

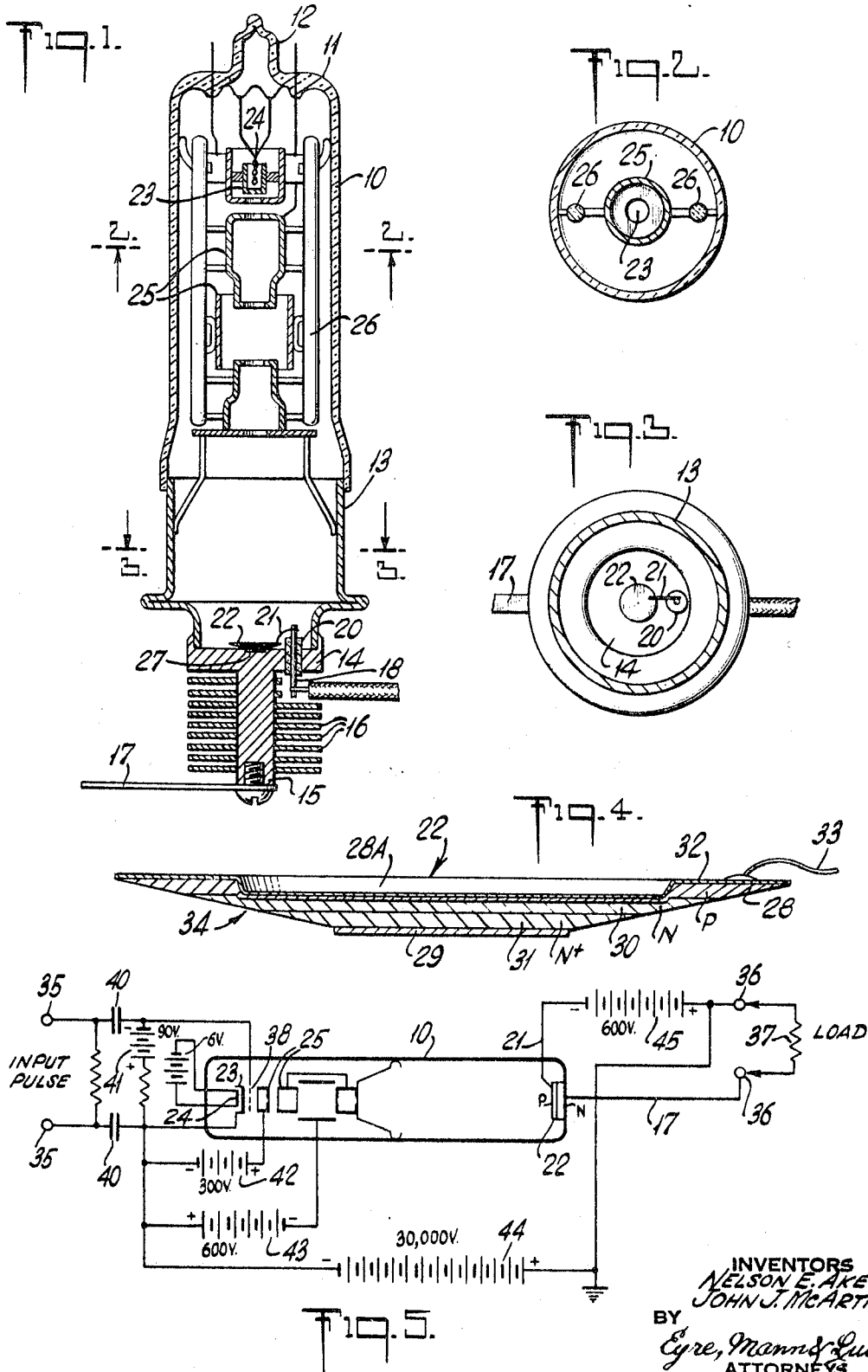
Aug. 5, 1969

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3,459,985

PULSE AMPLIFIER

Filed Aug. 11, 1967



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3,459,985

PULSE AMPLIFIER

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Filed Aug. 11, 1967, Ser. No. 659,947

Int. Cl. H01j 29/10, 31/26

U.S. Cl. 313-89

6 Claims

ABSTRACT OF THE DISCLOSURE

A pulse amplifier comprises an electron gun which generates an electron beam of high energy and an aluminum covered semiconductor diode connected in series with an output circuit. The intensity of the electron beam is controlled by a grid coupled to an input circuit. The output circuit includes a source of direct current power.

This invention comprises a cathode ray tube in combination with a semiconductor diode. The cathode ray generating means is similar to the electron gun in modern television picture tubes except that the electron beam carries more current and covers a wider area. The usual control grid is used to vary the intensity of the beam and since this control means is efficient and includes no appreciable inductance, very short pulses of electrons may be controlled. A semiconductor diode is positioned in line with the beam and its conductance is controlled by the high speed electrons which penetrate the first conductive type layer.

One of the features of the invention is a covering of metallic aluminum, about 0.1 micron thick which acts as an electrode.

Another feature of the invention is the formation of a sharp edge around the entire diode. The edge is formed by grinding away a portion of the disk so that the junction between different conductivity types is at least seven times as far away from the edge as it would be if the usual disk shape were retained. This shape increases the voltage breakdown and almost eliminates the surface reverse current leakage.

For a better understanding of the present invention, together with other features and objects thereof, reference is made to the following description taken in connection with the accompanying drawings.

FIG. 1 is a cross sectional view of the pulse amplifier.

FIG. 2 is a cross sectional view of the amplifier shown in FIG. 1 and is taken along line 2-2 of that figure.

