No. 793,608. PATENTED JUNE 27, 1905.

V. POULSEN.

APPARATUS FOR ALTERNATING CURRENTS.

APPLICATION FILED SEPT. 15, 1904.

3 SHEETS—SHEET 1.

Fig. 1.

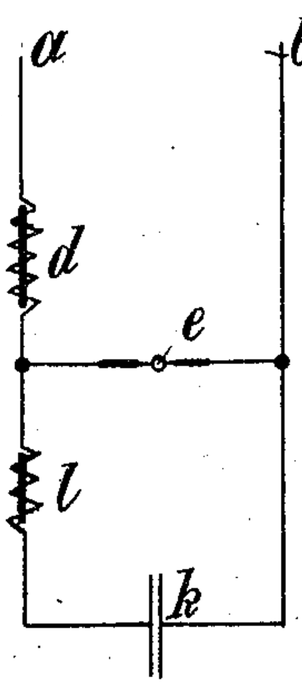


Fig. 2.

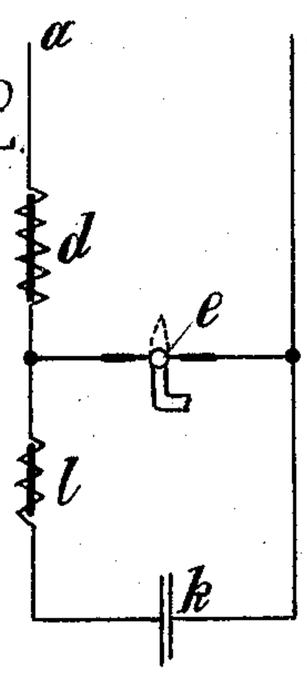


Fig. 3.

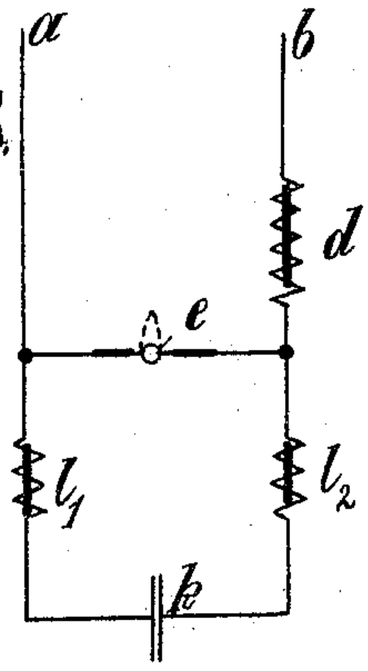


Fig. 4.

