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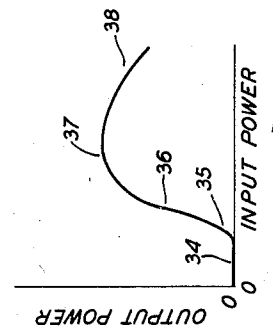
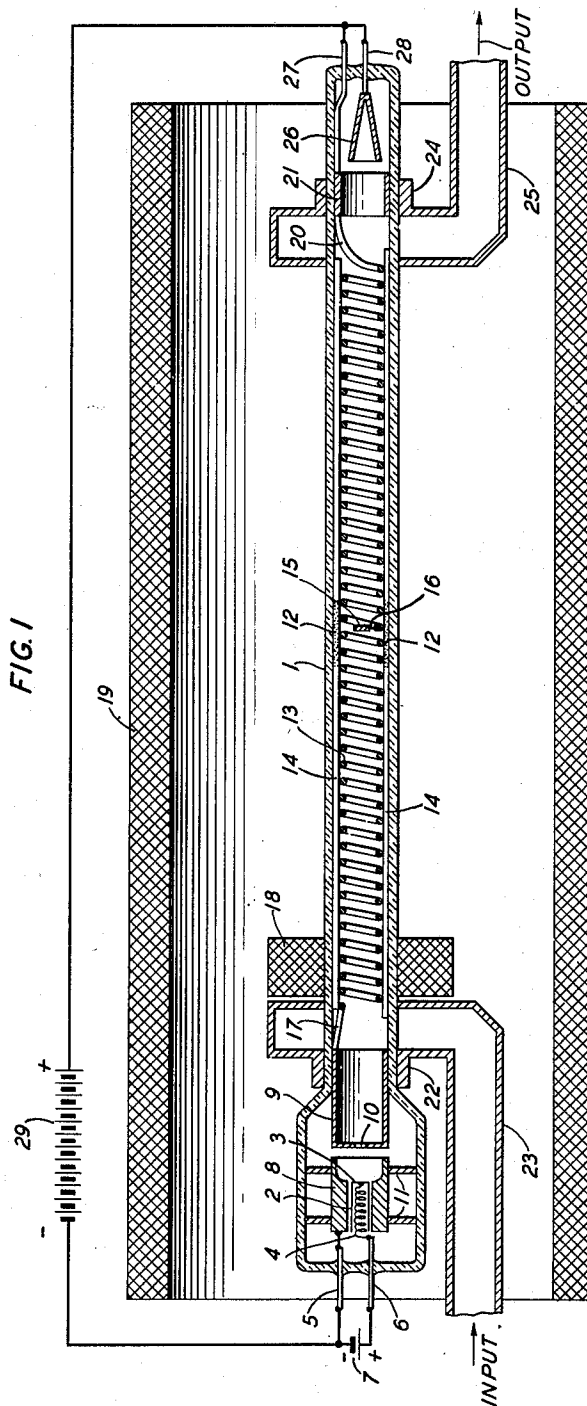
J. R. PIERCE

