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ELIMINATION OF SPURIOUS ADDITIONS TO RADIO SIGNALS

Filed April 16, 1940

3 Sheets-Sheet 1

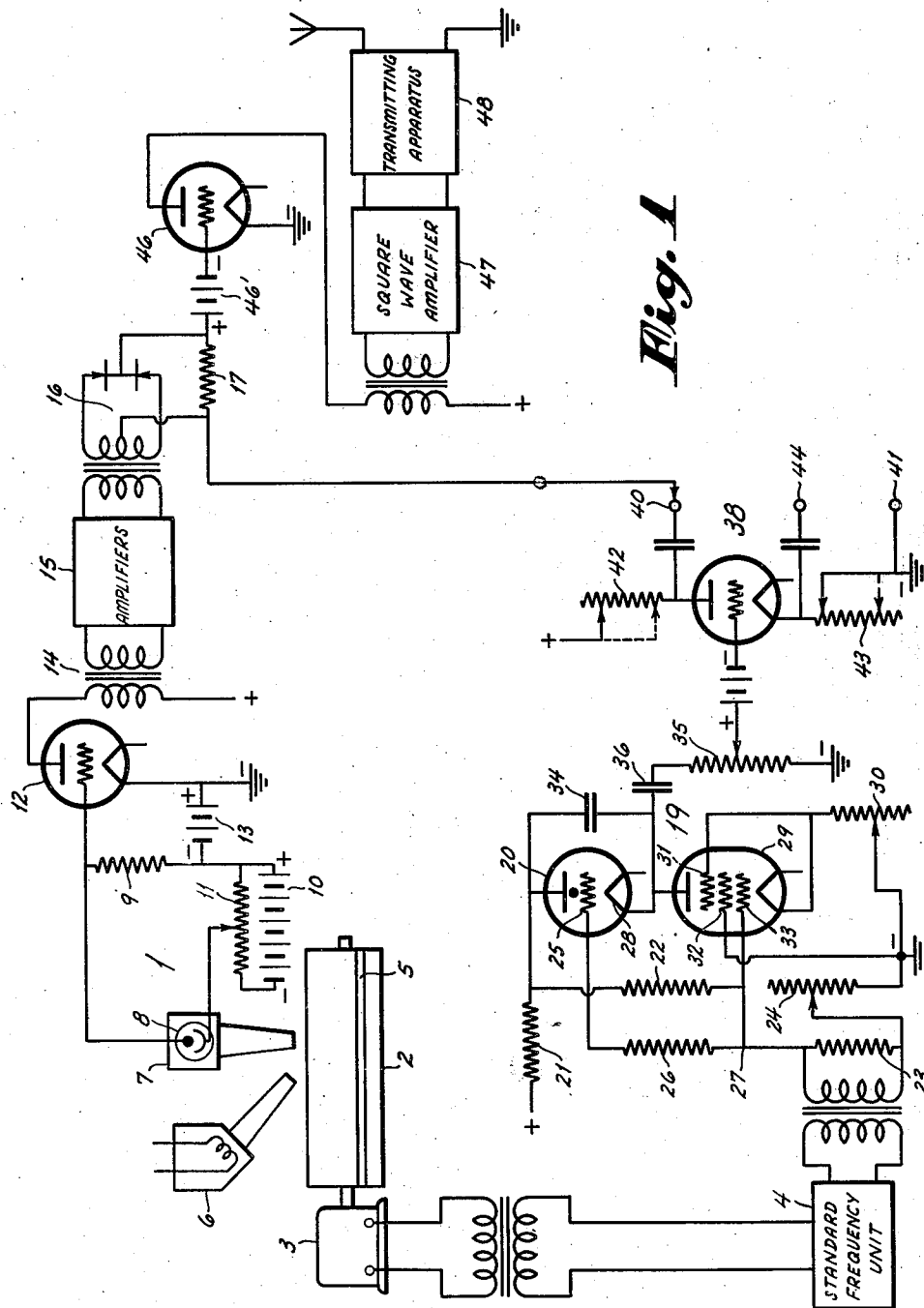


Fig. 1

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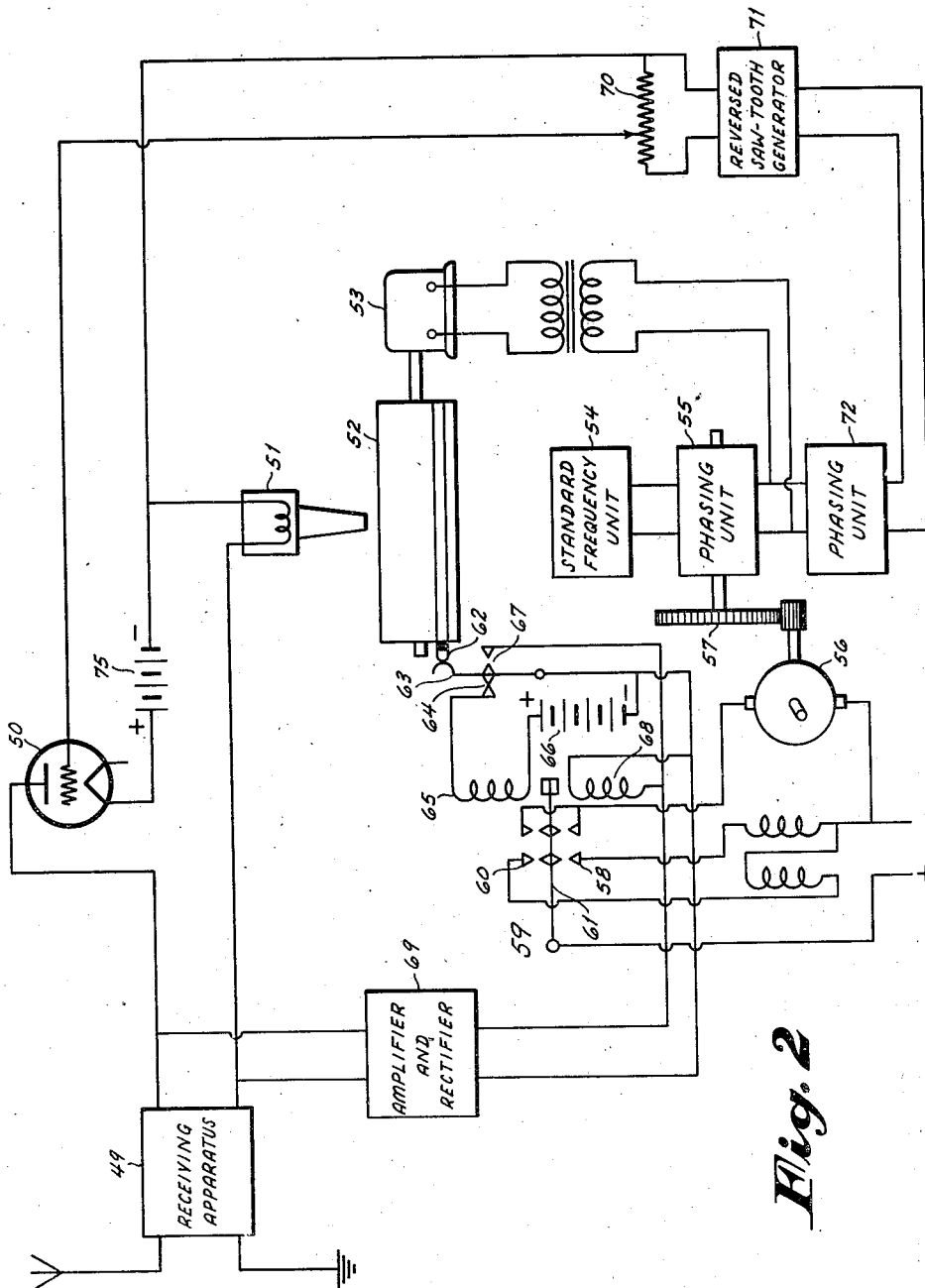


