

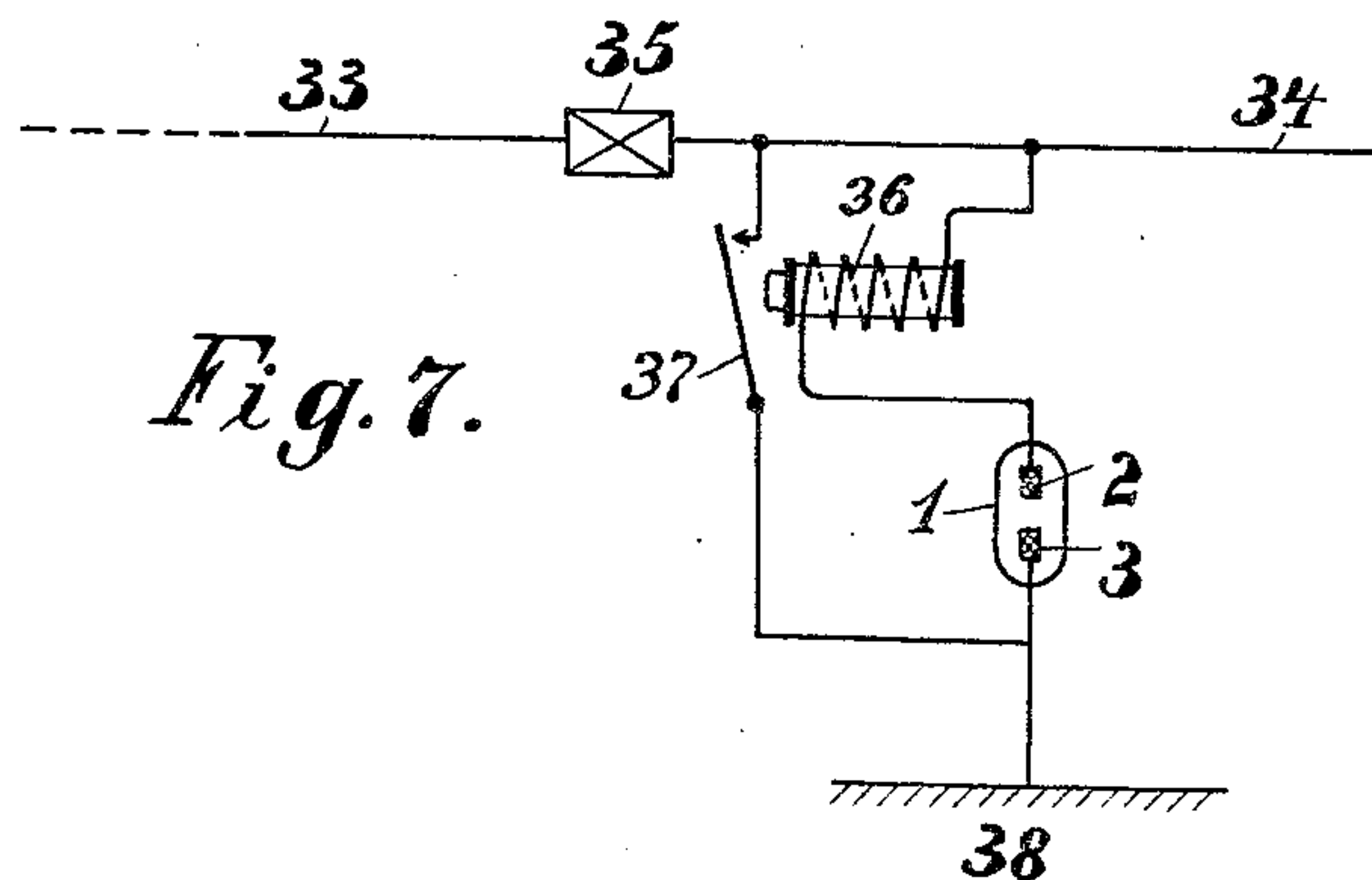
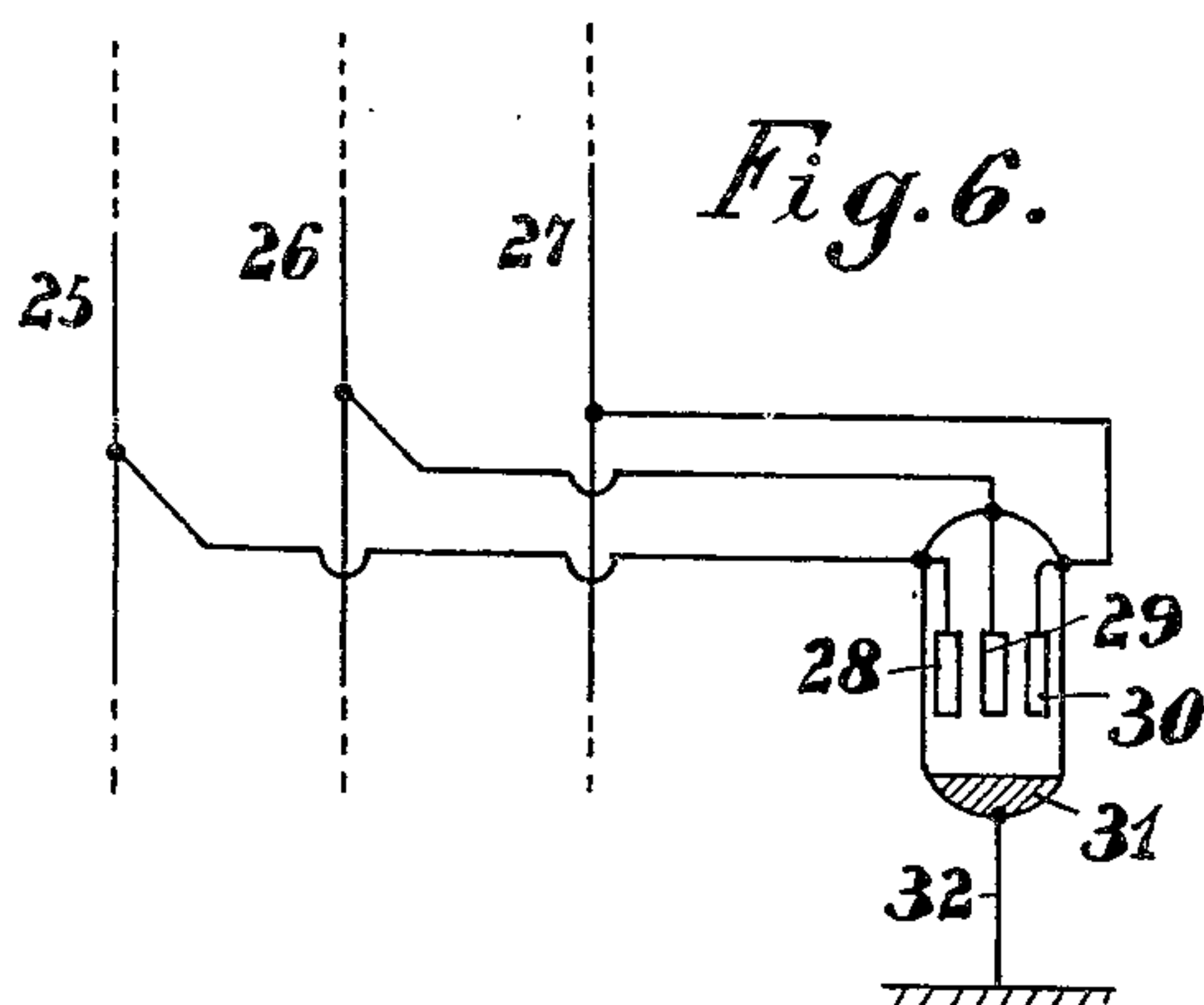
