

[54] **TRAVELING WAVE TUBE POWER SUPPLY**

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[58] Field of Search**315/3.5, 57, 105; 330/43; 331/82**

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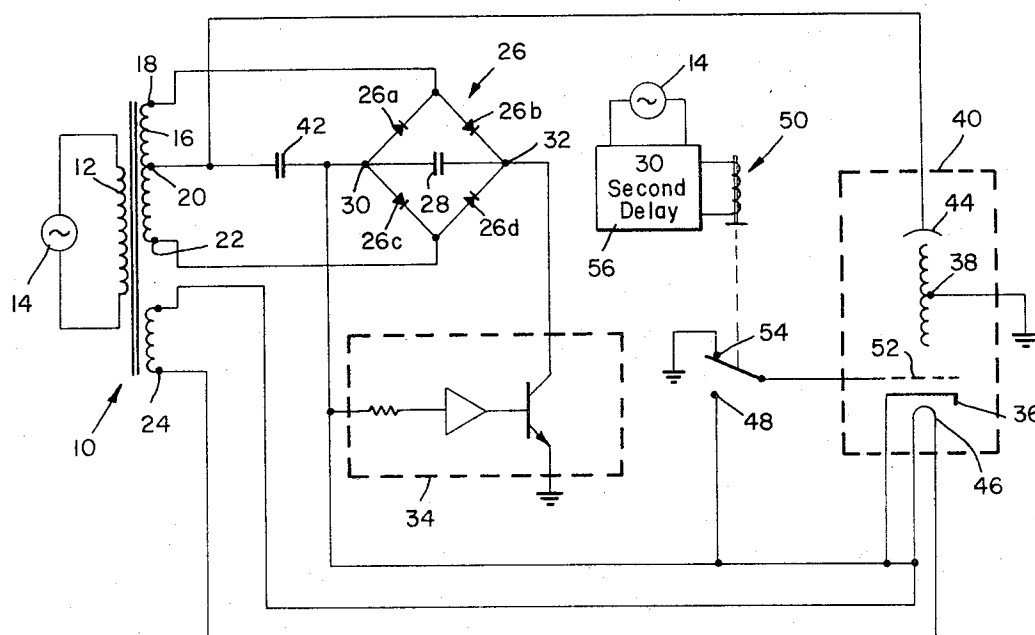
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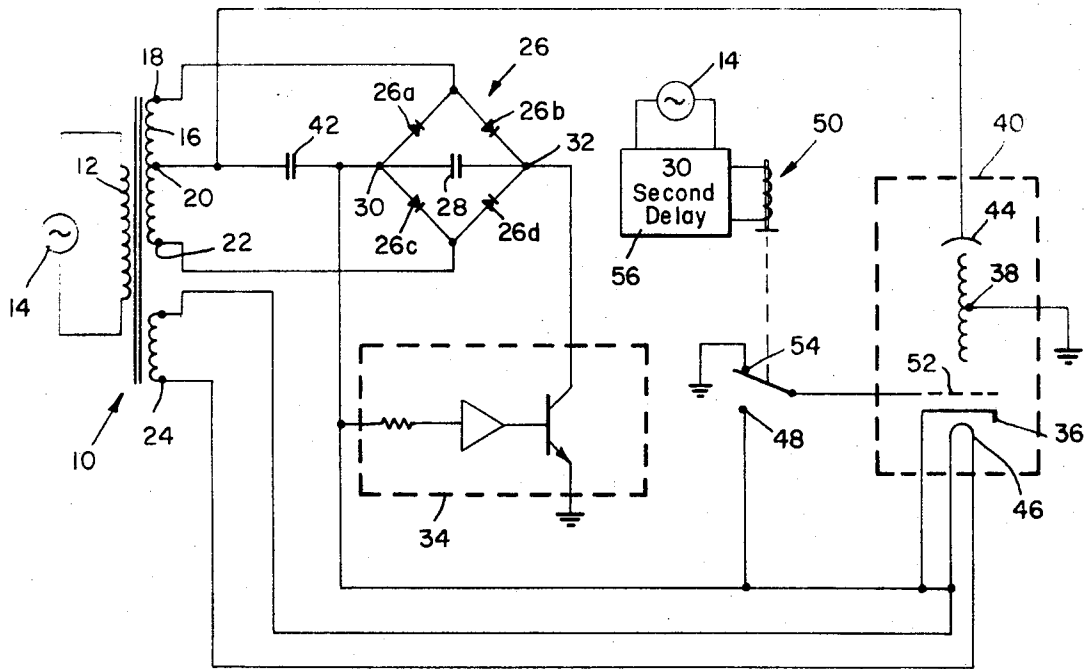
[57] **ABSTRACT**

A traveling-wave tube power supply utilizes a single high voltage power transformer. A full-wave bridge rectifier arrangement is connected to the high voltage secondary winding which together with a filtering capacitor provides the requisite potential between the TWT cathode and the slow wave structure. A "depressed" cathode/collector potential is obtained across one output side of the bridge rectifier and a center tap of the high voltage secondary. This arrangement provides a high voltage, low current cathode/slow wave structure potential, and a lower voltage (by approximately 50 percent) high current cathode/collector potential.