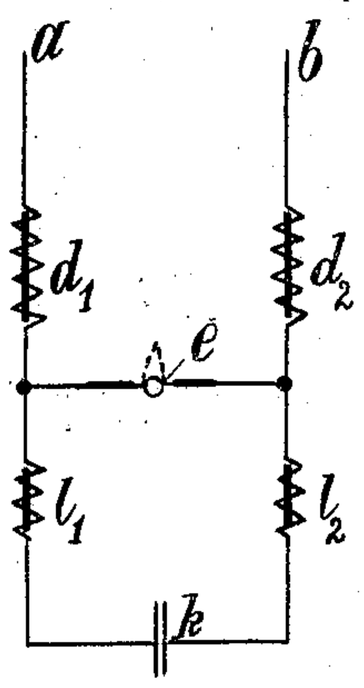
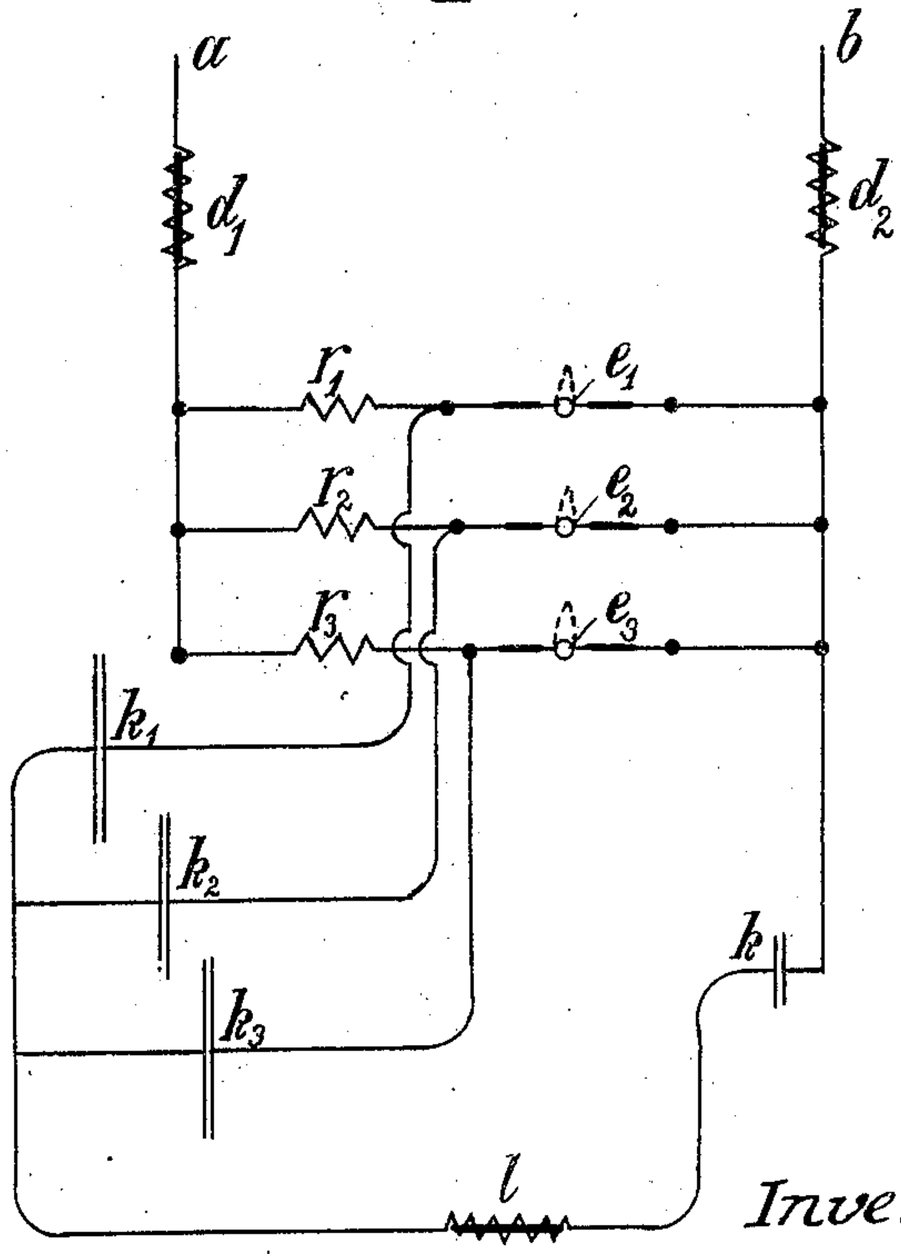


Fig. 5.



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3 SHEETS—SHEET 2.

Fig. 6.

