

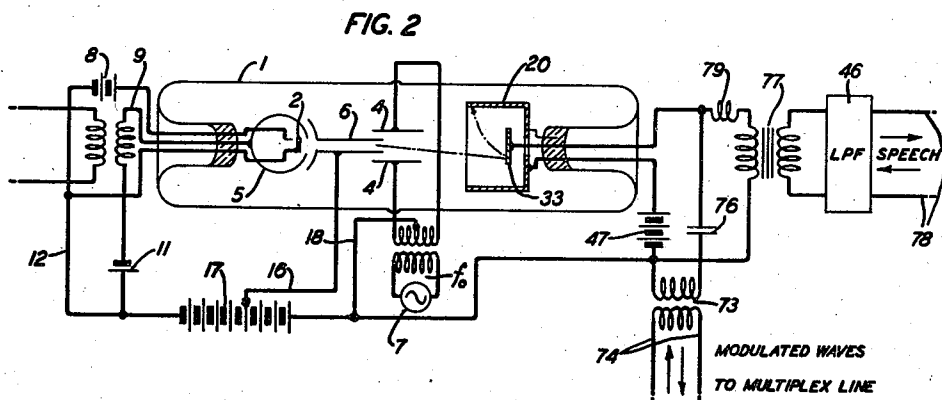
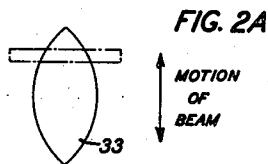
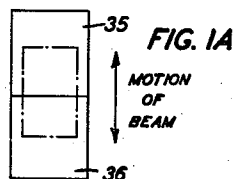
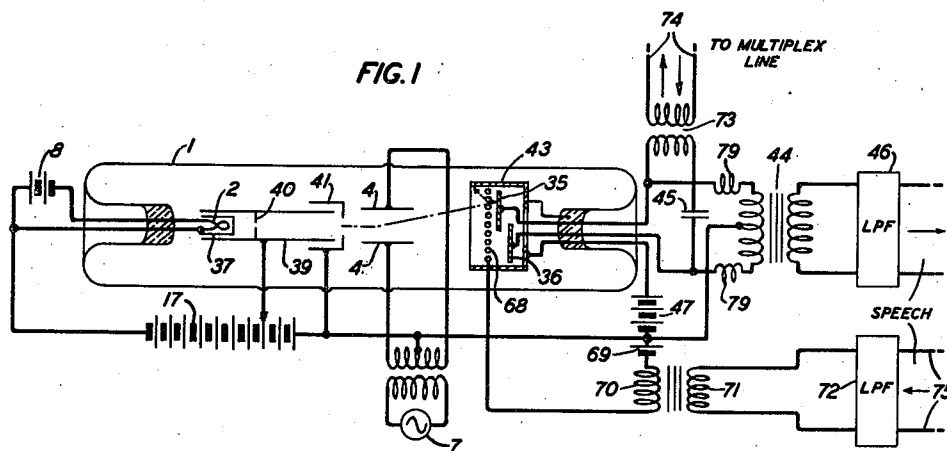
Feb. 1, 1944.