2,790,927

TRAVELING WAVE SLICER TUBE

Filed May 10, 1951

2 Sheets-Sheet 1



INVENTOR
J. R. PIERCE

BY

N. S. Ewing
ATTORNEY

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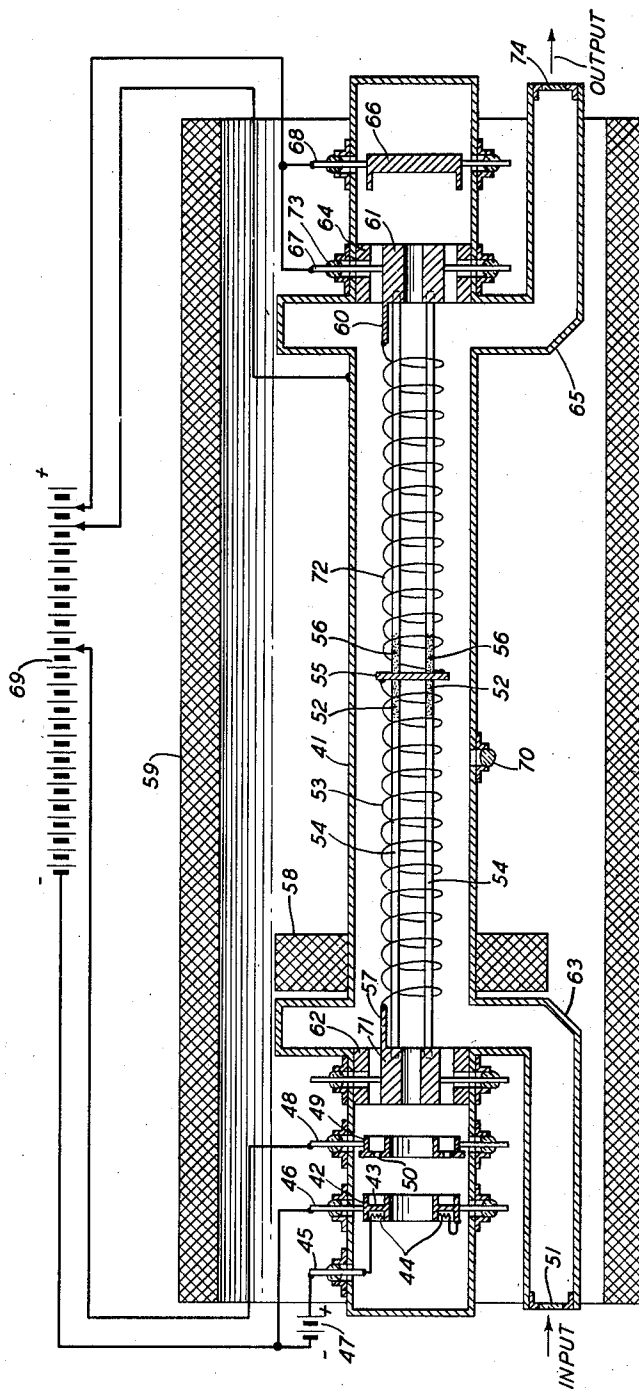
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FIG. 3



INVENTOR
J. R. PIERCE

BY

N. A. Ewing
ATTORNEY

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TRAVELING WAVE SLICER TUBE

John R. Pierce, Berkeley Heights, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

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11 Claims. (Cl. 315—3.6)

This invention relates to pulse systems of communication and more particularly to apparatus for use in such a system.

An object of the invention is to provide an electron tube adapted to use in a receiver or repeater of such a system and operable to discriminate against the noise energy associated with received high frequency signals.

Another object is to provide such a tube capable of operating with wavelengths in the millimeter range and pulse lengths from $\frac{1}{100}$ to $\frac{1}{1000}$ of a microsecond.

Among the advantages of a microwave pulse transmission system are its capability of providing a great many communication channels and the possibility, at receiving or repeater stations, of regenerating (practically reconstructing) received signal pulses for decoding or retransmitting free of masking noise energy with which they have become mingled during the process of transmission. Realization of these advantages requires among other things that the apparatus employed be capable of very wide band and high frequency operation.

These requirements are met, with respect to what has been termed a radio frequency slicer tube, according to this invention by utilizing a tube of the traveling wave type. The slicer tube functions to transmit applied high frequency signal pulses within a certain range of amplitude, rejecting those below or above that range. In this manner the objectionable noise received with and between the signal pulses, generally below or above the signal level, is eliminated. The use of such a slicer tube in a pulse repeater system is referred to and illustrated in my copending application, Serial No. 184,046 filed September 9, 1950 and issued as Patent 2,735,933 on February 21, 1956.

The present invention is explained more fully in the following description and the accompanying drawings, in which:

Fig. 1 shows a vacuum tube illustrative of the invention and employing a narrow axial electron beam;

Fig. 2 is a diagram used in explaining the operation of a tube such as Fig. 1 or Fig. 3; and

Fig. 3 illustrates an embodiment of the invention operating in the same manner as the tube of Fig. 1 but employing a hollow tubular electron beam.

Referring now to Fig. 1, the internal parts of the radio frequency slicer tube are contained in a vacuum-tight envelope 1 which may be of glass or other suitable insulating material. The tubular cathode 2, with a disk-shaped portion 3 which may be concave and is coated with emissive material, is heated by heater 4. The cathode 2 is connected at its base to the focusing electrode 8 which is supported in envelope 1 by the accurately fitted disks 11. One end of the heater 4 is connected to the cathode at the portion 3 and thence through electrode 8 and lead 5 to the connection between one pole of battery 7 and the negative pole of battery 29. The other pole of battery 7 is connected by means of lead 6 to the other end of heater 4 so as to heat the cathode and cause portion 3 to emit electrons thermionically. Accelerating electrode 9 is