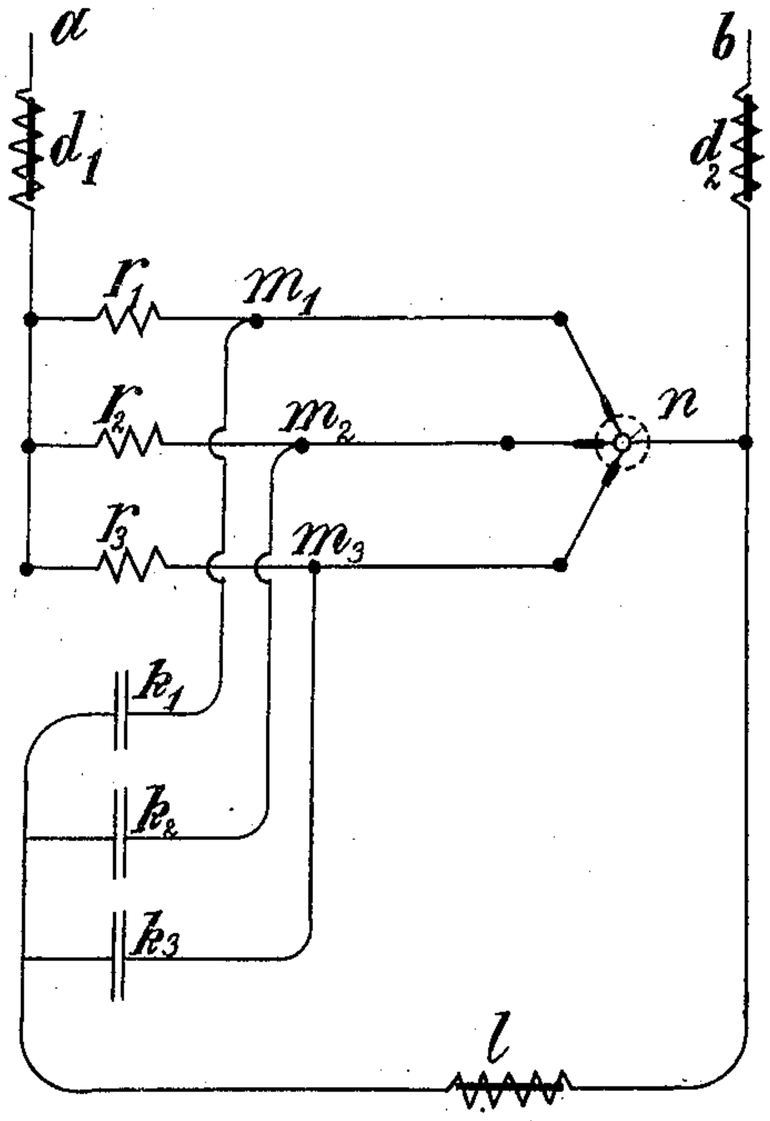


Fig. 7.

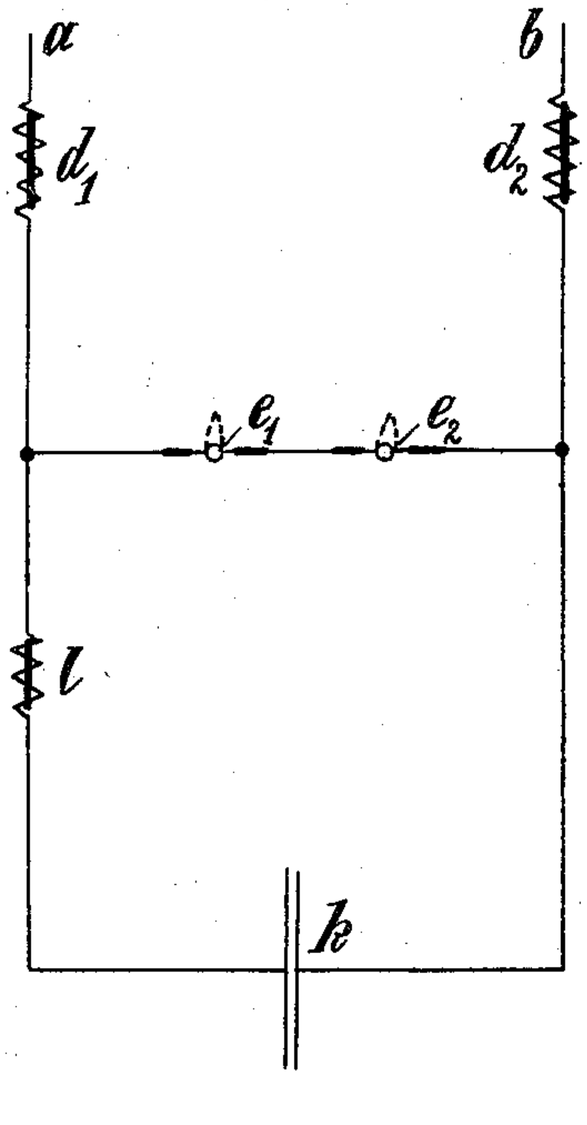


Fig. 8.

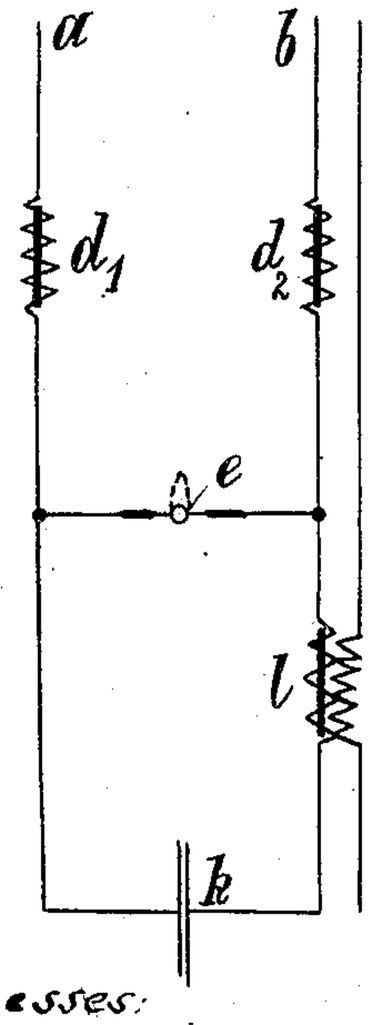


Fig. 9.

