

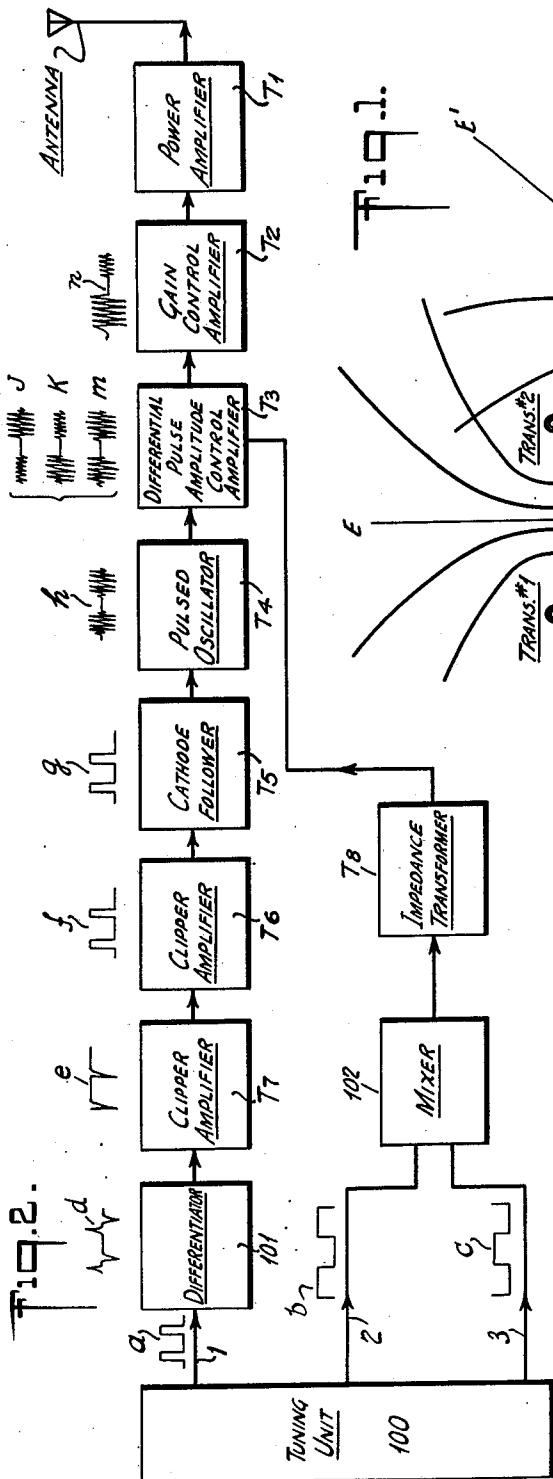
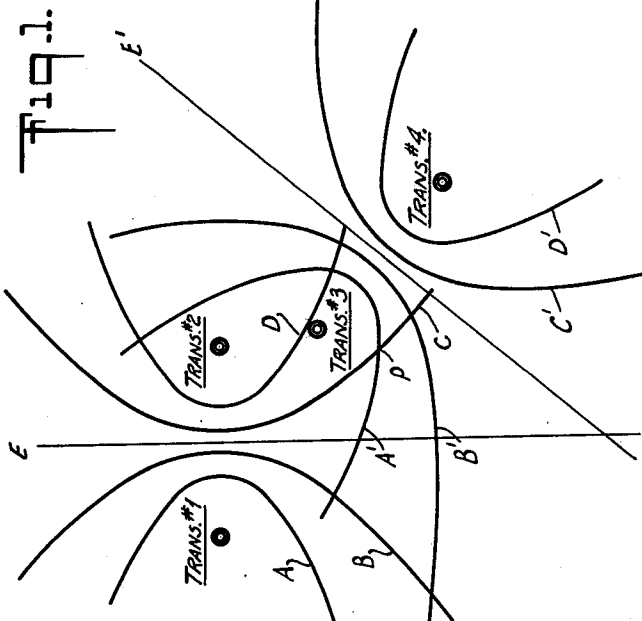
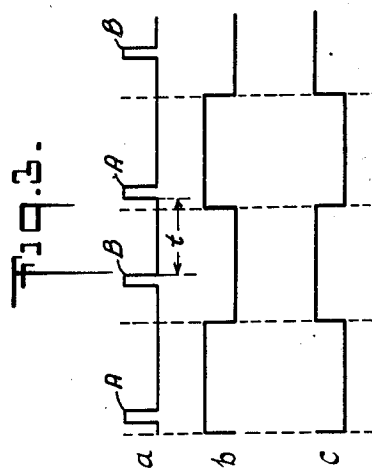
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G. D. HULST, JR
PULSE TRANSMISSION SYSTEM

2,472,706

Filed July 3, 1943

3 Sheets-Sheet 1



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June 7, 1949.

