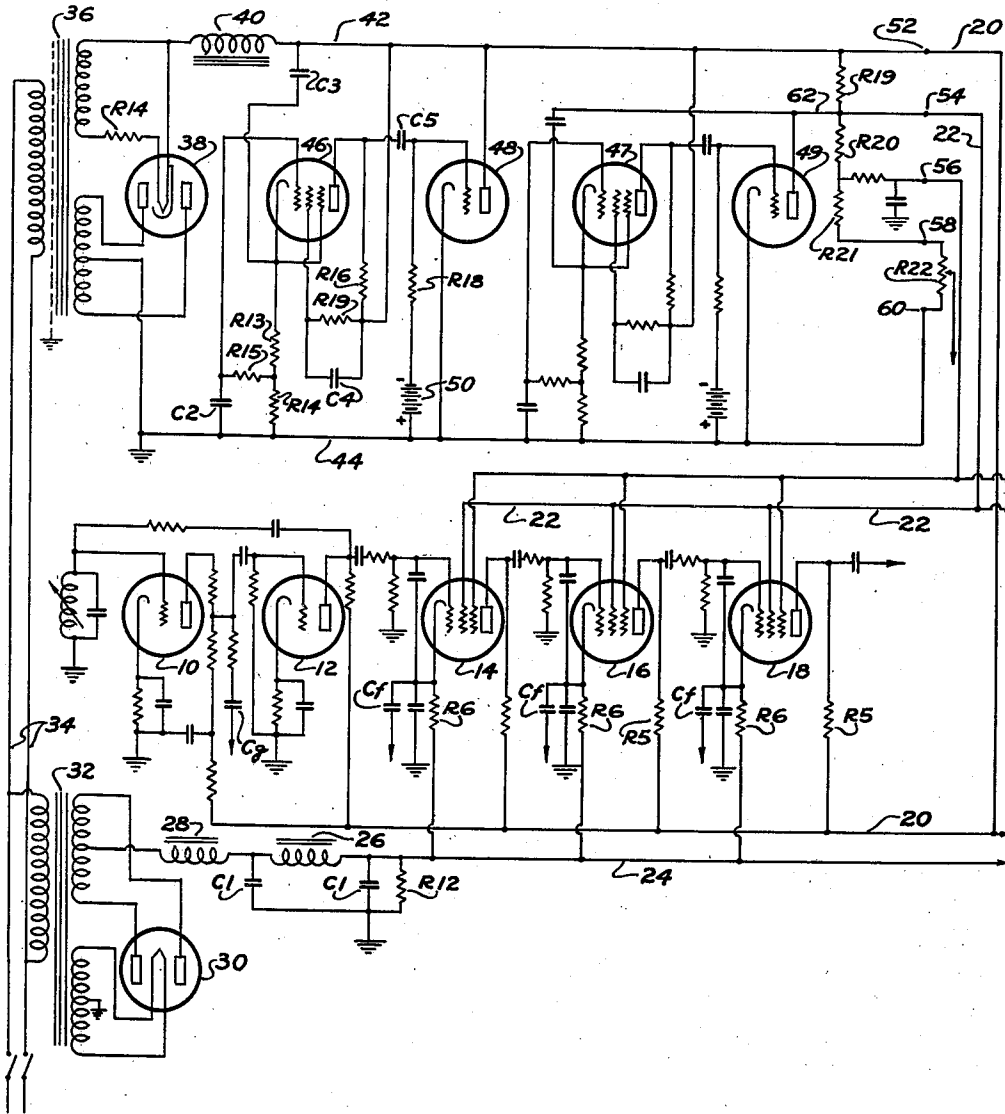


Nov. 12, 1940.

H. E. MEINEMA
ELECTRICAL FILTER SYSTEM

2,221,198

Filed Jan. 6, 1939



Inventor
Herbert E. Meinema
By *Williams, Bradbury,
McCabe & Hinkle*
Attys.

UNITED STATES PATENT OFFICE

2,221,198

ELECTRICAL FILTER SYSTEM

Herbert E. Meinema, Chicago, Ill., assignor to
Hammond Instrument Company, Chicago, Ill.,
a corporation of Delaware

Application January 6, 1939, Serial No. 249,572

11 Claims. (Cl. 178—44)

My invention relates generally to improved power supply means for electrical musical instruments employing a large number of vacuum tubes as parts of the signal generating and controlling means, and for other loads the impedance of which may vary at audio or higher frequencies.