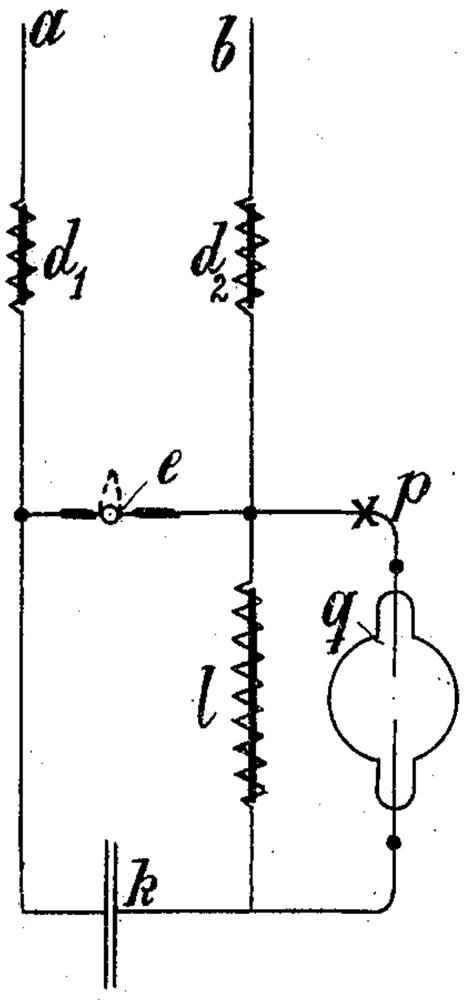
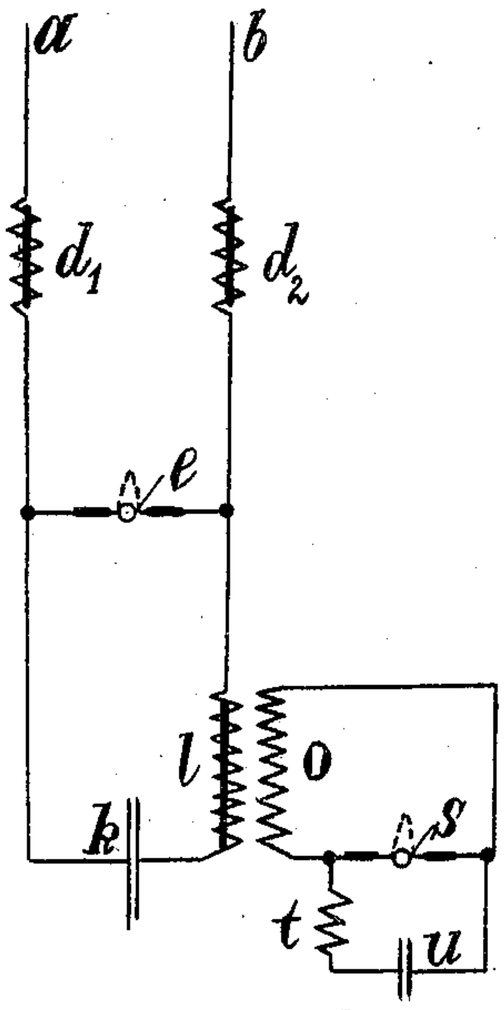


Fig. 10.



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APPARATUS FOR ALTERNATING CURRENTS.

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3 SHEETS—SHEET 3.