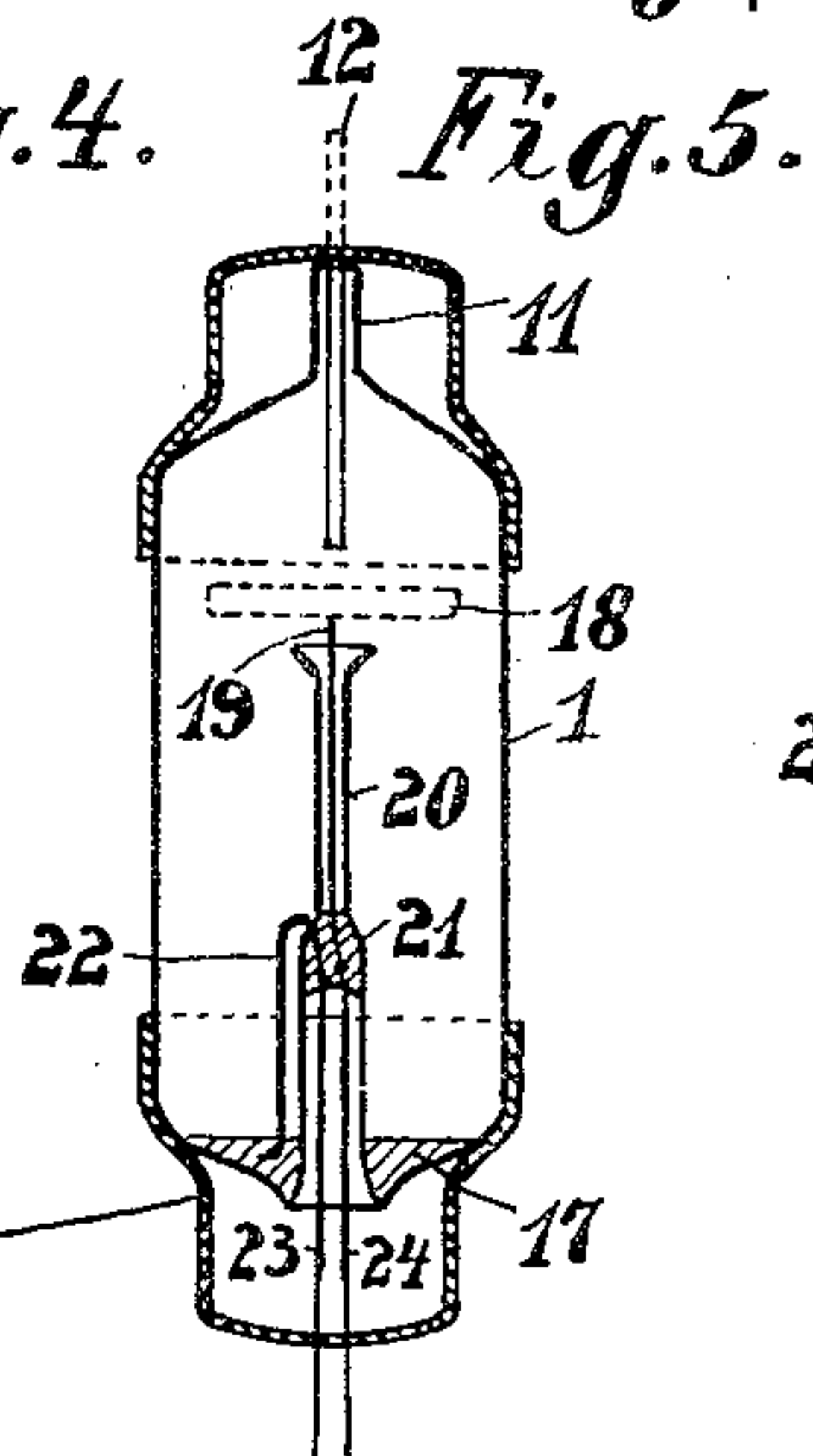
