and others.

An important feature of this arrangement is that a portable, low cost electro-therapy generator can be constructed capable of applying the different forms of electro-therapy currents to the muscles of a patient. Another important feature of this arrangement is that muscles located in different areas of the body may be alternately and repeatedly stimulated with electro-therapy currents without the necessity of readjusting the pads prior to applying the electro-therapy currents to a particular area. Another feature is that muscles located in different areas of the body may be stimulated simultaneously with electro-therapy currents. Still another important feature is the employment of at least two grid condensers in the feedback circuit of this arrangement, one of which is adapted to be connected in parallel with the other, thus providing a greatly simplified, efficient way of varying the range of audio oscillations of the tetanizing and surge currents as well as changing the range of time intervals between each instantaneous pulsation of the pulsating current. Another feature of this arrangement is that means are provided whereby a single secondary coil in the power input circuit of this arrangement serves to step-up the line voltage to be applied to the plate side of the electron tube in the circuit and step-down the line voltage so as to supply filament voltage to the electron tube.

Other features and advantages will be apparent from the drawings, in which:

Fig. 1 is a circuit diagram showing one form of my low voltage electro-therapy generator; and Fig. 2 is a front elevational view of the control panel of my low voltage electro-therapy generator.

Referring now more particularly to the circuit diagram of Fig. 1, the particular embodiment shown includes generally a power input circuit, an electron tube feedback circuit coupled to the power input circuit so as to produce predetermined electrical pulses, and an output circuit operatively coupled to both the power input and the feedback circuits.

Referring first to the power input circuit, line voltage, such as 60 cycle 110 volts, is developed across leads **10** and **11**, being applied to the primary winding of an auto-transformer **12** through the series connected fuse **13**, mechanical timer switch **14** and selector switch **15** in lead **10**. The mechanical timer switch **14** acts as an off-on switch as well as having a spring wound clock mechanism so as to time the desired length of treatment. As here shown, the selector switch **15** is a standard single wafer type having two separate sections which operate concurrently, each section having three positions—P, S and T. One section is located in the feedback circuit and the other in the power input circuit. Referring to that section of the selector switch **15** in the power input circuit, the P and T contacts are connected directly to one end of the primary winding, but when the switch is in the S position, a surge switch **16** is then connected in the lead **10** between the contact S and the primary winding, and a coil **17** is connected across leads **10** and **11**, being in parallel with the primary winding of the auto-transformer **12**. When connected across leads **10** and **11**, the line voltage applied to this coil actuates an electrical motor, here shown diagrammatically as **18** having a rotatably mounted radial disc cam **18***a*. The cam is so positioned that upon rotation, the cam portion closes the surge switch **16** causing it to alternately open and close the lead **10** for predetermined periodical time intervals, thus turning the line voltage applied to the primary off and on in a similar manner. The surge switching mechanism only operates when the selector switch **15** is in the S position and in the particular embodiment shown alternately and repeatedly closes the switch for six seconds and then opens it for six seconds.

The secondary winding of the auto-transformer **12** has a tap **19**. One end of this winding is connected to the plate **20** of a pentode tube **21**, such as a No. 47 radio tube, through the primary coil of a coupling transformer **22**. This end is also connected to the screen grid **23** so as to produce rectified electrical half waves in the primary coil of the transformer **22**. If the line voltage is 60 cycle 110 volts, rectified 60 cycle half waves are formed in the primary coil. The other end of the secondary winding serves as a common point **24** and is connected to one side of the filament **25**, with the tap **19** being connected to the other side of the filament. In this way, the secondary winding of the auto-transformer **12** provides stepped-up line voltage which is applied to both the plate and the screen grid, and stepped-down filament voltage.

The suppressor grid **26** is connected to the common point **24**, this being standard practice for proper operation of the pentode tube 21. A pilot lamp 27 is connected between the tap 19 and the common point 24. It is on continuously when using pulsating or tetanizing currents, i. e., when the selector switch 15 is in the T or P position. When surge current is used, the lamp is only on when the surge switch 16 is closed.