Fig. 11

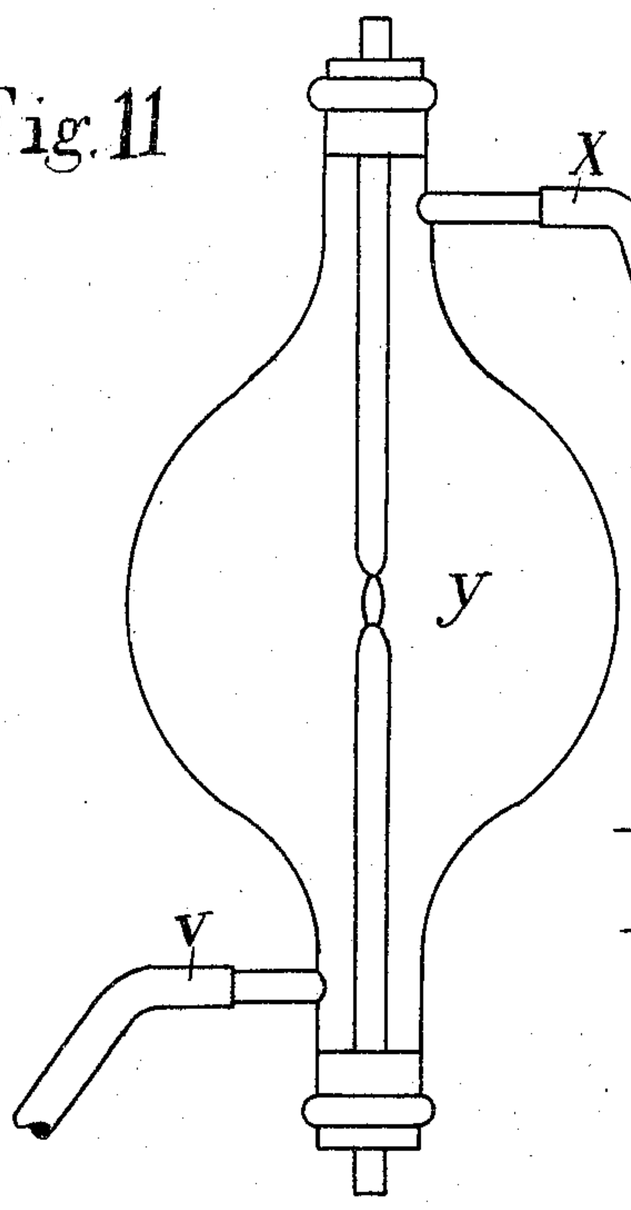


Fig. 12.

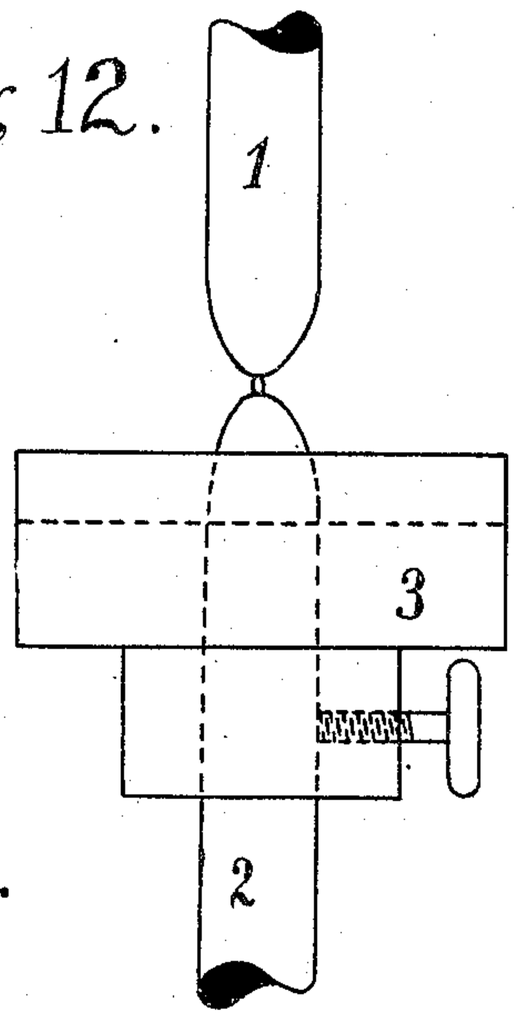


Fig. 13.

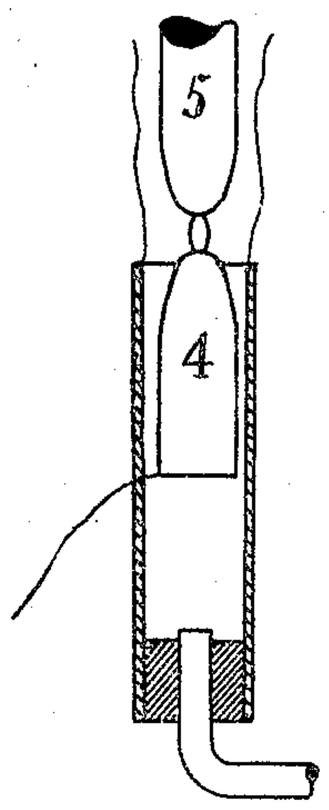


Fig. 14.

