

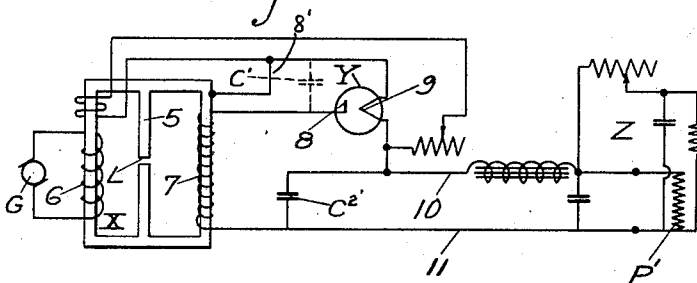
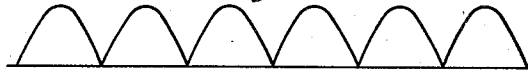
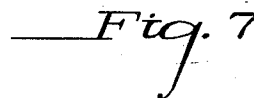
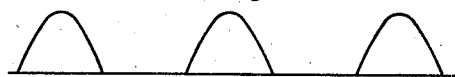
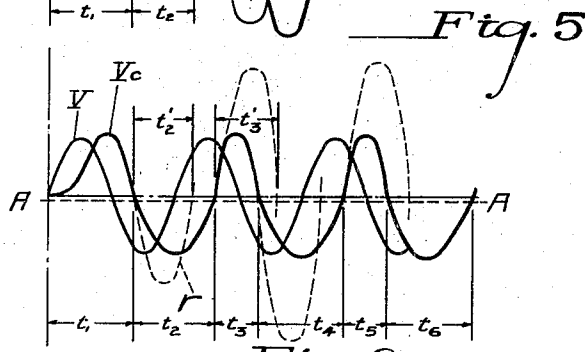
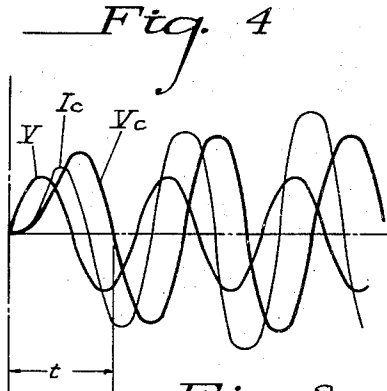
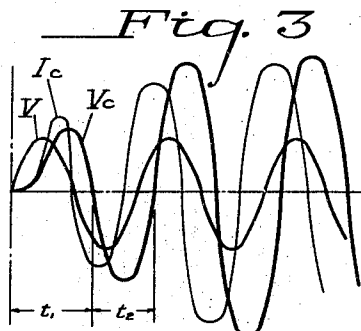
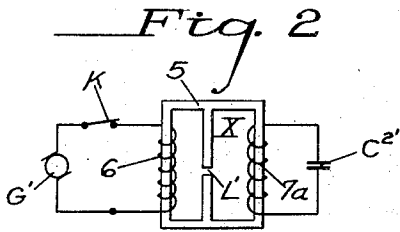
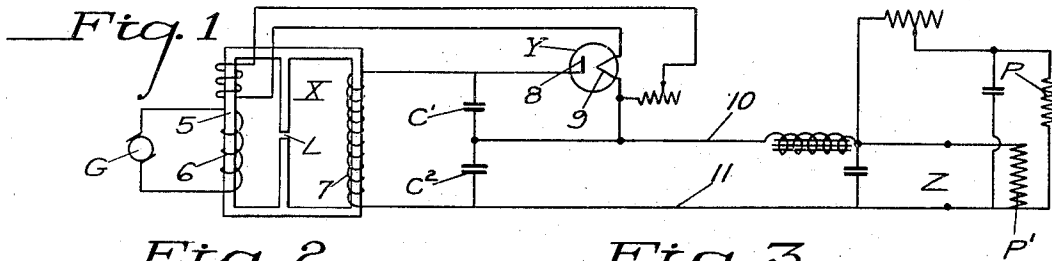
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RECTIFICATION OF ALTERNATING CURRENTS

Filed Nov. 13, 1924



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RECTIFICATION OF ALTERNATING CURRENTS.

Application filed November 13, 1924. Serial No. 749,661.

This invention relates to the rectification of alternating currents, and particularly to the rectification of such currents as to produce a substantially constant direct current, capable of use, for instance, in the plate circuit of a vacuum tube.