In a preferred embodiment, the filament power supply may share the same transformer primary winding as the high voltage power supply since the filament and cathode are connected to the tube's modulation anode during tube warm-up.

4 Claims, 1 Drawing Figure





TRAVELING WAVE TUBE POWER SUPPLY

BACKGROUND OF THE INVENTION

This invention relates generally to microwave amplifiers, and more particularly relates to an improved power supply for use with a traveling-wave tube (TWT) or other amplifier capable of operation in a depressed collector mode.

In a microwave amplifier of the traveling-wave type, a stream of electrons traveling from a cathode to a collector electrode interact with an electromagnetic wave traveling along a slow wave structure such as a conductive helix wound about the path of the electron stream. The net result may then be a transfer of energy from the electron stream to the traveling-wave, resulting in amplification of the traveling-wave. In order to increase efficiency, traveling-wave tubes have been operated with what is referred to as "a depressed collector potential." It has been found experimentally that in the case of a typical traveling-wave tube, such as Hughes Aircraft Company Model 848H, the voltage potential across the cathode and collector elements of the tube need be only about 50 percent of the potential of the cathode relative to the slow wave structure, in which case the power dissipated in the electron stream from the cathode to the collector may be essentially halved without any adverse effect on the tube's gain or power output characteristics. Prior art power supplies for such depressed collector operation usually comprised a regulated power supply to provide the optimum potential from the cathode to the helical structure and a second depressed collector power supply to provide the appropriate collector potential relative to the cathode. An alternate prior art method of achieving the depressed cathode potential was to provide an external resistance between the slow wave structure's power supply and the collector, but this merely substituted an external power loss for that otherwise internal to the tube. In the particular case of pulsed traveling-wave tube operation, some prior art power supplies provided the depressed collector potential by means of a transformer and a diode coupled to the power supply for the slow wave structure.

Accordingly, one object of the present invention is to provide an efficient power supply for use with a traveling-wave tube wherein the collector potential is depressed approximately 50 percent relative to the potential of the conductive helix.

Another more specific object of the present invention is to provide a traveling-wave tube power supply having fewer transformers, transformer windings, and other magnetic components.

Another object of the present invention is to minimize the traveling-wave tube's turn-on transient.

An overall object of the present invention is to provide an improved design for a traveling-wave tube power supply which results in savings with respect to cost, space and weight.

SUMMARY OF THE INVENTION

A traveling-wave tube power supply, according to the present invention, utilizes a single high voltage power transformer. A full wave bridge rectifier arrangement is connected to the high voltage secondary winding which, in combination with a filtering capacitor, provides the requisite potential between the

cathode and the slow wave structure. The "depressed" cathode/collector potential is obtained between the negative side of the bridge rectifier and a center tap of the high voltage secondary. This arrangement provides a high voltage, low current cathode/slow wave structure potential, and a lower voltage (by approximately 50 percent) high current cathode/collector potential.

According to another, more specific aspect of the present invention, the filament power supply may share the same transformer primary winding as the high voltage power supply since the filament and cathode are connected to the tube's modulation anode during tube warm-up.

Other objects, advantages and characteristics of the present invention become readily apparent from the following detailed description of a preferred embodiment of the invention when considered in conjunction with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

The single FIGURE illustrates a preferred embodiment of the invention in circuit diagram format, including an integral filament winding and a voltage regulator in the high voltage circuit.

DETAILED DESCRIPTION

In the illustrated preferred embodiment of the present invention, it may be seen that the inventive power supply includes a transformer 10 having a primary winding 12 connected to an alternating current voltage source 14 (which may be a solid state switching converter operating from 28 volts d-c, or 115/208 volts 400 hz power as are typically found in airborne applications), and a secondary winding 16 having high voltage output terminals 18 and 22 (which may in the case of the aforementioned TWT have a potential therebetween of approximately 3,000 volts) as well as a center tap terminal 20. Transformer 10 also includes, in the case of the illustrated preferred embodiment, a filament winding 24 (which may have an output potential of about 6.3 volts).