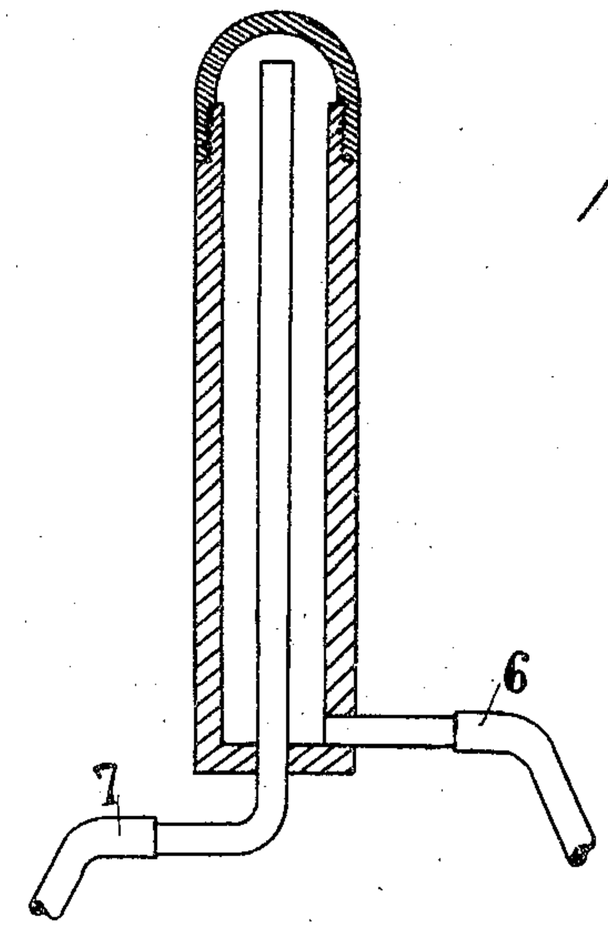
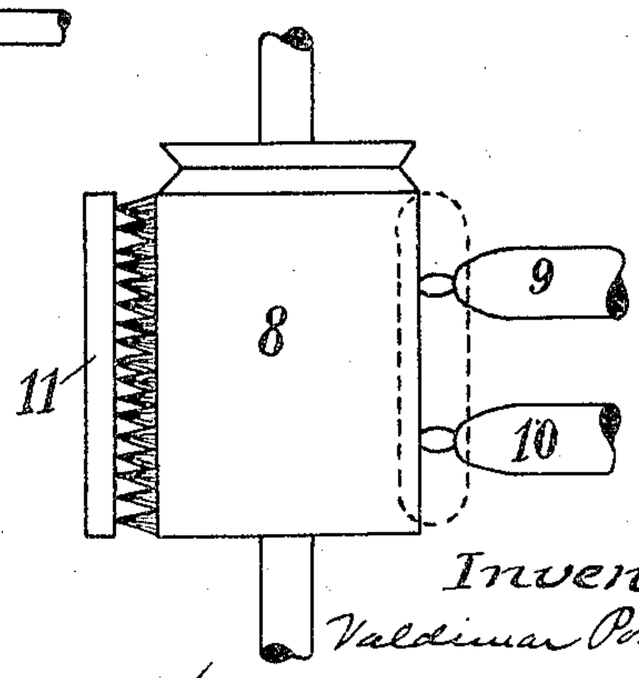


Fig. 15.



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No. 793,608. Patented June 27, 1905.

UNITED STATES PATENT OFFICE.

VALDEMAR POULSEN, OF FREDERIKSBERG, DENMARK.

APPARATUS FOR ALTERNATING CURRENTS.

SPECIFICATION forming part of Letters Patent No. 793,608, dated June 27, 1905.

Original application filed June 19, 1903, Serial No. 162,183. Divided and this application filed September 15, 1904. Serial No. 224,509.

To all whom it may concern:

Be it known that I, VALDEMAR POULSEN, a subject of the King of Denmark, residing at Frederiksberg, Denmark, have invented certain new and useful Improvements in Apparatus for Producing Alternating Currents, of which the following is a full, clear, and exact description, the present application being a division of my application filed June 19, 1903, Serial No. 162,183.

As demonstrated by Duddell in his British Patent No. 21,629 of 1900, it is possible by the suitable employment of self-induction, capacity, and an electric arc to produce an alternating current from a continuous current. In this way only a proportionately-low efficiency has hitherto been reached and no greater number of vibrations than at the utmost twenty to thirty thousand per second. The present invention aims to produce alternating currents in a similar manner, but of greater useful effect and, if required, of a much greater number of vibrations (two hundred thousand to one million or more) by placing the arc and preferably the neighboring parts of the electrodes in an atmosphere containing hydrogen or a compound of hydrogen.

The details of the invention will hereinafter appear, and the novel features thereof will be set forth in the claims.

In the drawings, Figure 1 is a diagrammatic view illustrative of Duddell's system. Figs. 2, 3, and 4 are similar views illustrative of the present invention. Fig. 5 is a view showing a similar construction with more electric arcs arranged in parallel. Fig. 6 shows a construction in which the different arcs which are arranged in multiple have a common electrode. Fig. 7 is a view showing the arcs in series. Fig. 8 is a view showing a construction in which a transformer is employed in connection with the other parts. Fig. 9 is a view showing the use of a vacuum-tube in connection with the other parts. Fig. 10 is a view of a device for transforming an alternating current produced according to the present invention. Fig. 11 is a view illustrative of one means by which an electric arc may be placed in an atmosphere containing hydrogen. Fig. 12 is a view showing one means whereby an electric arc may be surrounded by vapor from a fluid, by which also the electrode may be cooled. Fig. 13 is a sectional elevation of a device by means of which an electric arc and the electrodes may be surrounded by an ascending current of a gas-containing hydrogen. Fig. 14 is a similar view showing an electrode and means for cooling the same by a current of water or the like, and Fig. 15 is a view of a construction involving a rotating electrode.

