

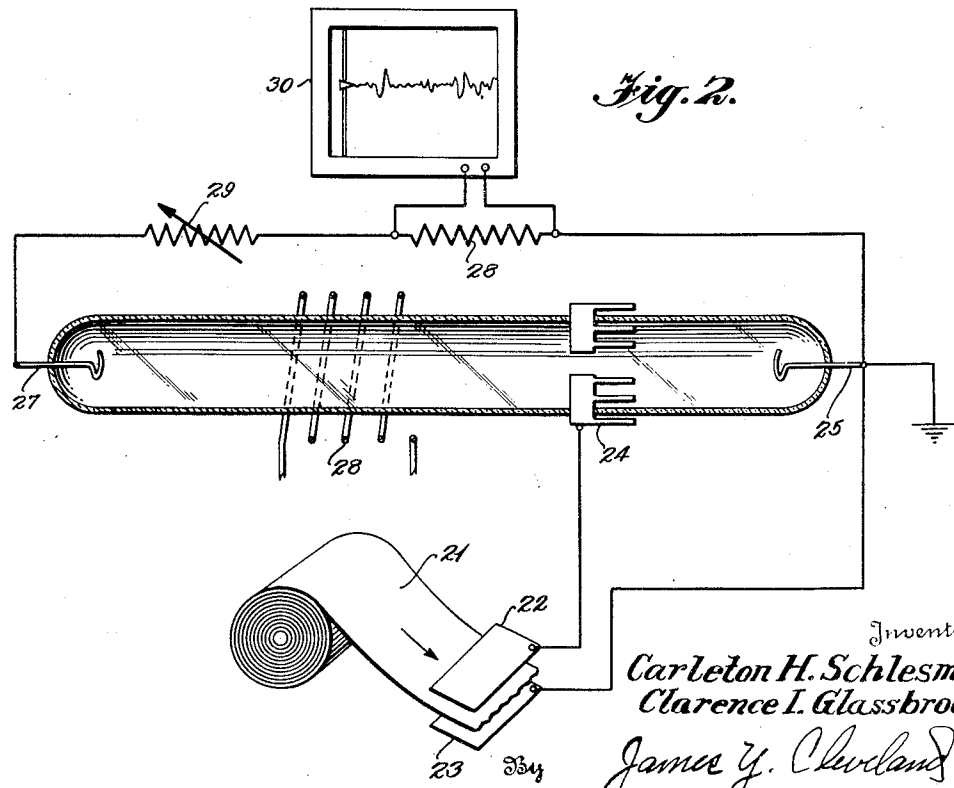
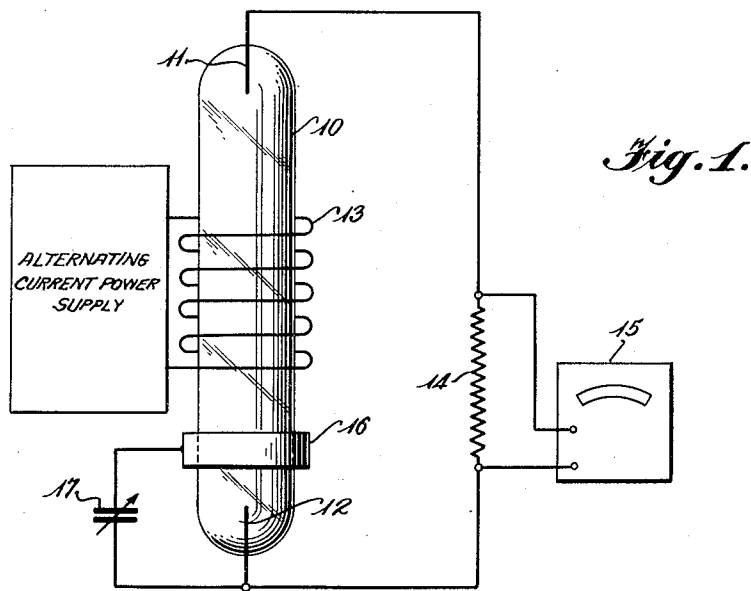
July 8, 1952