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connected through the helix 13 and lead 27 to the positive pole of battery 29. Electrons drawn from the cathode surface 3 by the positive electrode 9 are focused by electrodes 8 and 9 in combination and pass through a small defining aperture 10 centrally located in electrode 9. Helix 13 is supported from envelope 1 by two or more ceramic rods 14. At the left, input, end, helix 13 is connected by a straight portion of coupling conductor 17 to electrode 9 and thence through the envelope 1 to one side of input wave guide 23 by means of the by-pass capacitance between electrode 9 and the wave-guide flange 22. At the right, output, end, helix 13 is connected by a straight portion of coupling conductor 20 to tubular electrode 21 and thence through the envelope 1 to one side of output wave guide 25 by means of the by-pass capacitance between electrode 21 and the wave-guide flange 24. By means of lead 27, helix 13 is held at the potential of the positive pole of battery 29 and this potential is adjusted so that the electron velocity along the helix is substantially equal to the phase velocity of wave propagation along the helix. An input signal applied to wave guide 23 is transferred to the left, input, end of helix 13, by coupling conductor 17 and travels to the right. Loss material 12, capable of absorbing high frequency energy, disposed on rods 14 near the center of the helix prevents any substantial amount of electromagnetic energy traveling along the helix at the left of that point from passing on to the right end of the helix. This effectively divides the helix 13 into two sections of transmission line with no substantial electromagnetic coupling between them, an input section between the input coupling conductor 17 and the loss material 12 and an output section between the loss material 12 and the output coupling conductor 20. Any wave traveling from the right end of the helix is radiated into the output wave guide 25 by means of the coupling conductor portion 20.

The electron stream emerging from aperture 10 is focused on a small central target or obstacle 15 which is supported on the axis of the helix and connected to it by a wire 16. The obstacle 15 is located in the region of the loss material 12 or slightly to the left of it. Obstacle 15 is large enough so that in the absence of an input wave signal on the helix, the electron stream is completely, or almost completely, intercepted by the obstacle. The electron stream emerging from the aperture 10 may be focused on obstacle 15 by means of a small focusing coil 18 or the larger solenoid 19. These coils may be energized to produce unidirectional magnetic fields from any suitable direct-current source not shown.

Since any electromagnetic wave energy traveling along the helix at the left of the loss material 12 is intercepted by that material and for very low input signal levels the electron stream is intercepted near the center of the helix by obstacle 15, small input signals applied to input wave guide 23 will not produce any output in wave guide 25. However, as the input signal level is raised, the fields of helix 13 will interact with the electron stream strongly enough to the left of the center of the helix so as to deflect the electrons radially and cause some of them to miss the obstacle 15. The electrons which miss the obstacle and pass into the right end of the helix will induce a signal in the helix which will be radiated into the wave guide 25 as output. These electrons will be collected by collector 26 which is connected through lead 28 to battery 29. Because the output is thus dependent upon the electrons which are deflected by the input signal so as to miss the obstacle 15, the output power will vary as a function of the input power somewhat as shown in Fig. 2. For low input powers, there will be no output power as indicated at 34. For somewhat higher input powers, there will be a small output power as indicated at 35. Thereafter, the output power will rise rapidly with input power as shown

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at 36. For still higher input powers, non-linearity will cause the output power to increase less rapidly with input power and finally a maximum output will be reached as shown at 37. Thereafter an increase of input power will result in a decrease in output power as shown at 38. This characteristic of the tube is desirable for use in reshaping pulses which have become distorted in amplitude because of noise. The noise between input pulses will be low enough that no output will result from it. Any irregularity in amplitude of input pulses will tend to produce less irregularity in output pulses if the input pulse power is such as to lie in the region around 37 of Fig. 2.

Fig. 3 illustrates an embodiment of the invention which functions in a manner similar to that of Fig. 1 but employs a tubular electron stream and a different type of construction. The evacuated envelope 41 of the tube is of metal and exhausted through tubulation 70 which may be of glass sealed to the envelope. The cathode 42 is ring shaped with a recessed annular surface 43 which is coated with emissive material and it is heated by means of heater 44. The heater 44 is connected through lead 45 to one side of battery 47 and through cathode 42 and lead 46 to the other side of that battery, the cathode being at the same time connected through lead 46 to the negative side of battery 69. The ring-shaped accelerating electrode 49 is connected through lead 48 to a tap on battery 69 which is positive with respect to the cathode. Electrons drawn from the cathode surface 43 by the positive electrode 49 in the form of a tubular stream pass through the nearly complete narrow circular slit 50 in the accelerating electrode 49 and along the outer surfaces of cylindrical electrodes 71 and helical coil 53. The helical coils 53 and 72 and the metal barrier disk 55 connecting them are supported by two or more ceramic rods 54, the ends of which are supported by the cylindrical electrodes 71 and 61. The electrodes 71 and 61 are supported and insulated from the envelope by a number of members, such as lead 67, which are sealed into the envelope by glass beads in the manner that lead 67 is sealed in by the glass bead 73. The lead 45, cathode 42, electrode 49 and collector 66 are similarly supported and insulated by glass beads as shown in the figure.

