March 8, 1949. W. G. BIRD 2,463,509

VOLTAGE DOUBLER CIRCUITS

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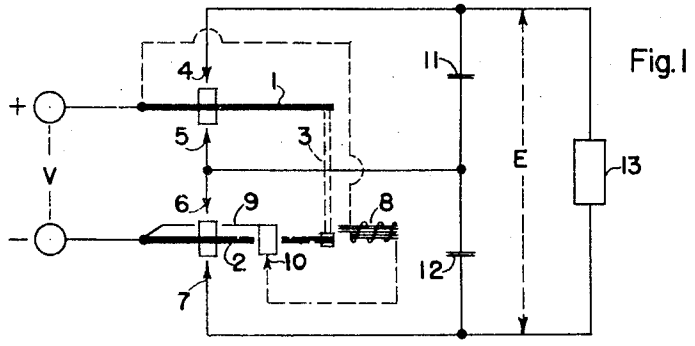


Fig. 1

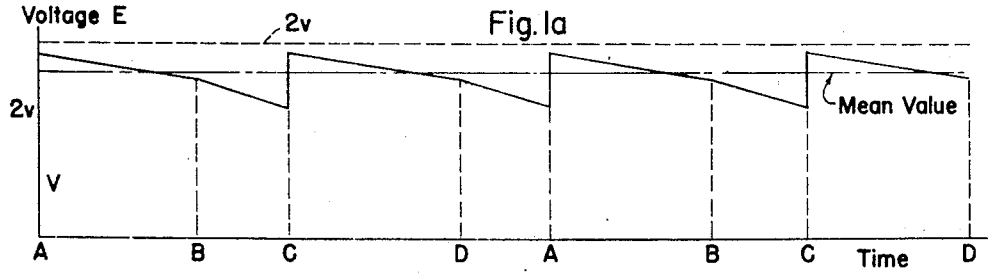
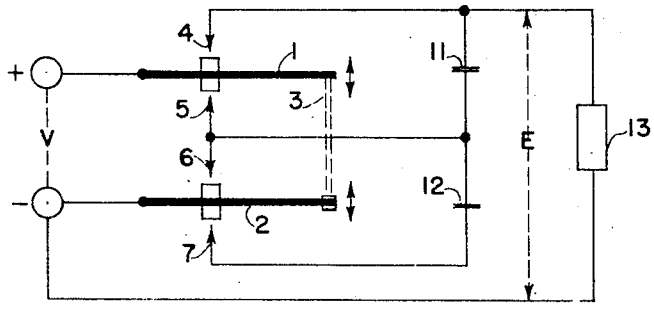