Fig. 2

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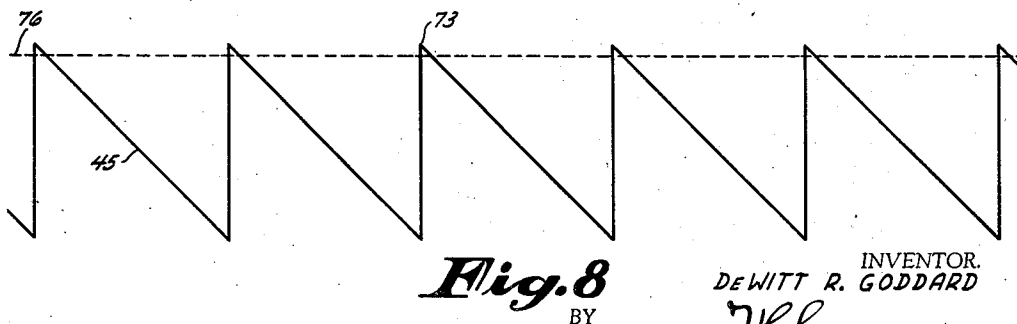
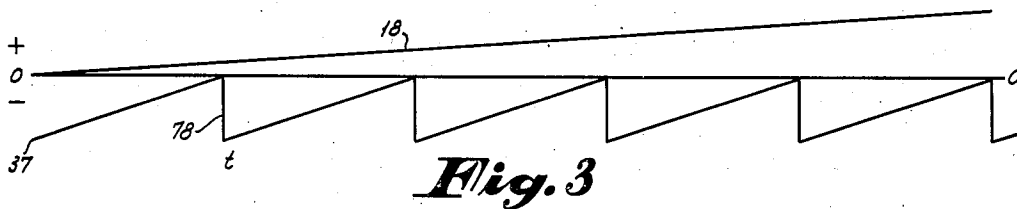
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## UNITED STATES PATENT OFFICE

2,274,829

ELIMINATION OF SPURIOUS ADDITIONS TO  
RADIO SIGNALS

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3 Claims. (Cl. 178—6.7)

This invention relates to facsimile and radio picture transmission and particularly to such transmission using the well-known constant frequency variable dot signals such as disclosed in the patent of Shore and Whitaker 2,083,245, June 8, 1937.

The constant frequency variable dot signaling system has various advantages, but it has one handicap due to multipath propagation in the upper atmosphere. It is well known that in radio transmission, signals take various paths between the transmitter and the receiver, some being refracted or reflected from higher ionized regions of the upper atmosphere than others, consequently the signal first to arrive over the shortest path will have spurious additions made to it by signals arriving over the longer paths.

The spurious additions to the signals make it necessary to reduce to speed of transmission so that this character elongation may be reduced to a small percentage of the signal character itself. In my invention I reduce the character distortion and practically eliminate it, so that the speed of transmission of pictures and facsimile is greatly increased.

One object of the invention is to increase the speed of picture and facsimile transmission by eliminating spurious additions to the signals due to multipath and other causes.

Another object of the invention is to cause all signal characters at the transmitter to end at the same phase relation, so that at the receiver a counter-effect may be produced to block out spurious additions to the end of the signals due to multipath effects.

Another object of the invention is to utilize at the transmitter a saw-tooth screen frequency that causes the variable dots or signals to end in the same phase relation with each other.

Another object of the invention is to use at the receiver a saw-tooth generator voltage reversed in respect to the saw-tooth voltage at the transmitter, so that a counter-voltage may be produced to eliminate spurious additions.

Other objects of the invention will appear in the following description, reference being had to the drawings in which:

Fig. 1 is an illustration of the transmitting system, well-understood units being indicated in block diagram.

Fig. 2 is an illustration of the receiving arrangement, well-understood parts also being shown in block diagram.

Fig. 3 is a graph of the saw-tooth transmitter voltage and a graph of the scanner output.

Fig. 4 is a graph of the combined output of the scanner and the saw-tooth generator.

Fig. 5 is a graph of the output of the square wave amplifier of Fig. 1.

Fig. 6 is a graph of the radio signals transmitted by the apparatus in Fig. 1.

Fig. 7 is a graph of the radio signals received at the receiving station with spurious additions.

Fig. 8 is a graph of the reversed saw-tooth generator voltage at the receiver.

