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VOLTAGE REGULATOR

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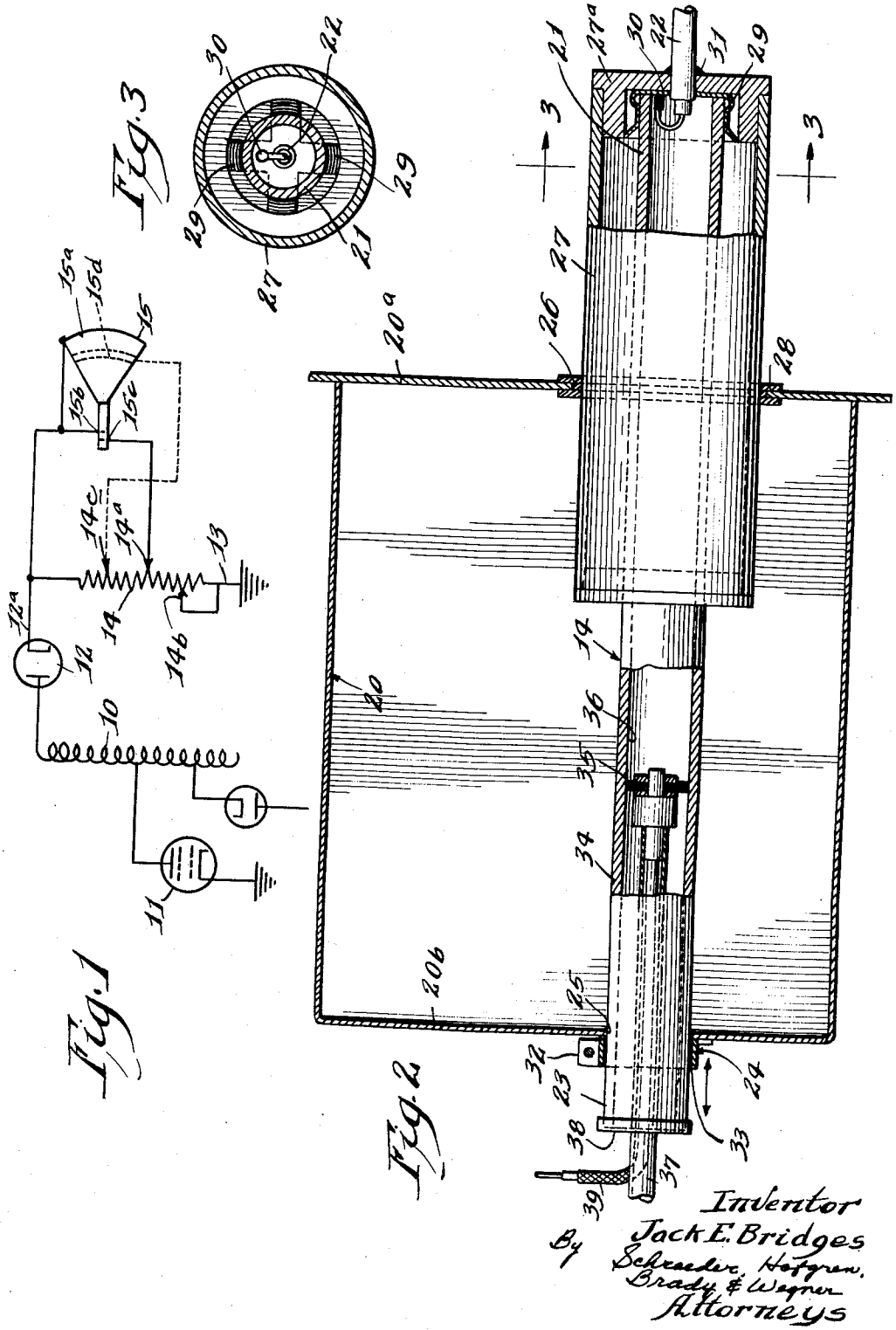

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3,047,793
VOLTAGE REGULATOR

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This invention is concerned with a voltage regulator and more particularly with a voltage regulator employing a semiconductor element which has an inverse resistance-voltage characteristic, and is especially adapted for high voltage use, as in a power supply for a color television receiver.

In a color television receiver, the tri-color cathode-ray tube has an ultor circuit which operates at a voltage of the order of 20,000 to 25,000 volts, and which is relatively sensitive to variations in voltage. That is, the quality of the picture displayed on the tube is adversely affected by fluctuations in the voltage applied to the ultor circuit. Regulated high voltage power supplies of the type presently used in color television receivers require relatively complicated and expensive circuits utilizing special high voltage vacuum tubes, such as the 6BK4 high voltage triode, in a "shunt-regulator" circuit.