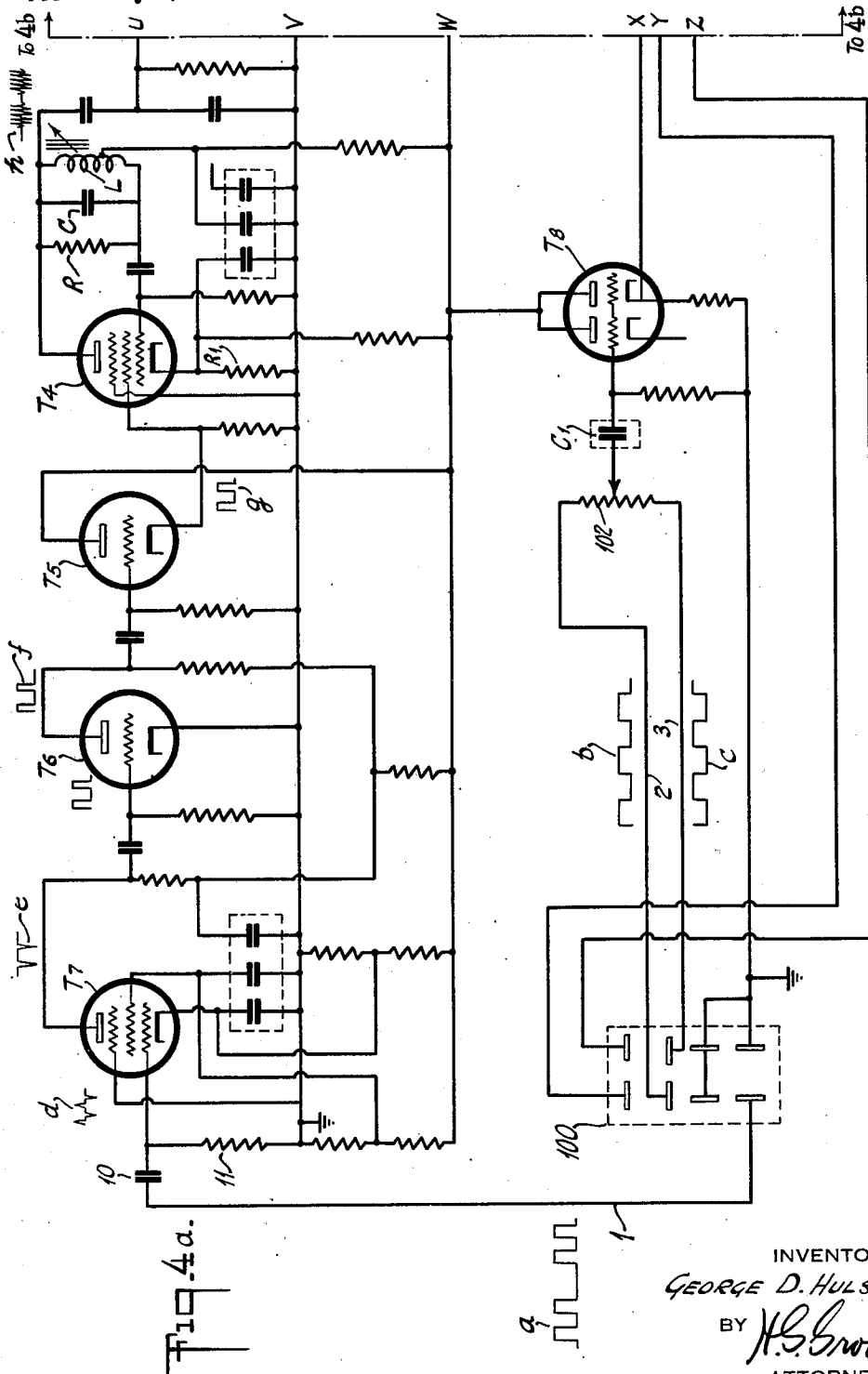
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PULSE TRANSMISSION SYSTEM