The primary object of the invention is to provide a rectifier permitting of the use of houselighting currents in the plate circuit of a vacuum tube radio set, particularly receiving sets, whereby the usual plate or "B" battery may be dispensed with.

A further object of the invention is to provide a method and means of rectification of alternating currents wherein the resulting direct current is substantially constant.

A further object of the invention is to increase the rectifying period of a one way rectifier, and thereby obtain efficiency greater than heretofore attainable with one way rectifiers. Furthermore, due to the longer rectifying period, the operation of the rectifier is more nearly constant, and the hum due to current changes more easily eliminated.

A further object of the invention is to establish a resonant circuit including a rectifier, and to shift the phase of the current in the resonating circuit from one point to another with respect to the supply current with each reversal of current flow in the supply circuit.

A further object of the invention is to use a rectifier for automatically varying the capacity of a resonating circuit.

To this end, the invention consists, generally, in establishing a capacity coupling across a rectifier, i. e., in parallel with the rectifier, and to couple this capacity and rectifier in series with a second capacity. The resulting operation, as well as other objects and advantages, may be more readily understood and appreciated by reference to the accompanying drawings, in which:

Fig. 1 is a circuit diagram, illustrating an embodiment of the invention;

Fig. 2 is a diagrammatic circuit, not embodying the invention, but provided for the purpose of developing the principle of the invention, illustrating a resonant circuit;

Fig. 3 is a diagram illustrating the effect of operating the circuit of Fig. 2 below resonance frequency;

Fig. 4 is a similar diagram, illustrating the effect of operating the circuit of Fig. 2 above resonance frequency;

Fig. 5 is a view similar to Figs. 3 and 4,

illustrating the wave effects of the circuit of Figs. 1 and 9;

Figs. 6, 7 and 8 are diagrams illustrating rectifying periods of usual one-way rectifiers, usual two-way rectifiers, and my invention utilizing a one-way rectifier, respectively;

Fig. 9 is a diagram similar to Fig. 1, showing a slight practical modification.

Referring to Fig. 1 of the drawings, X designates a transformer, Y a suitable rectifier, and Z is a filtering circuit.

The transformer has a core 5 on which is a primary winding 6 and a secondary winding 7. At L in the core is a leak. The primary 6 may be connected in an alternating current circuit G, such as the usual house-lighting circuit.

One side of the secondary 7 is connected to one electrode 8 of the rectifier Y, which is shown as consisting of a hot cathode tube, but the invention is not restricted to use with any one particular type of rectifier. The other electrode 9 of the rectifier is connected with one side 10 of any preferred or standard filter circuit Z, which may include a choke and suitable condensers, and the load circuits P and P', the other side of the filter circuit connecting through wire 11 with the other end of the secondary.

In parallel with or shunted across the rectifier, is a capacity, such as condenser C'. In series with the rectifier and condenser C' is a second condenser C². The circuit including the secondary 7 of the transformer, the rectifier and capacity C' in parallel, and the condenser C² form a resonating circuit. The condenser C², while being in series with capacity C', is connected across the load circuit. The provision of the leak L in the transformer, from a practical standpoint, is necessary to accomplish resonance in the circuit.

This is the general nature of the invention. Its operation may be best understood by reference, first, to Fig. 2, showing a simple resonating circuit embodying a transformer having the core leak L', the secondary 7', and condenser C²'. When switch K in the alternating primary circuit G' is closed, the current and voltage will, if the capacity C²' is such that the circuit will operate below resonance frequency, pass through the variations graphically illustrated in Fig. 3. In this figure, V represents the supply voltage, V_c the condenser voltage, and I_c the condenser current. Space t' indicates the period

of time through which the condenser is charging. It will be seen that, in this figure, curve I_c always crosses the median in advance of line V . In Fig. 4, I have illustrated the effect of varying the capacity C^2 , so that the frequency in the resonant circuit is higher than the resonance frequency. The same symbols designate corresponding curves. By comparison, it will be seen that t in Fig. 4 is longer than in Fig. 3, and that line I_c crosses the median after line V . The principle of our invention may now be understood. According to its theory, we vary the capacity in the resonant circuit during the operative period of the rectifier, from the condition shown in Fig. 3 to the condition shown in Fig. 4, thereby lengthening the rectifying period. Then, at the end of the rectifying period, the capacity of the resonant circuit is changed to bring about the conditions existing in Fig. 3.