It is a general object of the present invention to provide a novel and improved regulated high voltage power supply, which is particularly adapted for color television receivers.

A particular object is the provision in a television receiver of a high voltage system, including a source of direct, high potential energy subject to potential amplitude variations, a variable impedance load connected to the source, and a semiconductor element having an inverse resistance-voltage characteristic, connected to the source for regulating the potential applied to the load. Another object is the provision of such a power supply for a cathode-ray tube having an ultor circuit and a focus electrode, with the ultor circuit connected to the regulated high voltage source and the focus electrode connected to a tap on the semiconductor element, so that the ratio of the ultor to focus potential is maintained substantially constant even though there should occur a variation in the absolute magnitude of the potentials. This reduces the defocusing or "blooming" effect sometimes noticed with high beam currents.

A further object is the provision of a power supply for a load requiring a plurality of related voltages, including a source of potential subject to variation, a voltage regulating semiconductor element having a resistance characteristic which varies inversely with the voltage applied thereto, connected in shunt with the source, a circuit connecting a portion of the load with the source, a tap on the semiconductor element, and a circuit connecting another portion of the load with the tap.

Still another object is the provision of a regulated power supply including a source of high voltage relative to a common potential, a voltage regulating element connected to the source and including a semiconductor element, the resistance of which varies inversely with the voltage applied thereto, and means providing an adjustable connection to the semiconductor element at the common potential. Yet a further object is the provision of such a power supply in which the voltage regulating element is elongated and is provided with a protective housing having a conductive portion at the common potential, and an opening therein, with one end of the regulating element connected to the source of high voltage and the other end extending out through the opening in the housing, and an adjustable connection to the element intermediate the ends and returned to the common potential with the exposed end of the elongated element permitting manipulation of the element relative to the adjustable connection.

Still another object is the provision of a power supply including a source of high voltage relative to a common potential, a tubular voltage regulating element of a semiconductor material, having an inner and outer surface, connected to the source, the resistance of the material varying inversely with the voltage applied thereto, means at the common potential providing an adjustable connection with one of the surfaces of the element and second means providing a connection to the other surface of the element intermediate the common connection and the connection to the source. Yet a further object is the provision of such a power supply in which the connection to the outer surface of the tubular regulating element is returned to the common potential and the adjustable connection to the inner surface of the element includes a manipulating element extending through the tubular member.

Other objects and advantages will become readily apparent from the following detailed description taken in connection with the accompanying drawings, in which:

FIGURE 1 is a schematic diagram of a portion of the high voltage circuit of a television receiver illustrating an embodiment of the invention;

FIGURE 2 is a view partially in elevation and partially in section illustrating a physical embodiment of the invention; and

FIGURE 3 is a sectional view taken generally along the line 3—3 of FIGURE 2.

While an illustrative embodiment of the invention is shown in the drawings and will be described in detail herein, the invention is susceptible of embodiment in many different forms, and it should be understood that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the invention to the embodiments illustrated. The scope of the invention will be pointed out in the appended claims.

The invention is illustrated and described herein as embodied in a high voltage circuit for a color television receiver and it is particularly adapted for such use. However, it may be used in other situations requiring regulation of high voltages, as of the order of several thousand volts and greater, particularly where the load supplied by the power source requires two or more related voltages, as will be apparent to those skilled in the art.

Turning now to the drawings, and particularly to FIGURE 1, the high voltage circuit of a television receiver is illustrated. In accordance with the usual practice, the high voltage is derived from the horizontal sweep transformer **10** which is connected in the anode circuit of the horizontal power amplifier **11**. Positive pulses appearing at the upper terminal of transformer **10** are rectified by diode **12** and a direct high voltage potential appears at the cathode **12***a* thereof. Connected in shunt with the high voltage supply, between the cathode **12***a* of diode **12** and a common reference potential or ground **13** is a voltage regulating element which is preferably of a semiconductor material having a resistance characteristic which varies inversely with the voltage applied thereto. The ultor circuit of a cathode-ray tube **15** is connected directly to the cathode **12***a* of the high voltage rectifier diode, and includes both a connection to the screen **15***a* of the cathode-ray tube and a connection to an accelerating electrode **15***b*. An adjustable tap **14***a* on the regulating element provides a potential for a beam-forming or focusing electrode **15***c* of the cathode-ray tube. The total impedance, and thus, to a certain extent, the regulating characteristic of element **14** may be varied by an adjustable connection **14***b* to the reference or common potential **13**. In a tube which uses post deflection accelera-

tion, the acceleration ring **15***d* is connected to a tap **14***c*, as shown in broken lines.

