Oct. 6, 1936. C. TRAVIS 2,056,376

VOLTAGE MULTIPLIER

Filed April 26, 1933

Fig. 1

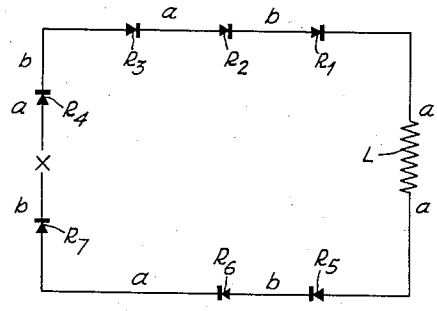


Fig. 2

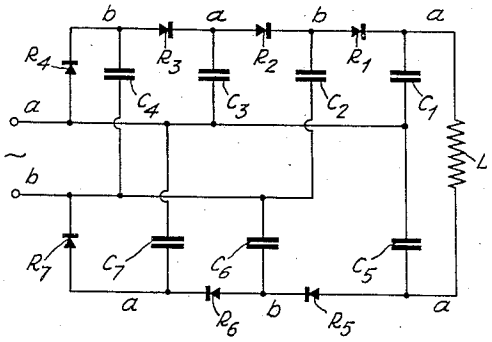


Fig. 3

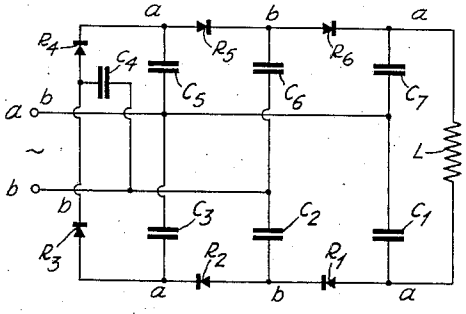


Fig. 4

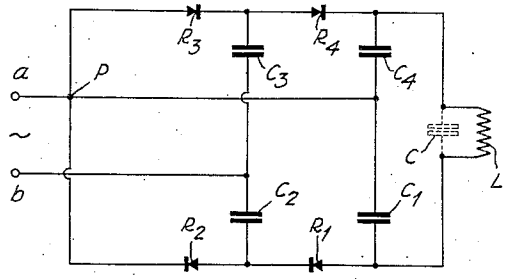
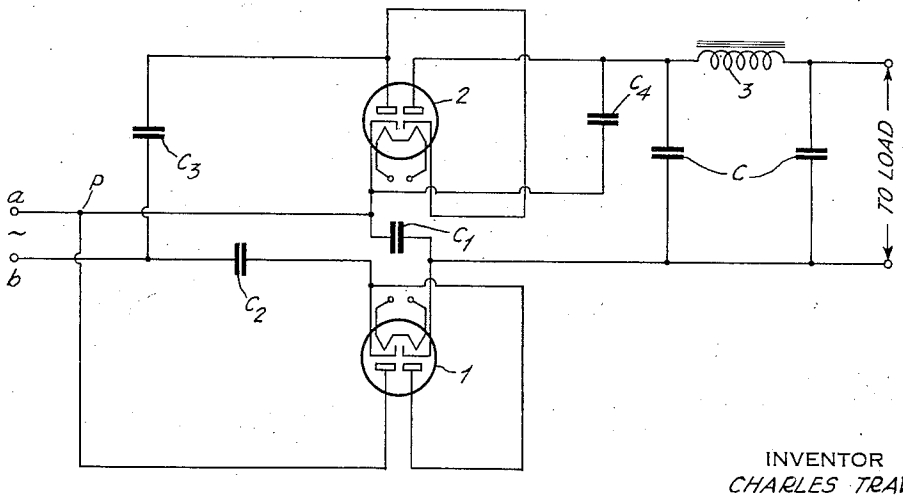


Fig. 5



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VOLTAGE MULTIPLIER

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12 Claims. (Cl. 175—363)

The present invention relates generally to voltage multipliers and more particularly to so-called transformerless voltage multipliers and rectifiers.

It is an object of the present invention to disclose a broad method of setting up voltage multiplier circuits especially for use in power supply circuits of radio receivers and the like possessing certain desirable heretofore unattained characteristics.

Specific objects of the present invention will unfold themselves in the following detailed specification when read in conjunction with the accompanying drawing.

It is well known in the art that any number of diodes may be connected in series with a load and separately excited with alternating current. The resulting direct current load voltage will be the sum of the individual voltages generated by the several rectifiers, and the same direct current will flow through all the rectifiers. Tests have indicated that the particular D. C. voltage developed across any particular rectifier or diode is to a large extent dependent upon the size of the condenser through which the alternating current is fed to the rectifier. For systems such as now known to the art reference is made to the publication "Electronics" of February 1932, pages 50 and 51. In particular attention is called to Fig. 5, page 51 of said publication wherein there is shown what is known as a voltage quadrupler. It is obvious at once that in the system shown by said Fig. 5 the load has the 110 A. C. across it through a pair of condensers C_3, C_4 in series. Thus if a large smoothing condenser is placed across the load, the line is more or less short-circuited as are likewise the rectifiers R_1 and R_4, hence, the filter would have to be of the choke first type as shown in said figure which is not a desirable arrangement.