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3 Sheets-Sheet 2



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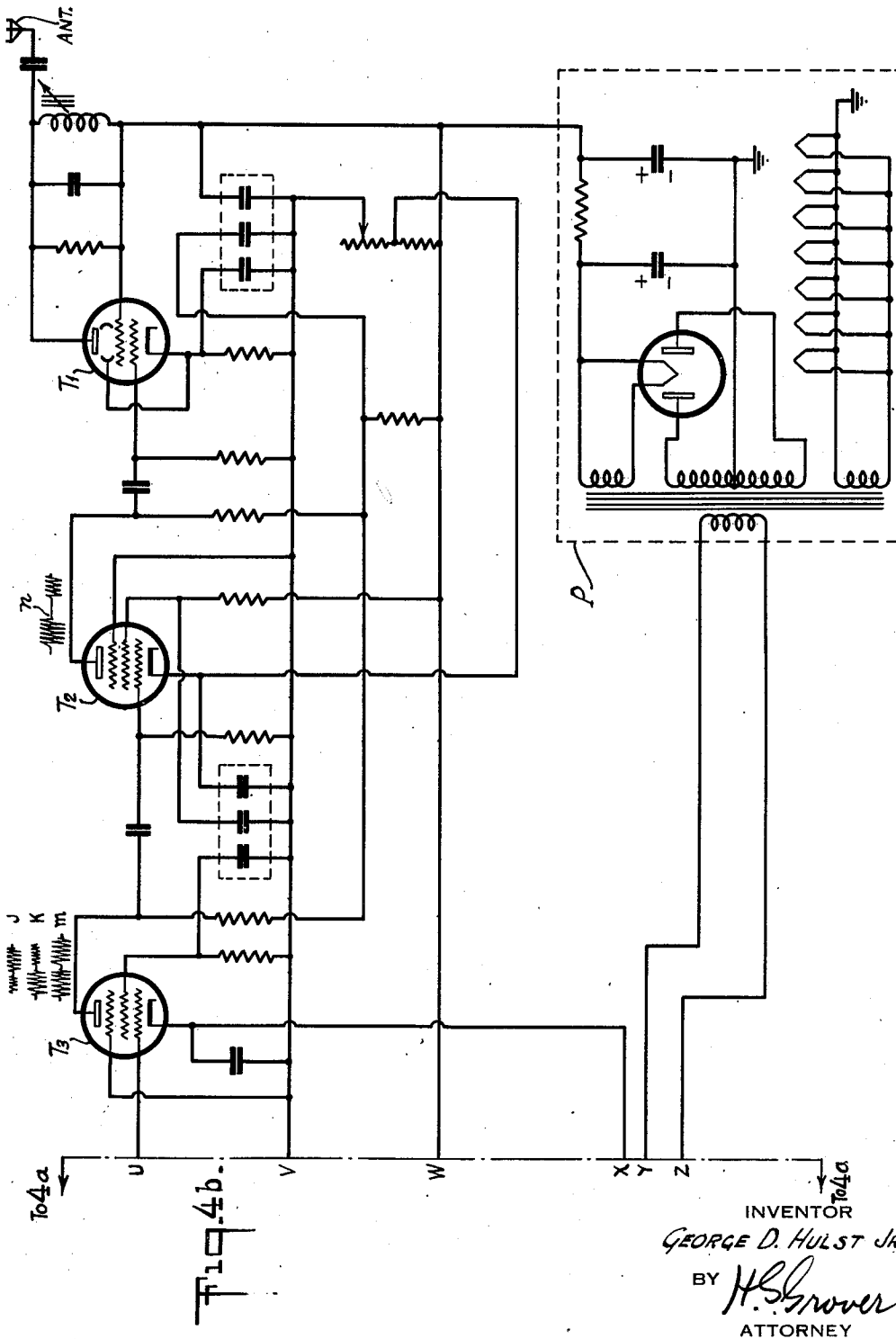
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PULSE TRANSMISSION SYSTEM

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3 Sheets-Sheet 3



UNITED STATES PATENT OFFICE

2,472,706

PULSE TRANSMISSION SYSTEM

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The present invention relates to apparatus for transmitting pulses of energy having certain desired phase relations and intensities, in order to simulate conditions at a receiver designed to receive pulses from different remotely located transmitters. The system of the invention as a whole is particularly applicable to training personnel in the field of navigation.

In the field of long range navigation, it is important for a ship at sea or an airplane to be able to determine its precise location irrespective of atmospheric conditions. In the case of an airplane flying in the dark or in inclement weather, it is important for the pilot to know his exact position at all times. With this end in view, it has been proposed to set up differently located pairs of radio transmitters and for these transmitters to send out pulses of radio frequency energy. The radio transmitters of each pair would be geographically spaced from each other at least several miles apart, and would transmit, at different intervals, periodically recurring pulses of the same carrier frequency and of the same repetition rate. Different pairs of radio transmitters would be located at different points and would have slightly different pulse repetition rates. Such a proposed system is presently used for military purposes and is known as the LRN system, the letters "LRN" being the abbreviation of the expression "long range navigation."

The method of operation of the LRN system may be better understood by referring to Fig. 1 of the accompanying drawing, wherein stations 1 and 2 represent one pair of radio pulse transmitters and stations 3 and 4 represent another pair of radio pulse transmitters. Transmitters 1 and 2 are spaced apart from each other by at least several miles, let us say fifteen miles, while transmitters 3 and 4 are similarly spaced apart from each other, although it should be understood that it is not necessary that the stations of each pair have the same geographic spacing as that of another pair. Transmitters 1 and 2 are remotely located with respect to transmitters 3 and 4, preferably by a distance appreciably greater than the distance between the stations of each pair. Stations 1 and 2 of one pair radiate short pulses of the same radio carrier frequency and of the same repetition rate, although at slightly different times. For example, stations 1 and 2 may each radiate pulses of about 40 microseconds duration having a carrier of 1.95 megacycles, these pulses recurring at a rate of twenty-five cycles per second. The time interval between the pulses radiated from the two stations of each

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pair should be shorter than the time interval between periodically recurring pulses. Thus, if the time interval between pulses from each station 1 or 2 is about 40,000 microseconds, then the time interval between the pulses from the two stations of each pair might be 15,000 microseconds. The repetition rate of the pulses from radio stations 3 and 4 differs slightly from that of stations 1 and 2 and might be $25\frac{1}{16}$ pulses per second, although the carrier frequencies of the pulses from the different pairs of stations may be the same (1.95 megacycles assumed above) or slightly different. The difference in the repetition rate of the pulses from the different pairs of stations is sufficient for an observer on a ship or airplane to distinguish between the pairs of stations.