Fig. 1a

Fig. 2



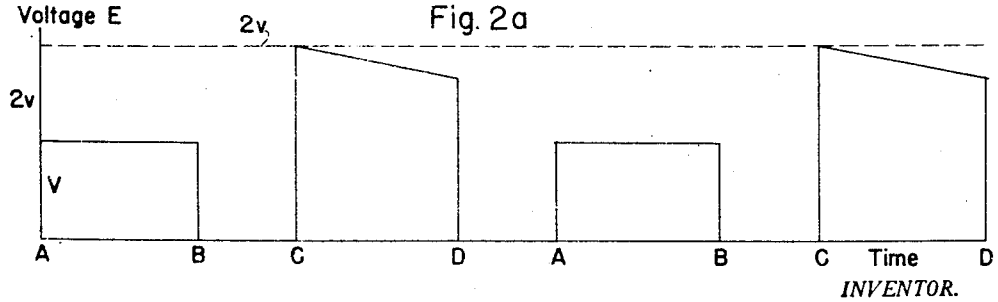


Fig. 2a

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Fig. 3

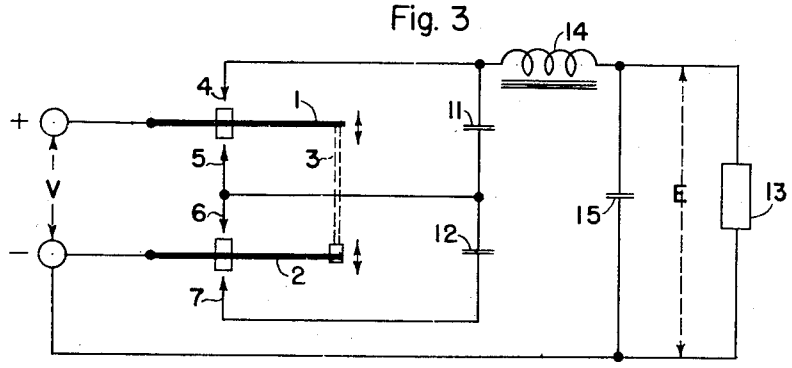


Fig. 3a

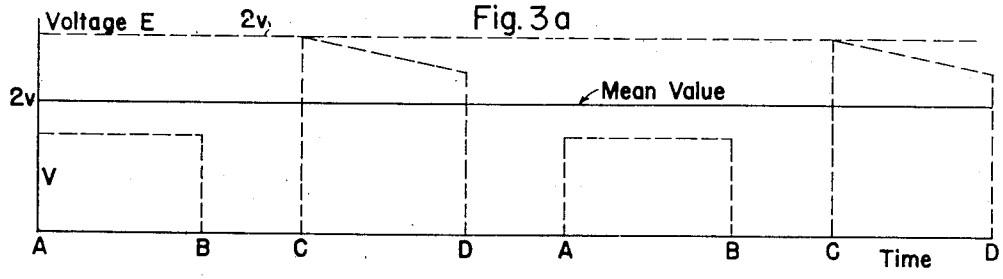


Fig. 4

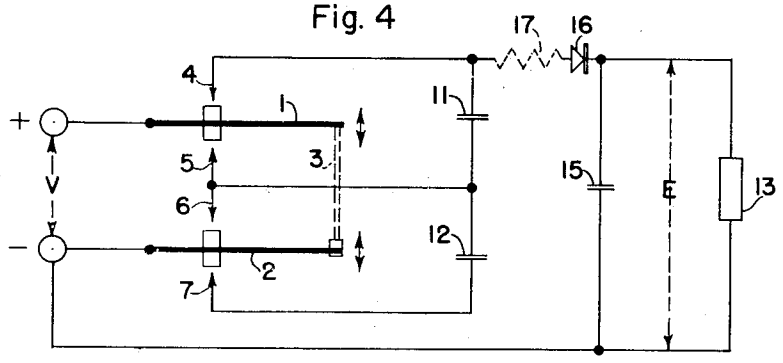
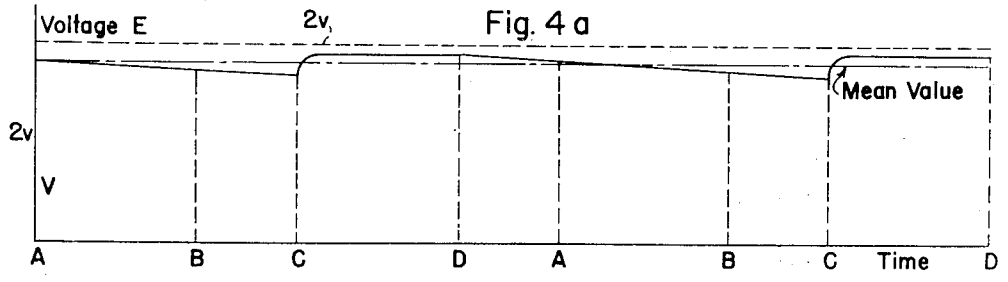


Fig. 4a



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VOLTAGE DOUBLER CIRCUITS

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3 Claims. (Cl. 320—1)

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This invention relates to voltage doubler circuits of the type using a double vibrator. A well-known type of double vibrator makes use of two reeds mechanically coupled together by an armature bar of an electro-magnet which is energized periodically from the mains by reason of the provision with one of the reeds of a relatively displaceable contact which by reason of the influence of the electro-magnet on said bar is displaced to break electrical contact with a lead forming part of the circuit in the electric-magnet, resulting in the armature reestablishing the contact to produce another impulse to maintain the armature and its associated reeds in vibration at a frequency depending upon the stiffness of the reeds and the relation of their masses to that of the armature.

It is well known that such a double vibrator can be utilized to develop from a direct current source of voltage of known value a voltage approximately equal to twice that value without the necessity of using transformers, large rectifiers or their equivalent. However, this result does not always obtain. For example, when the appropriate load is effectively common with one side of the mains, e. g. when it is desired to apply voltages to the anode of a directly heated valve, the filament of which is ultimately connected to direct current mains either directly or through resistance, the voltage across the load becomes a very widely fluctuating one, in spite of the use of a conventional smoothing choke and a by-pass condenser. The object of the present invention is to overcome this disability, this desideratum being achieved by employing in a suitable part of the circuit a rectifier in place of the aforesaid choke or resistance.

