June 15, 1948. M. E. SALLACH 2,443,198

PULSE SELECTOR UNIT

Filed Sept. 6, 1946 2 Sheets-Sheet 1

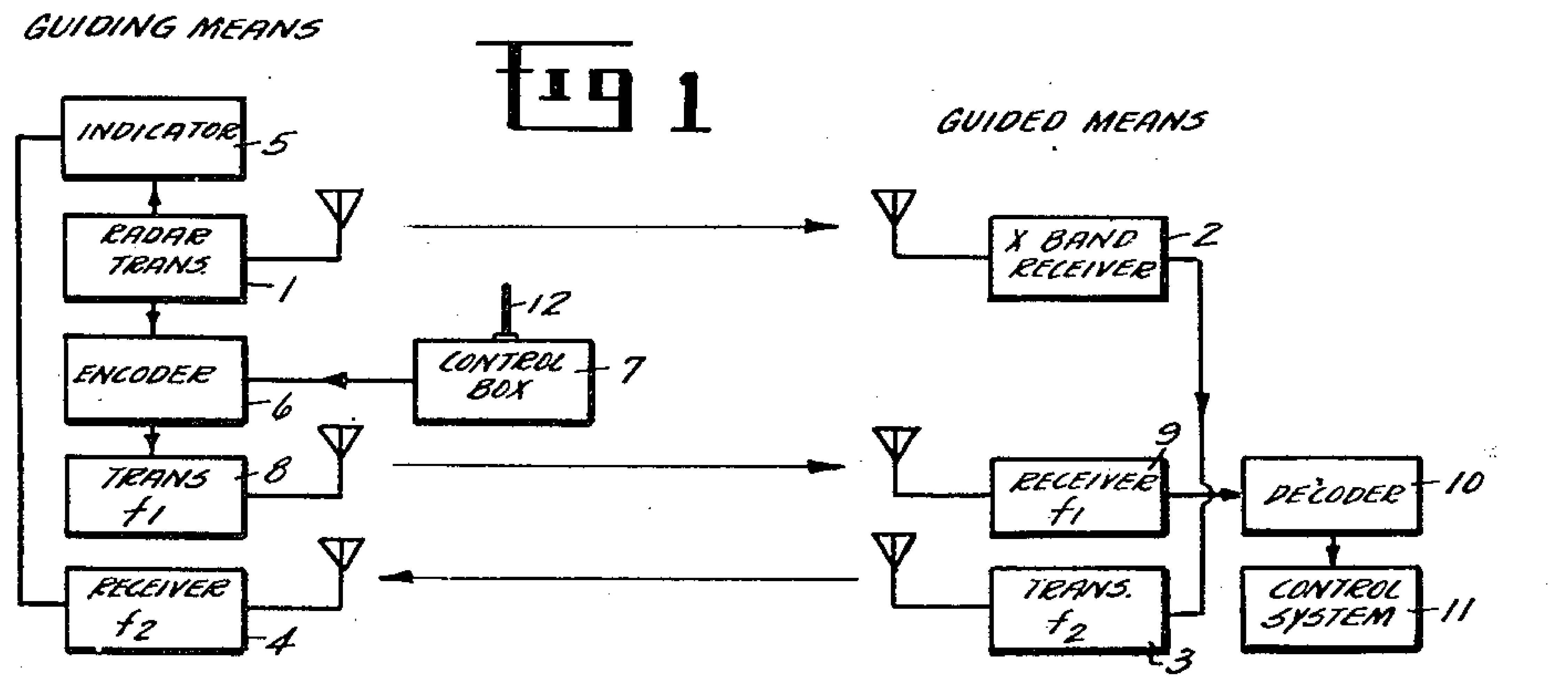

Fig 1

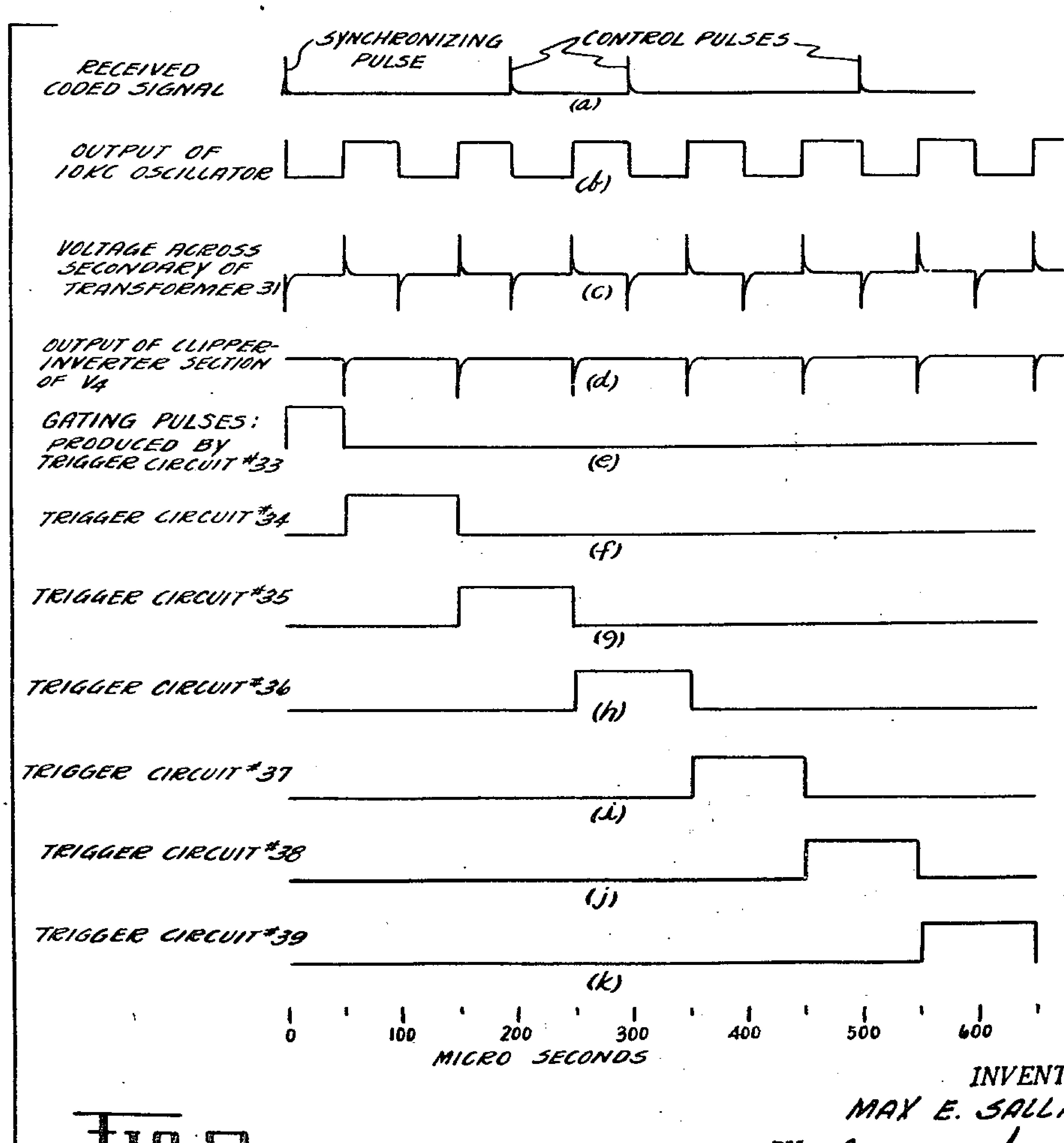

Fig 2

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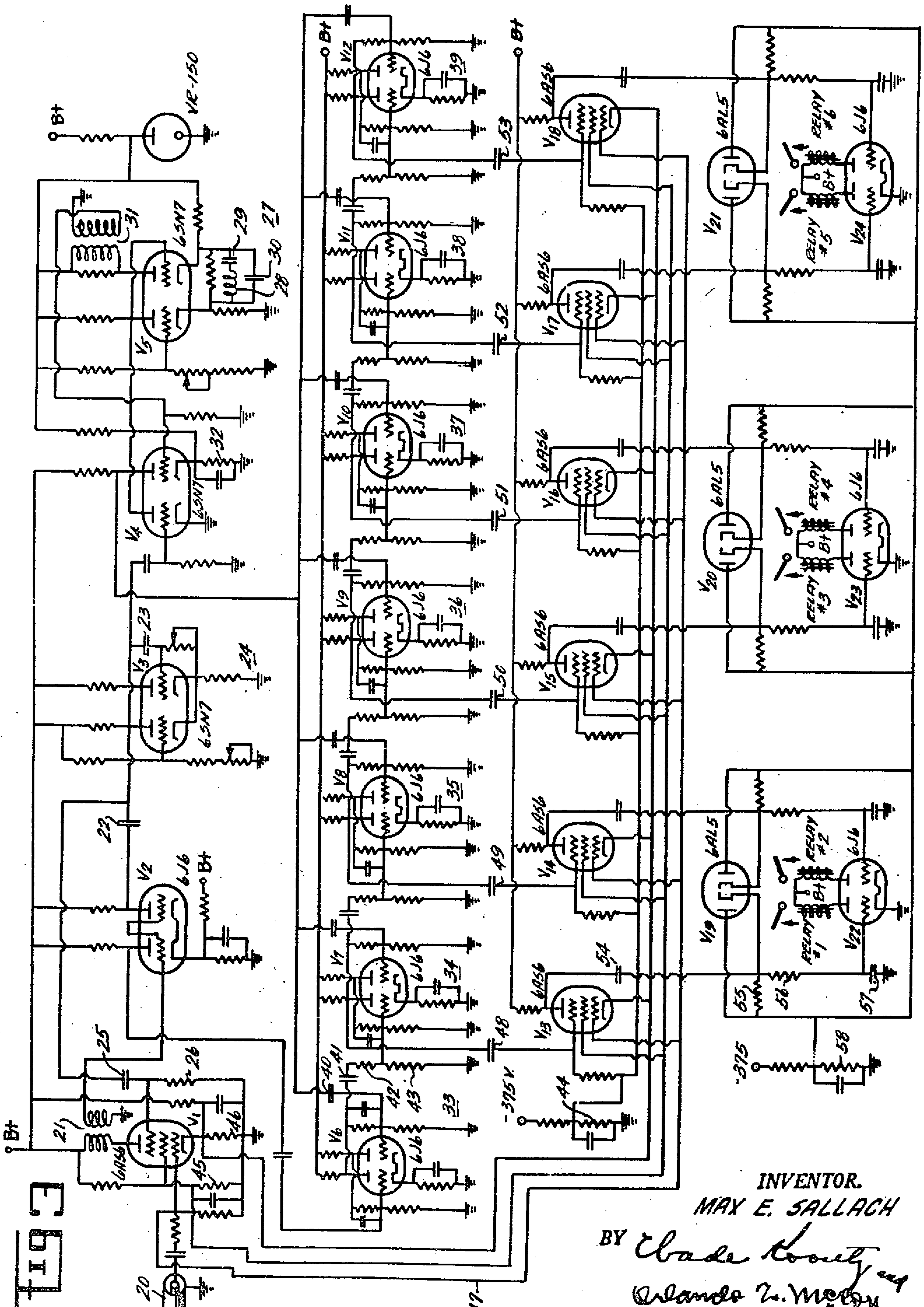

FIG. 3

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Patented June 15, 1948

2,443,198

UNITED STATES PATENT OFFICE

2,443,198

PULSE SELECTOR UNIT

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Application September 6, 1946, Serial No. 695,068

2 Claims. (Cl. 177—353)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

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The invention described herein may be manufactured and used by or for the Government for governmental purposes without payment to me of any royalty thereon.

This invention relates to a decoding circuit for use in systems of radio control, such as, for example, the systems used in connection with radio controlled aircraft or guided missiles. It is the object of the invention to provide a decoder capable of analyzing a coded signal of the type containing a synchronizing pulse and one or more control pulses occurring at predetermined times after the synchronizing pulse, and causing corresponding control functions to be performed.

In the drawings:

Fig. 1 is a block diagram of a typical system in which the decoder may be used;

Fig. 2 shows a number of wave forms obtained in the circuit of the decoder; and

Fig. 3 is a schematic diagram of the decoder circuit.