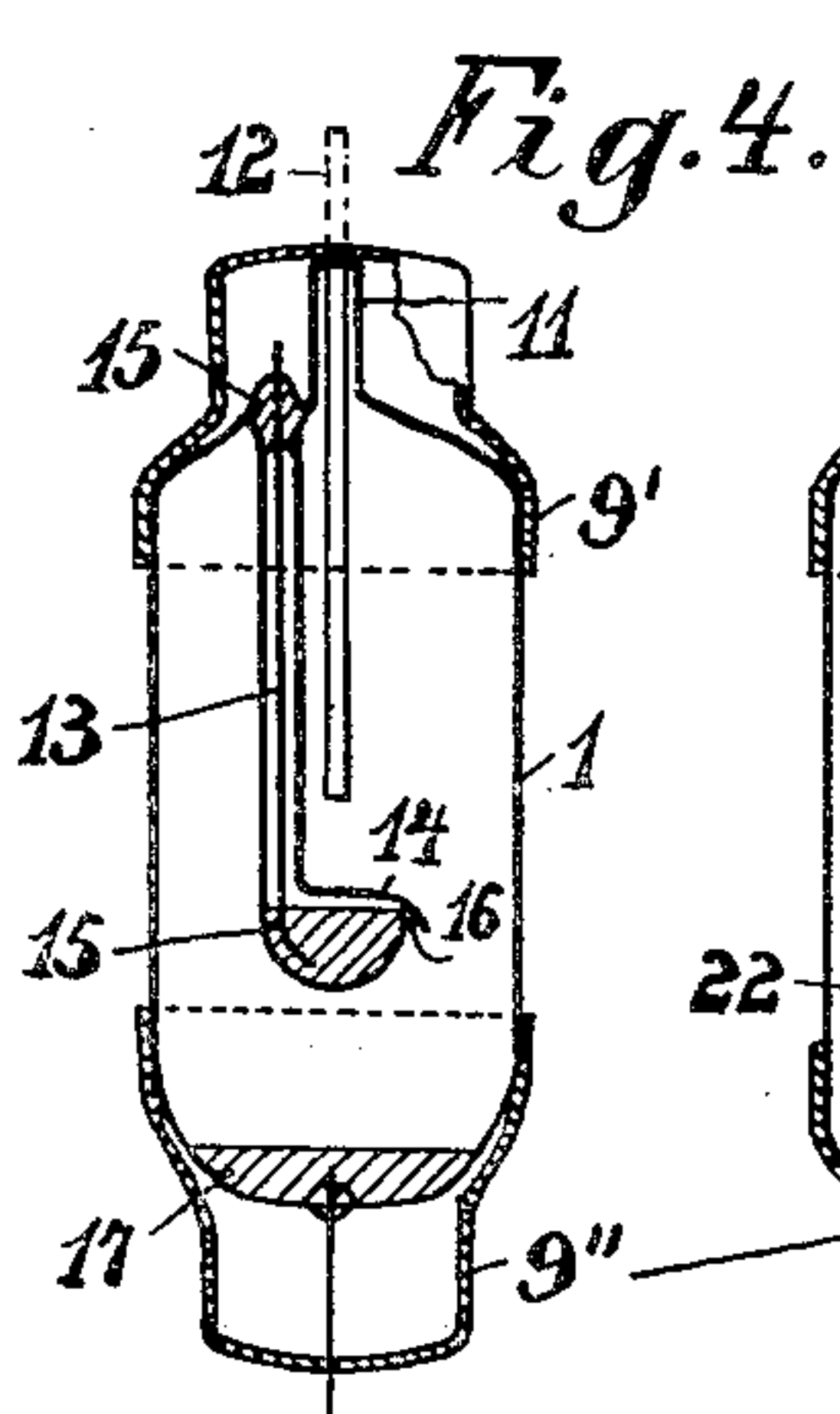
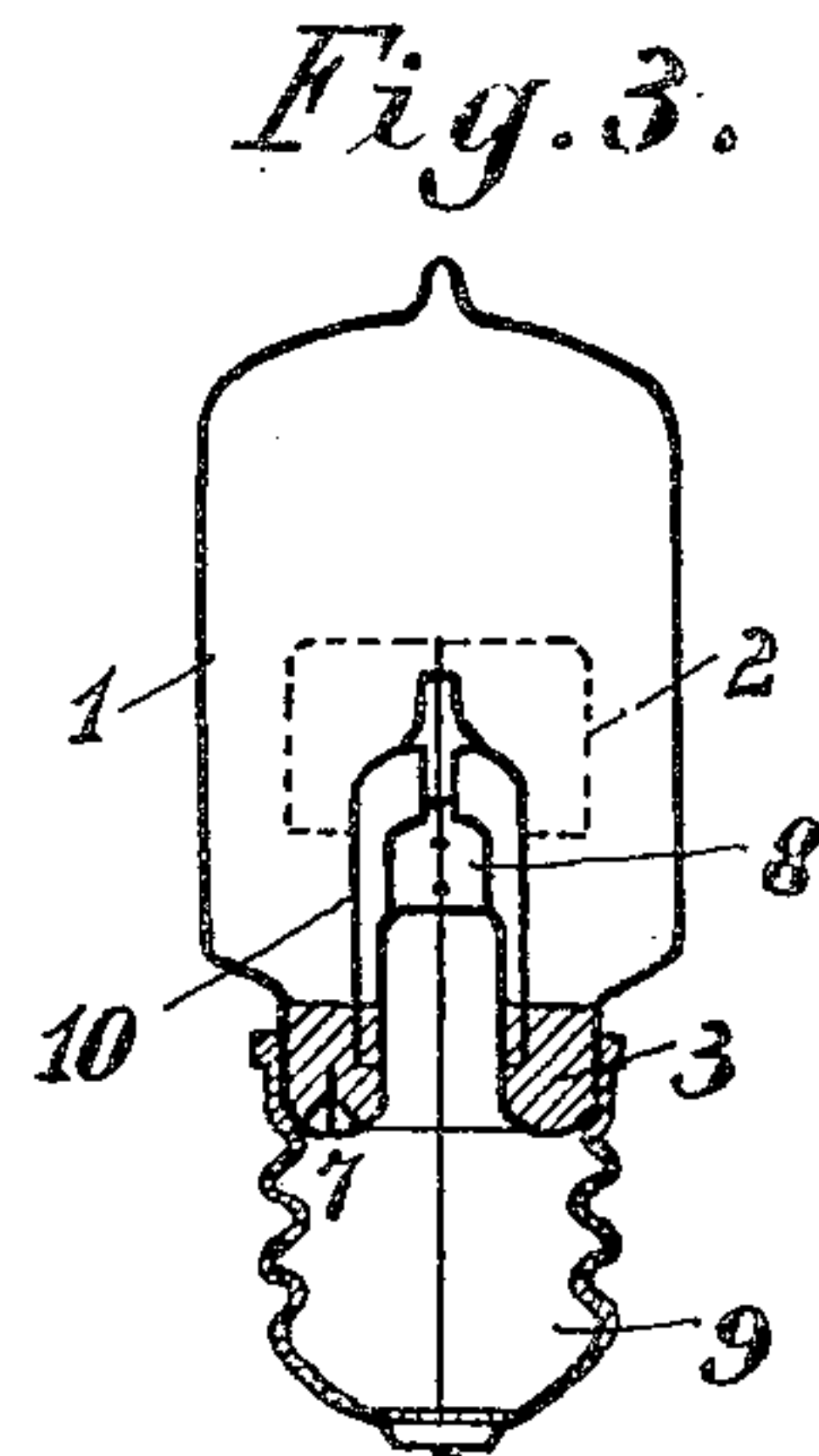