Referring now to the feedback network, one end is connected to the control grid 28 and the other end to the common point 24. This network includes a secondary coil of the coupling transformer 22, a first grid condenser 29 of .25 mfd. permanently connected in series with the secondary coil, and a first grid resistor 30 of 10,000 ohms in permanent shunt with the series connected secondary coil and condenser 29. The feedback section of the selector switch 15 is connected in the shunt side of this network between the control grid 28 and the first grid resistor 30. When the selector switch 15 is in the S or T position, only the grid resistor 30 is shunt connected with the series connected secondary coil and grid condenser 29. The network then serves as a straight feedback causing audio oscillations to be superimposed on the rectified electrical half waves in the primary coil of the coupling transformer 22. A second grid condenser 31 also of .25 mfd. may be parallel connected with condenser 29 through a single pole single throw frequency switch 32, the arm end of which is connected to condenser 29 and the other side of the switch to the second grid condenser 31, thus providing a simple, efficient means for changing the range of audio oscillations superimposed on the rectified electrical half waves produced in the primary coil of the coupling transformer 22. If only the first grid condenser 29 is employed in this network, approximately 2,000 cycle audio oscillations are superimposed on the rectified electrical half waves in the primary coil. When the second grid condenser 31 is parallel connected with the first grid condenser 29, approximately 1,000 cycle audio oscillations are superimposed on the rectified electrical half waves produced in the primary coil. Although only 2 grid condensers are shown, it is to be understood that any number may be similarly connected in parallel depending on the particular value of audio oscillation desired.

A second grid resistor 33 is connected in series with the first grid resistor 30 when the selector switch 15 is in the P position. This second grid resistor has a sufficiently large value of resistance so as to provide a blocking feedback network producing instantaneous rectified electrical pulsations at spaced time intervals in the plate side of the pentode tube 21. In the particular embodiment shown, the second grid resistor 33 has two series connected resistance elements, one being a 250,000 ohm resistor and the other a 1 megohm pulsating control potentiometer 34 whose arm is connected to the control grid 28. Varying the effective value of resistor 34 changes the time interval between the instantaneous electrical pulsations, and the range over which the instantaneous pulsations may be varied is changed by utilizing the second grid condenser 31 in parallel with the first grid condenser 29. As here shown, the instantaneous pulsations can be varied from approximately 1 to 7 per second when the two grid condensers 29 and 31 are connected in parallel and from approximately 2 to 14 per second when the second grid condenser 31 is not used.

Turning now to the output circuit, the particular embodiment shown has two separate, but similar networks and the following description will therefore be limited to one of them. A coil 35, here shown as a tertiary winding of a coupling transformer 22, is magnetically coupled to both the power input and feedback circuits and has a load resistor 36 of 3,000 ohms connected between its ends. This load resistor is in the form of a potentiometer and serves as a volume control switch for varying the strength of the generated electro-therapy current delivered to the outlet terminals 37. The arm of this potentiometer is connected to one side of the outlet terminal 37 through a three-position alternator switch 38 and the other side of the outlet terminal is connected to one end of the load resistor 36. The alternator switch as here shown may be a standard single wafer type having two separate sections which operate concurrently, each section being connected in one of the output networks and having three positions —L, R and B. The arm of the volume control potentiometer in one output network is connected to the L and B contacts of its alternator switch section whereas the arm of the other potentiometer is connected to the R and B contacts of its alternator switch section. Thus, when the alternator switch is in the L position, only one outlet terminal is in operation; when in the R position, only the other outlet terminal is in operation, and; when the switch is in the B position, both outlets are in operation.

Although not shown in the drawings, each outlet terminal has associated therewith a two-wire line cord. A pad is connected at corresponding ends of each wire and the other ends of the wires are connected to a plug which is inserted in the outlet terminal 37. Thus, there is a separate and complete two-wire circuit through each outlet terminal. By placing the pads connected to one outlet terminal over a muscle group and the other pads connected to the other outlet terminal to another muscle group located in a different area of the body, the desired form of electro-therapy current may be applied separately to each group, simultaneously to the different groups, or alternately and repeatedly to first one and then the other group by proper manipulation of the alternator switch 38.

Referring now to Figs. 1 and 2, the general operation of the system will be described. Fig. 2 is a view of the control panel and this will first be briefly described. In the upper center portion of the panel is the timer switch 14, which, as previously described, serves as an off-on switch as well as timing the length of treatment. To the left of this switch is the three-position selector switch 15 and to the right is the pulsating control switch 34. The three-position alternator switch 38 is located directly below the timer switch 14. To the right of this switch is one of the volume control potentiometers 36 and the fuse 13, while to the left is the other volume control potentiometer and the pilot lamp 27. The frequency switch 32 is located directly below the alternator switch 38 with the two outlet terminals 37 on either side.

Assuming that the patient is to be treated with tetanizing current, the selector switch 15 is placed in the T or tetanizing position and after setting the frequency switch 32 in either the 1,000 or 2,000 cycle position, depending upon the type of treatment desired, the timer switch 14 is turned on, being set at the desired time period of treatment. A steady, 60 cycle 110 volt line voltage is applied directly across the primary winding of the autotransformer 12. The resulting stepped-up line voltage in the secondary winding of this auto-transformer is applied to both the plate 20 and the screen grid 23 so that rectified 60 cycle half waves are produced in the primary coil of the coupling transformer 22. If the single pole, single throw frequency switch 32 is in the 2,000 cycle position, then the grid condenser 29 is connected in the feedback network and 2,000 cycle oscillations are superimposed on the rectified 60 cycle half waves produced in the primary coil, thus forming a tentanizing electrotherapy current. 1,000 cycle oscillations may be obtained by setting the frequency switch 32 in the 1,000 cycle position which connects the second grid condenser 31 and grid condenser 29 in parallel.