Across the output terminals 18 and 22, there is provided a bridge rectifier arrangement 26 comprising four diodes 26a, 26b, 26c, and 26d. The output of bridge rectifier 26 is a d-c voltage approximately 1.4 times the RMS value of the potential across output winding 16. A filtering capacitor 28 is provided between bridge rectifier negative terminal 30 and positive terminal 32 for the purpose of filtering the high voltage power supply output. Also provided in series with terminal 32 to ground is a conventional voltage regulating circuit 34 for maintaining a regulated voltage across the cathode 36 and the helical slow wave structure 38 of traveling wave tube 40. (It should be noted that circuit 34 is not required if the input source 14 is well regulated). Direct electrical connection is made between negative terminal 30 and TWT cathode 36, while the connection between positive terminal 32 and slow wave structure 38 passes serially through regulator circuit 34.

The depressed collector potential, which is about 50 percent that of the cathode/slow wave structure potential, is provided between bridge rectifier negative terminal 30 and output winding center tap 20. A second filter capacitor 42 is provided to smooth out the

resultant d-c voltage. Terminal 20 is connected to the collector electrode 44 of TWT 40.

The voltage to the filament 46 of TWT 40 is provided by the filament winding 24. One side of the filament winding is connected to the cathode 36 and also to a terminal 48 of a high voltage vacuum relay 50 which selectively connects the anode 52 of TWT 40 (sometimes referred to as a grid or modulation anode) to either the aforesaid terminal 48 or to the potential of the slow wave structure 38 via a ground terminal 54. Relay 50 is provided with a 30 second delay circuit 56, such that it is activated approximately 30 seconds after the input voltage 14 is applied to the power supply circuit. Prior to the expiration of the 30 seconds, the modulation anode 52 is shorted to the cathode 36, thereby preventing the premature failure of the TWT 40 due to destruction of the emitting surface on the cathode. It should be noted that as illustrated in the drawing, the contacts of relay 50 are in their normal, steady state "on" condition, with the modulation anode connected to ground via terminal 54.

OPERATION

Regulated or unregulated input power applied across input winding 12 is converted to high voltage a-c at transformer output terminals 18 and 22. It is converted to d-c via bridge rectifier 26 and capacitor 28, the positive side of the bridge rectifier output being connected to ground via the optional voltage regulator circuit 34. (It should be noted that the voltage regulator circuit is only required if the input power is not adequately regulated since changes in the cathode/slow wave structure potential will modulate the output of the amplifier.) The negative output of the bridge rectifier is connected to the cathode 36 of TWT 40. Thus, it can be seen that a regulated d-c voltage, 3,500V in the case of the aforementioned TWT No. 848H) is applied between the cathode and the slow wave structure, thereby causing the electron stream from the cathode to the collector to be accelerated to the speed of the traveling wave passing along the tube's slow wave structure. Between center tap 20 and rectifier output 30 a potential is available which is approximately 50 percent that of the high voltage output from bridge rectifier 26, diodes 26a and 26c acting in combination with center tapped

winding 16 as a conventional d-c power supply circuit, with capacitor 42 smoothing the resultant full wave d-c output.

What is claimed is:

1. In a depressed collector power supply suitable for use with a traveling-wave tube having a cathode, a slow wave structure and a collector:
 - a power transformer having a high voltage secondary winding with a center tap;
 - a high voltage circuit comprising:
 - a full wave bridge rectifier connected across said high voltage secondary, said bridge rectifier having negative and positive output terminals, and
 - means for connecting said negative and positive output terminals respectively to the cathode and the slow wave structure of said traveling wave tube;
 - a depressed collector voltage circuit comprising:
 - a center tap on said power transformer secondary winding, and
 - means for connecting said center tap and said bridge rectifier negative terminal respectively to the collector and the cathode of said traveling-wave tube.
2. The power supply of claim 1 wherein:
 - said high voltage circuit further comprises a first filter capacitor across said bridge rectifier output terminals; and
 - said depressed collector voltage circuit further comprises a second filter capacitor between said secondary winding center tap and said bridge rectifier negative terminal.
3. The power supply of claim 2 wherein said high voltage circuit includes means for regulating the voltage potential between said cathode and said slow wave structure.
4. The power supply of claim 1 wherein:
 - said traveling-wave tube includes a modulation anode;
 - said power transformer further includes a low voltage filament secondary winding; and
 - said power supply further includes means for shorting said modulation anode to the traveling-wave tube cathode during initial cathode warm-up.

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