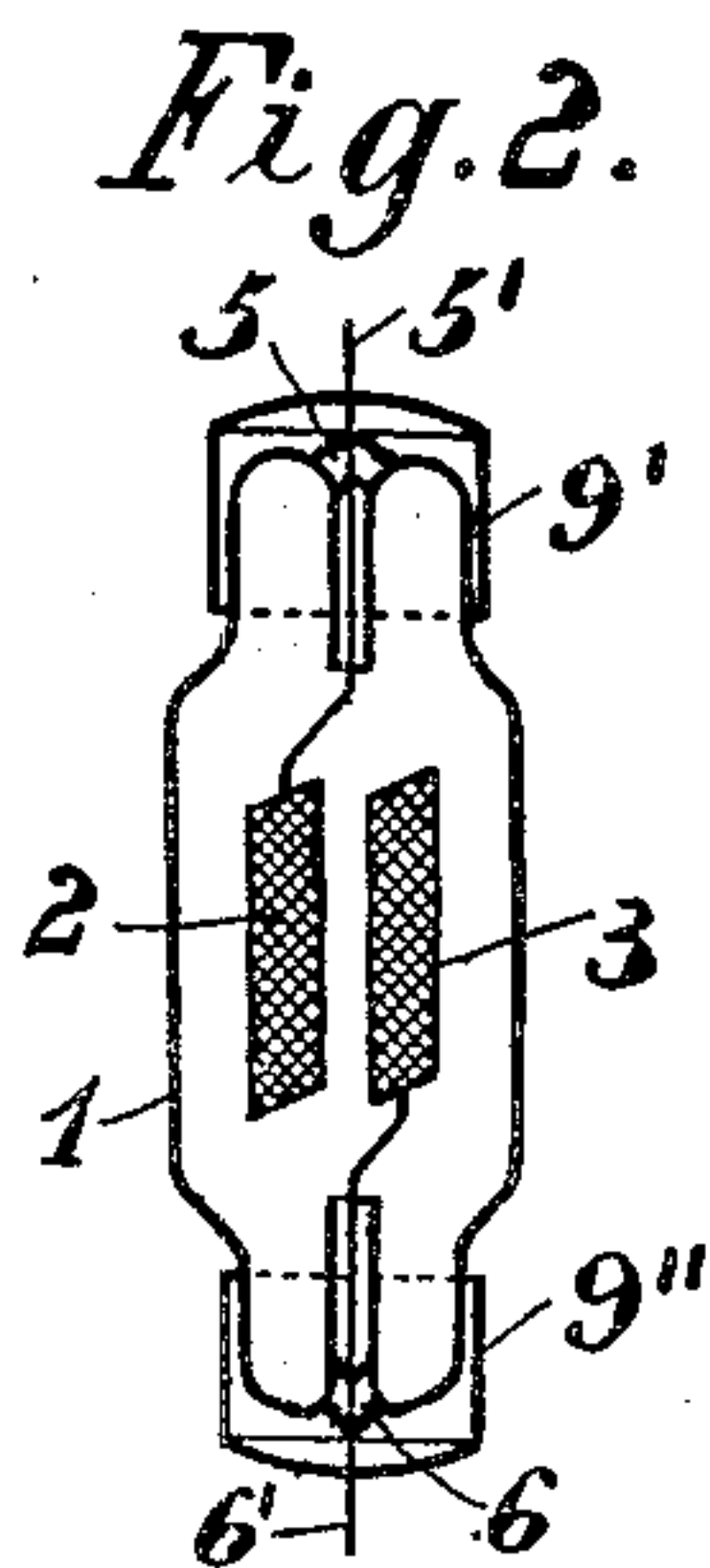
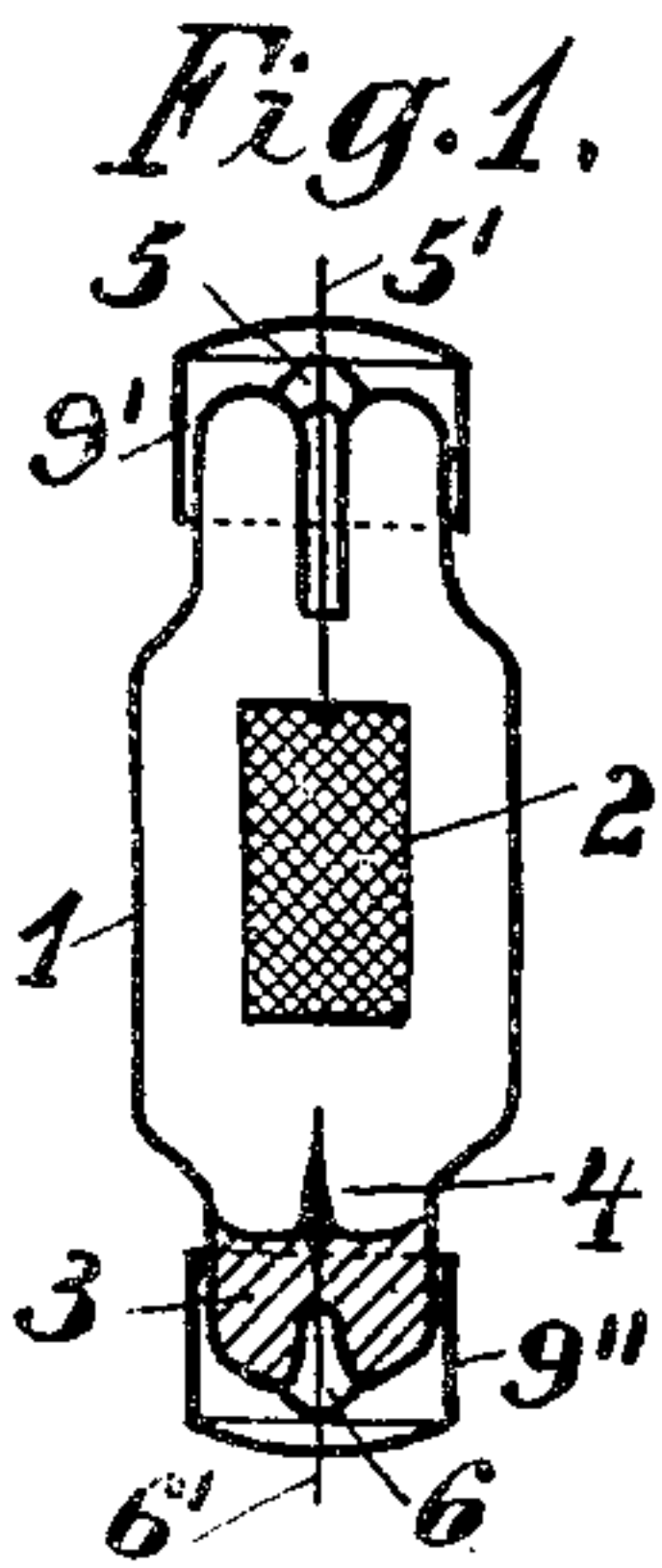
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F. SCHRÖTER

