June 3, 1958 S. E. WARRING 2,837,601

ARRANGEMENT FOR GENERATING AMPLITUDE MODULATED PULSE TRAINS

Filed May 18, 1954 2 Sheets-Sheet 1

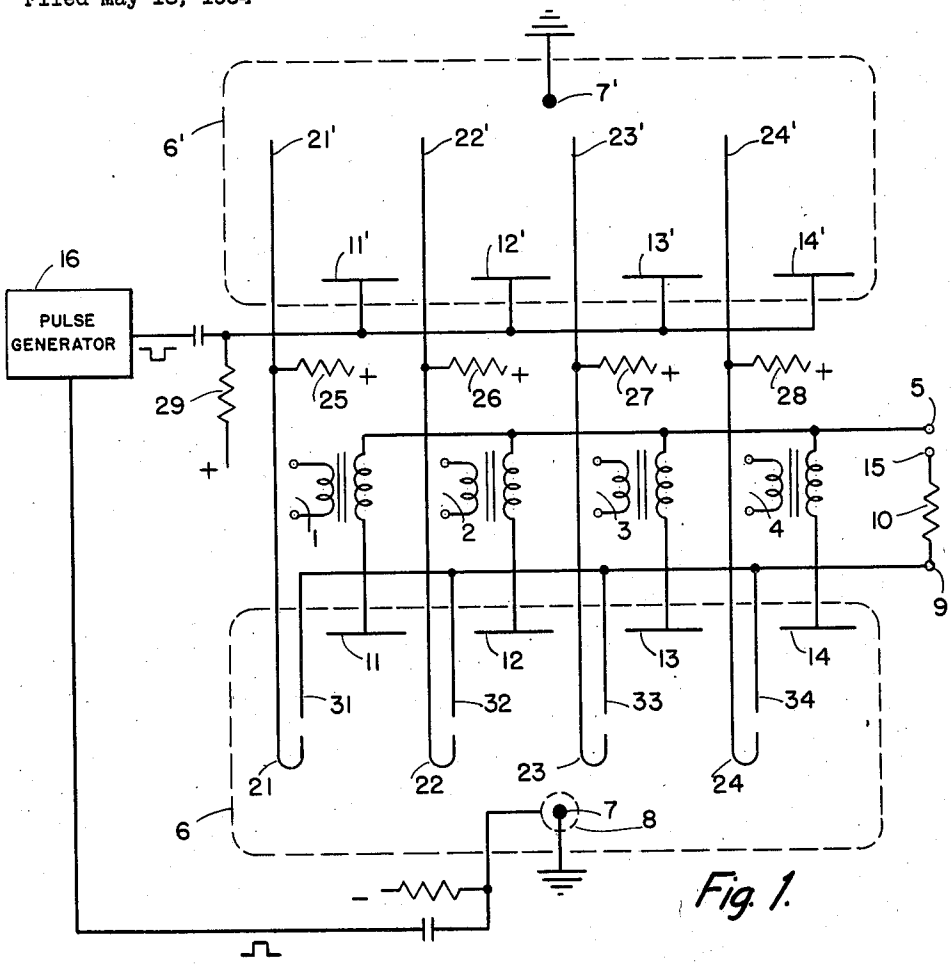

Fig. 1.

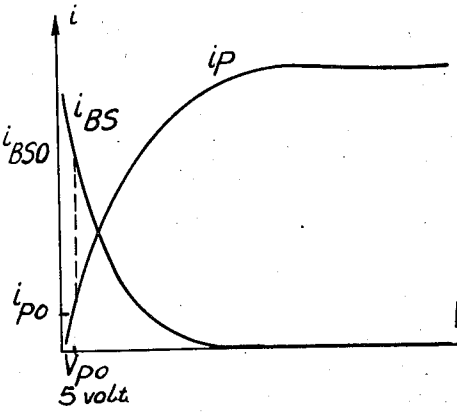

Fig. 2

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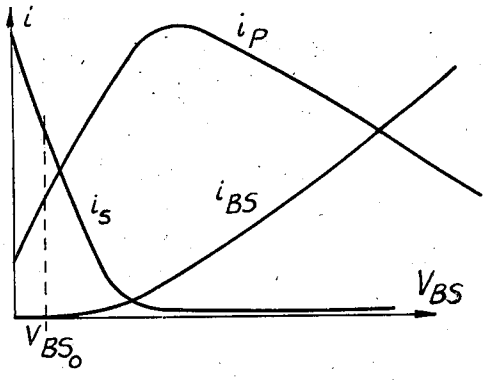