C. H. SCHLESMAN ET AL  
ELECTRONIC TUBE

2,602,914

Filed April 2, 1946

3 Sheets-Sheet 1



Inventor  
Carleton H. Schlesman  
Clarence I. Glassbrook  
James Y. Cleveland.  
Attorney

July 8, 1952

C. H. SCHLESMAN ET AL

2,602,914

ELECTRONIC TUBE

Filed April 2, 1946

3 Sheets-Sheet 2

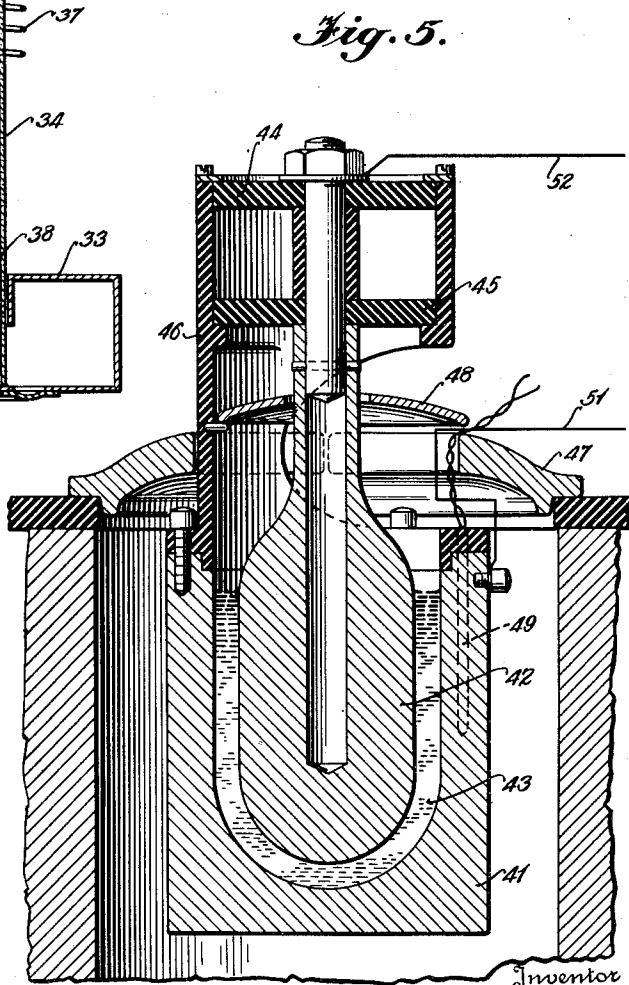
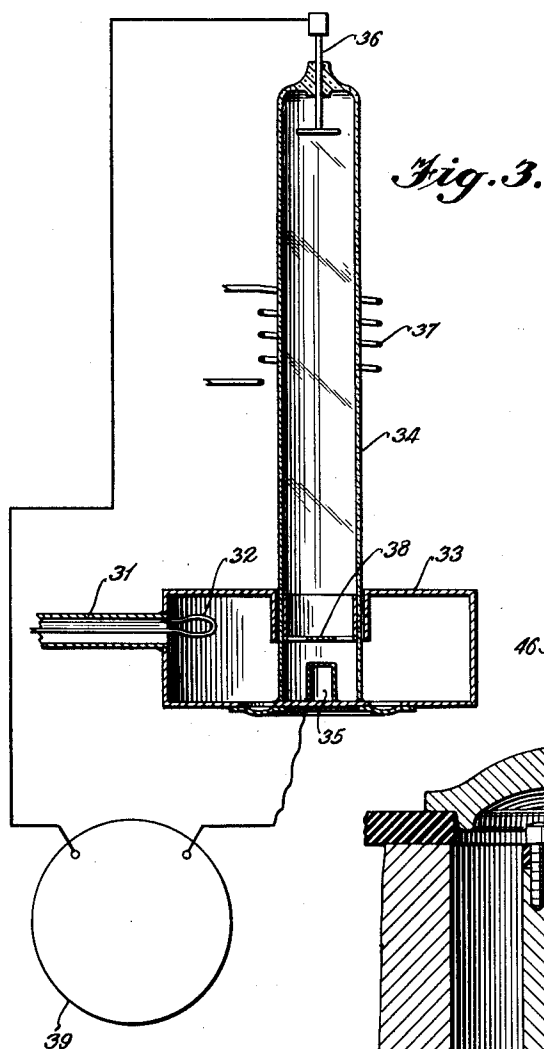


Fig. 4.