The curved lines A, B, C, D of substantially hyperbolic shape, located between radio transmitting stations 1 and 2, are several of many loci along any one of which there is a fixed difference in distance between the two stations of this one pair. Similarly, curved lines A', B', C' and D', located between radio pulse transmitters 3 and 4, are several of many loci along any one of which there is a fixed difference in distance between the two stations 3 and 4. The straight line E between stations 1 and 2, and the straight line E' between stations 3 and 4 are lines on all points of which the distance between the stations of the respective pairs is the same.

An observer on a ship or plane desiring to determine his position in accordance with the above long range navigation (LRN) system, is supplied with a map showing the location of the different pairs of pulse transmitting stations 1, 2; 3, 4 etc. and also the loci, and is also supplied with a receiver which can be tuned to alternately receive the pulses radiated from the different pairs of stations. This receiver is equipped with circuits for calculating the time required for the pulses from the stations of a pair to travel to the receiver, and converting and swiftly registering or indicating this time. By tuning the receiver to receive the pulses of a particular repetition rate from one pair of transmitting stations, let us say 1 and 2, the observer determines the difference in time it takes for the radiated pulses from the two stations of this pair to reach his receiver. This time difference is proportional to the distance difference from the observer to the pulse transmitters and thus the observer learns that he is on a particular position of a particular locus, let us say curve C, but he may not know his exact position on this locus. Then, by tuning his receiver to the repetition rate of another pair of

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radio pulse transmitting stations, let us say 3 and 4, he determines the difference in time it takes for the pulses radiated from stations 3 and 4 to reach his receiver, and from this time difference he may learn that he is on locus A'. Since loci C and A' intersect at only one point P, the observer then knows his exact position on the map. In this way, the observer knows at all times the direction in which he is traveling and his exact position, and if he is in a bomber plane he will know when he is over the target.

In such navigation systems, the pulses from the different transmitting stations of each pair do not always arrive at the receiver with the same intensity, due to fading and atmospheric conditions. The present invention involves apparatus designed to simulate the various conditions of reception at a receiver designed for use in such a long range navigation system, and its primary purpose is to train personnel in an understanding of the long range navigation system described above.

One feature of the present invention comprises the circuit apparatus for producing a series of pulses of different amplitudes or intensities.

A more detailed description of the invention follows in conjunction with a drawing, wherein:

Fig. 1 illustrates a series of curves given to explain the operation of a long range navigation system;

Fig. 2 illustrates in outline form an embodiment of the invention;

Fig. 3 illustrates a series of curves of different wave forms and their time relations produced by the timing unit employed in the present invention; and

Figs. 4a and 4b, taken together, illustrate the circuit details of Fig. 2.

Referring to Fig. 2 in more detail, there is shown a timing unit 100 supplying over leads 1, 2 and 3 wave forms *a*, *b* and *c*, respectively. These wave forms are shown in more detail in Fig. 3. Wave form *a* comprises a series of non-overlapping pulses A and B which periodically recur at the same repetition rate, for example, twenty-five times per second. It should be noted that there is a small fixed time interval *t* between the pulses B and A and that this time interval is shorter than the time interval between sequentially recurring pulses A, A or between sequentially recurring pulses B, B. The timing unit also produces wave forms *b*, *c* whose pulses are of opposite polarity relative to each other. The pulses of wave forms *b* and *c* are square in form, of equal length and amplitude, and equally spaced. They may have the same or a slightly different amplitude from the pulses of wave form *a*. It should be noted that the square wave pulses of form *b* lead by a small fixed time interval the pulses A of wave form *a*, and that the square pulses of wave form *c* lead by a small fixed amount the pulses B of curve *a*. The phase relations of these wave forms are adjustable in the timing apparatus. The apparatus in the timing unit 100 which produces wave forms *a*, *b*, *c* includes suitable means for synchronizing or locking-in the various circuits which produce the different wave forms, in order that the phase relation shown in Fig. 3 may be obtained. No claim is made to the timing unit per se in the present invention, since such apparatus is known in the art and used in the receiver of the long range navigation system described above.