Fig. 3

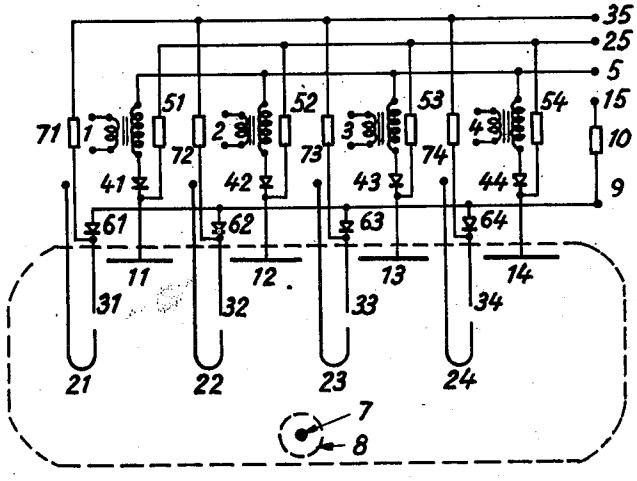

Fig. 4

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2,837,601

Patented June 3, 1958

2,837,601

ARRANGEMENT FOR GENERATING AMPLITUDE MODULATED PULSE TRAINS

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Application May 18, 1954, Serial No. 430,687

Claims priority, application Sweden June 17, 1953

4 Claims. (Cl. 179—15)

This invention relates to an arrangement for generating amplitude modulated pulse trains belonging to different channels in a pulse communication multiplex system, comprising a trochotron as described for instance in U. S. Patents 2,563,807 or 2,591,997 or a similar electron tube with a plurality of electrodes forming a compartment for each channel, arrangements for applying to the control electrodes of said compartments voltages for directing the electron beam to the compartments successively.

The invention is characterized by arrangements for applying the signal, which is to be transmitted, to one of two further electrodes in each compartment, said further electrodes being so arranged, that the current to the other of said further electrodes is a linear function of the voltage, which is applied to the first of said further electrodes within certain limits for said last voltage, and by the cathode current of the trochotron being switched on in synchronism with said directing voltage, so that amplitude modulated pulses are obtained across a load impedance, which is connected to all said other further electrodes.

The trochotron is defined as an electron tube, in which the electrons are caused to move in crossed electric and magnetic fields and which is provided with control electrodes for selectively guiding the electrons to any of a plurality of electrodes (plates), and specific embodiments are shown for example in the U. S. Patents 2,513,-260 and 2,591,997.

Previously known arrangements for generating amplitude modulated pulse trains belonging to different channels are generally rather complicated and require usually at least one electron tube or in any case a great number of components for each individual channel equipment.

The invention makes possible an arrangement for generating amplitude modulated pulse trains, which arrangement is so simple, that the number of components per channel equipment may be reduced to the smallest conceivable number.

The invention will be closer described in connection with the accompanying drawing, where Fig. 1 shows an arrangement according to the invention, Figs. 2 and 3 show the current distribution within a compartment as a function of some different electrode voltages and Fig. 4 shows a modification of the arrangement according to Fig. 1.

