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R. U. CLARK

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FILTER CIRCUITS

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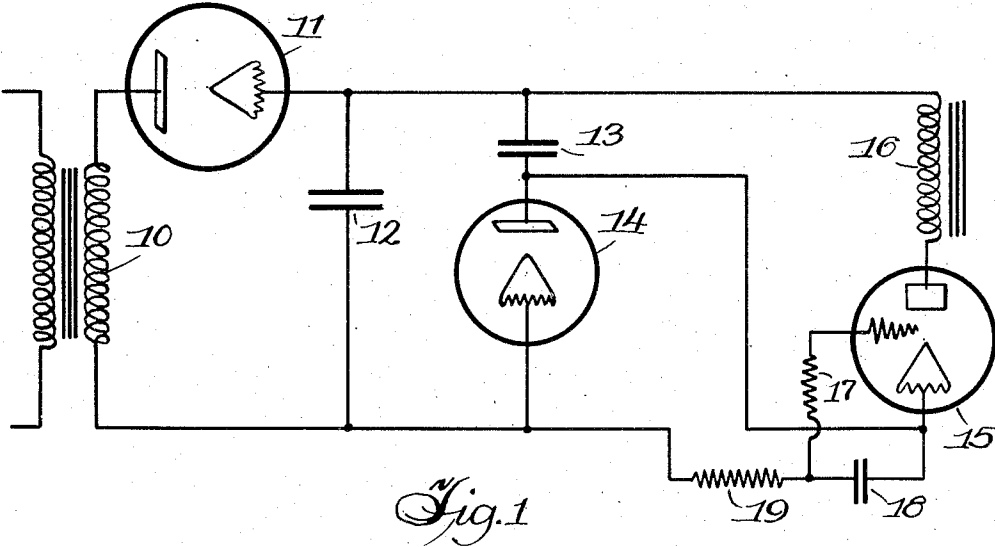
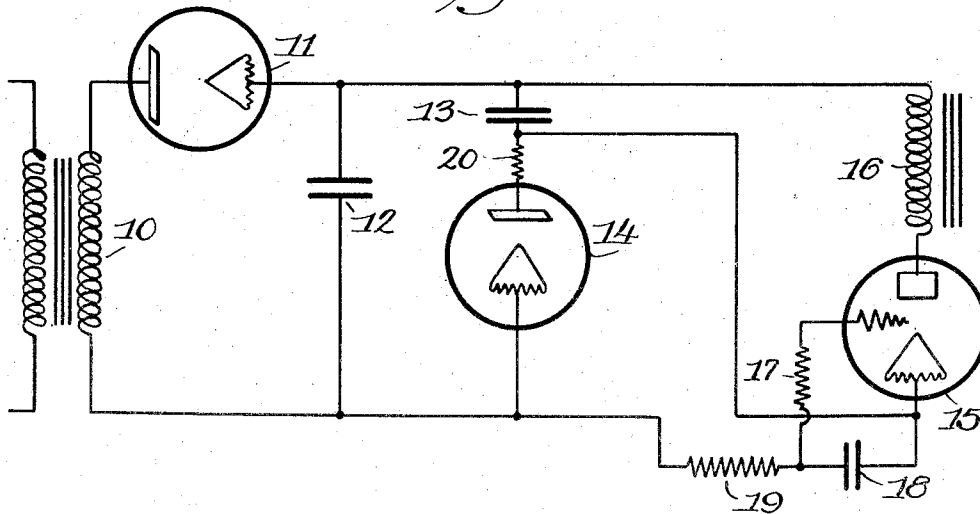


Fig. 2



Witness:  
Chas. E. Koud.

Inventor:  
Richard U. Clark,  
Clarence J. Loftis Atty.

## UNITED STATES PATENT OFFICE

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## FILTER CIRCUITS

Richard U. Clark, Fort Wayne, Ind., assignor, by  
mesne assignments, to The Magnavox Com-  
pany, Incorporated, a corporation of Indiana

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9 Claims. (Cl. 178—44)

One of the longstanding objections of the con-  
ventional radio sets in use has been the pro-  
nounced irritating noise and hum in the repro-  
ducing means set up by the harmonics or little  
humps in the wave of the power supply, to which  
the human ear is most sensitive. It is, therefore,  
the primary object of my invention to solve this  
problem by providing means for killing these  
harmonics and thus prevent such objectionable  
action in the reproducing means.

It is a further object of my invention to pro-  
vide an improved method of attenuating various  
ripple voltages in a rectified A. C. wave or dis-  
torted or pulsating D. C. wave.

A further object of my invention to effectively attenuate the  
higher harmonics of such a wave while still  
maintaining certain desired phase relations of  
such harmonics within the circuit.