Briefly, the voltage regulating element operates in the following manner. Assuming a steady state condition, a current determined by the amplitude of the high voltage and the resistance of element **14** will flow through the regulating element. If the high voltage appearing at the cathode **12***a* of the diode should begin to rise, the resistance of regulating element **14** drops, due to its inverse resistance-voltage characteristic, and the current drawn therethrough increases at a rate faster than the rate of increase of the high voltage. This added current drain flowing through the internal impedance of the high voltage source has a tendency to drop the potential appearing at the cathode **12***a*. Conversely, if the high voltage of cathode **12***a* tends to decrease, the resistance of regulating element **14** increases, reducing the bleeder-current drawn therethrough at a faster rate than the voltage decreases, tending to increase the terminal voltage.

The semiconductor regulating element **14** may be of any suitable material which has an inverse resistance-voltage characteristic so that the resistance decreases as the voltage applied thereto increases, and vice versa. Examples of such materials are the rutile form of titanium, silicon carbide, and P-N junctions (preferably operating in reverse Zener characteristic) as of germanium or silicon. Suitable materials are sold under the trademarks "Carboloy" and "Thyrite" by General Electric Company, and "Globar" by The Carborundum Co., Niagara Falls, New York. Similar materials are also sold by Victory Engineering Corp., Union, New Jersey.

The regulating element **14** is preferably a single unitary piece, for ease in mounting, but may be made up of a series of smaller sub-elements, as discs, rods, or the like, secured together in a suitable manner.

The actual resistance voltage characteristic of the material depends to a certain extent on the circuit with which it is used and the degree of regulation desired. Conditions in the voltage regulating circuit may be expressed by the equation $I=KV^n$ where I is the current through the regulating element, K is a constant determined by the physical size and electrical characteristics of the regulating element, V is the voltage applied thereto, and the exponent n is a measure of the rate at which the resistance of the element changes with the voltage. For example, the following chart illustrates the effect of varying the exponent n on the bleeder current, with a selected voltage regulation of 9%. The no load condition, zero beam current in the cathode-ray tube, corresponds with an ultor voltage of 25 kilovolts; and a full load condition, 800 microamperes beam current (maximum brightness), corresponds with an ultor voltage of 22.8 kilovolts.

N	Bleeder Current (μ amp.)	
	No Load	Full Load
6.58	560	300
8.6	560	250
9.85	560	200

Semiconductor elements or devices of the character contemplated herein are available with characteristics having a value for the exponent "n" as high as 9 or 10. Satisfactory operation has been achieved with material having an exponent of the order of 6.5 to 7.

Turning to the physical embodiment of the invention illustrated in FIGURES 2 and 3, the regulating element **14** is illustrated as an elongated tubular member. A protective housing **20** is provided for the regulating element and may enclose other elements of the high voltage system, such as the horizontal transformer **10** and diode **12**. The housing **20**, as shown in FIGURE 2, includes a panel **20***a*, which is a portion of the chassis on which other components of the television receiver are mounted, and a cover or cage **20***b*, all preferably of a conductive material, so that the enclosure is at the chassis or common reference potential. One end **21** of the tubular member **14** is connected with the source of high voltage potential through an insulated conductor **22**, while the other end **23** is returned to the chassis or common potential through a sliding connector **24** secured to housing **20**. The high voltage enclosure **20** is provided with a pair of aligned openings **25** and **26** through which the ends **21** and **23** of the semiconductor element **14** extend.

The high voltage end **21** of the regulating element is enclosed within an elongated sleeve **27** of insulating material which is slidably carried in opening **26** by a grommet **28**. An insulating end cap **27***a*, which closes the end of insulating sleeve **27**, is provided with a spring clip **29** which centers the end **21** of the regulating element and secures it within the insulating sleeve. The high voltage connection is preferably effected by soldering the end of the high voltage conductor to the spring clip **29**, as indicated at **30**, with the spring clip contacting the end of the regulating element. The high voltage cable **22** is mechanically secured to end cap **27***a* by cement **31**.

The common connection **24** at the end **23** of the regulating element includes a split clamping ring **32** with a conductive lining **33** which engages the outer surface **34** of the regulating element. The end **23** of the regulating element which extends from the enclosure **20** is thus at the common reference or ground potential, and may be grasped manually to adjust the position of the regulating element **14** with respect to the connection **24**, adjusting the active length of the regulating element and thus the operating characteristics of the regulating circuit.