Inventor  
Carleton H. Schlesman  
Clarence I. Glassbrook

By James Y. Cleveland  
Attorney

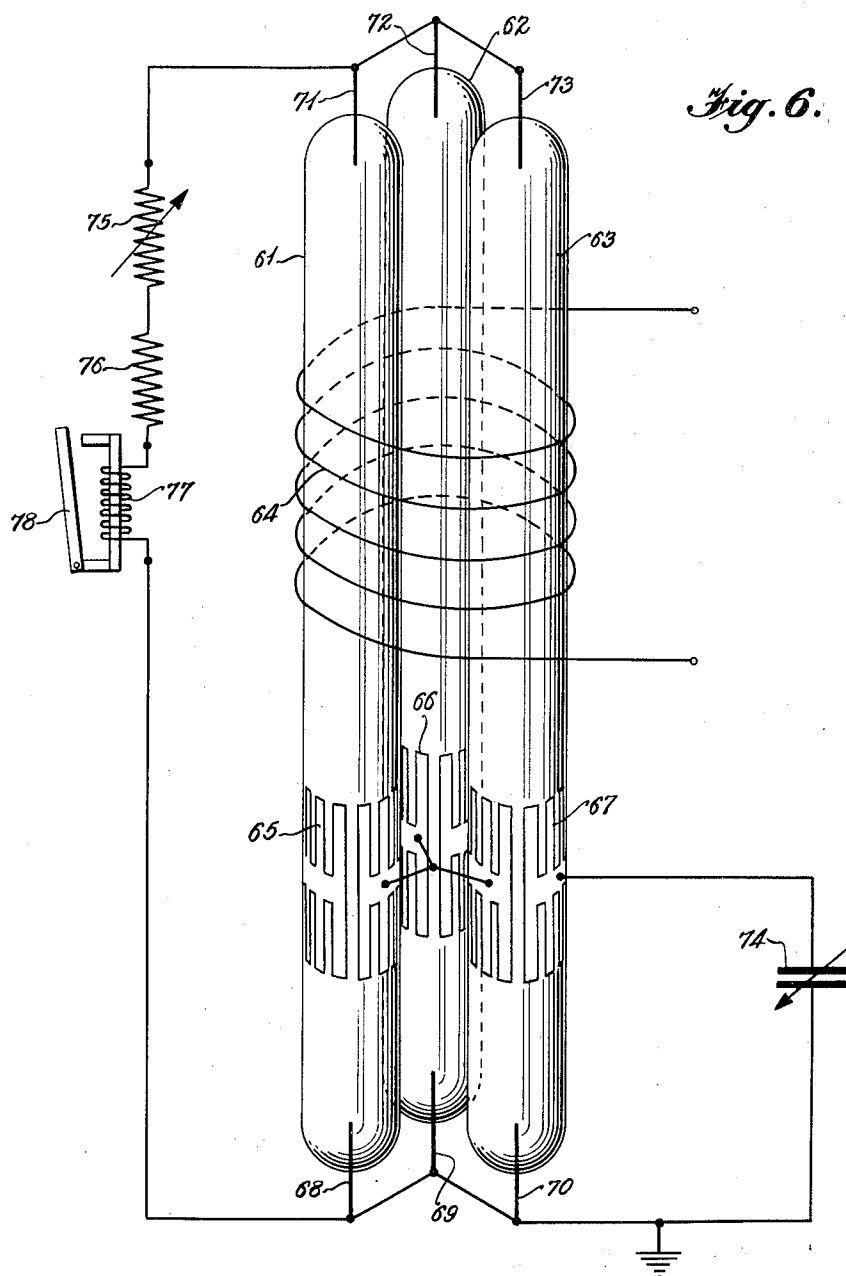
July 8, 1952

C. H. SCHLESMAN ET AL  
ELECTRONIC TUBE

2,602,914

Filed April 2, 1946

3 Sheets-Sheet 3



Inventor  
Carleton H. Schlesman  
Clarence I. Glassbrook  
By *James Y. Cleveland*  
Attorney