The invention will be more clearly understood by reference to the accompanying drawings in which—

Figure 1 shows a circuit appropriate to a known type of double vibrator;

Figure 1*a* shows the voltage changes which occur with the circuits shown in Figure 1;

Figure 2 shows a circuit in which one side of the load is effectively common with one side of the main;

Figure 2*a* is a diagram showing the voltages appearing across the load in employing the circuit shown in Figure 2;

Figure 3 shows a modification of the circuit shown in Figure 2 in which use is made of a conventional smoothing choke and a by-pass condenser;

Figure 3*a* is a diagram showing the voltages

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appearing across the load with the circuit proposed in Figure 3;

Figure 4 is a diagram showing one embodiment of the present invention; and

Figure 4*a* is a diagram of the voltage cycle appropriate to the circuit shown in Figure 4.

Referring to the drawings in Figure 1 is shown diagrammatically the circuit appropriate to a "double" vibrator of known type, in which the vibrator comprises two reeds 1 and 2, mechanically coupled together by a rigid bar 3 so as to vibrate in synchronism. Pairs of contacts 4, 5 and 6, 7 cooperate with the two reeds 1 and 2 respectively, and their positioning is such that when the two reeds are displaced together in one arc of swing, reed 1 touches contact 4 at practically the same time as when reed 2 touches contact 6, and similarly with contacts 5 and 7 on the other arc of swing.

The system is maintained in vibration by making the connecting bar 3 of soft iron and placing it adjacent to an electro-magnet 8, which is energized periodically from the mains through a contact 10 cooperating with a split portion 9 of the reed 2. Thus if a voltage V from the mains be applied to the two reeds in the manner shown, there will, on switching on, be a magnetic impulse tending to pull the bar 3 to one side, so breaking electrical contact between 9 and 10. Thereupon the armature flies back until contact is remade and another impulse given, so maintaining the armature and its associated reeds in vibration at a frequency depending upon the stiffness of the reeds and their masses with that of the armature.

It is well-known that such a "double" vibrator can be utilized to develop from a direct current source of voltage V, a direct current voltage approximately equal to 2V without the necessity of using transformers, large rectifiers, or their equivalent. This is done in the circuit depicted in Figure 1, where 11 represents a suitable condenser across contacts 4 and 5, and 12 a similar condenser across contacts 6 and 7. The load to which it is desired to apply this double voltage is represented by 13. With this circuit it is apparent that the condensers 11 and 12 are alternately coupled directly to the mains supply V and therefore very quickly charge up each to a voltage V, so that the total voltage E across the two would, in the absence of any load, be equal to 2V.

However, when there is a load present, the voltage E changes in an obvious manner somewhat as depicted in Figure 1*a*, if the beginning

of the cycle A be taken to coincide with the time at which the reeds have just touched contacts 4 and 6 respectively. In this diagram the periods BC and DA correspond to those periods when the reeds are touching neither contact and are roughly in the middle of their swing, so that the leakage from the condensers 11 and 12 is somewhat increased during these periods, as shown.

It follows that the mean value of E actually appearing across the load will be somewhat less than 2V by an amount depending upon the sizes of the condensers 11 and 12 in comparison with the load 13, and also that there will be a slight "ripple" on E; this latter, however, can be eliminated if desired in the usual way by employing suitable chokes or resistances and by-passing condensers.

A more serious trouble arises, however, when one side of the load 13 is effectively common with one side of the mains, as depicted in Figure 2. Such a case arises, for example, when it is desired to apply the voltage E to the anode of a directly heated valve, the filament of which is ultimately connected to the direct current mains even if through resistances. In this case it is easy to see, by following out a cycle of events, that the voltages E appearing across the load are as represented in Figure 2*a*. Thus, when the reeds 1 and 2 are touching contacts 4 and 6, respectively, the momentary voltage E is obviously the same as that across condenser 11, which is V. Again, when the reeds are touching neither contact during phases BC and DA, the momentary voltage E is zero, since although the condensers 11 and 12 remain substantially fully charged, there is now no closed circuit. On the other hand, when the reeds 1 and 2 touch contacts 5 and 7 respectively, the voltage E will momentarily rise to a value 2V, because of the voltage V remaining on condenser 11 which is superimposed upon the voltage V across condenser 12. During this phase CD, however, the voltage E will gradually fall as condenser 11 discharges.