Referring to Fig. 1, the scanning apparatus generally indicated at 1 consists of a drum 2 rotated by a synchronous motor 3 fed from a standard frequency unit 4. There are a number of standard frequency units well known in the art, one being a tuning fork unit such as described on pages 76 to 79 of an article by Callahan, Whitaker and Shore, in a book entitled "Radio Facsimile," volume 1, and published by RCA Institutes Technical Press, New York, N. Y. Such a standard frequency unit is capable of maintaining a constant frequency having a maximum variation of only one part in a hundred thousand or better.

The scanning drum 2 has the usual clamp 5 for holding the white paper on which the subject photograph, picture or design is recorded and which is to be transmitted. The illuminating unit 6 projects light on to the part of the drum being scanned at any given instant and the optical pick-up for the scanner is indicated at 7. This contains a photoelectric cell 8 for converting variations in light into variations in electrical potential. The variations of potential are produced in resistor 9 by a battery 10 having a potentiometer 11 to which one electrode of the photo-cell, say the anode, is adjustably connected. In this case the cathode is connected to the upper end of the resistance 9, as shown in the drawings, and the positive terminal of the potentiometer is connected to the lower end of that resistance. Amplifier tube 12 has its grid connected to the negative end of resistance 9 and its cathode is connected to the other end of the resistance through a negative bias source 13. The plate or anode of the tube 12 is connected to the positive terminal of a source of supply through the primary of the transformer 14, the negative terminal of this source of supply being connected to ground and to the cathode.

With the arrangement described, total black portions of the picture being scanned will produce maximum anode current in the output of vacuum tube 12 and pure white portions of the picture will produce minimum current or no

current at all. This is the customary way of connecting the scanner, but of course this may be reversed and maximum anode current produced by the white portions of the picture by reversing the input connection of amplifier tube 12 so that it works up from cut-off instead of down to cut-off, as shown in Fig. 1. The output of transformer 14 is fed into a sufficient number of amplifying stages 15 to produce the desired amplification of the output of the picture scanner. These amplifying stages are well known in the art and are indicated by blocks diagram only.

The output of the amplifying stages 15 is rectified at 16, preferably by Fleming tube rectifiers, but this has been indicated generally, as the particular form of rectification per se forms no part of my invention. The output voltage of the rectifier 16 in resistance 17 for a brief instant may be indicated by the graph 18 in Fig. 3. This is to be combined with the output of the saw-tooth generator generally indicated at 19 in Fig. 1.

The saw-tooth generator 19 is well known in the art and various circuits and tubes are used for producing saw-tooth voltages such as in sweep circuits of television apparatus and the diagram illustrated in Fig. 1 is by way of example only.

The saw-tooth generator 19 consists of a gas triode 20 having its plate or anode connected to the positive terminal of a source of supply through a suitable resistance 21. Resistances 22, 23 and 24 are connected across from the negative terminal of resistance 21 to ground, which, as usual, is the negative terminal of the source of supply. The grid 25 of the gas tube is connected through resistance 26 to the point 27 at the lower end of resistance 26. The cathode 28 of the gas tube is connected to ground through a pentode 29 and an adjustable resistance 30. The anode of the pentode 29 is directly connected to the cathode 28 and its cathode is connected to the upper end of resistance 30, as shown in Fig. 1. One grid 31 of the pentode is also connected to this end of the resistance. A second grid 32 is connected directly to ground and a third grid 33 is connected to the point 27.

A condenser 34 is connected between the anode and cathode of the gas tube 20 and the charging and discharging of this condenser in connection with the gas tube is what produces the saw-tooth voltage. The pentode 29 in this hook-up has no function other than to keep the charging current of the condenser 34 substantially constant and a suitable inductance or other equivalent may be substituted for it, but the pentode is preferred.

The output or load resistor 35 of the saw-tooth generator is tapped across the anode and cathode of the pentode through the adjustable resistance 30 and a blocking condenser 36, the latter being used to prevent passage of direct current to the load resistor. The saw-tooth voltage produced at the terminals of condenser 34, as will later be described, takes the form shown by graph 37 in Fig. 3 and since this is the form of saw-tooth wave that is desired for combination with the scanner output, the terminals of the condenser could be connected to resistance 17 if desired, but in that case it would be advisable to place the pentode between the positive terminal of the source of supply and the gas triode, as shown in the sweep circuit of the "Tube Handbook" of RCA Manufacturing Company given for gas triode No. 885. However, the reversal of this voltage in the illustration given in Fig. 1 is read-

ily produced by the direct current amplifying stage 38.