The present invention is primarily directed toward devising a circuit arrangement and method of feeding the A. C. into the rectifiers in such a way that the A. C. does not come across the load with the result that conventional filter circuits may be utilized.

Reference is now directed to the appended drawing wherein:—

Fig. 1 is a schematic diagram utilized to explain certain features of the invention in connection with an odd number of rectifiers in series;

Fig. 2 is a more complete diagram of the system shown in Fig. 1;

Fig. 3 illustrates the invention applied to a system utilizing an even number of rectifiers;

Fig. 4 shows in diagrammatic form a voltage quadrupler connected in accordance with the invention; and,

Fig. 5 illustrates a voltage quadrupler utilizing a particular type of rectifier tube.

Reference will now be had to Fig. 1 wherein a load L is shown connected in a circuit with seven rectifiers R_1—R_7. In order to prevent the load being connected across the A. C. source both sides of the load must be at the same phase. The two phases are herein designated for convenience as phase *a* and phase *b*. For example, the two ends of the load are designated to be at phase *a*. The rectifiers must, of course, form a series chain with the load, and the problem is then to find how the rectifiers may be excited while observing the foregoing condition, namely, having both ends of the load at the same phase. With an odd number of rectifiers as shown in Figs. 1 and 2, and starting with the two ends of the load at phase *a* it is seen that poling the rectifiers alternately since the A. C. source must be connected across each rectifier R_1—R_7 it is found that somewhere in the chain an *a* pole comes immediately adjacent to a *b* pole owing to the fact that there are an odd number of rectifiers. In Fig. 1 this is shown as occurring at point *x* and the A. C. source is inserted here to preserve the proper alternation of polarities as shown in Fig. 2. It follows then that with an odd number of rectifiers the A. C. source on line must be in series with the rectifiers and load and the D. C. must flow through the line if A. C. across the load is to be avoided. In Fig. 2 each rectifier R_1—R_7 is fed through a condenser feed branch the condensers of which are preferably of the electrolytic type and are indicated as C_1—C_7 in the drawing.

For the case where an even number of rectifiers are employed reference to Fig. 3 is made. In said figure an even number of rectifiers R_1—R_6 are connected in series with a load L. Starting as before with the two ends of the load L in the same phase (*a* for convenience) it is seen that the *a* and *b* poles alternate completely around the chain, hence, the A. C. line or source cannot be in series with the chain of rectifiers and fulfill the aforementioned conditions, namely, the avoidance of the A. C. line across the load. In accordance with the invention the A. C. source in the case of an even number of rectifiers is shunted through condensers across each rectifier while the D. C. path does not include the source. In Fig. 3 the A. C. source is connected across R_1 through condensers C_2 and C_1; rectifier R_2 through C_3 and C_2; R_3 through C_3 and C_4; R_4 through C_4 and C_5; R_5 through C_5, C_6; and, R_6 through C_6 and C_7.

The D. C. path comprises rectifiers R_1—R_6 and load L.

It is obvious from the showing in Fig. 3 that condenser C_4 may be omitted and a direct connection made to the *b* line without interfering with the operation of the system, however, for evident reasons such as undetermined grounded lines in the A. C. system it is best to provide the condenser C_4.

It is seen from what has so far been described that with an odd number of rectifiers the D. C. path may include the A. C. source while for an even number of rectifiers the D. C. path does not include the A. C. source. By following this rule the A. C. is never connected across the load directly and furthermore a filter of the usual condenser first type may be employed.

In Fig. 4 a voltage quadrupler is shown as comprising four rectifiers R_1—R_4 forming a D. C. chain with a load L. Since there are an even number of rectifiers the A. C. source cannot be connected in the D. C. chain, hence, the A. C. source is connected across the various rectifiers through condenser branch circuits. It should be noted that the terminal *a* of the A. C. line is connected directly to the rectifier-load chain at the point P. It is to be understood, however, that connection through a condenser is the better practice for the reasons pointed out previously in connection with the description of condenser C_4 of Fig. 3.

In the system of Fig. 4 a filter condenser C may be inserted directly across the load without danger of short circuiting the A. C. source.

In Figure 5 two double space path tubes 1 and 2 have been substituted for the four rectifiers R_1—R_4 of Fig. 4. The two circuits are otherwise alike except that a well known type of filter arrangement has been shown interposed between the voltage multiplier and the load. This filter circuit comprises filter capacities C and choke 3.

In the various circuits shown I prefer to use electrolytic condensers although other type of condensers may be substituted.

In the cases where the A. C. source or line is inserted in series with the chain as where an odd number of rectifiers is present it is to be understood that the D. C. passes through the A. C. source. This presupposes a D. C. path through the A. C. lines. If such a path is not present it must of course be provided by suitable means.