The wave form *a* of the timing unit is supplied over lead 1 to a differentiator circuit 101 which

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converts the pulses in lead 1 to the peaked wave form represented by *d*. The peaked wave form *d* is then impressed upon the clipper amplifier T7 which converts the positive and negative impulses of wave form *d* to negative impulses *e*. The output of the clipper amplifier T7 is then impressed upon a clipper amplifier T6 which converts the wave form *e* to the wave form *f*. The pulses of wave form *f* are shorter in duration than the pulses of wave form *a*. The output of clipper amplifier T6 is then impressed upon an impedance transformer tube T5 (sometimes referred to as a cathode follower) which provides an output of wave form *g* of substantially the same form as wave form *f*. The input to the impedance transformer tube is of high impedance, while the output taken from the cathode of the tube is of low impedance. Wave form *g* is used to key a suitable radio frequency oscillator T4 which is pulsed to produce output pulses of radio frequency oscillations shown by wave form *h*. The output of the pulsed oscillator T4 is then impressed on a differential-pulse-amplitude-control amplifier T3, upon which is also impressed the output of impedance transformer tube or cathode follower T8.

At this time it should be noted that the impedance transformer T8 has impressed thereon the output of a mixer 102, the latter in turn having supplied thereto pulses of wave forms *b* and *c* from the timing unit 100 over leads 2 and 3, respectively. The mixer 102 serves to increase the amplitude of either one of the wave forms *b* or *c* with respect to the other so as to supply an output wave form which can vary in shape anywhere from that of *b* to that of *c*. By way of analogy, the mixer 102 can be compared to a faucet to which hot and cold water is supplied over separate conduits. By suitable adjustment of the faucet, the outlet may be made to supply more cold water or more hot water.

The impedance transformer T8 merely serves to couple the connection from the mixer 102 which is at a high impedance to the connection to the unit T3 which is at a low impedance. The differential-pulse-amplitude-control amplifier T3 supplies an output having either one of the three wave forms J, K or *m*, depending upon the input supplied thereto by the mixer circuit 102. Thus, if the mixer circuit 102 minimizes the amplitude of the square pulses of wave form *b* with respect to the amplitude of the square pulse from wave form *c*, the output from unit T3 will have a wave form shown by J. On the other hand, if the amplitude of the square pulses of wave form *c* is increased by the mixer with respect to the amplitude of the square pulses of wave form *b*, then the output from the unit T3 will have a wave form shown by K. If the mixer 102, however, is adjusted so that the wave forms *b* and *c* impressed thereon compensate or neutralize each other in the mixer, then the output of the mixer will be a straight line, in which case the unit T3 will supply a wave form of the type shown by *m*. It should be noted that the pulses of radio frequency energy in the output of unit T3, which may be of either of the three forms J, K or *m*, have a time appearance which is identical with or registers with the time appearance of the pulse of wave form *a* in lead 1 connected to the output of the timing unit.

The output of unit T3 is impressed upon the gain control amplifier T2 which serves to amplify the output of unit T3 and in turn impresses the amplified pulses of radio frequency energy upon the power amplifier T1. The output of the power

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amplifier T1 is coupled to a suitable antenna ANT for radiating the pulses.

Figs. 4a and 4b, taken together, illustrate in detail the circuit diagram of Fig. 2. In this figure, box 100 represents the timing unit and merely shows the prongs to which the various leads of the system of the invention are connected. The lead 10 upon which is impressed the two series of periodically recurring spaced pulses A and B of wave form *a*) is connected to the differentiator circuit comprising the condenser 10 and resistor 11. The peaked impulses of wave form *d*) of the wave converted by the differentiator is impressed upon the control grid of the clipper amplifier T7, in whose output appears the wave form *e*). The clipper amplifier T7 is a vacuum tube normally biased past cut-off, and it is only the positive peaks of wave form *d*) which cause tube T7 to pass current momentarily and thus produce the inverted impulses of wave form *e*). The wave form *e* from clipper amplifier T7 is impressed upon the grid of triode clipper amplifier T6. This triode is a tube which is biased to pass current normally but is biased past cut-off by the impulses of wave form *e*). The output of clipper amplifier T7 will have the wave form *f*) and will be impressed upon the grid of the impedance transformer tube or cathode follower T5. This impedance transformer tube is sometimes called a cathode follower because of the fact that its output is taken from the cathode of the tube. Tube T5 merely serves to couple the high impedance input of its grid circuit to a low impedance output from its cathode circuit. The pulses in the cathode circuit of the impedance transformer T5 are represented by wave form *g*) and these pulses are impressed on the second grid of a pentode oscillator T4 for pulsing or keying the same.