It will be seen that the saw-tooth voltage in load resistor 35 is the inverse of that shown by graph 37, because the drop in resistance 35 is the plate voltage minus the voltage at the terminals of condenser 34. It is well known that the anode current in an amplifying stage such as indicated at 38 is in phase with its input voltage; therefore the anode current in this stage also is the inverse of graph 37. The output voltage of this stage 38 between terminal 40 and ground terminal 41 is the supply voltage minus the drop in resistance 42 and therefore this output voltage is the inverse of the input voltage, that is, the output voltage is shown by graph 37.

Resistance 42 is adjustable and an adjustable resistance 43 is also shown in the cathode lead. This adjustability taken with terminals 44 permits one to make proper connections and adjustments to produce a saw-tooth voltage that is the inverse of graph 37 for the saw-tooth generator at the receiver. The graph of receiver saw-tooth voltage is shown at 45 of Fig. 8, though of course this reversed saw-tooth voltage could be obtained by connecting directly to the load resistance 35 and in various other ways.

As the circuit is connected in Fig. 1, the saw-tooth voltage and the amplified output of the scanner are combined in the input circuit of tube 46, having negative bias 46'. The output of this tube 46 is fed into a square wave amplifier 47 and this is fed into the transmitting apparatus 48 and the scanner is radiated for transmission to the receiver. Square wave amplifiers, modulators and other apparatus for transmission of signals are well known in the art and the particular form used is immaterial as far as my improvement is concerned. This apparatus has therefore been indicated in block diagram only to prevent needless complication of this disclosure.

At the receiver any suitable receiving apparatus 49 may be used, consisting of radio frequency amplifiers, heterodyne oscillators, detectors and audio amplifiers, as well as tone frequency generators and rectifiers. These are all well known in the art and per se form no part of my invention; therefore to simplify the disclosure these have been indicated only generally by the block diagram 49. The operation of the entire system will be later described, but in brief it may be said that the signal output of the apparatus 49 takes the form of the graph in Fig. 7. This signal is passed through a chopping tube 50 for elimination of the spurious "tails" or additions and then passes into the illuminating or other element 51 for producing a record on the drum 52 rotated in synchronism with the drum 2 at the transmitter by a synchronous motor 53 fed from a standard frequency unit 54 through a suitable automatic phasing unit 55. This standard frequency unit is the same as the standard frequency unit 4 and will remain in synchronism with it to one part in about a hundred thousand. However, slight corrections of the speed of the drum 52 are produced by the phasing unit 55 consisting of well-known capacity and inductance elements controlled by a reversible shunt motor 56 through a reduction gear chain 57. The reversible motor 56 has one terminal connected to the source of supply, say the negative, and one field connected to contact 58 of a single pole double throw switch generally indicated at 59. The other and opposing field of motor 56 is connected to contact 60. The positive terminal of

the supply source in this case is then connected to the movable switch member 61. The armature is connected to the negative terminal and to the switch contacts 61' so that this terminal of the armature is always connected by the switch to the positive terminal.

Recorder drum 52 has a lug 62 engaging a switch blade 63 once each revolution. When the switch blade is operated by the lug, contacts 64 are closed and magnet 65 is energized by current from source of supply 66. When the projection 62 disengages the switch lever 63, this lever springs back into normal position, opens contact 64 and closes contacts 67, which short-circuits the magnet 68. Magnet 68 is energized by the signal pulses from the receiver 49 after appropriate amplification and rectification at 69.

The input circuit of tube 50 is connected to potentiometer 70 in the output of the reversed saw-tooth generator 71. As already stated, this generator may be the same as that indicated at 19 and 38 in Fig. 1, except that the connections to the 38 amplifier are so made that the voltage is the inverse of that shown in Fig. 3; that is, it is like graph 45 in Fig. 8.

