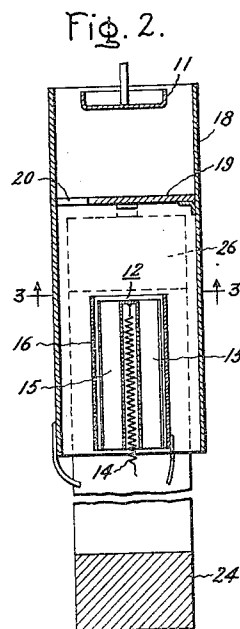
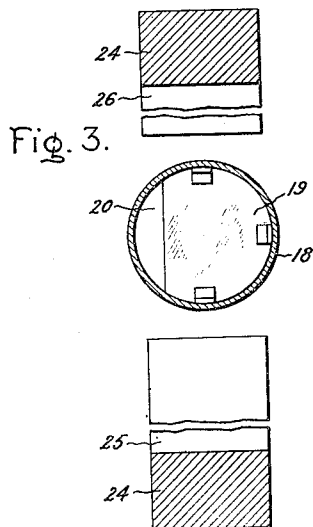
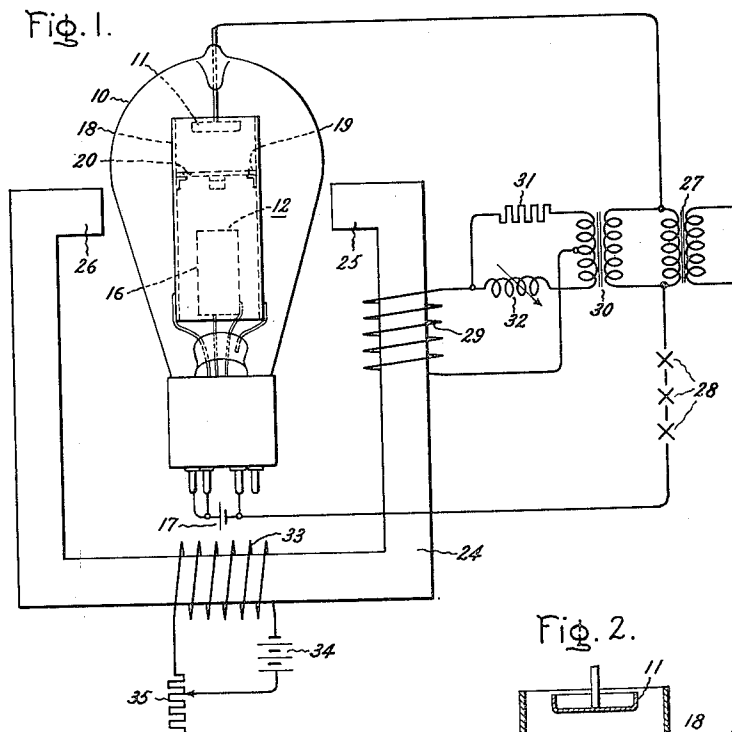


Oct. 8, 1940.

E. D. McARTHUR
DISCHARGE APPARATUS
Filed Dec. 29, 1939

2,217,415

2 Sheets-Sheet 1



Inventor:
Elmer D. McArthur,
by *Harry E. Dunham*
His Attorney.

Oct. 8, 1940.

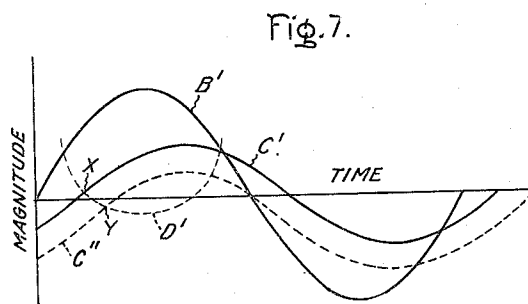
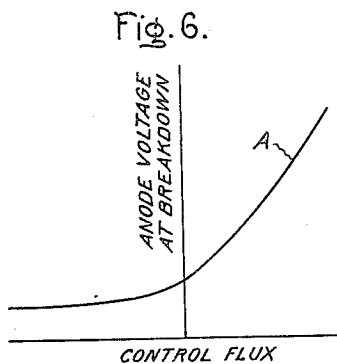
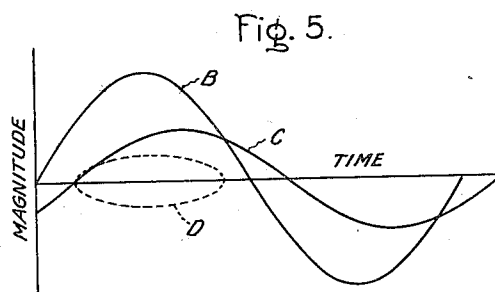
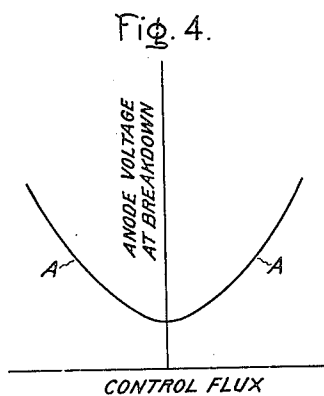
E. D. McARTHUR