At the left, input, end, the helix 53 is connected by a coupling stub 57 to electrode 71 and thence through the by-pass capacitance between electrode 71 and the metal ring 62 to the envelope and one side of the input wave guide 63. At the right, output, end the helix 72 is connected by a coupling stub 69 to electrode 61 and thence through the by-pass capacitance between electrode 61 and the metal ring 64 to the envelope and one side of the output wave guide 65. By means of lead 67, the helices 53 and 72 and the electrodes 61 and 71 are connected to a tap on battery 69 and held at a potential positive with respect to the cathode. This potential is adjusted so that the electron velocity along the helices is substantially equal to the phase velocity of wave propagation along the helices. The tube envelope is connected to a tap on battery 69 and the electron collector 66 is shown connected through lead 68 to the same tap on the battery 69 as is lead 67 though it may be connected to some other point on the battery. An input signal wave entering the input wave guide 63 through window 51 is transferred to the left, input, end of helix 53 by the coupling stub 57 and travels to the right. Loss material 52, capable of absorbing high frequency energy, disposed on the rods 54 at the other end of helix 53 terminates the helix in its characteristic impedance. No substantial amount of the input electromagnetic energy traveling along helix 53 passes beyond this resistive termination 52 and the barrier 55 to the helix 72. The helices 53 and 72 are, therefore, two sections of transmission line with no substantial electromagnetic coupling between them and correspond to the input and output line sections, respectively, of the helix 13 of Fig. 1.

The tubular electron stream emerging from the cir-

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cular slit 50 is very narrow and is focused on the edge of the disk 55. Electric focusing between electrode 49 and electrodes 71 and 62 may be used to do this, and in addition, a longitudinal magnetic field such as produced by electromagnets 58 and 59 and a potential difference between 71 and 62 may be employed. The electromagnets 58 and 59 may be energized by means of any suitable direct-current source, not shown. The electron stream is so focused on disk 55 that when no input high frequency signal is applied at the input wave guide 63 the disk stops it completely. When a high frequency input signal of sufficient amplitude is applied, however, the stream is deflected inward and outward and on the outward deflection some of the electrons pass the disk and travel along the outer surface of helix 72. These induce a signal in helix 72 which travels along the helix and is radiated into the output wave guide 65 by means of the coupling stub 69 from which it may pass out through the sealed in window 74. The helix 72 is terminated at the other end by loss material 56 disposed on the rods 54. The electrons which travel beyond the barrier 55 are collected on collector 66. The operation of the tube of Fig. 3 is thus similar to that of the tube of Fig. 1 and, similarly, the output power will vary with the input as shown in Fig. 2. Consequently it will discriminate against noise and other irregularities in the signal in the same manner as indicated in the description of Fig. 1 above.

Although the invention has been described with particular reference to the illustrative embodiments it should be understood that other arrangements may be devised without departing from the spirit and scope of the invention.

What is claimed is:

1. An electronic high frequency signal translating device comprising an evacuated envelope containing two sections of transmission line in tandem arrangement, each said section being several wavelengths long and capable of propagating a high frequency electromagnetic wave longitudinally at a velocity within the range of practical electron velocities, a cathode spaced from one end of said line arrangement, electrode means for producing a stream of electrons from said cathode and directing it longitudinally along said sections of line in coupling relation thereto, and means comprising a barrier electrode, capable of intercepting substantially all of the electrons in the stream when there is no substantial electromagnetic wave being propagated along the section of transmission line nearer the cathode, located between said sections of line and in the path of said electron stream for intercepting electrons traveling therein.

2. An electronic high frequency signal translating device comprising an evacuated envelope containing an input transmission line section in the form of an elongated helix, an output transmission line section in the form of an elongated helix, the two said line sections being in substantial axial alignment and in proximity end to end, a cathode spaced from the input transmission line helix at the end farther from the output transmission line helix, means for producing from said cathode a stream of electrons and directing it along said helices in coupling relation thereto, an electron intercepting barrier located in the path of the electron stream between the input helix and the output helix and capable of intercepting substantially all of the electrons in the stream when there is no substantial signal applied to the input helix, high frequency loading means terminating each of the transmission line helices at the ends adjacent to each other, coupling means at the end of the input helix nearer the cathode for applying a high frequency signal thereto whereby the electron stream may be deflected to permit electrons to pass said barrier and travel along the output helix to induce signal energy therein and coupling means at the end of the output helix farther from the cathode for extracting signal energy therefrom.