The saw-tooth generator 71 in Fig. 2 is synchronized with the local standard frequency unit 54 by connection thereto through phasing unit 55. The connections from the saw-tooth generator 71 are passed through an additional phasing unit 72 so that hand adjustments may be made to alter the phase of the saw-tooth voltage and thus place it in the right time-relation to place the peaks 73 (Fig. 8) in opposed phase with the peaks of the saw-tooth generator in Fig. 3. The bias 75 in chopper tube 50 of Fig. 2 is so proportioned that the tube conducts current, being above the cut-off point, except when the peaks 73 of the saw-tooth voltage above a value indicated by the dotted line 76 send the input voltage below the cut-off point and thus block the tube.

The operation of the system is as follows:

The scanner sends out signal pulses varying from zero for pure white to maximum for black, though as previously said, the opposite could be the case, if desired, by reversing the connection to resistance 9 or otherwise. The output is appropriately amplified, preferably at audio frequency, at 15 as distinguished from direct current amplification. The audio output of the amplifier 15 is then rectified at 16, which produces a potential in resistance 17 that for a brief instant may be depicted as an amplitude variation such as graph 18 in Fig. 3. This indicates, with the assumption made, that the scanner is moving from lighter to darker elements in the subject being scanned.

To convert this amplitude variation into constant frequency variable dot signals, the voltage in resistance 17 is combined with the saw-tooth voltage at the output of amplifier 38. While the operation of a saw-tooth generator is well known in the art, it will be advantageous to digress to briefly disclose how the saw-tooth voltage is produced.

The voltage applied to condenser 34 charges it in accordance with the well-known voltage-time characteristic, which may be indicated by substantially a straight line such as the slanting portion 77 of graph 37 until the voltage at the time  $t$  is sufficient to cause the gas triode 20 to strike with the bias produced across resistance 24 plus the voltage at that instant introduced into resistance 23 by the standard frequency, which may be 810 cycles per second, for example. Thus

the standard frequency unit, causes the condenser always to strike in a definite phase relation to the standard frequency. The frequency of charge and discharge of the condenser may be the same as that of the standard frequency unit or it may be any multiple thereof, depending upon the time constants of the charging circuit.

The condenser discharges practically instantaneously through the gas triode, which produces the substantially vertical portion 78 of graph 37 of Fig. 3.

As already noted, the charging current of condenser 34 passes through pentode 29. The pentode circuits are adjusted to hold this charging current substantially constant, which is a well-known action. As the condenser builds up in voltage the output voltage of the pentode in resistance 35 therefore varies inversely as the voltage of the condenser. That is, the voltage will take the form of the saw-tooth graph of Fig. 8, though this graph is not intended to show the relative values of the voltage.

The amplifier 38 as connected with the adjustment indicated in full lines, will reverse this voltage between the terminal 40 and ground, as previously explained, so that a voltage of the form of graph 37 is combined with the scanner output as at 18 (Fig. 3) in the input of mixing amplifier tube 46. The negative bias 46' of the grid of tube 46 is adjusted to block the tube with zero scanner output. Hence the saw-tooth voltage can pass only as the scanner output rises above zero. The output current in tube 46 therefore takes the form shown in graph 80 of Fig. 4. The output of tube 46 is passed through the square wave amplifier, which may be adjusted to have no increase of output above a voltage limit indicated by the dotted line 81. This output will take the general form of graph 82 in Fig. 5.

An inspection of Fig. 5 shows that the amplitude variation of the scanner has been converted to constant frequency variable dot length variation. This frequency is the same as that of saw-tooth generator 19 which is the same as, or is any desired multiple of, the standard frequency of unit 4.

The output of the square wave amplifier may be further amplified either with or without tone frequency conversion and used to modulate an appropriate radio oscillator. All of this apparatus is well known and is generally indicated at 48. The radiation from the antenna will take the form indicated in the graph of Fig. 6.

The signals received and converted by the receiving apparatus 49 of Fig. 2 will usually not have the form of graph 82 of Fig. 5, due to multipath effects. As already stated, they will have "tails" or additions, as indicated at 84 in Fig. 7. The apparatus, the operation of which has thus far been described, is known in the art and is not part of my invention except insofar as it may be a necessary part of the combination claimed.