On Fig. 1, *a* and *b* indicate the feed-conducting wire for continuous current; *d*, a self-induction coil; *e*, a voltaic arc formed between two carbons; *l* the self-induction coil of the circuit of the alternating current, and *k* a condenser. The number of vibrations of the circuit of the alternating current is then found to be approximately $\frac{10^3}{2\pi}\cdot\frac{1}{\sqrt{LK}}$, where L is a henry and K a microfarad. On account of the self-induction coil *d* alternating currents are prevented from flowing out in the feed-conducting wires. As stated, the alternating currents produced in this way are rather limited both as regards intensity and number of vibrations. However, by introducing the electric arc into an atmosphere of hydrogen or some other hydrogen compound the efficiency, intensity, and number of vibrations can be increased considerably. The reason for this advantageous effect can possibly be found in dissociation of the hydrogen in the electric arc. Possibly also the great diffusibility of the hydrogen is here a concurrent cause.

A plain form for carrying out the invention is as shown on Fig. 2, wherein the electric arc is located in the inner part of a hydrogen or illuminating-gas flame near the emanation-opening. Similar letters in Fig. 2 refer to similar objects in Fig. 1. Fig. 3 shows the same device, but with two self-inductions l' and l^2, placed on each side of the electric arc in the circuit of vibrations.

On the device shown in Fig. 4 two self-induction coils, (d' and d^2,) which prevent the alternating current from flowing out upon the conductors of the continuous current are in-

serted, one on each side of the electric arc. Experiments with this apparatus show that as the intensity of the continuous current increases the amplitude of the alternating currents diminish or collapse and will finally cease; but the reason for this phenomenon is not at present known.

Fig. 5 shows a device by which it is possible to transform a considerable quantity of energy with same number of vibrations in the system of alternating currents by means of more electric arcs placed in parallel. The letters a, b, d', and d^2 refer to the same objects as in the previous case. The three electric arcs e', e^2, and e^3 are here directly connected with one of the feed-conducting wires, while they are connected with the other feed-conducting wire through resistances r', r^2, and r^3, (preferably also self-inductions,) sufficiently large to enable the electric arcs to be kept burning simultaneously. One pole of each of the electric arcs e', e^2, and e^3 is connected with one coating of one of the condensers k', k^2, and k^3, the other coatings of which are mutually connected and connected with one coating of the common condenser k. The other coating of this condenser is connected with the other pole of the electric arcs. The self-induction of the vibration system is here represented at l and the resistance in the electric arcs e', e^2, and e^3. The capacity of each of the condensers k', k^2, and k^3 is greater than the capacity of the condenser k and the capacities are mutually adjusted in such a manner that the electric arcs e', e^2, and e^3 are approximately or completely syntonized. As will be seen, the condensers k', k^2, and k^3 keep the electrodes m', m^2, and m^3 thus separated from each other, so that continuous current cannot pass from one electrode to the other. As the electrodes n', n^2, and n^3 have all the same potential, they may be replaced by a single electrode. Fig. 6 shows the diagram thus simplified. The common electrode is marked n. The other letters refer to the same objects, as in Fig. 5. Furthermore, this diagram differs from the diagram shown in Fig. 5 by the common condenser k being left out. In this and similar ways as many electric arcs as wished may be joined in parallel and a syntonic addition of the alternating currents produced by the electric arcs can be obtained. Of course the alternating currents produced by the parallelly-placed electric arcs can have different numbers of vibrations, and the interference effect resulting therefrom can be employed. When very high numbers of vibrations are wanted and a condenser of low capacity for this reason must be used, more electric arcs can, as shown in Fig. 7, advantageously be placed in a series. If, as shown in Fig. 8, the self-induction l forms the primary coil of a transformer, preferably oil-insulated, an alternating current of higher or lower potential can be induced in the secondary coil of same. The secondary conductor, combined with the devices known in wireless signaling, can be used in wireless telegraphy and telephony, and on account of the continuance of the produced waves of determinate length the system is fit for syntonized telephony and telegraphy. Such a transforming can also be used for producing Rœntgen rays, cathode rays, and light in vacuum-tubes.

Wireless signaling and all the other problems named can be carried out even without a real transformer when sufficient difference of potential between the coatings of the condenser k is produced. Fig. 9 shows such a device where the vacuum-tube q is arranged in parallel with the self-induction l. If necessary, a resistance or condenser can be inserted some place in the circuit—for instance, at p—in series with the vacuum-tube. It is not necessary, though, that the feed-conductors a and b conduct continuous current. An alternating current can also in the named manner be transformed into an alternating current of some other frequency. Fig. 10 shows a diagram in which an alternating current produced in the described manner in the secondary coil o induces another alternating current of same frequency, which alternating current again, by means of the electric arc s, the condenser u, and the self-induction t, is transformed into an alternating current of some other frequency.