3. An electronic high frequency signal translating de-

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vice comprising two sections of high frequency wave transmission line substantially free of mutual electromagnetic coupling, one an input section and the other an output section, each said section being capable of propagating an electromagnetic wave therealong at a velocity within the range of practical electron velocities, a cathode, means for producing from said cathode a stream of electrons along said input and output sections in the order named and in coupling relation to each section, and an electron intercepting barrier located along the path of the electron stream between said sections, said barrier being adapted to intercept substantially completely the electron stream before it reaches the output section when the input section is not energized by high frequency input, and to permit electrons in the stream to pass the barrier and thence travel along the output section when the input section is energized by a high frequency input signal and thereby deflects the electron stream laterally.

4. An electronic high frequency signal translating device comprising two sections of high frequency wave transmission line in substantial alignment longitudinally, one an input section and the other an output section, each said section being capable of propagating an electromagnetic wave therealong at a velocity within the range of practical electron velocities, the adjacent ends of the two sections being terminated in substantially matching impedances which completely absorb electromagnetic wave energy traveling toward those ends and prevent the transfer of such energy from one section to the other, a cathode, means for producing from said cathode a stream of electrons along said input and output sections in the order named, at a velocity substantially equal to the phase velocity of wave propagation along the line sections and in coupling relation to each section, and an electron intercepting barrier located along the path of the electron stream between said sections, said barrier being adapted to intercept substantially completely the electron stream before it reaches the output section when the input section is not energized by high frequency input, and to permit electrons in the stream to pass the barrier and thence travel along the output section when the input section is energized by a high frequency input signal and thereby deflects the electron stream laterally.

5. A device according to claim 4 in which said matching impedances are in the form of loss material capable of absorbing high frequency energy located in the high frequency electric field of each line section.

6. A device according to claim 4 in which each line section is in the form of a helically wound conductor and the cathode is adapted to the production of an electron stream through the interiors of the helical sections.

7. A device according to claim 4 in which each line section is in the form of a helically wound conductor and the cathode is adapted to the production of a tubular electron stream along the exteriors of the helical sections.

8. A device according to claim 4 including also means for coupling a high frequency signal input circuit to one end of said input line section and means for coupling a high frequency signal output circuit to one end of said output line section.

9. An electronic high frequency signal translating device comprising an evacuated envelope containing two sections of transmission line in tandem arrangement, each said section being several wavelengths long and capable

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of propagating a high frequency electromagnetic wave longitudinally at a velocity within the range of practical electron velocities, a cathode spaced from one end of said line arrangement, electrode means for producing a stream of electrons from said cathode and directing it longitudinally along said sections of line in coupling relation thereto, an electrode having an electron stream defining aperture spaced from said cathode between it and said line sections, and means comprising a barrier electrode, capable of intercepting substantially all of the electrons in the stream when there is no substantial electromagnetic wave being propagated along the section of transmission line nearer the cathode, located between said sections of line and in the path of said electron stream for intercepting electrons traveling therein.

10. An electronic high frequency signal translating device comprising an evacuated envelope containing two sections of transmission line in tandem arrangement, each said section being several wavelengths long and capable of propagating a high frequency electromagnetic wave longitudinally at a velocity within the range of practical electron velocities, a cathode spaced from one end of said line arrangement, electrode means for producing a stream of electrons from said cathode and directing it longitudinally along said sections of line in coupling relation thereto, an electrode having an electron stream defining aperture spaced from said cathode between it and said line sections, means comprising a barrier electrode located between said sections of line and in the path of said electron stream for intercepting electrons traveling therein and means located along the path of said stream of electrons between said aperture and said barrier for focussing the electron stream on said barrier.

11. An electronic high frequency signal translating device comprising two sections of high frequency wave transmission line substantially free of mutual electromagnetic coupling, one an input section and the other an output section, each said section being capable of propagating an electromagnetic wave therealong at a velocity within the range of practical electron velocities, a cathode, means for producing from said cathode a stream of electrons along said input and output sections in the order named, means comprising a high frequency wave input connection for energizing said input section and thereby deflecting transversely electrons in said stream, and an electron intercepting barrier capable of intercepting substantially all of the electrons in the stream when there is no substantial wave energization of the input section located along the path of the electron stream between said sections, the transverse dimensions of said barrier being such that with deflection of the electrons exceeding a predetermined amount electrons will be enabled to pass the barrier and travel along said output line section.

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