ELECTRIC VACUUM VALVE TUBE

Filed March 30, 1921



Witnesses:

Gertrude G. G.
G. V. Rasmussen

Inventor:

FRITZ SCHRÖTER

By

Paul H. Schenk
Attorneys

UNITED STATES PATENT OFFICE.

FRITZ SCHRÖTER, OF BERLIN-SCHMARGENDORF, GERMANY, ASSIGNOR, BY MESNE ASSIGNMENTS, TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

ELECTRIC VACUUM VALVE TUBE.

Application filed March 30, 1921, Serial No. 456,983, and in Germany January 29, 1914.

The present invention relates to improved vacuum-valve tubes, which are especially suitable for protecting electric circuits and apparatus against excess voltage and may, for instance, be used for protecting telephone- or telegraph-lines against high voltages, due to their contacting with high-tension-lines, or which may be due to electric influence or any other causes. Such excess voltage may be dangerous not only to the insulations of the apparatus concerned, but also to human beings. In the vacuum-valve tubes hitherto employed for protecting against excess voltage electrodes of carbon, graphite or metals, not easily vaporized, were used and they allowed the passage of the discharge only at a voltage of from about 300 volts upwards. It was not possible to pass the discharge through such tubes at a voltage of 200 volts or less. Moreover the tubes hitherto used were very unsafe as regards the constancy of the discharge voltage, for, after a repeated passage of the discharge, nearly all the gas contents became occluded by the vapors of the electrode metal so that the tube broke down at much higher voltages only.

The object of the present invention comprises an improved electric vacuum-valve tube, which will become conductive at voltages below 150 volts without showing any perceptible occlusion of the gas-contents. Therefore, such a tube is far more durable and safer than former constructions.

The invention is characterized in that rare gases such, for instance, as argon, neon, helium, are fed to the vacuum tube in small quantities and electrodes are provided within the tube, which consists of a strongly electropositive metal, such, for instance, as alkaline metal or earthy alkaline metal, which are easily volatilized by the heat generated by the discharge. The electrodes are arranged at so small a distance apart, say 1 to 10 millimetres, that owing to the high conductivity of the rare gases, the low cathode drop of the electropositive metal, and the small distance between the electrodes, the discharge will start without auxiliary means at so low a voltage that a good protection of the line is ensured. Owing to the small distance apart of the elec-

trodes the narrow space between the electrodes will be filled, as soon as the discharge takes place, with highly conductive metal vapors emanating from the electrodes so that the electrical resistance of the discharge path drops to a minimum. The filling of the tube with rare gases facilitates the vaporizing or volatilization of the electrode metal. This effect is particularly strong when the electrodes are but a slight distance apart, since in this case the heat is better maintained or preserved between the electrodes so that a strong current will pass from one to the other. Since immediately after the start of the discharge the metal vapor will become the carrier or conductor of the current, the rare gas will take but a small share in the carrying of the current, and, for this reason, there will be no occlusion of the rare gas contents. The electrodes may consist wholly of these metals. But such metals may also be used as surface coatings on conductors of other material or they may even be used in combination with other metals, for instance, as an alloy. Thus, for instance, alloys of potassium or sodium with lead, mercury, thallium, will suitably answer the purpose in question, in which the composition of the ingredients is so chosen that the melting point does not exceed 300° C. Likewise, pure alkaline metals may be used, which are employed as surface coatings for other conductors, or may even form the electrode itself. These metals are known especially by their intensive photo-electric efficiency, which advantageously supports their effect. By the vapors of the various kinds of electrodes just described rare gases are not perceptibly occluded. Consequently a constant discharge voltage is maintained in the tube. Owing to the high conductive capacity of the metal vapors, the current passing through the tube after the discharge has jumped across the gap; is so strong that it is capable of energetically exciting an electromagnet, the armature of which establishes electric connections, to close a circuit in which flows a strong current to blow out a filament, fuse or the like in order to interrupt the endangered conduit. The electromagnet may also be used in known manner

for releasing automatic switches for switching off the endangered conduits. The discharge current itself may also be employed owing to its high energy for blowing fuses.

5 The rare gases used must be very pure. They are kept in a pure state by the metal vapors generated at the penetration of the discharge, especially if electrodes containing alkaline metal, are used, and this is due

10 to the fact that the impurities, escaping from the hot electrodes or other parts of the tube, are fixed by the metal vapors. For filling the tubes any known rare gases may be taken. Should helium or neon be used

15 the pressure may be between 0.5 and 8 m/m. but satisfactory results may even be attained with still higher pressures. When employing argon the pressure may vary within wide limits; satisfactory results were

20 obtained at a pressure between 1 and 3 m/m. of mercury. The alkaline metals used, or their alloys, must be free of oxides when fed to the tube and to attain this result at the beginning an additional receptacle is

25 attached to the tube initially, from which receptacle the metal, after having been heated in vacuo, is distilled into the tube. Or a second tube may be placed within an

30 additional receptacle, through which the metal is passed and fed to the tube in a molten state. This may also be effected in a vacuum. Or an inert gas such, for instance, as nitrogen is passed through the tube, whereby the molten metal is forced

35 from a special receptacle through some sort of a syphon into the tube.

Both electrodes of the vacuum tube are made with advantage of alkaline metal or coated with the same.