The oscillator T4 is shown to be of the Hartley type and includes an oscillatory circuit comprising an inductance L, a condenser C, and a shunt damping resistor R. The inductance L is adjusted by means of a suitable iron plug. Oscillator T4 is normally biased to cut-off in the absence of input pulses, and is momentarily biased to the current passing condition by the impulses of wave form *g*) applied to a screen grid from the impedance transformer T5. The output from the oscillator comprises pulses of radio frequency energy represented by wave form *h*). These pulses of wave form *h* take a little time to build up and also have a small decay time, but are controllable by the design of the oscillator within certain limits. The build up time is controlled by the transconductance of the tube T4 and the gain of the oscillator when considered as an amplifier, while the decay time is controlled by the timing of the tuned circuit. The cathode bias provided by resistor R assures a current cut-off condition during the absence of input pulses to the screen grid of tube T4. The pulses of radio frequency energy in the wave form *h* in the output of the oscillator are impressed upon the control grid of the differential-pulse-amplitude-control amplifier tube T3.

The differential-pulse-amplitude-control amplifier T3 has impressed upon its cathode the output of the impedance transformer T8. Tube T8 has impressed upon its grid the output of the mixer 102 through a blocking condenser C1. Mixer 102, in effect, consists of a resistor to whose opposite terminals are connected leads 2 and 3, in turn extending to the timing unit 100. As mentioned above, lead 2 has impressed thereon square pulses of the wave form *b*) while lead 3 has im-

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pressed thereon square pulses of the wave form *c*). A tap on the mixer 102 which connects to the impedance transformer T8 through condenser C1 serves to provide any suitable adjustment over the length of the resistance constituting the mixer. If the tap is at its uppermost terminal, square pulses of the wave form *b*) will be passed on to the impedance transformer T8 and then to the differential transformer without diminution of intensity, while square pulses of the wave form *c*) will be considerably decreased in intensity or amplitude and have no effect in the output of the impedance transformer T8. Conversely, if the tap on the mixer 102 is in its lowermost position, the square pulses of wave form *c*) will be passed on to the impedance transformer T8 and then to the unit T3 without change in amplitude, while the square pulses of wave form *b*) will be considerably decreased in amplitude and intensity and have no effect on the output applied to unit T3. If the tap on the mixer is exactly in the center, the square pulses of wave form *b*) and *c*) which are of opposite polarity will cancel or neutralize each other in effect, and no pulse will be passed on to the cathode of tube T3 from the impedance transformer T8. It will thus be seen that the relative amplitudes of the square pulses corresponding to wave forms *b*) and *c*) in the output of the mixer 102 depends upon the precise position of the tap on the mixer resistor. The output of tube T3 will comprise radio frequency pulses having either of the three wave forms J, K or *m*), depending upon the position of the tap on the mixer 102. The gain control amplifier T2 serves to amplify the pulses impressed on its control grid from the output of the differential-pulse-amplitude-control amplifier T3. Assuming that the tube T3 happens, at one particular moment, to be passing pulses of the wave form K, then the output of the gain control amplifier T2 may have the wave form *n*), the latter showing by comparison with the wave form K the gain provided by the tube T2.

The output from the gain control amplifier T2 is supplied to the power amplifier T1, which in turn supplies the amplified pulses of radio frequency energy to a suitable antenna ANT. A suitable power supply unit is shown in box P for supplying positive polarizing potentials to the electrodes of the various tube circuits and for supplying heating current to the filaments of the different tubes.

In one embodiment successfully constructed and tried out in practice, the circuit of Figs. 4a and 4b was constituted as follows: The condenser 10 and resistor 11 of the differentiator circuit had respective values of 250 μmf and 120,000 ohms. Tube 7 was an RCA 6SJ7 tube. The two triodes T5 and T6 formed one tube within a single envelope and was an RCA 6SL7GT tube. The oscillator tube T4 was an RCA 6SK7 tube, and produced oscillations of 1.95 megacycles. The shunt resistor R of the oscillator was 120,000 ohms, while the condenser C of the oscillator was 100 μmf having zero drift. The tubes T3 and T2 were each RCA 6SK7 tubes. The power amplifier T1 was an RCA 6V6GT tube, and the two condensers connected to its output were each of 25 μmf and had zero drift. The antenna was of the telescopic rod type which could be extended to a length of 48 inches. With the antenna extended to its full length of 48 inches, it radiated a field of approximately 10,000 microvolts per meter at a distance of thirty feet in any direction. The frequency of the output was adjustable by means of a screw driver acting on the iron plug in coil L.

of the oscillator to provide a tuning range between 1780 and 2080 kilocycles. The amplitude of either of the two output pulses from the antenna corresponding in time relation to the two pulses A and B of wave form a could be attenuated individually and continuously by means of the mixer to less than $1/100$ of the other pulses (40 decibels). When the tap on the mixer controlled by a knob was set at its center position, the amplitudes of both pulses from the antenna were the same. The time duration of each output pulse from the antenna was about 35 microseconds, the build up time being about 8 microseconds, the flat top or constant amplitude time being about 12 microseconds, while the decay time was about 15 microseconds. The time interval between adjacent pulses of each series A or each series B was of the order of 40,000 microseconds, while the time interval between pulses A and B was of the order of 15,000 microseconds. The output of both series of pulses was continuously variable over a range of 100 to 1, by means of a knob, and this action was completely separate from the action of the knob controlling the tap on the mixer, for which reason it was possible to simulate a wide variety of field conditions.