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2,340,742

SPACE DISCHARGE APPARATUS AND CIRCUIT

Original Filed May 27, 1939 2 Sheets-Sheet 1



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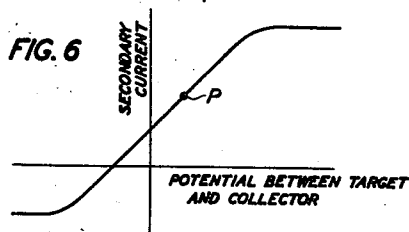
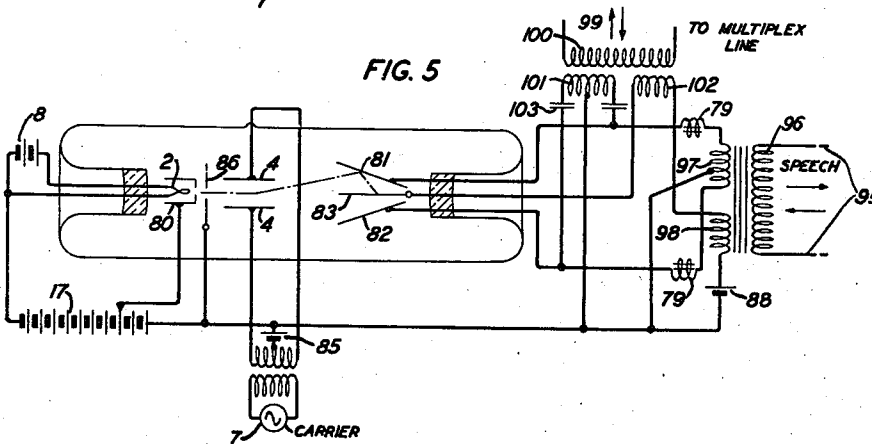
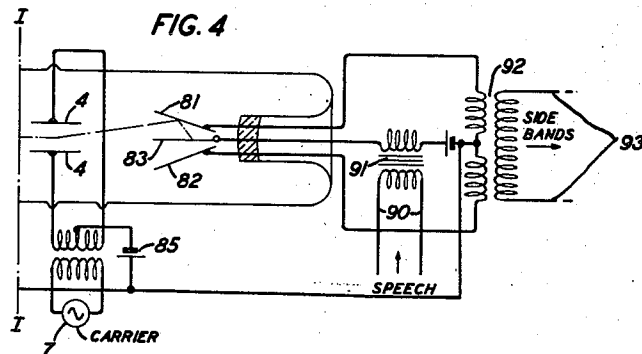
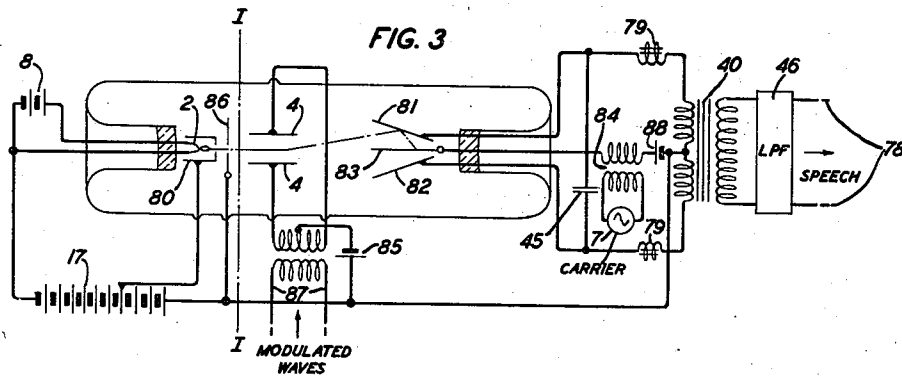
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SPACE DISCHARGE APPARATUS AND CIRCUIT

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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

2,340,742

SPACE DISCHARGE APPARATUS AND
CIRCUIT

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Original application May 27, 1939, Serial No. 276,044, now Patent No. 2,257,795, dated October 7, 1941. Divided and this application June 19, 1941, Serial No. 398,742

9 Claims. (Cl. 179-15)

The present invention relates to electrical wave shaping or wave control for such purposes as signal transmission or signal reception. This is a division of my prior application Serial No. 276,044, filed May 27, 1939 for Electron discharge apparatus and circuits, Patent No. 2,257,795, dated Oct. 7, 1941.

A particular object of the invention is to adapt electric discharge devices of the cathode beam type to serve as effective electrical wave controllers for these and kindred purposes.

I have discovered that the cathode beam type of discharge device affords a very effective means of controlling waves to secure desired types of output products. My present invention is concerned with methods and structures using cathode beam tubes whereby desirable types of wave control are achieved, principally in translating from one frequency range to another for purposes of intelligence transmission.