40 I will now describe my invention with reference to the accompanying drawings in which Fig. 1 shows diagrammatically one embodiment of the invention wherein the electro-positive material comprising one

45 electrode is located in one end of the tube and the said material comprising the other electrode is contained in a metal wire; Fig. 2 shows a modification of Fig. 1 wherein the two electrodes of the tube are of similar

50 shape; Fig. 3 shows two electrodes in a tube with an insulating member around a stem which supports one of the electrodes; Fig. 4 shows on an enlarged scale a structure whereby two different electrodes may be pro-

55 duced in one operation; Fig. 5 is a modification of Fig. 4 and is similar to Fig. 3 in that it shows an insulating member around a member constituting a support for one of the electrodes of the tube; Fig. 6 shows a

60 tube containing more than two electrodes and a way of connecting it in a circuit involving a plurality of lines; and Fig. 7 shows a way of connecting a two-electrode tube in a circuit to be protected.

65 Fig. 1 shows a tube containing electrodes

2 and 3. 5 and 6 are the seals for the conductors 5' and 6', by means of which current is fed to the interior of the said tube 1 and 9', 9'' are the usual bases. The electrode 2 may consist of a flat or otherwise shaped

70 fabric of metal wire, such, for instance, as brass, nickel or silver. 4 is a drawn-out pointed conductor, located opposite to the said electrode 2 and consisting of the same

75 or any other metallic or non-metallic substance. On the bottom of the tube there is positioned the electrode 3, which consists of alkaline metal or an alloy of the same; this metal or alloy is introduced with advantage

80 in a molten state, and coats the conductor 4, thereby producing on the same a thin layer of electropositive substance. By such arrangement the penetration of the discharge through the tube is facilitated. As

85 the discharge passes through the tube for some time, during which the electrode 3 acts as a cathode, the electrode 2 is coated with a sufficient quantity of the vaporized electropositive metal, which adheres with sufficient strength on the same.

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Fig. 2 shows another form of embodiment of the invention. In the same the two electrodes 2 and 3 resemble each other as regards their shape. They are, for instance,

95 formed so as to consist of small faces of metal-fabric. The alkaline metal or a correspondingly acting metal is introduced into the tube through a tubular projection and allowed to vaporize, in order to coat the two

100 electrodes properly.

The tubes as above described are connected up with the circuit by means of supplying contacts or bases 9' and 9'' on the two end portions 5 and 6. These contacts may be

105 metal sleeves, which are cemented upon the tapered ends of the tube.

Another form of embodiment, provided with advantage with an Edison-base, is shown in Fig. 3. According to this embodiment a central portion 8 is molten down

110 within the glass bulb 1 in a manner, resembling the method employed in the case of incandescent electric lamps. By means of this central portion 8 the current feeding means is led into the interior of the glass

115 bulb 1. The said central portion 8 carries the electrode 2, whilst the electropositive substance 3 is located on the bottom as a second electrode, receiving current through the seal 7. 10 is an insulating sleeve, which serves

120 as a cover to protect the central portion 8 against direct influence of the electropositive substance, which is strongly reactive. The current supply through 8 is connected up

125 with the one pole and the current supply 7 with the other pole of the base 9.

In each case the alkaline metal is admitted through a tubular projection such as 11 shown in Figs. 4 and 5, which may be provided on a suitable part of the tube and

130

which, after the alkaline metal and the gas has been fed, is molted off. The electropositive metal is in most cases fed in a molten state through the tubular projection, or, if in a vaporous state in such a manner that substances, giving off free metal when being heated, such, for instance, as metal compounds of the nitrogen-hydrogen acid, are heated in a tubular projection of the tube, after which the metal is distilled into such tube.

Figs. 4 and 5 show on an enlarged scale in what manner two different electrodes may be produced in one single operation when filling in the molten electropositive substance. According to these embodiments the containers or carriers for the electrode-substance are arranged within the discharge-tube in such a manner that the electrode-metal, when entering the tube 1, coats, sprinkles or fills on its way all electrode-containers, -carriers or -supports. This is attained in that the one electrode positioned at a higher level is constructed so as to form some sort of an overflow-basin, or by forming it as a screen, fabric or the like, through the holes or meshes of which the electrode metal may pass downwards, in order to form the second electrode. With reference to these Figs. 4 and 5, 1 designates the discharge-tube, 11 a tubular projection, through which a pipe 12 extends for allowing the molten electropositive substance or the alloy to be filled in, 9' and 9'' are the usual contact bases.

According to Fig. 4 the upper electrode has the form of an overflow or dripping pan 14, which is attached to a pipe 13, of insulating material, such, for instance, as glass, the said pipe simultaneously protecting the metallic conductor 15, arranged within it. The overflow-pan 14 further possesses an outflow-piece 16, which facilitates the flowing off of the metal, often strongly adhering to the glass. The quantity of the metal is so calculated that, after the overflow-pan 14 has been filled up, the surplus flows down to the bottom of the discharge-tube 1, where it forms the second electrode 17. Current is fed to the electrode 14 by means of the conductor 15 above mentioned.

Fig. 5 illustrates the embodiment of the inventive idea in a manner resembling Fig. 3, and according to the same a stem portion 21, as used in incandescent electric lamps, is provided, the current feeding conductors 23 and 24 passing through the said portion 21. The conductor 19 is arranged within, and protected by, an insulating tube 20 and with its top part comes into contact with a screen- or basket-like container of metal or any other suitable substance, which retains sufficient of the liquid electrode metal admitted that a layer of the said metal is formed. The meshes of the screen retain a part of the said metal, whilst the surplus flows down to the

bottom of the tube 1 and in turn forms there the electrode 17, to which current is fed by means of the conductor 22.