## UNITED STATES PATENT OFFICE

2,602,914

## ELECTRONIC TUBE

Carleton H. Schlesman, Camden, and Clarence I. Glassbrook, Glen Echo Farm, N. J., assignors to Socony-Vacuum Oil Company, Incorporated, a corporation of New York

Application April 2, 1946, Serial No. 658,898

7 Claims. (Cl. 321—32)

1

This invention relates to the art of electrical amplification or rectification and more particularly to an improved electrical device useful either as an amplifier or as a rectifier.

The electrical art has long included many examples of thermionic rectifier and amplifier tubes in which a cathode is heated to cause a stream of electrons to flow from it to an anode. The current between the electrodes so produced has been controlled in many ways, as for example by the use of one or more grids between the cathode and the anode.

Also known to the prior art are glow discharge tubes in which a current is caused to flow, not by heating the cathode, but by impressing a sufficient potential between the cathode and the anode to ionize the gas which lies between them. This latter type of device has proven advantageous in many uses but has the inherent drawback of requiring a relatively high potential across its electrodes. Hence, while it is often used as a rectifier tube, it is seldom, if ever, used as an amplifier tube. Additionally, where similar electrodes are used in a tube rectification is rarely accomplished.

In accordance with the principles of the present invention, an entirely new type of electrical amplifier or rectifier may be constructed, which device possesses all of the advantages of each of the aforementioned types of amplifier or rectifier and at the same time avoids the disadvantages and possesses additional advantages that none of the previously mentioned types of device possess.

The new device is capable of amplifying direct currents, low frequency, medium frequency and high frequency currents in essentially the same device. Amplifiers for direct and low frequency currents are very difficult to construct and adjust such as, for example, those used in seismographs and other apparatuses.

The new device comprises, basically, a pair of electrodes in contact with a gas and means independent of the electrodes to subject the gas to a high frequency electrical field sufficient to ionize it and cause it to glow uniformly throughout the area between the electrodes. Under such circumstances, a current is caused to flow in an external circuit between the electrodes without the necessity of heating one of the electrodes or of applying a potential to the electrodes. This current tends of its own volition to be unidirectional and by applying the R. F. field at the proper position along the length of the tube, controlling the pressure and power within the tube, the

2

direction of flow of current can be predetermined and assured. Furthermore, the amount of this current flow can be easily and efficiently controlled by the novel use of grid or shielding arrangements.

Since it is not necessary for the high frequency field that actuates the tube to have any direct connection with any circuit in which the tube is to operate, a single source of high frequency current can actuate a large number of tubes. The tubes may be placed in the circuits in which they are to be used without the circuit designer becoming involved in many of the problems that now arise from the practice of using a common plate power supply source. The new rectifier or amplifier device is also of interest because of its adaptability to use with a very wide range of frequencies and because the glow discharge necessary to cause the tube to operate generates very little heat.

A detailed understanding of the principles of this invention and the application of these principles to practical problems may be had by reference to the appended drawings which illustrate preferred embodiments and uses of the new amplifier or rectifier device, and to the following description of the apparatus illustrated in these drawings.

In the drawings:

Figure 1 is a diagrammatic illustration of a simple rectifier for converting high frequency alternating current into direct current;

Figure 2 is a diagrammatic illustration of a modified form of the tube of Figure 1, arranged in a circuit for testing sheet material;

Figure 3 is a diagrammatic illustration of a modified form of the tube of Figure 1, arranged for detecting and amplifying ultra high frequency currents;

Figure 4 is a diagrammatic illustration of a preferred form of grid for the device of Figure 3;

Figure 5 is a diagrammatic illustration of a device for determining the dielectric constant of fluids using a tube constructed according to the principles of this invention; and

Figure 6 is a diagrammatic illustration of a series of tubes according to this invention, all energized by a single high frequency field.