A similar current is induced in the coils 35 of the two separate output networks and this induced current is delivered to the two outlet terminals 37 from the volume control potentiometer switch 36 through the alternator switch 38. By changing the setting of the two volume control potentiometer switches 36, the strength of the electro-therapy current delivered to each outlet terminal may be independently varied.

When the selector switch is in the S or surge position, the previously described operation occurs except that the surge switching mechanism including the coil **17**, the motor **18**, the radial disc cam **18***a*, and the surge switch **16** are connected in the power input network. As a result, the surge switch **16** is alternately and repeatedly opened and then closed for time intervals of six seconds which causes the line voltage applied to the primary windings to be similarly turned off and on. During the "on" period, the electro-therapy current gradually builds up in from 2 to 3 seconds to full force and at the end of the six second "on" period, it is shut off for six seconds. The pilot lamp **27** is only lighted during the "on" period.

When the selector switch is in the P or pulsating position and the generator is operated as described above, the second grid resistor **33** is connected in series with the first grid resistor **30** and instead of superimposing audio oscillations on the rectified electrical half waves produced in the primary of the coupling transformer **22**, a blocking feedback network is formed whereby pulsating current having instantaneous rectified pulsations at spaced intervals is produced in the primary coil of the coupling transformer **22**. With the frequency switch **32** set at 1,000 cycles, the instantaneous pulsations of current can be varied from about 1 to 7 per second by rotating the pulsating control switch **34** from slow to fast and from 2 to 14 per second when the frequency switch is set at 2,000 cycles.

In order to deliver the desired form of electro-therapy current to different groups of muscles, each outlet terminal **37** is provided with a two-wire line cord. Two pads are connected at two corresponding ends of the wires and the other ends of the wires are connected to a plug which is inserted in one of the outlet terminals **37**. As a result, there is a full two-wire circuit through each outlet terminal and the output circuits can be operated independently of each other. The volume control potentiometer **36** in each outlet circuit operates independently of the other so that different groups of muscles may be treated with different strengths of electro-therapy current. By connecting the output circuits to the alternator swich **38** as previously described, one can apply electrotherapy current to first one group of muscles, as for example the flexor group, and then to the other opposite extensor group merely by placing the pads connected to one of the output terminals over the extensor group and the pads connected to the other ouput terminal over the flexor group and then repeatedly and alternately, alternating the alternator switch **38** to first the L and then the R position. This avoids the necessity of moving the pads or interchanging the plugs. Different strengths of current can be applied to each group which is being alternately treated by adjusting the volume control potentiometers **36**. Different muscle groups may be subjected to the desired form of electro-therapy current merely by setting the alternator switch in the B position. In addition, the different strengths of electro-therapy current may be applied to each group simultaneously by adjusting the volume control potentiometers **36**.

In the particular embodiment shown, the RMS output voltage developed at the outlet terminals **37** varies between 15 and 18 volts when normal 110 line voltage is applied and the output current varies from 5 to 6 ma. with the peak currents varying from 43–46 ma. at full output setting of the potentiometer type volume controls **36**.

While I have shown and described certain embodiments of my invention, it is to be understood that it is capable of many modifications. Changes, therefore in the construction and arrangement may be made without departing from the spirit and scope of the invention as disclosed in the appended claims.

We claim:

1. A low voltage generator comprising: an electron tube; a power supply circuit including a transformer having a primary winding connected to line voltage and a secondary winding containing a tap, the ends of said secondary winding being connected to the plate side and one end of the filament respectively of said tube to provide stepped-up line voltage to the plate, and the tap being connected to the other end of the filament to provide stepped-down filament voltage; a feedback circuit coupled to said tube to produce predetermined electrical pulses; at least two separate complete output circuits operatively coupled to the plate circuit of said tube, each of said output circuits having an outlet; and switch means for utilizing the outlets alternately.

2. A low voltage generator comprising: an electron tube; a power supply circuit including a transformer having a primary winding connected to line voltage and a secondary winding containing a tap, the ends of said secondary winding being connected to the plate side and one end of the filament respectively of said tube to provide stepped-up line voltage to the plate, and the tap being connected to the other end of the filament to provide stepped-down filament voltage; a feedback circuit including a first condenser permanently connected in a tuned portion therof, a second condenser, and a single pole single throw frequency switch selectively connecting the second condenser in parallel with the first condenser and opening such parallel connection; at least two separate complete output circuits operatively connected to the plate circuit of said tube, each of said output circuits having an outlet; and switch means for utilizing the outlets separately and simultaneously.