By using two sets of training apparatus, each of the type shown in Fig. 1 or Fig. 3, it is possible to simulate the conditions at a receiver designed to receive pulses from two pairs of geographically spaced radio pulse transmitters, the transmitters of each pair transmitting short pulses of radio frequency energy of the same repetition rate but spaced apart in time, and the two pairs having slightly different pulse repetition rates.

What is claimed is:

1. In combination, an oscillator of radio frequency energy normally biased to cut-off, a circuit for impressing upon said oscillator two series of unidirectional current pulses to thereby cause said oscillator to produce two corresponding series of pulses of radio frequency energy, a utilization device, an amplifier between said oscillator and said utilization device, and means coupled to said amplifier for causing the same to change the relative amplitude of one of said series of pulses of radio frequency energy relative to the amplitude of the other series of pulses of radio frequency energy.

2. In combination, an oscillator of radio frequency energy normally biased to cut-off, a circuit for impressing upon said oscillator two series of unidirectional current pulses to thereby cause said oscillator to produce two corresponding series of pulses of radio frequency energy, a utilization device, first and second amplifiers in cascade coupling said oscillator to said utilization device, and means coupled to said first amplifier for changing the relative amplitudes of said two series of pulses of radio frequency energy.

3. In combination, an oscillator of radio frequency energy conditioned to be normally non-conductive, a circuit for impressing upon an electrode of said oscillator two series of unidirectional current pulses to thereby cause said oscillator to produce two correspondingly positioned series of pulses of radio frequency energy, a utilization device, a vacuum tube coupling the output of said oscillator to said utilization device, and means for applying to an electrode of said vacuum tube other unidirectional current pulses of relatively different time duration than said first unidirectional pulses to thereby cause said vacuum tube to change the relative amplitudes of the two series

of pulses of radio frequency energy passed thereby.

4. In combination, an oscillator of radio frequency energy conditioned to be normally non-conductive, a circuit for impressing upon an electrode of said oscillator two series of unidirectional current pulses of the same repetition rate but displaced from one another in time, to thereby cause said oscillator to produce two correspondingly positioned series of pulses of radio frequency energy, a utilization device, a vacuum tube coupling the output of said oscillator to said utilization device, and means for applying to an electrode of said vacuum tube other unidirectional current pulses of relatively different time duration than said first unidirectional pulses but synchronized with respect to said first unidirectional pulses to thereby cause said vacuum tube to change the relative amplitudes of the two series of pulses of radio frequency energy passed thereby.

5. In combination, an oscillator of radio frequency energy conditioned to be normally non-conductive, a circuit for impressing upon an electrode of said oscillator two series of unidirectional current pulses of the same repetition rate but displaced from one another in time to thereby cause said oscillator to produce two correspondingly positioned series of pulses of radio frequency energy, a utilization device, a vacuum tube having a control electrode coupled to the output of said oscillator and an output electrode coupled to said utilization device, and means for applying to the cathode of said vacuum tube other unidirectional current pulses of relatively different time duration than said first unidirectional pulses but synchronized with respect to said first unidirectional pulses, to thereby cause said vacuum tube to change the relative amplitudes of the two series of pulses of radio frequency energy passed thereby.

6. The method of operating electrical apparatus which includes generating a multiplicity of spaced pulses of radio frequency energy of the same amplitude, producing a series of unidirectional pulses independently of said pulses of radio frequency energy and which are synchronized with respect to said multiplicity of pulses of radio frequency energy, and changing the amplitudes of only certain ones of said multiplicity of pulses of radio frequency energy as a function of the amplitude of said series of unidirectional pulses.

7. A signaling system having an oscillator of radio frequency energy, said oscillator having as a part thereof a control element for determining whether or not said oscillator produces oscillations, means for impressing upon said control element of said oscillator two time spaced series of pulses of substantially uniform amplitude and duration and of the same repetition rate, to thereby cause said oscillator to produce two correspondingly positioned series of pulses of radio frequency energy, and means synchronized with respect to said two series of pulses for changing the amplitude of one series of pulses of radio frequency energy relative to that of the other series of radio frequency energy.

8. A pulse generating system having means for first producing two series of pulses of uniform amplitude and duration and having the same repetition rate but differently phased in point of time, the duration of each pulse being short compared to the time interval between pulses, the spacing between a pulse of one series and the

adjacent pulse of the other series being shorter than the spacing between adjacent pulses of any one series, and means synchronized with respect to said two series of pulses for subsequently changing the relative amplitudes of said two series of pulses while maintaining the same repetition rate and relative phase relation.