It is a further object to provide an electric  
wave filter which eliminates stray magnetic fields  
and mechanical vibrations.

The above and other features, advantages and  
capabilities will become apparent from a detailed  
description of the accompanying drawing in  
which I have illustrated a preferred embodiment  
of my invention.

Fig. 1 is a schematic wiring diagram of a cir-  
cuit embodying my invention, and

Fig. 2 is the same circuit with a modification  
thereof.

In Fig. 1 I show a conventional in-put power  
transformer 10 feeding an electrical rectifier 11  
which is connected in series with one side of the  
out-put of the transformer.

Connected directly across the out-put of the  
rectifier 11 is a filter condenser 12, one side of  
the condenser being connected to the out-put  
terminal of the rectifier and the other side to  
the remaining terminal of the out-put of the  
power transformer. The purpose of this con-  
denser is to greatly cut down the pulsation or  
distortion in this rectified current obtained from  
the rectifier. In other words, reduce the humps  
of the rectified wave.

Connected to the point of the common connec-  
tion between the lead from the rectifier 11 and  
the lead from the condenser 12 there is one ter-  
minal of the condenser 13. The other terminal  
of the condenser 13 is connected to the positive  
in-put terminal of a thermionic device 14. A  
lead from the condenser 13 to the thermionic de-  
vice 14 is connected by a wire to the cathode of a  
power tube or amplifier tube 15. The remaining  
electrode of the thermionic device 14, which in  
effect is the negative electrode, is connected to

the common point in connection of the out-put  
of the transformer 10 and condenser 12. To the  
common connection between the condenser 12  
and 13 I connect one terminal of the primary of  
an amplifier out-put transformer 16. The other  
terminal of this transformer is connected to the  
plate or anode of the power or amplifier tube 15.  
Connected to the grid of the amplifier 15 is a  
grid resistor 17 having a small condenser 18 con-  
nected from its other terminal to the cathode  
connection of the power tube 15. At the point of  
connection between the resistor 17 and small  
condenser 18 is connected a second resistor 19.  
The other terminal of this resistor is in turn  
connected to the cathode of the thermionic filter  
device 14.

The circuit shown in Fig. 2 is identical with  
Fig. 1, save that I have added an element 20  
which may be either in the form of an ohmic  
resistance or R. F. inductance of from 3 to 50  
millihenries. This may be connected as shown  
or preferably in series with the negative or cath-  
ode lead. I have also found an air core induc-  
tance preferable to an iron core.

In the conventional filter circuit heretofore  
used with a second condenser connected across  
the first condenser in series with a choke coil,  
the choke coil is used for the purpose of further  
eliminating or cutting down the ripple or humps  
in the wave to a low volume. This works fairly  
well for cutting down the fundamental frequency  
and first few harmonics but is not effective in  
direct proportion to its inductance in cutting  
down the higher harmonics which might be de-  
scribed as small humps which go to make up the  
large fundamental humps in a wave which give  
it its general form. Moreover, because of the  
fact that the windings of most choke coils have  
a so-called distributive capacity effect upon the  
inductance of the coil, particularly noticed at  
high frequencies, the impedance of the choke  
does not increase in direct proportion with fre-  
quency increase. This is especially true for poorly  
designed choke windings and particularly so for  
random windings. This latter type of winding  
is used in loud speaker field coil construction and  
such speaker fields are used to a very great ex-  
tent in place of the above mentioned choke coils  
in filters of electrical reproducers.

It is also a well known fact that the impedance  
of the conventional iron core choke will not  
increase in direct proportion with frequency  
increase. Also the impedance will vary mate-  
rially with a variation of the direct current in  
the coil. These variables must be allowed for.

It is also known that in certain types of coils, because of the distributive capacity some of the higher frequencies in the distorted wave are allowed to leak through this distributive capacity which acts as a bypass or bridge around the choke and, therefore, these high harmonics are likely to appear across the second condenser which is undesirable since they will be later amplified within the tubes of any radio set or similar device with which this circuit is to be used. These higher frequencies are very pronounced in their effect upon the human ear as evidenced by the objectionable, irritating noise or hum they create in the loud speaker of any radio set with which they may be used.

It is, therefore, extremely important that the harmonics or little humps be eradicated or rendered incapable of setting up these irritating, objectionable characteristics in the speaker.

In the old conventional hookup utilizing a conventional choke coil such circuit in nowise completely solved the problem in overcoming these objectionable features arising as a result of the harmonics or small humps.