I have found, in accordance with this invention, that the character of the output products can be varied within wide limits and can be accurately predetermined by suitable control of such variables as the cross section of the beam in relation to the shape of the target or targets and the manner of control of the beam. I have found that the output products can be restricted to particular frequency regions and the device thus made to serve a filtering function, as well as a frequency-translating function. Certain forms, in accordance with the invention, operate as two-way transducers offering a simplification of two-way carrier terminal apparatus. These and various other modifications will be set forth in detail in the description to follow, in conjunction with the drawings.

In the drawings, Fig. 1 is a diagrammatic view partly in section of a beam tube and circuit therefor in accordance with one form of the invention;

Fig. 1A shows the plan of the target and beam section;

Fig. 2 shows a modified tube construction and circuit;

Fig. 2A shows shapes of target and beam section for the Fig. 2 construction;

Fig. 3 shows an alternative type of tube construction and circuit according to the invention;

Fig. 4 shows a modification of the portion of the Fig. 3 construction to the right of the broken line I-I;

Fig. 5 is a view, generally similar to Fig. 3, of a modified circuit according to the invention; and

Fig. 6 shows the characteristic of the tube using secondary emission.

In Fig. 1 the tube 1 comprises an elongated cylindrical envelope having a cathode 2 at one end, two half-targets 35 and 36 at the other end, and having deflecting plates 4 suitably placed at an intermediate point. The beam in this case preferably has a square cross section and is normally half on each portion of the target as indicated in Fig. 1A. To prevent a gap between adjacent edges of the two halves of the target one half may be placed back of the other with a slight overlap as in Fig. 1. The beam is oscillated upward and downward by the deflecting plates 4 at the frequency, f_0 , for example, so as to impinge to a less extent on one section of the target and correspondingly more on the other and then vice versa. The amplitude is preferably less than sufficient to interrupt the beam on either target.

The beam-forming and focusing elements comprise cathode 37 heated by filament 2 from battery 8, first anode or accelerating electrode 39 and second anode 41. About midway of tube 39 is a septum 40 having a square aperture for defining the cross section of the beam.

Target 35 is connected to the upper terminal of output winding 44 while target 36 is connected to the lower terminal. The mid-point of winding 44 is connected to the positive pole of anode battery 17. If the collector 43 were not used, the beam in moving into increasing incidence upon target 35 would send increasing electron current to the upper terminal of coil 44, while at the same instant the decreasing incidence of the beam on target 36 would decrease electron flow to the lower terminal of this coil, both effects being cumulative in the secondary circuit through filter 46. Condenser 45 stores the rectified pulses representing demodulated speech, and delivers a smoothed speech signal. This condenser may be omitted in the case of a modulator.

Collector 43 is preferably used to secure increased output. It is polarized positive with respect to target 35, 36 by the extra battery cells 47. When the beam is increasing on target 35 (for example) electrons are emitted in increasing number from 35 and in decreasing number from 36 and collected on 43. Thus, the direction of electron flow in the external circuit including winding 44 is opposite to that described above. With only those circuit elements present which have been described thus far, when the tube is serving as a modulator, filter 46 may be a band-pass filter designed to pass one or both side-bands. When the tube is used as a demodulator filter 46 may be a speech frequency filter.

Fig. 1 shows a two-way construction which is

capable of modulating a carrier wave by speech for transmission and of demodulating received modulated waves for purposes of speech reception. A controlling grid 68 is inserted just ahead of the half-targets 35 and 36. This grid is connected to one terminal of speech coil winding 70, the other terminal of which is connected through battery 69 to the positive pole of battery 17 and to the mid-point of winding 44. The other winding 71 of the speech transformer is connected to any suitable speech input circuit 75 which is shown as including low-pass filter 72 passing speech frequencies.

The output circuit for received speech is through output winding 44 and speech filter 46. High frequency choke coils 79, 79 pass speech frequencies readily but oppose passage of carrier frequencies. The high frequency termination for connection to the multiplex carrier line or system is shown at 74. It is coupled through high frequency transformer 73 in series with tuning condenser 45 across the half-targets 35 and 36. The carrier wave source is source 7.