9. A pulse transmission system for simulating the conditions at a receiver adapted to receive pulses from differently located pulse transmitting stations comprising means for generating two series of non-overlapping unidirectional pulses of uniform duration and of the same repetition rate, means for also generating other unidirectional pulses of the same repetition rate as said first pulses, synchronized therewith, but displaced therefrom in point of time, an oscillator of alternating current, a circuit for impressing upon said oscillator two series of pulses representative of said first two series for causing said oscillator to produce two corresponding series of pulses of alternating current energy, a differential-pulse-amplitude control tube, and circuits for impressing upon different electrodes of said control tube the pulses of alternating current energy and said other unidirectional pulses for producing two series of output pulses of alternating current energy of different amplitudes.

10. A pulse transmission system for simulating the conditions at a receiver adapted to receive pulses from differently located pulse transmitting stations comprising means for generating two series of non-overlapping unidirectional pulses of uniform duration and of the same repetition rate, means for also generating other unidirectional pulses of the same repetition rate as said first pulses, synchronized therewith, but displaced therefrom in point of time, a circuit for changing amplitudes of only said last unidirectional pulses, an oscillator of alternating current, a circuit for impressing upon said oscillator two series of pulses representative of said first two series for causing said oscillator to produce two corresponding series of pulses of radio frequency energy, a differential-pulse-amplitude-control tube, and circuits for impressing upon different electrodes of said control tube the pulses of radio frequency energy and the changed amplitude unidirectional pulses for producing two series of non-overlapping output pulses of radio frequency energy of different amplitudes and of the same repetition rate.

11. A pulse transmission system comprising a source of periodically recurring waves, a differentiator coupled to said source, a clipper amplifier, a connection from said differentiator to said clipper amplifier, whereby said amplifier produces pulses whose duration is shorter than that of the periodically appearing waves of said source, a radio frequency oscillator under control of said amplifier for producing pulses of radio frequency energy whose duration is shorter than the time interval between pulses, an amplitude control tube, a connection from the output of said oscillator to an electrode of said control tube, a source of pulses operating in synchronism with said first source, and a connection from said source of pulses to another electrode of said control tube, to thereby vary the amplitude of said pulses of radio frequency energy as available in the output of said control tube.

12. A pulse transmission system comprising a source of periodically recurring waves, a differentiator coupled to said source, a clipper amplifier,

a connection from said differentiator to said clipper amplifier, whereby said amplifier produces pulses whose duration is shorter than that of the periodically appearing waves of said source, a radio frequency oscillator under control of said amplifier for producing pulses of radio frequency energy whose duration is shorter than the time interval between pulses, and an amplitude modulator coupled to the output of said radio frequency oscillator.

13. A pulse transmission system comprising a radio frequency oscillator, said oscillator having as an integral part thereof a control element for determining whether or not said oscillator produces oscillations, a source of periodically recurring unidirectional current pulses coupled to said control element of said oscillator for controlling said oscillator to produce correspondingly positioned pulses of radio frequency energy of uniform duration and amplitude, and means coupled to the output of said oscillator for changing the amplitude of said pulses of radio frequency energy.

14. A pulse transmission system comprising a radio frequency oscillator, said oscillator having as an integral part thereof a control element for determining whether or not said oscillator produces oscillations, a source of periodically recurring pairs of pulses coupled to said control element of said oscillator for controlling said oscillator to produce periodically recurring pairs of correspondingly positioned pulses of radio frequency energy of uniform duration and amplitude, and means coupled to the output of said oscillator and synchronized with respect to said source for changing, by a fixed amount, a characteristic of only one of the pulses of each of said pairs of radio frequency pulses.

15. The method of operating electrical apparatus which includes generating a multiplicity of pulses of radio frequency energy, producing independently of said pulses of radio frequency energy a series of unidirectional current pulses of substantially rectangular wave form and which are synchronized with respect to said multiplicity of pulses of radio frequency energy, and changing the amplitudes of only certain ones of said multiplicity of pulses of radio frequency energy as a function of the amplitude of said series of unidirectional pulses.

16. A signaling system having an oscillator of radio frequency energy, said oscillator having as a part thereof a control element for determining whether or not said oscillator produces oscillations, means for impressing upon said control element of said oscillator two time spaced series of pulses of substantially uniform amplitude and duration and of the same repetition rate, to thereby cause said oscillator to produce two correspondingly positioned series of pulses of radio frequency energy, and means including apparatus for producing in synchronous relation to said first pulses two series of unidirectional pulses of rectangular wave form for changing the amplitude of one series of pulses of radio frequency energy relative to that of the other series of radio frequency energy.

17. A pulse transmission system comprising a radio frequency oscillator having as part thereof a control electrode, a source of first and second series of periodically recurring unidirectional current pulses coupled to said electrode and controlling said oscillator to produce correspondingly

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positioned pulses of radio frequency energy of uniform duration and amplitude, and means coupled to the output of said oscillator for changing at will the amplitude of those pulses of radio frequency energy corresponding to one series relative to those of the other series.

GEORGE D. HULST, JR.

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