Referring to Fig. 1, the control system consists of a guiding means and a guided means, the guiding means comprising a radar transmitter 1 which transmits a series of pulses to the receiver 2 of the guided means. The output of this receiver is used to trigger transmitter 3 of the guided means, which transmits pulses back to receiver 4 in the guiding means. The output of receiver 4 is applied to the indicator 5 to give information about the position and motion of the guided means. The encoder 6 is triggered by a pulse synchronized with the transmitted pulses of the radar transmitter and generates a coded signal consisting of one or more coded pulses occurring at predetermined times after the initial triggering pulses. The number of control pulses present in the signal and the time at which they occur is controlled by stick 12 of control box 7. The encoded signal is applied to transmitter 8 of the guiding means which transmits the signal to the receiver 9 of the guided means. The coded output signal of receiver 9 is applied to the decoder 10 which analyzes the signal and causes the control system 11 to produce the desired changes in the motion of the guided means.

Reference is made to Fig. 3 for a description of the manner in which the decoder 10 of Fig. 1 analyzes the coded signal and causes the desired control circuits to operate. The form of the coded signal is shown in Fig. 2(*a*) and consists of a synchronizing pulse followed by one or more control pulses, each corresponding to a particular control function that it is desired to produce in the guided means. The particular circuit described is designed to work with a signal consisting of any combination of six control pulses occurring at multiples of 100 microseconds but not exceeding 600 microseconds after the synchronizing pulse. The signal shown in Fig. 2(*a*) comprises three control pulses occurring at 200, 300 and 500 microsecond intervals after the synchronizing pulse. The coded signal (obtained from transmission line 20) is amplified by gated video amplifier V_1 and applied by means of transformer 21 to the control grid of the right hand section of tube V_2, the output of which is applied to the control grid of the right hand section of V_3 through condensers 22 and 23.

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The tube V_3 is part of a conventional one cycle multivibrator circuit 24 having a condition of stability in which the current in the right hand section is a maximum and that in the left hand section is cut off. The application of a negative pulse to the grid of the right hand section causes a rapid transition to the condition in which the current in the left hand section is a maximum and the right section is cut off. This condition exists until the condenser 23 has discharged sufficiently to permit the grid of the right hand section to rise to the cut off point, at which time the multivibrator rapidly reverts to the initial condition with the right hand section conducting and the left hand section cut off. This cycle of operation produces a negative pulse at the anode of the left hand section, the length of which is determined by the time constant of the discharge path of condenser 23, which in this particular case is adjusted to give a pulse having a length somewhat in excess of 650 microseconds. The negative pulse produced at the anode of the left hand section of V_3 is applied to the suppressor grid of V_1 by means of condenser 25 and resistor 26, therefore, after the synchronizing pulse of the coded signal has passed through stages V_1 and V_2 and triggered the multivibrator circuit 24, the negative pulse produced by the multivibrator and applied to the suppressor grid of V_1 renders this tube inoperative for the duration of the pulse and therefore does not permit V_1 to pass any of the control pulses of the coded signal.

The negative pulse produced by the multivibrator 24 is also applied to the left hand section of V_4 which acts as a keying amplifier. This amplifier converts the pulse into a positive pulse which is applied to the anode of the left hand section of V_5 and to the grid of the right hand section of V_5. The dual-triode V_5 is part of an oscillator 27 which is a form of multivibrator having its frequency stabilized by the resonant circuit comprising conductance 28 and condensers 29 and 30. The oscillator is adjusted to a frequency of 10,000 cycles per second and, since the keying pulse applied thereto has a length in excess of 650 microseconds as stated above, the oscillator produces 6½ complete cycles during the time it is keyed by the pulse. The output wave of this oscillator is shown in Fig. 2(*b*) and is developed across the primary winding of transformer 31. This transformer is a differentiating device which produces across its secondary winding a voltage proportional to the rate of change of the voltage applied to the primary winding and therefore converts the output of the oscillator into a series of pulses of alternate polarity and spaced at 50 microsecond intervals as shown in Fig. 2(*c*). This series of pulses is applied to the grid of the right hand section of tube V_4 which is biased to cut-off by means of the potential drop across resistor 32. When so biased, the tube will not pass negative pulses applied to its grid, however, positive pulses applied to the grid appear amplified and inverted in polarity in the output circuit. The output circuit of this section of V_4 therefore contains a series of negative pulses, as shown in Fig. 2(*d*), spaced at 100 microsecond intervals and starting 50 microseconds after the occurrence of the original synchronizing pulse.