The manner in which the electric arc is placed in a hydrogenic atmosphere can be very different. Besides the gas-flame (shown in Fig. 2) alcohol-vapor, ether-vapor, or the like can be used, which vapors, probably by the influence of the electric arc, will be dissociated into hydrogen and carbon. The electric arc can also be placed in a reservoir containing hydrogen or a gaseous hydrogen compound. Such a device is shown in Fig. 11. The gas in question can, through the tubes v and x, be conducted to and from the reservoir y in which the electric arc is placed, and, if necessary, the gas can be replenished by simultaneously conveying and removing the gas without essentially altering the pressure in the reservoir. The pressure can be higher or lower, preferably much higher or much lower, than the pressure of the atmosphere.

Fig. 12 shows the electrodes 1 and 2 arranged vertically one above the other, the lowermost electrode being surrounded by a cup 3 with water or some other liquid and volatile hydrogen compound which by the heat from the electric arc is brought to evaporate and thereafter is dissociated in the arc.

The electrodes need not consist of carbon, but can also consist of metals—for instance, copper, silver, platina, aluminium, &c.

Fig. 13 shows another arrangement in which the gas streams out through a tube which surrounds the electrode 4. The outstreaming gas surrounds the electric arc and the neigh-

boring part of the electrode 5 and is eventually lighted.

An artificial augmentation or diminishing of the temperature of the electrodes or one of the electrodes can be of essential importance for a continual maintenance of the electrical vibrations and contribute to keeping the electric arc quiet. If wanted, one electrode can be heated while the other is cooled off. Fig. 14 shows an electrode which can be cooled off by leading a jet of water in through the tube 6 and out through the tube 7, or vice versa. The employment of such a cooled-off copper electrode as anode and a carbon rod as cathode is very appropriate.

An inconvenient deposit of carbon may take place in the employment of carbureted hydrogen, as atmosphere, or when carbon is employed as material for the electrodes, or the electrodes may be worn out in an irregular manner. Therefore it may be preferable to devise the electrodes mutually movable, so that the pole area continually is changed.

Fig. 15 shows a device in which the cylindrical electrode 8 can rotate while the electrodes 9 and 10 stand still. Preferably a brush 11 can serve for cleaning and polishing of the surface of the cylinder 8. The cylinder can easily be arranged for cooling—for instance, by being made hollow and with a hollow shaft through which water can be passed.

The devices and diagrams here described are only examples of constructions and may be varied and mutually combined in various manners without altering the nature of the invention.

What I claim is—

1. An apparatus for producing alternating currents of high frequencies, consisting of electrodes between which an electric arc can be formed, means for supplying an electric current thereto, means for subjecting said arc to an atmosphere containing hydrogen and a circuit including the electrodes, a self-induction device and a device having capacity.

2. An apparatus for producing alternating currents of high frequencies, consisting of electrodes between which an electric arc can be formed, means for supplying an electric current thereto, means for subjecting said arc to an atmosphere containing hydrogen at a pressure different from one atmosphere and a circuit including the electrodes, a self-induction device and a device having capacity.

3. An apparatus for producing alternating currents of high frequencies, consisting of electrodes between which an electric arc can be formed, means for supplying a continuous electric current thereto, means for subjecting said arc to an atmosphere containing hydrogen, a circuit including the electrodes, a self-induction device and a device having capacity.

4. An apparatus for producing alternating currents of high frequencies, consisting of a plurality of pairs of electrodes between which electric arcs can be formed, means for supplying current thereto, means for subjecting said arcs to an atmosphere containing hydrogen and a circuit including all of said pairs of electrodes as well as a self-induction device and a device having capacity.

5. An apparatus for producing alternating currents of high frequencies which consists of an electrode common to a plurality of other electrodes, the latter connected in parallel, means for supplying a continuous current to form an arc between the common electrode and each of the other electrodes, means for supplying hydrogen to each arc and a circuit containing a self-induction device and a device having capacity and including all of the arcs, substantially as described.

6. An apparatus for producing alternating currents of high frequencies, consisting of electrodes between which an electric arc can be formed, means for supplying an electric current thereto, means for subjecting said arc to an atmosphere containing hydrogen, a circuit including the electrodes, a self-induction device and a device having capacity, and a translating device shunting the self-induction device.

In witness whereof I subscribe my signature in the presence of two witnesses.

VALDEMAR POULSEN.

Witnesses:

C. V. SCHON,

C. BUDELE.