2,217,415

DISCHARGE APPARATUS

Filed Dec. 29, 1939

2 Sheets-Sheet 2



Inventor:
Elmer D. McArthur,
by *Harry E. Irwinham*
His Attorney.

UNITED STATES PATENT OFFICE

2,217,415

DISCHARGE APPARATUS

Elmer D. McArthur, Schenectady, N. Y., assignor
to General Electric Company, a corporation of
New York

Application December 29, 1939, Serial No. 311,543

4 Claims. (Cl. 250—27.5)

This application relates to discharge apparatus of the type in which the discharge takes place through an ionizable medium such as an ionizable gas. More particularly, the invention relates to an improved arrangement for controlling apparatus of this character.

In my prior Patent 2,039,101, granted April 28, 1936, there is described a controlled discharge system in which the control function is accomplished by means of a magnetic field acting transversely to the discharge path. The particular apparatus disclosed is characterized by the fact that the control action is solely dependent upon the magnitude of the magnetic field and is entirely independent of its direction. There are certain applications in which this feature has been found to be not wholly advantageous, and it is an object of my present invention to provide improved discharge apparatus in which control of the discharge is directly dependent upon the direction of a magnetic field intersecting the discharge path.

The features which I desire to protect herein are pointed out in the appended claims. The invention, itself, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the drawings in which Fig. 1 is a diagrammatic representation of a discharge apparatus embodying the invention; Fig. 2 is a sectional view of the electrode structure shown in Fig. 1 such view being taken in a plane ninety degrees displaced from that of Fig. 1; Fig. 3 is a section taken on line 3—3 of Fig. 2; Figs. 4 and 5 are graphical representations illustrating the operating characteristics of previously known types of apparatus; and Figs. 6 and 7 are additional graphical representations useful in explaining the operation of the apparatus in Fig. 1.

Referring particularly to Fig. 1, there is shown a discharge device comprising a bulbous glass envelope 10, having an anode 11 at one end thereof and a cathode 12 at the other end. The anode may comprise simply a disklike member of a refractory metal. The cathode, which is better illustrated in Fig. 2, includes a central heater 14 and a plurality of vanelike emitting surfaces 15, extending outwardly from the heater. The whole cathode structure is enclosed within an open-ended metal cylinder 16.

The region between the anode and cathode is surrounded by a generally tubular metallic structure 18 (see Fig. 2) which is provided with a transverse wall portion or barrier 19. As appears more clearly in Fig. 3, the wall portion 19 is im-

perforate over an area which subtends the direct path between the anode 11 and the cathode 12 but is provided at one side with a discharge-permeable opening 20 through which a discharge between the anode and cathode may pass.

Outside the tube there is provided means for producing a magnetic field in a direction which is transverse to the discharge path between the anode 11 and the cathode 12. In the particular arrangement illustrated this means comprises a magnetic yoke 24 and pole pieces 25 and 26 which are arranged adjacent to the walls of the tube 10 in a region between the anode and the cathode. As will be explained more fully hereinafter, it is the function of the magnetic structure to control or assist in the control of the discharge within the tube.

In order to energize the apparatus, an alternating voltage, provided by a transformer 27 (Fig. 1), is impressed between the anode 11 and the cathode 12, the latter element being maintained in emitting condition by means of heating current supplied from an appropriate source such as a battery 17. The cylinder 18, and consequently the associated barrier 19 is preferably maintained at cathode potential or at a few volts above or below cathode potential so as to provide a region of low electrostatic gradient in which the magnetic field provided by the poles 25 and 26 may act. A pulsating current load 28 is connected in series with the tube 10 so as to be energized by the unidirectional current which it supplies.