It will thus be seen that the voltage E appearing across the load 13 is now a very widely fluctuating one, and even though a conventional "smoothing" choke 14 and by-pass condenser 15 be employed, as depicted in Figure 3, one can only hope to obtain ultimately a final mean value of E (as depicted in Figure 3*a*) which is as much as 50% above V, depending upon the relative lengths of the "non-touching" periods BC and DA in comparison with the "touching" periods AB and CD.

In order to overcome this disability, the circuit depicted in Figure 4 may be employed, in which circuit a rectifier 16, with or without series resistance 17, is used in place of the croke or resistance 14 depicted in Figure 3. In this new circuit it is apparent that in the steady state both condensers 11 and 12 are each charged up to a voltage of approximately V, and when the reeds 1 and 2 are touching contacts 5 and 7, contact 4 will be at a potential approximately 2V relative to the negative side of the mains. Thus as long as the condenser 15 is at a potential less than 2V, current will tend to flow through the rectifier 16 during this phase of the cycle if the former be connected up in the right sense as shown. The charge thereby accumulated on condenser 15 cannot, however, flow back during the remainder of the cycle (when, for example, the reed 1 touches contact 4) on account of the blocking action of the rectifier. It follows that the voltage across condenser 15 will tend to rise very quickly to a value nearly 2V and remain near this value to an extent depending upon the value of the condenser 15 in relation to the load 13. The voltage cycle is thus somewhat as depicted in Figure 4*a*.

It is clear that in the ultimate "steady" condition, the maximum reverse voltage to which the rectifier 16 will be subjected occurs when reeds 1 and 2 touch contacts 4 and 6, and is then equal to V. The maximum forward voltage to which it can be subjected is, however, 2V at the start when both condensers 11 and 12 are charged but condenser 15 is uncharged. To prevent an excessive transient current passing at this moment, therefore, it may be advisable to insert in series with the rectifier a resistance 17. As, moreover, current obviously only flows through the rectifier during the phase CD (i. e. with contact 4 at a potential 2V relative to the negative side of the mains), it is easy to calculate the average current through the rectifier if the value of the condenser 15 and load 13 be known. Hence, all the particulars can be ascertained for choosing a suitable unit.

Having now described my invention, I claim:

1. A voltage doubler circuit having a pair of series connected condensers arranged to be charged alternately from a direct current source in such manner that the charges therein produce additive voltages in the circuit, wherein the load lines are connected one effectively to one side of the direct current source and the other to a point in the circuit which periodically experiences a potential difference with respect to the first mentioned load line according to the sum of said additive voltages, the two load lines being shunted by a condenser, and a rectifier being included in said other load line between its point of connection with the circuit and the shunt condenser connection, such rectifier operating in a sense to prevent current from flowing back from the shunt condenser towards the direct current source and the pair of series connected condensers.

2. A voltage doubler circuit having a pair of series connected condensers arranged to be charged alternately from a direct current source in such manner that the charges therein produce additive voltages in the circuit, wherein the load lines are connected one effectively to one side of the direct current source and the other to a point in the circuit which periodically experiences a potential difference with respect to the first mentioned load line according to the sum of said additive voltages, the two load lines being shunted by a condenser, and a rectifier being included in said other load line between its point of connection with the circuit and the shunt condenser connection, such rectifier operating in a sense to prevent current from flowing back from the shunt condenser towards the direct current source and the pair of series connected condensers, a double vibrator being employed for charging the series connected condensers, said vibrator having two reeds joined one to each side of said source and four co-operating contacts of which a pair are joined in common to a tap between said series connected condensers and the other two contacts are joined to either side of said pair of condensers.

3. A voltage doubler circuit having a pair of series connected condensers arranged to be charged alternately from a direct current source in such manner that the charges therein produce additive voltages in the circuit, wherein the load

lines are connected one effectively to one side of the direct current source and the other to a point in the circuit which periodically experiences a potential difference with respect to the first mentioned load line according to the sum of said additive voltages, the two load lines being shunted by a condenser, and a rectifier being included in said other load line between its point of connection with the circuit and the shunt condenser connection, such rectifier operating in a sense to prevent current from flowing back from the shunt condenser towards the direct current source and the pair of series connected condensers and a resistor in one of said load lines to limit the current which passes through the rectifier.

WILLIAM GEORGE BIRD.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,255,299	Rockwell	Sept. 9, 1941
2,267,233	Elstrom	Dec. 23, 1941