Fig. 1 shows an arrangement according to the invention, and for the case of simplicity only four channel equipments are shown in the drawing, because the channel equipments are identically equal. 1–4 are modulation transformers, the primary windings of which are connected to the incoming low frequency channels. The secondary windings of the transformers are connected between a common bias source 5 and the corresponding receiving electrodes (plates) 11–14. 6 is the envelope of the trochotron, which besides the previously mentioned plates 11–14 contains inter alia a cathode 7 surrounded by a control grid 8. Within the envelope of the

trochotron there are also four control electrodes (spades) 21–24 and four auxiliary electrodes (byspades) 31–34. Each of the control electrodes 21 to 24 is connected to corresponding control electrodes 21′ to 24′ in another trochotron 6′, the controlling trochotron. The control electrodes 21 to 24 and 21′ to 24′ are connected to a positive voltage source through resistors 25 to 28, respectively. The auxiliary electrodes 31 to 34 in trochotron 6 are connected to a common point 9, which is connected through a load impedance 10 to a bias source 15. In the controlling trochotron 6′, the plates 11′ to 14′ are connected together and are normally supplied with a positive bias through a resistor 29. The plates 11′ to 14′ are also connected to a pulse generator 16, which supplies negative stepping pulses to the plates thereby causing the electron beam to step from compartment to compartment. The pulse generator 16 also generates positive gate pulses which are impressed upon control grid 8 thereby allowing the cathode current to flow during the pulse time of each channel pulse. These gate pulses are synchronized with the stepping pulses fed to plates 11′ to 14′.

This arrangement for controlling the stepping of a trochotron by means of a second trochotron is more fully described in our application Ser. No. 368,474, filed July 16, 1953, by the same assignee.

The operation of the arrangement may be better understood by referring to Fig. 2. Fig. 2 shows the distribution of the current within a compartment as a function of the plate voltage V_p. In the figure i_p indicates the current to the plate and i_{BS} the current to the auxiliary electrode in the same compartment. If the potential of the auxiliary electrode is rather high, practically no current will flow to the control electrode in the same compartment, even though the plate voltage V_p is varied within the whole voltage range shown in Fig. 2. At a certain rather low plate voltage V_{po} a current i_{po} to the plate and a considerably greater current i_{BSO} to the auxiliary electrode are obtained. For small variations of the plate voltage around the value V_{po}, the current to the auxiliary electrode will vary rather linearly with the plate voltage around the value i_{BSO}. In the arrangement according to Fig. 1 point 5 is connected to a bias source with a rather low potential V_{po}, appropriately only about 5 volts higher than the potential of the cathode, which latter is supposed to be of zero potential. Point 15 is, however, connected to a bias source with such a high potential, that the current to the control electrode in the same compartment will be rather low.

The arrangement operates in the following manner. The electron beam of the controlling trochotron 6′ is in some known manner arranged to be moved from compartment to compartment. This causes the control electrodes 21′ to 24′ of the controlling trochotron and the corresponding control electrodes 21 to 24 of the trochotron 6 to have their potential decreased successively. Because of the negative bias of the control grid 8 in relation to the potential of the cathode 7 the electron beam of the trochotron 6 is normally cut off. Positive pulses of short duration are applied to the control grid 8. These pulses are synchronized with the voltage drop pulses of the control electrodes 21 to 24, so that said first mentioned pulses cause cathode current pulses to flow to the different compartments successively. They may be obtained from stepping pulse generator 16. When a cathode current pulse arrives to a compartment, the current will be distributed between the plate and the auxiliary electrode of the compartment, the distribution being dependent upon the potential of the plate. Thus the auxiliary electrode will receive a current during the duration of the cathode current pulse, the magnitude of which is de-

pending on the potential of the plate, i. e. upon the instantaneous value of the modulation voltage, which is applied to the cathode current receiving plate. At point 9 there will thus appear a pulse train composed of different amplitude modulated pulse trains, each of which represents a certain channel.

Fig. 3 shows the distribution of the current in a compartment as a function of the voltage V_{BS} of the auxiliary electrode in the same compartment. In the figure i_p indicates the current flowing to the plate, i_{BS} the current flowing to the auxiliary electrode and i_s the current to the control electrode in one and the same compartment. As is seen from the figure the current distribution between the different electrodes of a compartment may be varied by means of varying the potential of the auxiliary electrode. The arrangement according to Fig. 1 may thus be modified in such a manner, that the modulation transformers are connected to the auxiliary electrodes instead of to the plates. The amplitude modulated pulse trains are in this case obtained from interconnected plates or from the control electrodes.