In the intended operation of the apparatus control of the discharge is accomplished by varying the excitation of the magnetic structure 24. This may be accomplished, for example, by providing the magnetic core with an exciting coil 29 which is energized from the source 27 through a phase-shifting network. The particular network shown comprises a transformer 30 having a secondary center tap which is connected with one end of the coil 29. The terminals of the transformer secondary respectively connect with a resistor 31 and a reactance 32, these elements being connected at a common junction point with the free end of the coil 29. By varying either the resistor 31 or the reactance 32, the phase relationship between the voltage supplied to the terminals of the tube 10 and that supplied to the coil 29 may be varied at the will of the operator. As will appear later, the effect of such variation is to vary the firing time of the tube. The magnetic core 24 may also be supplied with a D—C biasing coil 33 whose function is to adjust the average value of the magnetic flux developed by the core.

The functioning of the magnetic structure as a control means may be readily understood when it is considered that the effect of a magnetic field acting transversely on an electron stream is to produce lateral deflection of the stream. Referring particularly to the disclosure of Fig. 2, it will be seen that the effect of magnetic flux lines terminating on the pole face 26 (shown in dotted outline) upon electrons proceeding from the cathode 12 will be to deflect such electrons either away from or toward the opening 20, depending upon the direction of the flux. The first type of deflection acts to prevent electrons emitted by the cathode from coming into the influence of the anode field and thus serves to impede the initiation of a discharge. In the second type of deflection, electrons are driven toward the opening 20 and the occurrence of a discharge is facilitated. The firing of the tube is therefore controllable by varying the direction of the magnetic field, a matter the importance of which will be explained in the following.

In this connection, reference has already been made to the magnetically controlled discharge apparatus which is disclosed in my prior Patent 2,039,101. The construction of that patent differs from that disclosed herein mainly in the fact that a direct passage is provided between the anode and cathode; that is to say, in that no means is provided for causing the discharge path to be offset from a direct line between the anode and cathode. As a result of the symmetry of this arrangement, the controlling effect of a magnetic field applied to the discharge path is solely dependent upon its magnitude and is entirely independent of its direction. Thus, with the construction referred to and with all other related constructions with which I am familiar, a control characteristic such as that shown in Fig. 4 is realized. This figure shows that any increase of the control flux above zero value in either direction tends to increase the anode voltage required to cause breakdown. As a consequence of this characteristic the operation of an apparatus having this characteristic is as indicated in Fig. 5, in which the curve B represents the variation of anode voltage with time and the curve C represents the variation of magnetic control flux with time. These variations are assumed to be of a common frequency as would be the case, for example, in a circuit arrangement such as that shown in Fig. 1. Due to the symmetrical control characteristic illustrated in Fig. 4, the region of magnetic field strength within which breakdown of the tube can occur is as indicated by the dotted ellipse D of Fig. 5. Specifically, firing of the tube can occur for any anode voltage existing between the extremities of the ellipse, provided the applied magnetic field is not sufficiently strong (in either direction) at the instant such voltage is attained to fall above or below the ellipse.

From a practical standpoint, with both field strength and voltage being of cyclically varying character as indicated, breakdown will actually occur at the first point of intersection of the curve C and the ellipse D. It will be noted, however, that for some conditions of operation and especially for the particular condition shown, the point of curve intersection becomes quite indefinite due to the substantial tangentiality of the curves. Consequently, with a symmetrical magnetic characteristic such as that under consideration, irregular and inconsistent operation of the apparatus may sometimes occur.

That this difficulty is overcome by the appa-

ratus construction shown in Fig. 1 hereof may be readily understood by reference to Figs. 6 and 7 which represent the magnetic control characteristics of such apparatus. In the first of these figures it appears that as the control flux is decreased from a high positive value, that is, from a high value in a direction tending to deflect the voltage stream away from the opening 20, the anode voltage at which breakdown can occur decreases continuously. Furthermore, when the control flux is again increased in a negative sense, a still further decrease in the breakdown voltage occurs, so that the curve A' tends to approach as a limit the value of anode voltage below which no discharge is possible under any circumstances (e. g., the ionization voltage of the discharge medium). As a consequence of this feature the operation of the tube is as indicated in Fig. 7 wherein the curves B' and C' correspond to the similarly identified curves of Fig. 5. In this case, however, the conditions under which breakdown may occur are represented by the dotted line D', it being understood that breakdown may occur for any value of the curve C' which is above this line. It is significant to note that, due to the form of the line D', the point of intersection of this line with the curve C' (i. e., the firing point of the tube) is perfectly definite, so that great certainty and consistency of operation of the apparatus may be realized. In view of this favorable consideration, the apparatus may be used for applications in which the symmetrically responsive devices heretofore available are considered insufficiently reliable.