More specifically my present invention relates to a final stage wave filter interposed between the conventional preliminary stage wave filter and the amplifying tube when used in connection with radio sets as illustrated in the drawing, and comprises generally in combination a second condenser, a thermionic device having its positive in-pu terminal connected to the second condenser, an amplifying tube having its cathode connected to the second condenser at the point where its electrode connects to the thermionic device, and an operative connection or connections between the amplifier tube grid and the cathode of the thermionic device. When so connected, particularly as shown in Fig. 2, as demonstrated from actual use, the effective passage of the higher harmonics is substantially prevented; they are either flattened out materially or reflected back and prevented, by a neutralizing action described later, from setting up objectionable actions in the reproducing means, such as irritating noise and hum.

One reason for this may be due to the fact that my thermionic device has a very low distributive capacity as compared with the choke coil and for this reason these higher harmonics are confined to the first condenser where they are dissipated or reflected back into the preceding network or elements of the circuit. It is believed that the net effect of these reflected harmonics is to add somewhat to the effective voltage across the first filter condenser. In any event whatever the theory may be I do know from actual use that this hookup provides a rectified out-put voltage of practically ripple free nature in which both the large and small humps are practically totally eliminated, that this voltage is applied to sensitive electrically actuated devices, particularly radio sets, without causing the objectionable features heretofore mentioned, and I further know from actual experience that with my circuit employing my thermionic impedance device that the direct current voltage drop across this member remains constant for a given load which is not the case with the choke coil hookup formerly used. One reason for this may be that the resistance of the winding of the choke coil varies with the temperature and after the choke coil has been in operation under load for several minutes its resistance to the load increases to a point where the direct current drop across the

choke may increase in value by 10 or more percent, as compared with its normal temperature starting value. This objection is overcome in my thermionic device and hookup and does not take place in its operation since the direct current drop is normally dependent on the load.

In my present device I contemplate the use of relatively large condensers as regards capacity.

As a concrete example of what this variation may amount to I have found from actual demonstration that with a given current of 50 milliamperes flowing through the thermionic device the drop across the thermionic device remains constant at 8 volts whereas the drop across the choke coil substantially in the same circuit was found to start at 7.9 volts and after twenty or thirty minutes of operation to have reached a value of 9.1 volts, which in many cases would constitute too wide a range of voltage variation. The fact that this voltage drop across the impedance member, whether it be across an old device or choke coil, or across my thermionic impedance member, is often desired to be used for biasing certain tube parts or elements in a circuit, shows the importance of a device which can effect a stable bias, such as my thermionic device, as distinguished from an unstable bias, such as the prior art.

It will also be found from actual experience that when the voltage drop across my thermionic impedance member is applied to the grid of one or more amplifier or power tubes of a radio circuit, or the like, it gives a more effective balancing out or neutralization of ripple in the amplifier tube or tubes because if the bias voltage above mentioned contains any minute superimposed ripples, such minute ripples are in more nearly correct phase relation to the ripple which appears across the entire output so far as effective neutralization of the amplifier plate ripple is concerned than is the ripple which appears across an impedance member of the choke coil type, formerly used for bias drop.

Where a relatively large value of secondary capacity is connected across the output of the rectifier 11 and condenser 12, which is desirable from an economic standpoint, the resultant A. C. component or ripple across the condenser 12 will be found composed of a fundamental frequency or ripple equal to that of the line frequency and the ripple wave will also be made up of quite a number of harmonics of this frequency in which it has been found that ripple values of appreciable magnitude are had up to at least the tenth harmonic.

In order to greatly attenuate the effect of the higher frequency components of the ripple across element 12 the condenser 13 and thermionic device 14 and high frequency impedance member 20 have been added in series across the output of condenser 12. Due to the peculiar effect of this combination of condenser and thermionic device the effective attenuation of the high frequencies is found to be very great resulting in a nearly ripple free output across the condenser 13 which may be used to supply plate voltage to an amplifier or power tube, such as the tube 15 shown in Fig. 1 and also the drop across the thermionic device 14 may be used, after passing through a conventional grid filter composed of the elements 18 and 19, to bias the grid of the tube 15 negatively in respect to its cathode by the approximate value of the drop across the thermionic device 14. Thus it can be seen that

my device furnishes a properly filtered plate supply for thermionic tubes or the like and also a suitable bias voltage properly phased for use with said thermionic amplifier tubes or for other desired purposes.

Although in the circuit shown in Fig. 1 my bias voltage for the amplifier tube 15 is dependent entirely upon the drop across the thermionic device 14 for its value I have found it desirable to add a small resistance or impedance element 20 shown in Fig. 2 in series with the thermionic device and by choosing the proper value of resistance for this element 20 I am able to regulate the voltage applied to the bias of the power or amplifier tube or grid to any desired value.

With my electrical wave filter attenuation of the wave can be accomplished without involving saturation of the thermionic device.