In electrical musical instruments of the kind disclosed in the patent to Laurens Hammond No. 2,126,682, dated August 9, 1938, there is an electron discharge device provided for each of the 85 or more notes of the instrument for generating the electrical impulses of the 85 different frequencies provided in the instrument. In addition, there is a control tube for each key of the instrument by which the transmission of the impulses provided by the generator tubes is controlled.

The plate current of each of the generating tubes is intermittent, and since the tubes draw plate current at a large variety of different frequencies, the load upon the power supply for these tubes is very irregular. While of course the fact that there is a large number of tubes operating at different frequencies tends, in some measure, to cause the drain on the power supply means to approach an average value, this tendency is not as pronounced as might be expected because of the fact that the frequencies of series of the tubes are harmonically related. Thus, an entire series of tubes, for example, the tubes generating frequencies for all of the C's, may draw plate current at the same instant.

In a system of signal generation of the character described in said patent, it is of importance that the voltage of the plate current supply and the screen voltage supply be regulated with a high degree of accuracy. To attain such regulation by the usual filter mesh consisting of choke inductances and condensers would be extremely expensive due to the size of the inductances and condensers required. In fact, even with extremely large chokes and condensers, the regulation would not be entirely satisfactory. To overcome these difficulties, I have provided an improved power supply system having its voltage controlled by the varying load provided by the electron discharge devices incorporated in the musical instrument.

It is thus an object of my invention to provide an improved power supply system for electrical musical instruments which has improved voltage regulation, which is relatively simply in

construction, and which may be economically produced.

Other objects will appear from the following description, reference being had to the accompanying drawing which is a wiring diagram of a representative portion of an electrical musical instrument, and the power supply system provided therefor.

Referring to the drawing, electron discharge devices 10, 12, 14, 16 and 18 form parts of the signal generating circuits for the musical instrument, devices 10 and 12 with their associated circuits form an oscillator for the highest frequency note of a series of notes which are in octave relationship. The signal generated by the oscillator 10, 12 is transmitted through a condenser Cg to the grid of a control tube through which the signal is transmitted to the output circuit under the control of a suitable key. The control tube, its key, and associated circuits, are not shown herein, but are disclosed in the aforesaid Patent No. 2,126,682.

The tubes 14, 16 and 18 form parts of successive stages of a frequency divider system, each stage including a condenser Cj through which the signal from its associated tube is transmitted to the grid of a control tube. The tubes 14, 16 and 18 are representative of approximately 73 similar tubes utilized in the complete instrument, while there are twelve tubes corresponding to the tubes 10 and 12, which in actual practice may be combined in a single twin triode.

The plates of the tubes 10, 12, 14, 16 and 18 are connected to a conductor 20 through suitable resistors such as the resistors R5 for the divider stage, while the screen grids of the tubes are connected to a conductor 22.

The cathodes of the tubes 10 and 12 are connected to ground through self-biasing resistors, while the cathodes of the tubes 14, 16 and 18 are connected to a conductor 24 through cathode resistors R6. The operation of the divider stages requires that the cathodes be connected to a negative potential in the order of -100 volts, and the conductor 24 is therefore connected through a filter circuit including chokes 26 and 28, condensers Cj and resistor R12 to a full wave rectifier 30 supplied with alternating current from a transformer 32, the primary of which is connected to an alternating current line 34.

The plate current supply is obtained from a power supply system comprising a transformer 36 connected to the line 34 and including a full wave rectifier tube 38 connected in the usual

manner to the secondary of the transformer 36. A resistance R14 of a few ohms is provided in the heater circuit for the tube 38 so as to delay heating of the cathode of this tube for a short interval, sufficient to prevent application of high voltage to the plates of the tubes of the instrument until their cathodes have attained operating temperature.

The cathode of the rectifier tube 38 is connected through a choke 40 with a conductor 42 forming the positive side of the power supply, while the conductor 44 forming the negative side of the power supply is connected to ground and to the mid-point of the secondary winding which is connected to the plates of the rectifier tube 38.

As is well understood, the voltage between the conductors 42 and 44 would, if means were not provided to prevent it, have a decided AC ripple voltage impressed thereon. This would be especially pronounced because it will be noted that the usual high capacity condensers between the conductors 42 and 44 are omitted. Furthermore, the regulation of the voltage between the conductors 42 and 44 would be poor because of the nature of the load supplied. As previously pointed out, this load is continuously changing at an irregular rate, and this variation in load would of course be reflected in variations in voltage between the conductors 42 and 44.

To remedy these difficulties, the rectifier is made of greater current delivering capacity than required for the maximum demand of the instrument, and a plurality of variable lossing circuits in shunt with the loads are employed to compensate for the variations in the impedance of the load.