As illustrated in Figure 1 the broadest aspect of this invention comprises a sealed chamber 10 into which extend a pair of electrodes 11 and 12 and in conjunction with which is some means such as a ring or coil 13 surrounding the chamber, which will provide a high frequency alternating current field capable of ionizing the gas in

3

the chamber. This coil is supplied with power through the leads shown from a source not shown.

The chamber itself is preferably made of glass or some other non-conducting material. The ionizable medium within the chamber is preferably a gas under a relatively low pressure, for example 10 microns of mercury. It may be an inert gas such as argon, neon or helium, or it may be some more complex gas that is nevertheless stable under the conditions of operation, that is, one which will not react and thus change the characteristics of the device.

The electrical field may be applied by a coil of wire or an external band coupled to a source of high frequency electrical energy. In some cases this coil may take the form of a step-up transformer in which the primary only is fed by the source of high frequency current and secondary is shunted by a condenser of such size as to form a resonant circuit which will raise the field intensity within the chamber. While the drawing shows the actuating coil 13 as a single coil surrounding the chamber between the electrodes, other constructions may be used in lieu thereof. In some constructions, for example, it may be desired to place the coil inside the chamber 10, and even if the coil is replaced by a step-up transformer with a secondary shunted by a condenser, this whole circuit may be pre-tuned and mounted within the chamber 10. Furthermore, although the electrodes are shown at opposite ends of the chamber 10 and the actuating coil near the center thereof, the construction may be such that the electrodes will be placed at the same end of the chamber or the chamber may have an entirely different shape from that shown in Figure 1.

Despite the fact that the electrodes as illustrated in Figure 1 are of the same shape, a unidirectional current will be generated when the high frequency field is applied to the coil 13 and this current may be measured by connecting the electrodes 11 and 12 to a direct current ammeter, or, as shown in the drawing, to the opposite ends of a resistor 14 across which is connected a direct current voltmeter 15.

The output of the new device may be controlled by placing a conductive ring 16 around the chamber 10 between the actuating coil and one of the electrodes 12 and connecting this metal ring 16 to the electrode 12 through a variable condenser 17. As the capacity of the condenser is varied it will be found that the direct current flowing between the electrodes 11 and 12 will also vary and the variation in current is quite sensitive to even a very small variation in the capacity of the condenser 17.

In lieu of the metal ring 16 a grid may be inserted into the tube or chamber 10 between the electrodes 11 and 12, or the metal ring may take the form of a Faraday shield to prevent the flow of eddy currents therein. Also, in place of the single metal ring 16 a pair of metal rings may be placed around the chamber 10, or a pair of grids placed within the chamber 10, and these rings or grids, or a combination of one ring and one grid, may be connected through a condenser or through a variable impedance consisting of a condenser and an inductance or a condenser and a resistance. Any of these arrangements may be used to control the flow of direct current between the electrodes and by tuning any of these arrangements the flow of this current may be varied.

One particularly advantageous use for the new

4

device is illustrated in Figure 2. In accordance with this figure the device is incorporated in an apparatus for inspecting sheet material. This novel apparatus inspects the sheet material both for thickness and flaws at a single operation.

Using the same principles as does the device of Figure 1, sheet material 21 may be passed between condenser plate 22 and condenser plate 23, one of which is connected to a Faraday shield type of controlling ring 24, the other of which is connected to one electrode 25 of a tube of the type shown in Figure 1. This tube comprises a container 26 for a gas under low pressure and a second electrode 27. It is actuated by a coil 28 supplied with high frequency current. The electrodes 25 and 27 of the rectifier or amplifier device are connected through a fixed resistance 28' and a variable resistance 29. The recorder 30 is connected across the fixed resistor 28' and the tape may be driven at a speed proportional to the speed of movement of the sheet material undergoing inspection. Thus the recorder produces a running record of the inspection. A variable resistor 29 serves to adjust the amplitude of the swing of the recorder needle and may be adjustable in a series of predetermined steps so as to change the scale on which the recorder operates.