I claim:

1. In a voltage multiplier circuit a source of alternating current, a load circuit, a rectifier assembly comprising an even number of rectifiers, said number being greater than two, said load and rectifiers being connected so as to form a series circuit, means for exciting each of said rectifiers with alternating current comprising capacitive branch circuits for connecting each rectifier across said source of alternating current, said branch circuits being connected with respect to the load so that both ends of the load are, in effect, connected to the same terminal of the alternating current source whereby both ends of the load are maintained at substantially the same alternating current potential with respect to the alternating current source.

2. A voltage multiplier circuit comprising a direct current closed path including an even number of rectifiers greater than two and a load circuit in series, a source of alternating current, means for connecting one terminal of said source to both ends of the load circuit whereby both ends of the load are at the same alternating current potential and capacitive paths for connecting each of said rectifiers across the source of alternating current.

3. In a voltage multiplier circuit adapted to be connected between a source of alternating current and a load circuit, a uni-directional direct current closed circuit comprising an even number of rectifiers greater than two and said source in series, means for connecting each of said rectifiers across said source of alternating current including at least one capacitive element and means for maintaining both ends of said load at the same alternating current potential comprising connections from both ends of the load to only one terminal of the alternating current source.

4. In a voltage multiplier circuit of the type comprising a plurality of rectifiers, the number thereof being an even number greater than two forming a closed D. C. series circuit including the load, the method of energizing the rectifiers with alternating current which comprises impressing the alternating current across each rectifier separately while maintaining both ends of the load at the same A. C. source voltage.

5. A voltage quadrupler circuit comprising four rectifiers connected in series with a load circuit, said rectifiers and load forming a closed unidirectional direct-current path, a source of alternating current, means for connecting each of said rectifiers across said source, said means including at least one condenser, means for connecting both ends of said load circuit to only one side of said alternating current source, the connection of said source side to each end of the load including at least one condenser, and a filter condenser shunted directly across the load circuit.

6. A circuit arrangement according to claim 5 wherein the rectifiers comprise thermionic paths arranged in pairs, each pair thereof being enclosed within an envelope.

7. In combination, an alternating current source including two line conductors, a load circuit, a rectifier assembly comprising a plurality of rectifiers connected in series with the load, means for separately exciting each of said rectifiers comprising a plurality of circuits each including at least one capacitive element for connecting each of the rectifiers across the source, the capacitive elements of all of said means being arranged in two sets, the elements in each set being in multiple, one of said sets being connected to one of said conductors while the other set is connected to the other conductor.

8. The combination with an alternating current source including two terminals of a load circuit and a rectifier assembly, said rectifier assembly comprising a plurality of rectifiers all connected in series with the load, means for separately exciting each of said rectifiers comprising a plurality of circuits each thereof including at least one capacitive element for connecting each of said rectifiers across the source, the capacitive elements of all said means being arranged in two sets, one set being connected to one of said terminals and the other set being connected to the other of said terminals, the elements of each set being star connected with respect to their respective terminal.

9. In a voltage multiplier circuit, a rectifier assembly comprising an even number of rectifiers greater than two and a load, said rectifiers and load forming a series closed circuit, a source of exciting current for said rectifiers including two line conductors, capacitive connections between

one of said line conductors and alternate junction points of successive rectifiers in said series circuit, capacitive connections between the other line conductor and the junction points in said series circuit of successive rectifiers not connected to the first named line conductor, the capacitive connection between the line conductor and the junction point of the two successive rectifiers having the load circuit between them, including capacitive connections from said line conductor to both sides of the load.

10. In a voltage multiplier circuit, a rectifier assembly comprising an even number of rectifiers greater than two and a load circuit, said rectifiers and load circuit being connected so as to form a series closed circuit, a source of exciting current for said rectifiers including two line conductors, connections between one of said line conductors and alternate junction points of successive rectifiers in said series circuit, connections between the other line conductor and the junction points in said series circuit of successive rectifiers not already connected to the first named line conductor, at least all but one of said connections being made through a capacitive element, the connection between the line conductor and the junction point of those two successive rectifiers having the load circuit between them, including connections from said line conductor to both sides of the load.

11. In a voltage multiplier circuit a rectifier assembly comprising an even number of rectifiers, said number being greater than two, and a load circuit, said rectifiers and the load circuit being connected together so as to form a series closed circuit, a source of alternating current for exciting said rectifiers including two line conductors, connections between one of said line conductors and alternate junction points of successive rectifiers in said series circuit, connections between the other line conductor and the junction points of successive rectifiers in said series circuit not already connected to the first named line conductor, at least all but one of said connections being made through a capacitive element, the connection between the line conductor and the junction point of those two successive rectifiers having the load circuit connected between them comprising capacitive connections from said line conductor to both sides of the load circuit whereby both ends of the load circuit are maintained at the same alternating current potential.

12. A voltage quadrupler circuit comprising four rectifiers connected in series with a load circuit, said rectifiers and load circuit forming a closed uni-directional direct current path, a source of alternating current, means for connecting each of said rectifiers across the source of alternating current, said means including at least one condenser, means for connecting both ends of said load circuit to only one side of said alternating current source to thereby maintain both ends of the load at the same alternating current potential, the connection of said source side to each end of the load including at least one condenser.

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