Variable control of regulation of the discharge may readily be accomplished by the use of the phase-shifting network of Fig. 1. Thus, it is apparent that by adjusting the reactance 32 to cause the phase relationship between the anode voltage and the magnetic excitation to change, the time of discharge may be regulated accordingly.

An alternative mode of control of the discharge may be realized by appropriate use of the biasing coil 33. Thus, energizing the coil from a variable potential source including, for example, a battery 34 and an adjustable resistance 35, the average value of the magnetic flux may be conveniently regulated. For instance, referring to Fig. 7, the change produced by adjustment of the current supply to the coil 33 may be such as to shift the axis of symmetry of the curve C' downwardly to cause the curve to assume the position indicated by the dotted line C''. Under these circumstances the firing point of the tube will be shifted from X to Y as denoted by the intersection of the curves C'' and D'.

While I have described my invention by referring to a specific embodiment thereof, it will be understood that numerous modifications may be made by those skilled in the art without departing from the invention. I, therefore, aim in the claims to include all equivalent variations which fall within the true spirit and scope of the foregoing disclosure.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In discharge apparatus of the type in which the discharge takes place through an ionizable medium, the combination which includes a cathode, an anode, a barrier intermediate the anode and cathode for causing a discharge between them to follow a path which has a portion offset from a direct line between the anode and cathode, means for producing a magnetic field inter-

secting the discharge path, said field being in such relation to the discharge path as to deflect electrons proceeding from the cathode either toward the said barrier so as to impede the initiation of a discharge or toward the said offset portion of the discharge path so as to facilitate such discharge, depending on the direction of the magnetic field, and means for variably controlling the magnetic field to control the discharge.

2. In discharge apparatus of the type in which the discharge takes place through an ionizable medium, the combination which includes a cathode, an anode, a barrier intermediate the anode and cathode and having a discharge-permeable opening therein at a point which is offset from a direct line between the anode and cathode, means for impressing a discharge-favoring potential between the anode and cathode, means for producing a magnetic field transversely to the discharge path said field being in such relation to the discharge path as to deflect electrons proceeding from the cathode either toward the said barrier so as to impede the initiation of a discharge or toward the said discharge-permeable opening to facilitate such discharge, depending on the direction of the magnetic field, and means for variably controlling the magnetic field to control the initiation of the discharge.

3. In discharge apparatus of the type in which the discharge takes place through an ionizable medium, the combination which includes a cathode, an anode, means defining a region of low electrostatic gradient between the anode and cathode, a barrier within said region having a discharge-permeable opening offset from a direct line between the anode and cathode, means for impressing a discharge-favoring potential between the anode and cathode, means for produc-

ing a magnetic field transverse to the discharge path in a region between the cathode and the said barrier, the magnetic field being in such relation to the discharge path as to cause electrons proceeding from the cathode to be deflected toward the barrier so as to impede the initiation of a discharge or toward the said discharge-permeable opening so as to facilitate such discharge, depending on the direction of the field, and means for variably controlling the magnetic field to control the initiation of the discharge.

4. In combination, an electron discharge device comprising an envelope containing an anode, a cathode and a conductive structure including a tubular member surrounding the region between the anode and cathode and a member extending transversely to the discharge path between the anode and cathode, the said transversely extending member being permeable to a discharge only at a part thereof which is offset from a direct line between the anode and cathode, an ionizable medium in said envelope, means for producing a magnetic field intersecting the discharge path between the anode and cathode in a region intermediate the cathode and the said transversely extending member, said field being in such relation to the discharge path as to deflect electrons proceeding from the cathode either toward or away from the discharge permeable part of the said transversely extending member, depending on the direction of the field, and thereby to facilitate or impede the initiation of a discharge through the device in accordance with the actual direction of deflection and means for controlling the magnetic field to control the initiation of a discharge.

ELMER D. MCARTHUR.