Circuits 33 through 39 form a cascaded arrangement of trigger circuits, each of which is of the Eccles-Jordan type. Referring to circuit 33, for example, the circuit comprises a dual-triode tube V_6 in which the anode of each section is coupled to the grid of the other section. This type of circuit has two conditions of stability which are the condition in which the current in the left hand section is a maximum and that in the right hand section is zero, and the condition in which the current is the right hand section is a maximum and that in the left hand section is zero. Due to the regenerative action of a circuit of this type, any external influence tending to change the circuit from one condition of stability will cause the change to progress in the same direction until the other condition of stability is reached. In the initial condition of operation of the decoder circuit, the left hand section of V_6 is conducting and the current in the right hand section is zero. The synchronizing pulse of the coded signal after amplification by V_1 and inversion by the left hand section of V_2 is applied as a negative pulse to the control grid of the left hand section of V_6, causing the current in this section to be reduced and, as explained above, the circuit to be triggered to the other condition of stability in which the current in the left hand section is zero and that in the right hand section is a maximum. Fifty microseconds later the first pulse of the series of negative pulses shown in Fig. 2(*d*) is applied to the control grid of the right hand section of V_6 through condenser 40. This pulse reduces the current in the right hand section of V_6 and causes the circuit to be triggered back to its initial condition of stability with the left hand section conducting and the right hand section cut off. This cycle of operation produces a positive pulse 50 microseconds in length at the anode of the left hand section of V_6 as shown in Fig. 2(*e*). A negative trigger pulse is produced from the trailing edge of this pulse by means of differentiating circuit comprising condenser 41 and resistors 42 and 43 and is applied to the control grid of the left hand section of V_7. This causes trigger circuit 34 to rapidly change from its initial condition of equilibrium, in which the left hand section of V_7 is conducting and the right hand section cut off, to the other condition of equilibrium in which the right hand section is conducting and the left hand section cut off. One hundred microseconds later the second negative pulse in the series shown in Fig. 2(*d*) is applied to the control grid of the right hand section of V_7, thus causing the trigger circuit 34 to revert to its initial condition of stability in which the left hand section of V_7 is conducting and the right hand section cut off. This cycle of operation produces at the anode of the left hand section a positive pulse of 100 microseconds duration as shown in Fig. 2(*f*). In a similar manner, the remaining circuits 35 through 39 produce successive 100 microsecond pulses as shown in Fig. 2(*g*) through (*k*), the last pulse in the series of Fig. 2(*d*) serving to trigger circuit 39 back to its original condition of stability in which the left hand section is conducting and the right hand section is cut off.

Six coincidence amplifiers, V_{13} through V_{18}, are provided, one of which is associated with each of the trigger circuits 34 through 39. Each of these amplifiers is a pentode having its cathode connected to ground through resistors 46 and its screen grid connected to the high potential end of resistor 45 to place the proper positive potential thereon. The control grids of all the amplifiers are connected together and, by means of lead 47, to the control grid of V_1, whereby the received coded signal is applied to the grids of these amplifiers at the same time that it is applied to V_1. Each of the coincidence amplifiers is biased to an inoperative condition by the application of a fixed negative potential to the suppressor grid; this potential is obtained from the drop across resistor 44. In order to cause the coincidence amplifiers to become operative at the proper times, provision is made for applying the 100 microsecond gating pulses produced by trigger circuits 34 through 39 to the suppressor grids of the corresponding amplifiers. This is accomplished by coupling the suppressor grid of each amplifier to the anode of the left hand section of the tube in the associated trigger circuit by means of condenser 48 through 53. Application of the positive gating pulse to the suppressor grid overcomes the negative bias on the grid and renders the amplifier operative for the duration of the pulse. Therefore, beginning 50 microseconds after the synchronizing pulse, coincidence amplifiers V_{13} through V_{18} are successively rendered operative for 100 microsecond intervals.

The decoder circuit described is designed to energize six control circuits which are represented in Fig. 3 by relays #1 through #6. The contacts of these relays may be connected in the control circuits so that closing the contacts energizes the circuits. The output of each of the coincidence amplifiers is rectified and the resulting direct voltage used to control the current in the relay coil. In the circuit of relay #1, for example, the output of V_{13} is applied through condenser 54 to the diode rectifier in the left hand section of V_{19}. The resulting direct voltage developed across resistor 55 is applied to the grid of the left hand section of V_{22} through filter elements 56 and 57 causing the grid potential to be raised. A delay bias is applied to the diode by means of the voltage drop across resistor 58 so that no rectification is obtained until the signal applied to the diode exceeds the voltage across this resistor, thus preventing operation of the relay by noise or other extraneous signals. The negative potential drop across resistor 58 is also applied to the grid of the left hand section of V_{22}, thus reducing the current through the coil of relay #1 below its threshold value in the absence of a signal. However, when control pulses appear in the output of V_{13}, the resulting rectified voltage applied to the grid of the triode overcomes the negative bias and raises the plate current to a value sufficient to operate relay #1. The construction and operation of the remaining relay circuits is the same as for relay #1.