A somewhat different form of the device of this invention is shown in Figure 3. This modified form of device is used for the direct measurement by a direct current meter of ultra high frequency currents. The ultra high frequency current to be measured is fed to the device through a coaxial cable 31 with a radiating loop 32 extending into a cavity resonator 33 which surrounds one end of the rectifier or amplifier device of this invention. The rectifier or amplifier device of this invention then consists of a chamber 34 with electrodes 35 and 36 extending into the ends thereof and an exciting coil 37 supplied with high frequency electrical current from a source not shown. A grid 38 mounted inside the chamber 34 and spaced from the lower electrode 35 will pick up sufficient of the ultra high frequency by capacitance through the chamber walls to control the direct current flow between the electrodes 35 and 36, which current can be measured by direct current ammeter 39. A plan view of a preferred form of the grid 38 is shown in Figure 4.

Because the measurement of ultra high frequency current is difficult, and the type of apparatus shown in Figure 3 is capable of measuring this type of current simply and directly, this particular application of the invention is of special value for this purpose.

If it is desired to use the principles of the invention as illustrated in Figure 2 for the measurement of the dielectric constant of liquids, this may be done as illustrated in Figure 5 by use of a dielectric constant measuring cell in place of the two condenser plates 22 and 23 of Figure 2. Such a dielectric measuring cell may consist of an outer or cylindrical electrode 41 and an inner electrode 42, the space between which may be filled by the liquid 43, the dielectric of which is to be measured. The central electrode 42 may be supported by being clamped to a pair of insulating rings 44 and 45 mounted in a support 46 which is in turn mounted on the outer electrode 41. The supporting parts are preferably of an insulating material and shielding members 47 and 48 may be provided to prevent extraneous capacity from affecting the operation of the device. A thermo-

5

couple 49 may be mounted in the outer electrode so that the temperature at all times can be known. The outer electrode 41 may then be connected into the circuit shown in Figure 2 through a conductor 51 and the inner electrode into the same circuit through a conductor 52.

When it is desired to use a plurality of the rectifier or amplifier devices of this invention and to energize them from a single source of high frequency electrical current this may be done as illustrated in Figure 6 by surrounding a series of such tubes 61 and 62 and 63 with a single radio frequency coil 64. As illustrated in Figure 6 control rings 65, 66 and 67 have the form of Faraday shields and are all connected in parallel as are the three lower electrodes 68, 69 and 70 and also the three upper electrodes 71, 72 and 73. As illustrated in Figure 1, the action of the devices in Figure 6 is controlled by the variable condenser 74 connected between the control rings and the lower electrodes. The output of the three devices connected in parallel is passed through a variable resistor 75, a fixed resistance 76 and the operating coil 77 of a relay 78. Obviously the output of the three devices may be connected to any other device which it is desired to operate and which will operate on the amount of current which the devices are capable of producing.

While the three devices in Figure 6 have been shown as connected in parallel it is also possible to connect the devices in a circuit where they are not in parallel, with equally satisfactory results. They may, for example, be connected in a radio circuit in which the three devices take the place of the ordinary radio tubes interconnected by transformers or resistance coupling or in any other way common in a radio circuit.

With the above teaching it will be apparent to those skilled in the art that the present invention, particularly that form shown in Figure 6, finds direct application in polyphase systems wherein it is desired not to disturb the phase relationship, for example, amplification of the separation phases can be effected.

The above applications of the present invention have been given by way of explaining it and it is to be understood that it has broader application and is to be limited only by the scope of the appended claims.

We claim:

1. A device of the type described that comprises a gas filled elongated envelope, electrodes extending into said envelope from opposite ends, an external circuit connected to said electrodes having only a load connected therein, a coil disposed about said envelope at a position between the electrodes, means for supplying alternating current to the coil to produce an electrical stress field in the gas within the envelope, a third electrode for said device disposed at a position between the coil and one end electrode, and means connected between the third electrode and the adjacent end electrode but independent of said current supplying means to control the output of said device to said load.