In the operation of this device for modulating the carrier wave by speech for transmission purposes the speech is received from circuit 75 through speech filter 72 and speech input transformer 70, 71 by which the speech variations are impressed between the mid-point of coil 44 and the control grid 68. As the beam is oscillated under control of carrier waves from source 7 secondary electrons are emitted as previously described from the targets 35 and 36 to the collector 43 and produce corresponding current changes in the output circuit. The secondary electrons emitted from the targets 35 and 36 have relatively low velocity and the number of such electrons passing over to the collector 43 can be readily controlled by the use of a rather coarse mesh grid at 68 which interposes very slight obstruction to the beam in its passage toward the targets. Speech potential variations on the grid 68 control the strength of the secondarily emitted electron current and thus modulate the carrier wave passing into the output circuit through coil 73 and condenser 45. In this way a modulated carrier wave is transmitted into circuit 74 and to the multiplex line. When modulated carrier waves are received from the multiplex line through circuit 74 and transformer 73 they have the effect of varying the potential of either target 35 or 36 with respect to the grid 68 since the grid 68 has its potential fixed by the connection to the mid-point of winding 44. These high frequency variations of potential difference between half-targets 35 and 36 and grid 68 control the strength of the secondarily emitted electrons from the half-targets to the collector 43 and thus vary the rectified or demodulated current in the output through winding 44 and permit speech to be received in the secondary circuit including filter 46. The preferred form of beam cross section and shape of target is indicated in Fig. 1A, although it will be apparent that various other forms may be used.

A two-way operation may be obtained without the use of a grid such as 68 of Fig. 1. Fig. 2, for example, shows a tube with two-way circuit connections for enabling the tube to serve both as a modulator and as a demodulator. In Fig. 2 the speech circuit 78 is a two-way circuit such as an ordinary telephone line leading to a subscriber's station or central office and including the speech filter 46. When speech is received from circuit 78 through the speech coil 77 it has the

effect of changing the potential of the target 33 with respect to the collector 20 at speech frequencies. These changes in potential affect the rate of passage of secondarily emitted electrons over to the collector 20 and thus modulate the carrier frequency wave in the output. It will be understood that the beam is oscillating at a carrier frequency under control of the source 7. The resulting modulated carrier wave passes through the branch including condenser 76 and winding 73 so that the modulated waves are impressed on branch 74 leading to the multiplex line. Modulated carrier waves received from the multiplex line in circuit 74 are impressed across the circuit between the target 33 and collector 20 and vary the difference of potential effective in attracting secondary electrons to the collector 20. This results in combining the effect of the local source of carrier waves with the received modulated waves in such a manner as to demodulate the received waves and produce speech currents in the speech circuit 78. High frequency retardation coil 79 is included in the branch leading to the speech transformer 77 to prevent shunting of the high frequency currents through the shunt capacity of the coil 77.

It is understood that in Figs. 1 and 2 the necessary frequency and phase relations are obtained between the incoming modulated waves and the waves from the local source 7 to secure maximum effects.

The target may have the shape indicated in Fig. 2A in which case, as explained in the parent patent in connection with Figs. 3A and 3B of the patent, the output current is nearly sinusoidal. When the number of secondary electrons drawn to the ring collector 20 is controlled by the input signal such as speech, modulation is produced of the frequency $2f_0$ as indicated in Fig. 4 of the patent. Absence of harmonics of the sweep frequency results in the production of only the two side-bands based upon the frequency $2f_0$.

It will be noted that in the structures shown in Figs. 1 and 2 the production of the secondary electrons is controlled by the beam and the number of secondary electrons utilized to produce output current is controlled by varying the potential difference between the secondary electron emitter and an adjacent electrode.