In order for any one of the relays to be energized, it is necessary that in its associated coincidence amplifier a control pulse be applied to the control grid during the time that a gating pulse is applied to its suppressor grid. For example, in the case of the coded signal shown in Fig. 2(*a*) control pulses occur at intervals of 200, 300 and 500 microseconds after the syncronizing pulse. It is also seen from Fig. 2 that trigger circuits 35, 36 and 38 respectively are producing gating pulses at these times. Therefore, associated coincidence amplifiers V_{14}, V_{15} and V_{17} will be operative at the times of occurrence of the first, second and third control pulses respectively and associated relays #2, #3 and #5 will be energized.

What I claim is:

1. A decoding circuit for analyzing a coded signal consisting of a sychronizing pulse and one or more control pulses occurring at predetermined intervals of time after said synchronizing pulse, said decoding circuit comprising means for generating a series of pulses spaced at equal intervals of time and beginning a fixed interval of time after said synchronizing pulse, a plurality of trigger circuits connected in cascade, said circuits being of the type having two conditions of stability, first means for triggering said circuits from one condition of stability to the other condition of stability and second means for triggering said circuits from said other condition of stability back to said one condition of stability whereby each circuit produces a pulse the duration of which is determined by the time interval between the operation of said first and second means, said first means comprising means for applying said synchronizing pulse to the first trigger circuit and means utilizing the trailing edge of the pulse produced by each trigger circuit to trigger the next succeeding trigger circuit, said second means comprising means for applying said series of pulses to each of said trigger circuits, a plurality of coincidence circuits one of which is connected to each of the said trigger circuits in said cascade excluding the first, a plurality of control circuits one of which is connected to each of said coincidence circuits, and means for applying the coded signal to each of said coincidence circuits whereby those control circuits are energized that are connected to coincidence circuits in which a pulse produced by said trigger circuits and a control pulse from said coded signal occur at the same time.

2. A decoding circuit for analyzing a coded signal consisting of a synchronizing pulse and one or more additional pulses each occurring at a multiple of a fixed time interval after said synchronizing pulse, said circuit comprising a local oscillator having a period equal to said fixed time interval, means responsive to said synchronizing pulse for keying said oscillator, means for deriving from the output wave of said oscillator a series of sharp negative pulses separated by said time interval and beginning a length of time after said synchronizing pulse equal to one-half said time interval, a plurality of trigger circuits, each trigger circuit comprising a first and a second vacuum tube, each tube having an anode, a control grid and a cathode, means coupling the anode of each tube in said trigger circuits to the grid of its associated tube whereby each trigger circuit has a first condition of stability in which the first tube is conductive and the second tube non-conductive and a second condition of stability in which the first tube is non-conductive and the second tube is conductive, means connecting said trigger circuits in cascade with the grid of the first tube of each trigger circuit coupled through a differentiating circuit to the anode of the first tube in the preceding trigger circuit, means for applying and synchronizing pulse to the grid of the first tube of the first trigger circuit in said cascade and means for applying said series of negative pulses to the grid of the second tube in each trigger circuit of said cascade whereby the occurrence of said synchronizing pulse causes the trigger circuits of said cascade to operate in succession to produce a series of pulses with the length of the pulse produced by the first trigger circuit being equal to one-half said time interval and the lengths of the pulses produced by the succeeding trigger circuits being equal to said time interval, a plurality of coincidence circuits, means for applying the pulse produced by each trigger circuit in said cascade excluding the first to one of said coincidence circuits whereby said coincidence circuit is rendered operative for the duration of said pulse, means for applying said coded signal to each of said coincidence circuits, and a control circuit connected to each of said coincidence circuits whereby those control circuits are actuated that are connected to a coincidence circuit to which a pulse from its associated trigger circuit and a pulse of the coded signal are applied at the same time.

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