The tube according to Fig. 4 may be provided with bases of any desired type, cement- to the two end portions. A preferred form of construction of the base consists in that the melting off point, remaining after having molten off the tubular projection 11, is covered by the base and thus protected against injury. The tube according to Fig. 5 is preferably fitted with an Edison-Swan or like base for the purpose of feeding current.

The tubes as described may be constructed so as to contain more than two electrodes. Tubes of this kind are especially useful in such cases, where a plurality of telephone- or telegraph-lines is to be protected. Consequently each line to be protected is connected up with an electrode and another common electrode of strongly electropositive metal is earthed. This arrangement is illustrated in Fig. 6. In the same 25, 26, 27 indicate three telephone- or telegraph-lines or other conduits to be protected. These three lines or conduits respectively are connected up with the three electrodes 28, 29 and 30 respectively. Opposite to the said electrodes 28, 29 and 30 there is located the common electrode 31, formed of a strongly electropositive substance, which is earthed by means of the conductor 32. The vapors generated from the substance of the electrode 31 form coatings of a like substance upon the electrodes 28, 29 and 30. It is thus possible to protect a plurality of lines or conduits by means of one single tube. It is to be understood that the embodiment just explained is only an example and may be varied according to requirements.

In such cases where a weak current line such, for instance, as a telegraph or telephone line 33, 34, is to be protected in the portion 34 against too high tensions towards earth by means of a vacuum valve 1 according to the present invention, an arrangement such as shown in Fig. 7 may be preferably used. According to this figure the line is interrupted by means of a melting fuse 35 and two conduits establish connection between the line 34 and the earth 38, the one passing through the coil 36 of an electromagnet and through the electrodes 2, 3, of the tube 1, the other passing through the switch 37, which may be closed by the attraction of the electromagnet, provided a sufficiently strong current passes through the coil 36. The fuse will not become effective normally, that is, as long as the tension towards earth 38 in the line 33, 34 is below a predetermined limit. As soon as this limit is exceeded, however, if, for example, the line 33 contacts with a high potential wire, a discharge current passes through the tube 1,

excites the coil 36, and thereby operates the switch 37. By the closing of this switch the high tension is permitted to pass to earth with practically no resistance. Accordingly a strong current is established which melts the fuse 35 and thereby separates the part 34 of the endangered line from the high tension. The above described arrangement is to be considered merely as an example. There may be cases in which the tube 1 may be branched off to earth directly from the line 34 without the use of electromagnetic switches or other auxiliary means. The electric arc generated in the tube 1 is strong enough to melt the fuse 35 owing to its strength of current. In case a temporary charging of the line 33, 34, is concerned the fuse 35 may be dispensed with and the tube 1 earthed directly. The strong charges then immediately flow off as soon as a certain tension is exceeded.

In case tubes with two electrodes only are used it will be sometimes necessary to put the tube in shunt to the telephone, which is thereby secured against too high voltages.

It is most important when manufacturing the tubes described that the metals or metallic carriers, which are coated with the electropositive metal, or are filled up with such metal, be absolutely pure and free from gaseous impurities. An exception is allowed with argon, with the use of which the remainder of small quantities of nitrogen in the gas will not affect the efficiency of the tube. On the contrary, it has been found advantageous to add small quantities of nitrogen to the argon. Advantageous results were obtained by the presence of 1% nitrogen. The quantity of nitrogen to be allowed, however, depends on the shape of the electrodes and their position with regard to one another, and, as a matter of fact, arrangements of electrodes exist, in which the presence of nitrogen increases the discharge potential to a disadvantageous extent.

In order to free the electrode-carriers described (2 and 4 in Fig. 1, 2 and 3 in Fig. 2; 2 in Fig. 3; 18 in Fig. 5) from surface impurities or from deleterious gases retained, a strong heating, when exhausting, and, in case of need, forcing through a dis-

charge, thus heating the electrodes, will be useful. This is attained by allowing a small quantity of gas, preferably that gas, which serves for the final filling of the tube, to enter the tube. Those gases, given off by the heated metal, are then exhausted and the pure filling gas is admitted.

I claim as my invention:—

1. In a device for protecting electric circuits and apparatus against excess voltage comprising a tube containing a plurality of electrodes, one of which embodied an overflow-pan, the method of forming said electrodes which comprises admitting molten metal to said pan from which the surplus of said metal flows off to form another electrode.

2. A protective device for electric circuits comprising a vessel containing inert gas, a container within said vessel, alkaline metal in said container and in one end of the vessel forming electrodes, and means for connecting said device to a circuit to be protected.

3. The method of forming electrodes in electric discharge tubes containing a plurality of electrodes located at different levels in said tube which comprises supplying molten metal first to the uppermost electrode and then successively to the remainder of said electrodes.

4. The method of forming electrodes in electric discharge tubes containing a plurality of electrodes, one of which comprises a carrier in the form of an overflow-pan, which comprises supplying molten metal first to the overflow-pan and then leading the overflow downwardly to another portion of the tube where another electrode is to be formed.

5. The method of forming electrodes in electric discharge tubes, from molten metal in electric discharge devices containing a plurality of electrodes, one of which is a carrier and contains a portion of the metal, which comprises supplying the metal first to the carrier and then leading the metal downwardly to a portion of the tube to form another electrode.

In testimony whereof I have affixed my signature.

FRITZ SCHRÖTER.