Another construction operating on this principle is shown in Fig. 3. A ribbon-like beam of electrons is drawn from filament 2 by first anode 80 containing a slit and is partially focused on the split target 81, 82. The beam has a uniform distribution of electrons over its cross section. Since it is only partially focused it has an appreciable thickness. Secondary electrons are driven out of targets 81 and 82 and attracted over to the collector 83, which has a small positive potential with respect to the targets, impressed from battery 88. Sweep plates 4 have a small negative bias applied to them with respect to second anode 86 to suppress any stray secondary electrons coming from 86.

In operating as a demodulator, the tube may have the incoming modulated waves impressed on circuit 87 leading to the sweep plates 4 and the carrier by which the waves are to be demodulated is applied through transformer 84 to the collector 83. The rectified pulses are temporarily stored in condenser 45 and the demodulated speech or signal passes through the choke coils 79 and repeating coil 40 to the outgoing line 78.

An analogous modulating circuit is shown in Fig. 4. The carrier is applied to the sweep plates

4 from carrier source 7, and the speech is applied through circuit 90 and repeating coil 91 to the collector 83. The resulting side-bands are transmitted through transformer 92 to outgoing line or circuit 93.

It will be obvious to vary the manner of association of the carrier and the speech or side-band waves with the tube, to enable the tube to act as modulator or demodulator. The carrier in Fig. 3 may be coupled through individual couplings to the targets instead of through the mid-branch and the same is true of the speech in Fig. 4.

A two-way modulator-demodulator using the same type of tube and suitable for use as a two-way carrier terminal is shown in Fig. 5. The speech circuit 95 is connected across the targets by means of repeating coil windings 96 and 97 of the repeating coil and is connected in circuit with the collector 83 by means of windings 98 and 99 of this coil. In similar manner the carrier circuit 99 is coupled by way of high frequency transformer windings 100, 101 across the targets and by means of windings 100, 102 in circuit with the collector 83. The carrier waves are applied to the sweep plates 4, 4.

For transmitting, speech from circuit 95 is impressed by windings 96 and 98 on the collector 83. The speech modulates the carrier frequency current as the beam oscillates between 31 and 32. The modulated wave is set up across the targets and applied to winding 101 and repeated into line 99. There is also direct transmission of speech but this can be suppressed, if desired, by the usual high-pass filter in line 99 commonly used in carrier systems.

Incoming modulated waves from circuit 99 appear across windings 101 and 102. The voltage induced in winding 101 has a symmetrical relation to the targets and does not result in demodulation. The voltage in winding 102 undergoes rectification in cooperation with the beam oscillations and produces demodulated speech across the targets and this is transmitted through windings 97 and 96 into circuit 95. Small condensers 103 in the leads from winding 101 prevent the shunting of demodulated speech through this winding. For maximum output the locally supplied carrier waves have frequency and phase agreement with the unmodulated carrier component on which the received side-bands are based.

The relation between secondary current from a target and voltage difference between the target and collector is of the form shown in Fig. 6. The bias applied to the collector from battery 88 is such as to cause operation about the point P, about mid-way of the straight portion of the characteristic.

While various illustrative embodiments have been set forth in the interest of a full and complete disclosure of the invention, various modifications will naturally occur to workers skilled in the art, and it is to be understood that the invention is not to be considered as limited to the particular embodiments shown and described herein but that its scope is defined by the claims.

What is claimed is:

1. In space discharge apparatus, beam-forming means, a target for the beam, said target having its surface treated to be an efficient emitter of secondary electrons under impact of primary electrons in the beam, beam-deflecting means for oscillating said beam across said target at high frequency, a collector having a positive potential with respect to the target and positioned to receive the secondary electrons from the target, 75

and an electrode interposed between the target and the collector to control the passage of secondary electrons to the collector.

2. A combination according to claim 2 including two sources of electrical waves, means for controlling said beam-deflecting means by the waves from one source, said electrode having its potential controlled by waves from the other source for controlling in accordance therewith the passage of secondary electrons to the collector, and an external circuit connected between said target and said collector and a load coupled to said external circuit.