Since the method by which this bias voltage is applied to the grid through the grid filter 18 and 19 is such as to have a hum-bucking action on the plate voltage, which is also applied to the same amplifier or power tube, it would be advantageous to use as element 20, something that would more effectively balance or buck out the various higher frequency components of the small value of ripple that may appear across the plate cathode circuit of the tube 15.

I have found that when element 20 is composed of a radio frequency choke of from a few to 50 millihenries in value and the desired ohmic resistance that a much more effective neutralization or bucking out of the hum across the plate to the cathode of the tube 15 takes place, therefore, I may incorporate as part of the present invention the use of a radio frequency element in series with my thermionic filter device for the purpose of phasing the voltage to be used for grid bias or any other similar purpose.

Although not shown in the present drawing it is very obvious that the position of the thermionic device may be changed in my filter circuit without materially changing its efficiency, as for instance, when it is desired to connect this device in the positive leg of the filter as might be the case were it connected in series with the positive sides of the two filter condensers 12 and 13 in the same position as would be normally occupied by a filter choke in a conventional filter. It is obvious that the device must be connected in such a direction that the flow of direct current is not blocked.

Where a filter circuit such as I have invented is applied directly to the conventional 110 volt D. C. supply or similar electric lighting main which may be supplied from a direct current generator or the like it will also be effective in the same general manner as previously described. The reason for this is that direct current as generally supplied by practically all service or substations usually has superimposed on it a percentage of ripple or noise frequencies which may be occasioned by commutation ripple in the generator or various other equally well known causes. Since it is common practice in certain types of circuits to use a rectifier directly connected to the line for obtaining a constant direct current for operating radio sets whether the supply line be direct or alternating current it will be evident that it will be advantageous to use my system whether the supply source be A. C. or D. C. and directly connected to the line if desired.

Having thus described my invention—I claim:

1. An electrical final stage wave filter adapted

for use in connection with a radio set comprising in combination, a condenser, a thermionic device in series with said condenser and said condenser and thermionic device shunting a direct current power supply, said thermionic device having its positive input terminal connected to said condenser, an amplifier tube having its cathode connected to said condenser at the point where its electrode connects to the thermionic device and an operative connection between the grid of the amplifier tube and the cathode of the thermionic device to prevent the passing of the higher harmonics into the amplifier or power output tubes for the purpose set forth.

2. In a radio set having a preliminary stage wave filter and an amplifying tube, a final stage wave filter interposed between the preliminary stage filter and amplifying tube, said final stage wave filter comprising in series combination a condenser and a thermionic device having its positive input terminal connected to said condenser, the amplifying tube having its cathode connected to said condenser at the point where the electrode is connected to the thermionic device and an operative connection between the grid of the amplifying tube and the cathode of the thermionic device to prevent the passing of the higher harmonics into the amplifier or power output tubes for the purpose set forth.

3. An electrical wave filter comprising in combination, a condenser, an inductance from 3 to 50 millihenries in series with a rectifier, all connected in a single series across the output of a unidirectional power supply to attenuate the ripple therein and to maintain the phase of the remaining output ripple substantially in phase relation with the input.

4. An electrical wave filter comprising in combination a condenser, an air core inductance in series with a rectifier, all connected in a single series across the output of a unidirectional power supply to attenuate the ripple therein and to maintain the phase of the remaining output ripple substantially in phase relation with the input.

5. An electrical wave filter comprising in combination a condenser, an air core inductance in series with a rectifier, all connected in series with each other and as a series across the output of a unidirectional power supply to attenuate the ripple therein and to maintain the phase of the remaining output ripple substantially in phase relation with the input for supplying plate power and grid bias voltage for electronic and ionic vacuum tubes.

6. An electrical final stage wave filter comprising in combination a condenser of relatively large capacity in series with the positive lead of the current supply being filtered, a thermionic device for attenuating the wave harmonics to a degree greater than the fundamental of said wave, without involving saturation in said thermionic device.

7. An electrical final stage wave filter comprising in combination a condenser of relatively large capacity in series with the positive lead of the current supply being filtered, a thermionic device for attenuating the wave harmonics to a degree greater than the fundamental of said wave and without material change in the phase of said wave components.

8. An electrical final stage wave filter comprising in combination a condenser of relatively large capacity in series with the positive lead of the current supply being filtered, a thermionic device

arranged in combination for attenuating the wave harmonics to a greater degree than the fundamental of said waves and for forming a direct current output across the condenser substantially free of ripple, said thermionic device being  
5 operated without saturation.

9. An electrical wave filter comprising in combination a condenser of relatively large capacity in series with the positive lead of the current sup-

ply being filtered, a thermionic device for attenuating the wave harmonics to a degree greater than the fundamental of said wave and without material change in the phase of said wave components and means for supplying a substantially  
5 ripple free output of direct current across the condenser.

RICHARD U. CLARK.