The variable impedance circuit shunting the entire load comprises an amplifying pentode 46, the grid of which is connected to the conductor 44 by a condenser C2 and the cathode of which is connected to the conductor 42 by a condenser C3. The cathode is likewise connected to the conductor 44 by series resistors R13 and R14, while a grid leak resistor R15 connects the grid to the junction between the resistors R13 and R14.

The plate of the pentode 46 is connected to the conductor 42 through a plate resistor R16, while the screen of the tube is connected to the conductor 42 through a voltage dropping resistor R17 which is by-passed by a condenser C4. The output of the tube 46 is impressed upon the input circuit of a triode 48 through a blocking condenser C5, the grid of the triode being biased by a suitable potential source 50 connected between the grid and cathode through a resistor R18. The cathode of the tube 48 is connected to the conductor 44 while its plate is connected to the conductor 42. The load resistance comprises a plurality of resistors R19, R20, R21 and R22 connected in series between the conductors 42 and 44, these resistors forming a voltage divider having terminals 52, 54, 56, 58 and 60. The terminal 52 is connected to the conductors 42 and 44, the latter supplying the plate current for the frequency generating tubes of the electrical musical instrument, while the terminal 54 has the conductor 22 connected thereto for supplying the voltage for the screen grids of said generating tubes.

Inasmuch as the current drawn by the screen varies in a manner similar to the variation in the current drawn by the plate circuits of the frequency generating tubes of the instrument, a variable impedance circuit is shunted between the

terminal 54 and the conductor 44. This variable impedance circuit comprises an amplifying pentode 47 and a triode 49 connected in a manner substantially identical with the connections for the tubes 46 and 48, except that instead of making the connections of the cathode of the tube 47 and the plate of the tube 49 to the conductors 42, these elements are connected to a conductor 62 which is connected to the terminal 54.

The operation of the system may be described by considering the effect of the simultaneous operation of a plurality of the frequency generating tubes 14, 16, 18, etc., such that they draw plate current substantially simultaneously. Such operation causes a decrease in the load impedance between the conductors 42 and 44, with the result that the voltage of conductor 42 with respect to the conductor 44 tends to drop. Such incipient change in voltage is amplified by the tube 46, causing increased current flow therethrough. This increased current flow causes the potential of the plate of the tube 46 to drop, which drop in potential is impressed upon the grid of the triode 48 so that the plate impedance of the latter is increased. The constants of the circuit elements are selected so that such increase in plate impedance accurately compensates for the decrease in the impedance of the load provided by the generator tubes of the musical instrument. Conversely, when the impedance of the load provided by the generator tubes increases, there is a tendency for the voltage between the conductors 42 and 44 to increase. This increasing change in voltage causes the plate impedance of the tube 46 to increase, and the resultant decrease in its plate current causes the plate potential to rise. The rising plate potential is impressed upon the grid circuit of the triode 48 with the result that the impedance of the latter is lowered. The decrease in the impedance of the shunt circuit through the triode 48 thus compensates for the increased impedance of the load provided by the frequency generator tubes, and, as a result, the voltage between the conductors 42 and 44 is maintained very accurately at its desired value. It will be apparent that the variable impedance shunt lossing circuit through the triode 48 is affected by any change in voltage between the conductors 42 and 44, irrespective of whether such change in voltage originates in the rectifier or is caused by a change in the impedance in the load. The circuit is thus effective to smooth out and substantially eliminate the ripple voltage which would otherwise be present in the output of the rectifier.

In a similar manner the variable impedance shunt circuit between the terminal 54 and the conductor 44, which includes the triode 49, is effective to prevent rapid changes in the voltage of the terminal 54. Since the control of the variable impedance shunt circuits is dependent upon a slight change in voltage of the output circuit, it will be evident that the alternating current component in the supply cannot be entirely suppressed. However, by providing the tubes 46 and 47 for amplifying the incipient changes in voltage, the alternating voltages of the supply may be almost completely suppressed.

From the above description of the operation of the system, it will be apparent that the network including the tubes 46 and 48 has its input and output circuits in shunt, and is effective to prevent any rapid change in voltage across the terminals of the input and output circuits. Thus, this network forms a filter which is operative ir-

respective of any phase shift in the voltage or in the current of the supply source. The degree of effectiveness of filtration is determined by the amplification present in the filter network. The amplification may be made of high magnitude by the use of high gain tubes, and thus render the network very effective to counteract, and thus prevent, alternating components of audio or higher frequency in the voltage of the supply.