2. A device of the type described that comprises a gas filled elongated envelope, electrodes extending into said envelope from opposite ends, an external circuit connected to said electrodes having only a load connected therein, a coil disposed about said envelope at a position between the electrodes, means for supplying alternating current to the coil to produce an electrical stress field in the gas within the envelope, a third electrode for said device disposed at a position be-

6

tween the coil and one end electrode, and impedance means connected between the third electrode and the adjacent end electrode but independent of said current supplying means to control the output of said device to said load.

3. A device of the type described that comprises a gas filled elongated envelope, electrodes extending into said envelope from opposite ends, a coil disposed about said envelope at a position between the electrodes, means for supplying alternating current to the coil to produce an electrical stress field in the gas within the envelope, a third electrode for said device disposed at a position between the coil and one end electrode, and a condenser connected between the third electrode and the adjacent end electrode but independent of said current supplying means to control the output of said device.

4. A device of the type described that comprises a gas filled elongated envelope, electrodes extending into said envelope from opposite ends, an external circuit connected to said electrodes having only a load connected therein, a coil disposed about said envelope at a position between the electrodes, means for supplying alternating current to the coil to produce an electrical stress field in the gas within the envelope, a third electrode for said device in the form of a band disposed around the envelope at a position between the coil and one end electrode, and means connected between the third electrode and the adjacent end electrode but independent of said current supplying means to control the output of said device to said load.

5. A device of the type described that comprises a gas filled elongated envelope, electrodes extending into said envelope from opposite ends, an external circuit connected to said electrodes having only a load connected therein, a coil disposed about said envelope at a position between the electrodes, means for supplying alternating current to the coil to produce an electrical stress field in the gas within the envelope, a third electrode for said device in the form of a grid disposed at a position between the coil and one end electrode, and means connected between the third electrode and the adjacent end electrode but independent of said current supplying means to control the output of said device to said load.

6. A device of the type described that comprises a gas filled elongated envelope, electrodes extending into said envelope from opposite ends, an external circuit connected to said electrodes having only a load connected therein, a coil disposed about said envelope at a position between the electrodes, means for supplying alternating current to the coil to produce an electrical stress field in the gas within the envelope, a third electrode for said device in the form of a Faraday cage disposed at a position between the coil and one end electrode, and means connected between the third electrode and the adjacent end electrode but independent of said current supplying means to control the output of said device to said load.

7. A device of the type described adapted to measure the dielectric properties of substances that comprises a gas filled elongated envelope, electrodes extending into said envelope from opposite ends, a coil disposed about said envelope at a position between the electrodes, means for supplying radio frequency current to said coil to produce an electrical stress field in the gas within the envelope, a third electrode for said device disposed at a position between the coil and one

end electrode but independent of said current supplying means, a pair of additional electrodes so arranged relative to each other as to define an area to be occupied by the substance whose dielectric properties it is desired to measure, means for connecting one of the pair of additional electrodes to the third electrode, and means for connecting the other of the pair of additional electrodes to the adjacent electrode that extends into the envelope, whereby the output of the device is a measure of the dielectric properties of the substance.

CARLETON H. SCHLESMAN.  
CLARENCE I. GLASSBROOK.

#### REFERENCES CITED

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

| Number    | Name     | Date          |
|-----------|----------|---------------|
| 1,328,041 | Fischer  | Jan. 13, 1920 |
| 1,925,110 | Parker   | Sept. 5, 1933 |
| 2,149,847 | Kolin    | Mar. 7, 1939  |
| 2,152,639 | Edgerton | Apr. 4, 1939  |
| 2,197,398 | Smith    | Apr. 16, 1940 |
| 2,347,715 | Spencer  | May 2, 1944   |

#### FOREIGN PATENTS

| Number  | Country       | Date          |
|---------|---------------|---------------|
| 451,830 | Great Britain | Aug. 12, 1936 |