Referring now to Fig. 1, it will be seen that during the idle period of the rectifier, condensers C' and C^2 are in series. During the active period of the rectifier, the condenser C' is partially short circuited by the rectifier. There is, consequently, more capacity in the resonance circuit during the active period of the rectifier than during its inactive period, inasmuch as one condenser has a greater capacity than two condensers in series.

We thus utilize the rectifier to automatically modify the capacity of the resonant circuit. In so doing, we may vary the circuit conditions from that illustrated in Fig. 3 to that illustrated in Fig. 4, and vice versa. We thereby increase the rectifying period and shorten the period during which the rectifier is not functioning. The resulting current variations are illustrated in Fig. 5, wherein the symbols are identical with those used in Figs. 3 and 4.

Referring to Fig. 5, the following operation would take place. During the first charging period the rectifier is inoperative and V_c is, according to Fig. 3. If this condition persisted, then $t^{2'}$ would be according to dotted line r . But the rectifier shunts the condenser, partially short circuiting it. Therefore, the condition of Fig. 4 takes place, and the time of charging the condenser t^2 is longer than $t^{2'}$. At the end of t^2 , the rectifier becomes inoperative, and, instead of $t^{3'}$ (dotted line), the condition of Fig. 3 takes place and the time t^3 is smaller than $t^{3'}$. It will thus be seen that periods t^2 , t^4 and t^6 will always be longer than periods $t^{3'}$, $t^{5'}$, etc.

The result is that the rectifier is much more constant than the usual type of rectifier and the hum due to current changes can thus be more easily eliminated.

The effect of the load resistance, such as a detector and amplifier tubes, and designated as P and P' , is to act as a partial shunt on C^2 , but this shunt is operating always and, due to the filtering circuits, the current drawn

from C^2 has a constant value. Hence, the effect of the load is merely to drop the base line in Fig. 5 to the position indicated by the heavy dotted line $A-A$, without materially affecting the length of the operative periods of the rectifier.

Figs. 6, 7 and 8 illustrate the wave forms or rectifier periods of the usual one-way rectifier, the usual two-way rectifier, and our present rectifier, respectively. It will be seen from these figures how much more nearly our invention approaches the constant of the two-way rectifier than the usual one-way rectifier.

In Fig. 9, we have illustrated a practical embodiment of the invention, wherein the condenser C' is omitted, and one electrode of the rectifier is grounded on the core of the transformer by wire $8'$. The same effect is then obtained between the core of the transformer and the secondary winding, as where a separate condenser C' is used. Otherwise, Figs. 1 and 9 are identical. In Fig. 9, we have dotted in a condenser to indicate that there is a capacity coupling across the electrodes of the rectifier.

Various changes and circuit modifications may be made in the circuits and apparatus utilizing the principles of our invention as herein set forth within the contemplation of the invention and under the scope of the appended claims.

We claim as our invention:

1. Means for effecting the rectification of alternating currents including a resonant circuit in which there is a rectifier, a capacity in parallel with the rectifier, and a capacity in series with the rectifier and said first mentioned capacity.
2. Means for effecting the rectification of alternating currents including a transformer having primary and secondary windings, a rectifier in circuit with the secondary, a capacity shunted across the rectifier, a capacity in series with the first capacity and the rectifier and a filter circuit shunted across said second capacity.
3. Means for effecting the rectification of alternating currents including a transformer having a core and primary and secondary windings, the core having a leak between said primary and secondary windings, a resonant circuit in which the secondary is included, and a rectifier and capacity connected in parallel included in the resonant circuit.
4. The method of rectifying alternating currents with a one-way rectifier consisting in increasing the rectifying period for the rectifier beyond one half cycle phase period of the supply current and decreasing the non-rectifying period of the rectifier below the other half cycle phase period of the supply current.
5. The method of rectifying alternating currents consisting in establishing a resonant

circuit for the rectifier and varying the capacity of said circuit by means of the rectifier to increase the rectifying period beyond a half cycle of the supply current and decrease the idle period of the rectifier for each half cycle of the supply current.

6. The combination with a rectifier having input and output electrodes, of an inductance connected across the input, a pair of condensers connected in series across the in-

ductance, a connection between the two condensers and one of the electrodes of the rectifier, a filter circuit connected with one side of the inductance and one of the electrodes, and means for impressing a voltage on the inductance.

In testimony whereof we hereunto affix our signatures.

THEODORE A. WILLARD.

FREDERICK S. McCULLOUGH.