FIG. 3 is another cross sectional view of the amplifier shown in FIG. 1 and is taken along line 3-3 of that figure.

FIG. 4 is a cross sectional view of the diode used in the amplifier, to an enlarged scale.

FIG. 5 is a schematic diagram of connections showing how the amplifier is used to amplify pulses.

Referring now to FIGS. 1 through 4, the amplifier comprises a glass envelope 10 having a base 11, in which lead-in wires are sealed, and a tip off tube 12 for exhausting and sealing the envelope. A portion of the envelope is made of metal, such as Kovar, and includes a cylindrical cavity 13 and a base disk 14. A metal stem 15 having a plurality of spaced disks 16 is secured to the base 14 to dissipate the heat generated by the passage of current through the diode. The stem 15 is used as one of the diode terminals for connecting to a conductor 17. The other diode terminal includes a lead-in conductor 18 held in an insulator bushing 20 and welded to a diode wire 21. The diode 22 is soldered to the center of disk 14 and axially aligned for receiving the electron beam.

The electron beam is formed by a cathode 23 formed

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in the shape of a cup and heated by a heater wire 24 connected to an external source of electrical power. A plurality of electrostatic focusing electrodes 25 are mounted in the envelope 10, such electrodes being secured to two glass rods 26. This part of the amplifier is old in the art and is substantially the same as the focusing means employed in television picture tubes. Each of the focusing electrodes 25 is connected to an external source of potential and these sources may be adjusted to provide a wide electron beam to cover the entire area of the diode 22. Details of focusing electrodes can be found in "Vacuum Tubes," a book published in 1948 by McGraw-Hill Company, New York, N.Y.

The diode 22 is shown in detail in FIG. 4 and comprises a disk of silicon having two conductivity types. The diode 22 is supported on a metal plate 27 (FIG. 1) made of molybdenum, tungsten, or an alloy having a coefficient of expansion similar to that of silicon. The metal plate 27 is soldered to the base 14 which may be made of copper. A nickel-gold layer 29 is deposited on the diode so that the diode may be soldered to the molybdenum plate.

The diode 22 comprises an upper P-type layer 28, an intermediate N-type layer 30, and a base layer 31 of N+ silicon to increase conductivity and reduce the amount of heat generated. The diode is first formed in the shape of a solid disk having flat upper and lower surfaces. Then a P-type is formed on the upper surface and an N+ layer on the lower surface. Next, the central portion of the upper layer is etched away to create a recess 28A and then a shallow P-type layer is added to the bottom of the recess. Finally, a very thin layer of aluminum 32 is evaporated onto the entire top surface to form an upper electrode and to create a surface for thermo-compression bonding of the conductor 33. The layer of aluminum may be about 0.1 micron thick. The diode is now attached to a jig and a portion of its lower edge ground away. The angle of the ground surface 34 is 8 degrees. The diode is now ready for assembly in the evacuated chamber 10.

FIG. 5 shows one of the circuits which may be employed with the pulse amplifier to accept input pulses at a pair of input terminals 35 and deliver an amplified pulse to a pair of output terminals 36 and a load 37. The input terminals are coupled to a control electrode 38 and the cathode 23 by means of a pair of capacitors 40 and a biasing battery 41. The focusing electrodes 25 are connected to sources of potential 42 and 43 for directing the electron beam into a focused stream that just covers the depressed area 28A of the diode 22. Both sources of potential 42 and 43 may be adjustable and both may be connected in series with a high resistance since they do not provide appreciable current to the electrodes.

A high voltage source of direct current power 44 is connected between the cathode 23 and one terminal 36 of the load. The load terminal may be grounded. This power source 44 produces the electric field which gives the electron beam its velocity and energy to penetrate the aluminum coating 32 and penetrate the P-type layer to cause conduction. When electron penetration is produced, pair production results and current flows through the diode 22 (in the reverse direction), through the load 37 and through a source of direct current power 45 which may be 600 volts.

In one practical example of the invention, the diode was made of a silicon disk .190 inch in diameter. The original thickness of the disk was .009 inch and after the first series of doping operations, the P-type layer, the N-type layer and the N+ layer were all about .003 inch thick. After etching out the upper depression and after additional doping, the upper P-type layer was .00012 inch thick.

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The foregoing disclosure and drawings are merely illustrative of the principles of this invention and are not to be interpreted in a limiting sense. The only limitations are to be determined from the scope of the appended claims.

What is claimed is:

1. A pulse amplifier comprising:

- (1) a sealed envelope;
- (2) a thermoemissive cathode mounted within said envelope and having electrical leads extending through said envelope for connection to an external circuit;
- (3) electrode means mounted within said envelope and having electrical leads extending through said envelope for connection to an external circuit, said electrode means being operative to control the electron beam generated by said cathode; and
- (4) a semiconductor device comprising first and second layers of semiconductor materials having first and second conductivity types, respectively, and a first metallic layer covering said first layer and lying between said cathode and said first layer, said device having electrical leads extending through said envelope for connection to an external circuit.

2. A pulse amplifier according to claim 1 wherein said semiconductor device further comprises a second metallic layer on said second layer of semiconductor material.

3. A pulse amplifier according to claim 1 wherein said

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first and second layers of said semiconductor device are P type material and N type material respectively.

4. A pulse amplifier according to claim 3 wherein said semiconductor device comprises a third layer of N+ type material.

5. A pulse amplifier according to claim 1 wherein the periphery of said semiconductor device is ground away to form a sharp edge.

6. A pulse amplifier according to claim 1 wherein one end of said envelope is formed by a metal base in which said semiconductor device is seated, said metal base being connected to a plurality of heat-radiating fins.

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U.S. Cl. X.R.

313—65