The described arrangements may be somewhat modified in order to decrease crosstalk between the pulse channels. Diodes 41–44, Fig. 4, may thus be connected between the secondary windings of the modulation transformers 1–4 and the corresponding modulation electrodes 11–14. The cathodes of said diodes are connected to the different modulation electrodes. Each of these electrodes are connected through a resistor 51–54 to a common bias source 25. The potential of said last bias source is some volts higher than the potential of the bias source 5. The diodes 41–44 are thus normally non-conducting and they will not be conducting until the current to the corresponding modulation electrode exceeds a certain value. The crosstalk, which is obtained from a modulation transformer via a modulation electrode, which for the moment does not receive current, and the capacitance between said modulation electrode and the electrodes, which are connected to the common outpoint 9, will thus be considerably reduced. Further, the cross talk is considerably reduced, which is obtained from the modulation electrodes, which for the moment do not receive current, to the modulation electrode, which for the moment receives current, through the capacitance between them.

Another possibility for decreasing the crosstalk between the pulse channels, also shown in Fig. 4, is the following. The common output point 9 is connected to the anodes of a number of diodes 61–64, the cathodes of which are connected to the electrodes 31–34, respectively, which are arranged to receive amplitude modulated pulse trains. The electrodes 31–34 are each connected through a resistor 71–74 to a common bias source 35. The potential of said bias source is some volts higher than the potential of the bias source 15. The diodes 61–64 are thus normally non-conducting and they will not be conducting until the current to the electrodes, which are connected to the diodes, exceeds a certain value. This arrangement considerably reduces the crosstalk from the modulation electrodes to the common output point 9, whereas the crosstalk between the modulation electrodes is not particularly reduced.

The two possibilities of reducing the crosstalk may be used either alone or together. They may of course also be used independent of which electrodes that are used as modulation electrodes, or which electrodes that are used to receive the amplitude modulated current pulses, which shall be applied to the output 9 of the arrangement.

I claim:

1. A device for generating a complex pulse train composed of a plurality of mutually time displaced channel pulse trains, said device comprising a trochotron tube having a cathode and a plurality of electrodes forming compartments one for each channel, each of said compartments including a control electrode, a first electron receiving electrode and a second electron receiving electrode, said first electrodes being each connected to a common bias source, modulation transformers, diodes, each of said connections to the common bias source including in series the secondary of one of said transformers and one of said diodes, means for selectively applying to said control electrodes a stepping voltage to direct successively the electron beam to the several compartments, circuit means for applying the modulating voltage of each channel to said first electron receiving electrode in the compartment corresponding to said channel, the primary of said transformers being included in each of said circuit means, said two electron receiving electrodes of each compartment being correlated so that the current to each of said second receiving electrodes is a linear function of the modulating voltage applied to said first receiving electrode of the same compartment, within certain limits of said modulating voltage, means for supplying cathode current simultaneously with the stepping voltage, and load impedance means connected to all said second electron receiving electrodes, said complex pulse train appearing across said second electron receiving electrodes.

2. A device according to claim 1, wherein the cathode of each diode faces the respective first electron receiving electrode.

3. A device according to claim 2, wherein a point between each of said first electron receiving electrodes and the cathode of the respective diode is connected to a second common bias source having a higher potential than said first source, and an impedance means is included in each of the connections to the second bias source.

4. A device according to claim 1, wherein said second electron receiving electrodes are connected to a second common bias source and a diode is included in each of said connections, the cathode of said diode facing the respective second electron receiving electrode, and wherein a point between each second electron receiving electrode and the cathode of the respective diode is connected to a third common bias source having a higher potential than said second source, and wherein an impedance means is included in each of the connections to the third bias source.

References Cited in the file of this patent

UNITED STATES PATENTS

2,563,807	Alfven et al.	Aug. 14, 1951
2,733,409	Kuckinsky	Jan. 31, 1956