Since the cathodes of the divider tubes 14, 16, 18, etc. need not have their voltage regulated very closely, the ordinary inductance-capacity filtering mesh shown herein is satisfactory. The current drawn from this mesh is comparatively small so that the cost of the inductances 26 and 28 and condensers C1 is not excessive. If desired, however, a filtering network such as that which includes the tubes 46 and 48 might be provided in place of the inductance 28 and condensers C1.

While I have shown and described a particular form of my invention, it will be apparent to those skilled in the art that the invention may be embodied in numerous other forms, all coming within the scope of my invention as defined by the following claims. I therefore desire by these claims to include within the scope of my invention all such equivalent systems and apparatus whereby substantially the results of my invention may be obtained by substantially the same means.

I claim:

1. In a power supply system for electrical apparatus in which the load impedance is continually changing, a source of direct current having a current output considerably in excess of the requirements of the apparatus, said source having a positive and a negative output terminal connected to the load provided by the apparatus, and a variable impedance lossing network having both its input and its output connected between said terminals, said network including an electron discharge device responsive only to changes in voltage across said terminals and having its output circuit connected to said terminals.

2. The combination set forth in claim 1 in which said network includes an amplifying electron discharge device for controlling the effective plate impedance of said first named electron discharge device.

3. The combination set forth in claim 1 in which said network includes means for increasing the changes in the voltage appearing across said terminals, and means for utilizing the increased voltage changes to control the effective plate impedance of said electron discharge device.

4. The combination set forth in claim 1 in which said network includes a second electron discharge device having a cathode, grid and plate, a condenser connecting said cathode to said positive terminal, a condenser connecting said grid to said negative terminal, and a condenser connecting said plate to the input circuit of said first named electron discharge device.

5. In a power supply system for a variable load, the combination of a pair of terminals for connection to such load, a source of current having undesired fluctuations in voltage and connected directly to said terminals, a variable impedance electron discharge device having its output connected across said terminals, a second electron discharge device for amplifying voltage fluctuations across said terminals, means

for causing the amplified voltage fluctuations to control said variable impedance device, a third electron discharge device having its output circuit shunted across a portion only of said load, and a fourth electron discharge device responsive to variations in voltage across said portion of said load for controlling the operation of said third electron discharge device, thereby to suppress voltage fluctuations across said portion of said load.

6. In electrical apparatus having a large plurality of electric current consuming devices drawing current at different frequencies, means for supplying power for the operation of said devices comprising, a source of direct current having a pair of output conductors supplying current to said devices, and means for compensating for variations in the current drawn from said source for the operation of said devices, said means comprising a shunt network between said conductors, said network including an electron discharge device for controlling the flow of current therethrough, and means responsive to changes in the voltage between said conductors at all frequencies at which said devices draw current for varying the plate impedance of said electron discharge device in a manner such that the current flow through said network will compensate for alternating voltages appearing across said load.

7. In a power supply system for a variable load, the combination of a pair of terminals for connection to such load, a source of current having undesired alternating voltage components connected directly to said terminals, a variable impedance device connected across said terminals, an electron discharge device for amplifying voltage fluctuations across said terminals, and means for causing the amplified voltage fluctuations to control said variable impedance device.

8. The combination set forth in claim 1, in which said source supplies a direct current having alternating current components impressed thereon.

9. In combination, a two terminal source of direct current having an alternating current component superimposed thereon, a pair of conductors, a choke coil connected between one of the terminals of said source and one of said conductors, a load impedance connected across said conductors, an electron discharge device having its output circuit shunting said load impedance, and a second electron discharge device responsive to variations in voltage across said conductors for controlling the operation of said first electron discharge device, thereby to suppress alternating voltages which may appear across said load impedance.

10. In a filtering system, a source of direct current of relatively high impedance, a pair of conductors connected to said source, load resistors connected across said conductors, an electron discharge lossing device connected across said conductors and controlled to conduct current whenever the voltage between said conductors changes in an increasing direction, and a second electron discharge lossing device connected between one of said conductors and a terminal intermediate two of said load resistors and controlled to conduct current when the voltage between said terminal and said conductor changes in an increasing direction.

11. In a filtering system, a source of direct current which may have an alternating com-

ponent, a load, the impedance of which may vary at audio or higher frequency, a pair of conductors directly connecting said source to said load, an electron discharge device having its output connected across said conductors, and means deriving a controlling voltage from said conductors for varying the impedance of said device, thereby effectively to suppress the alternating current components of said source and the alternating current components due to variations in said load.

HERBERT E. MEINEMA.