3. A low voltage generator comprising: an electron tube; a power supply circuit coupled to said tube; a straight feedback circuit coupled to the plate circuit of said tube so as to produce predetermined audio oscillations therein; converting means for changing the straight feedback circuit to a blocking feedback circuit so as to produce predetermined electrical pulsations at spaced time intervals; switch means for selectively connecting the converting means in the straight feedback circuit; at least two separate complete output circuits operatively coupled to the plate circuit of said tube, each of said output circuits having an outlet; and switch means including a switch in each output circuit and a single switch operating member for utilizing the outlets alternately.

4. A low voltage generator comprising: an electron tube; a power supply circuit coupled to said tube; a straight feedback circuit coupled to the plate circuit of said tube so as to produce predetermined audio oscillations, said feedback circuit including a first condenser permanently connected in a tuned portion thereof, a second condenser, and frequency switch means for selectively connecting said second condenser in parallel with the first condenser; converting means for changing the straight feedback circuit to a blocking feedback circuit; surge switch means for energizing and deenergizing said power supply at predetermined periodic time intervals when the straight feedback circuit is in effective operation; switch means for selectively and independently connecting surge switch means concurrently with the straight feedback circuit and the converting means in the straight feedback circuit; at least two separate complete output circuits operatively coupled to the plate circuit of said tube; and switch means for utilizing the outlets separately and simultaneously.

5. A low voltage generator comprising: a pentode; a coupling transformer; a power supply network having one end connected to the plate of the pentode through the primary coil of the transformer and to the screen grid of the pentode, the other end being connected to one end of the filament of the pentode so as to produce rectified electrical half waves in the plate circuit of the pentode; a feedback network having one end connected to the control grid of the pentode and the other end connected to said end of the filament, said feedback network including the secondary coil of the coupling transformer, a first grid

condenser permanently connected in series with the secondary coil, a first grid resistor in permanent shunt with the series connected secondary coil and first grid condenser so as to produce audio oscillations superimposed on the rectified electrical half waves, a second grid condenser, and frequency switch means connecting the second grid condenser in parallel with the first grid condenser, a second grid resistor having substantially larger resistance than the first grid resistor; selector switch means for connecting the second grid resistor in series with the first grid resistor to provide a blocking feedback network; at least two separate complete output circuits operatively coupled to the plate circuit of the pentode, each output circuit having an outlet; and switch means for utilizing the outlets separately and simultaneously.

6. Apparatus of the character claimed in claim 5 in which the power supply network includes a transformer having a primary winding connected to line voltage and a secondary winding containing a tap, one end of said secondary winding being connected to the plate of the pentode through the primary coil of the coupling transformer and to the screen grid, the other end of the secondary winding and the tap being connected to the ends of the filament of the pentode to provide stepped-up line voltage to the plate and the screen grid and stepped-down filament voltage.

7. A low voltage generator comprising: a pentode; a coupling transformer; a power supply network including an auto-transformer having a primary winding connected to line voltage, surge switch means adapted to be connected in the primary winding circuit for opening and closing the primary circuit at periodic time intervals, a secondary winding containing a tap, one end of said winding being connected to the plate of the pentode through the primary coil of the coupling transformer and to the screen grid, the other end of the secondary winding serving as a common point and being connected to one end of the filament and the tap being connected to the other end of the filament; a feedback network having one end connected to the control grid of the pentode and the other end to the common point, said feedback network including the secondary coil of the coupling transformer, a first grid condenser permanently connected in series with the secondary coil, a first grid resistor in permanent shunt with the series connected secondary coil and first grid condenser to provide a straight feedback network, a second grid condenser, a single pole single throw frequency switch connecting the second grid condenser in parallel with the first grid condenser and opening said parallel connection, a second grid resistor, switch means for selectively and independently connecting the surge switch means in the primary winding circuit concurrently with the straight feedback network, and the second grid resistor in series with the first grid resistor to provide a blocking feedback network; at least two separate and complete output circuits magnetically coupled to the primary coil of the ocupling transformer, each output circuit having an outlet; and switch means for utilizing the outlets separately and simultaneously.

References Cited in the file of this patent

UNITED STATES PATENTS

1,568,979	Knudsen	Jan. 12, 1926
1,961,253	Schrenk	June 5, 1934
2,022,067	Wheeler	Nov. 26, 1935
2,513,760	Toulon	July 4, 1950
2,622,200	Hodgson	Dec. 16, 1952
2,668,540	Browner	Feb. 9, 1954

FOREIGN PATENTS

506,544	Great Britain	May 31, 1939