An intermediate voltage is obtained from the regulating element, as for the focus electrode of the cathode-ray tube, by means of a sliding contactor including a disc **35** of conductive material which engages the inner surface **36** of the tubular regulating element **14**. The disc **35** is mounted at the end of a tubular manipulating member **37** which extends outwardly through the end **23** of the element **14**. The manipulating element **37** is centered and supported by end cap **38**. The connection for the focus element is made by an insulated conductor **39** which extends through the tubular manipulating element **37** and is secured at its inner end to the conductive rubber slider **35**.

The voltage regulator is initially adjusted for proper operation by adjusting the position of the element **14** relative to the connection **24**. The proper focus voltage is then secured by adjusting the position of slider disc **35**.

The material from which the regulating element is made is rather hard and it is undesirable to make sliding connections thereto through metallic contactors as the surface of the metal is abraded and small particles ground off which may cause trouble with the set. Accordingly, lining **33** and disc **35** are preferably made of a non-abradable conductive soft material, as rubber, plastic, felt or the like containing distributed conductive carbonized particles. Not only is there less abrasion of the sliding contact surface, but any particles which are ground off have a relatively high resistance and are not likely to cause any difficulty.

The arrangement disclosed, in which the focus potential is secured from the regulated supply has the advantage that, as the ultor voltage varies, even though the variation is slight as a result of the regulating action of element **14**, the focus voltage also varies. Thus, the ratio of the ultor to focus voltage remains substantially constant throughout the operating range of the system. This reduces the defocusing effect sometimes encountered in color television receivers during high-lights, when the beam amplitude is maximum and the ultor circuit is loaded to its maximum capability, dropping the ultor voltage, even in a regulated power supply, as a result of the internal impedance of the supply; the focus circuit being

unloaded, its voltage remains substantially the same, and the change in the relative value of the voltages defocuses the picture to an extent that is sometimes objectionable. Furthermore, the focus supply illustrated in the drawing is of relatively low impedance and therefore the focus voltage is independent of leakage current between the focus electrode and the ultor or cathode electrodes of the cathode-ray tube.

An additional feature of the novel regulating circuit is that the high voltage is drained off rapidly through the semiconductor regulating element when the set is turned off. This eliminates the need for special safety devices normally used in color television sets, which may either delay the removal of the chassis cover or mechanically short the high voltage to ground as the cover is removed.

I claim:

1. In a regulated power supply having a source of high voltage relative to a common potential: an elongated tubular voltage regulating element of a semiconductor material, the resistance of which varies inversely with the voltage applied thereto, said element having an inner and an outer surface and having one end connected to said source of high voltage; a protective housing for said element, having a conductive portion at said common potential, with a pair of aligned openings therein; means mounted in fixed relationship with said housing providing an adjustable connection with the outer surface of said tubular element and connected to said common potential, both ends of said element extending from the openings in said housing with the end opposite said one end being at said common potential and exposed for manipulation of the element with respect to said adjustable connection; an insulating shield for the exposed portion of said one end of said element; means providing a connection to the inner surface of said element intermediate the connection at said common potential and the connection at said one end; and a manipulating element for said intermediate connection extending out through said opposite end of said element.

2. In a regulated power supply having a source of high voltage relative to a common potential: an elongated voltage regulating element of a semiconductor material, the resistance of which varies inversely with the voltage applied thereto and having one end connected to said source of high voltage; a protective housing for said element having a conductive portion at said common potential, and an opening therein, said one end of said element extending through said opening; means providing an adjustable connection to said element, said means being mounted in fixed relationship with said housing and being returned to said common potential; and an elongated insulating sleeve surrounding the exposed portion of said one end of said element and slidably carried in the opening through which said one ends extends.

3. In a regulated power supply having a source of high voltage relative to a common potential: a voltage regulating element connected to said source and including a semiconductor element, the resistance of which varies inversely with the voltage applied thereto; a protective housing for said element, having a conductive portion at said common potential with an opening therein; means providing an adjustable connection to said element, said means being returned to said common potential; and means, at said common potential, extending through the opening in said enclosure for adjusting the relative position of said element and said connection means.

4. In a regulated power supply having a source of high voltage relative to a common potential: a voltage regulating element connected to said source and comprising an elongated, continuous tubular semiconductor element having outer and inner surfaces for electrical connection, the resistance of said element varying inversely with the voltage applied thereto; means providing an adjustable connection to a surface of said semiconductor element, at a point spaced from the connection with said source, said means being at said common potential, there being a voltage gradient along said surfaces from said source to said connection means; and connector means associated with the other of said surfaces of said element and spaced from the first-mentioned means, providing a second adjustable connection to said semiconductor element at a potential level intermediate the common potential and the high voltage, the voltage between the point of connection with said source and said first-mentioned connector, and the voltage between the first-mentioned and second-mentioned connector maintaining a relatively fixed ratio for supplying related loads.

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