3. A two-way translation device for a carrier channel for translating low frequency signals into modulated carrier waves and vice versa comprising a space discharge device having provision for producing variable electron current flow to a working electrode within the device at a fundamental frequency that is constant and high compared to any signal frequency, a circuit including said electrode and a space path within the device, a signal frequency coupling to said circuit, for impressing signals on and receiving demodulated signals from said circuit, and a carrier frequency coupling to said circuit for impressing signal modulated carrier waves on said circuit for demodulation in said device and for, alternately, receiving from said circuit signal modulated carrier waves, the carrier frequency being determined by said fundamental frequency.

4. In a space discharge apparatus, means to produce an electric discharge stream between a cathode and an anode structure, an external circuit connecting said cathode and anode structure, means to oscillate said stream relative to said anode structure at a constant high frequency to produce corresponding high frequency current in said external circuit, a two-way high frequency path coupled to said circuit, a two-way low frequency path coupled to said circuit, and means controlling said apparatus to modulate said high frequency current by signals received over said low frequency path and to demodulate modulated high frequency waves received over said high frequency path.

5. In combination, an electron discharge device including beam-forming means and a pair of targets, means to sweep the beam across said targets to drive out secondary electrons from said targets, a collector adjacent said targets positively biased with respect to said targets for collecting secondarily emitted electrons from the targets as a result of impact of the beam, said targets positioned to form a dihedral angle opening toward the beam and said collector being positioned between said targets.

6. In combination, an electron discharge device comprising beam-forming means, a two-part target, a source of positive potential therefor, a collector of secondarily emitted electrons adjacent said target, means to sweep the beam across said target at a high frequency to drive out secondary electrons from said target, a two-way low frequency circuit and a two-way carrier circuit each connected across the two parts of said target, and means coupling each of said circuits in series relation between said collector and said source of positive potential, whereby intermodulation occurs between said high frequency wave and the waves impressed upon said collector from either of said two-way circuits, and the products of the intermodulation are repeated into the opposite one of said two-way circuits.

7. In a carrier wave signaling system, a space

discharge device for producing modulation products between a carrier wave and a signaling wave, said device having beam-forming means and a target, beam-deflecting means to move the beam transversely over said target at the carrier frequency under control of the carrier wave, said beam in striking said target driving out secondary electrons therefrom, a collector for said secondary electrons located adjacent said target, means controlled by signals to vary the proportion of the secondarily emitted electrons reaching the collector in dependence upon the signal amplitude variations, to cause modulation products between signal amplitude variations and carrier wave variations, an outgoing circuit from said device and means to impress the resulting modulation products upon said outgoing circuit.

8. In a signaling system, a cathode beam tube having beam-forming electrodes and a target capable of emitting secondary electrons when the beam is incident thereon, a collector adjacent said target, means causing the beam to drive out from said target a varying number of secondary electrons varying from instant to instant at a high frequency to produce secondary electron current varying at high frequency between said target and said collector, a circuit for secondary electron current flow connected between said target and said collector, a source of signal waves and means to impress said signal waves between said target and said collector to produce signal-modulated

high frequency waves in said circuit, a source of signal-modulated high frequency waves and means to impress said latter waves between said target and said collector to produce demodulated-signal waves in said circuit.

9. In a signaling system, a cathode beam tube having beam-forming electrodes and a target capable of emitting secondary electrons when the beam is incident thereon, a collector adjacent said target, means causing the beam to drive out from said target a varying number of secondary electrons varying from instant to instant at a high frequency to produce secondary electron current varying at high frequency between said target and said collector, a first circuit connected to receive high frequency currents resulting from the secondary electron current flow between said target and said collector, a second circuit for low frequency signal waves connected between said target and said collector, means to impress signal-modulated high frequency waves on said first circuit, the frequency of which is so related to said high frequency of variation of said secondary electron current as to reproduce the demodulated-signal waves in said low frequency circuit and means controlled by signals for modulating the high frequency secondary electron current between said target and said collector to produce signal-modulated high frequency waves in said high frequency circuit.

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