The signals of Fig. 7 have to pass through chopper tube 50 before reaching the recording light or equivalent unit 5, and the passage is controlled by the variable bias applied to the grid of tube 50 by the potentiometer 70. The adjustment of the circuit is such that the "tail" part of the signal is blocked out by the saw-tooth tip voltages in the potentiometer.

The saw-tooth generator 72 is like that of generator 19 but the voltage curve is the inverse of Fig. 3 or like that in Fig. 8. One way this reversal can be accomplished has already been described. The saw-tooth generator is adjusted to

have a definite phase relation in respect to the standard frequency unit 54, which is in synchronism with the standard unit 4 at the transmitter with a variation of not more than one part in a hundred thousand. The adjustment also is such that the frequency of the saw-tooth generator 71 is the same as that of the saw-tooth generator 19 at the transmitter within the same limit of accuracy. The departure of frequency between the two frequency standards will be so slight that it will amount merely to a slight phase shift which is corrected by the phasing unit 55 and this is adjusted automatically by the motor 56.

If drum 52 is in synchronism with drum 2 at the transmitter, then magnet 65 is energized and maximum current from the transmitter also energizes magnet 68 because the impulses sent out by the gripper 5 are caused by its dark surface. The magnetic pull is thus balanced and switch bar 61 is not operated. If drum 52 at the receiver creeps ahead of synchronism, switch 63 will close contacts 64 while the scanner at the transmitter is receiving light from the pure white edge of the paper just ahead of the gripper 5. No signal will therefore be transmitted and magnet 68 will not be energized. Magnet 65 will then close contacts 60 and the energized field will rotate motor 56 in the direction that retards the phase by operation of phase unit 55 and thus retard motor 53 driving drum 52. This brings the drum 52 into synchronism. If the drum 52 drops behind the transmitter drum 2, the signals sent out by the dark surface of gripper 5 will energize magnet 68 before the switch 63 is operated by lug 62. This will close contacts 58 and energize the other field of motor 56 and the phase unit 55 will be rotated in the opposite direction to advance the phase of the driving voltage of motor 53. This will speed it up and bring drum 52 back into synchronism.

Since saw-tooth generator 71 takes the corrected phase produced by the phase unit 55, it will have its phase correctly adjusted. However, its phase will be initially adjusted by the hand-operated unit 72, so that it will be 180° out of phase with the saw-tooth voltage of the transmitter.

It will thus be seen that the peaks 73 are always in position to block the passage of the "tails" added to the signal by the multipath effects. The signals received by the lamp or other unit 51 of the receiver have the form of those transmitted at the receiver as shown by graph 82 of Fig. 5.

It will be clear that other blocking means may be provided in the place of tube 50, such tube being given merely as one example. Other means of correcting the phase relation between the receiver and transmitter may also be used. My

invention is therefore not to be limited to the embodiment disclosed.

Having described my invention, what I claim is:

1. In radio signaling, means for producing signal character voltages, each ending at the same phase of a predetermined frequency, means for producing a radio frequency wave, means for modulating said wave by said signal voltages, means for transmitting the modulated wave over a radio link, means at the receiving end of said link for receiving the modulated wave and extracting the signal character voltages, means for producing at said receiving end an alternating voltage of said frequency having maximum value at said phase, a mixing circuit and means for introducing the signal character voltages and said alternating voltage into the mixing circuit to block out spurious additions to the signal voltages after said phase.

2. In radio systems, a scanner for producing an output voltage with varying amplitude, a generator having a saw-tooth voltage wave form with one side substantially perpendicular to the wave axis, means for combining the voltage of the scanner and that of said generator to produce constant-frequency variable dot-length signals ending at the same phase in the cycle, means for transmitting said signals, means for receiving and detecting said signals, a second generator having a saw-tooth voltage wave form with one side substantially perpendicular to the wave axis at said phase, and means for combining the voltage of the detected signals with the peaks of the voltage wave of the second generator to block out spurious additions to the signals after said phase.

3. In radio signaling, means for producing signal character voltages, each ending at the same phase of a predetermined frequency, means for transmitting the signal characters over a radio link, means for receiving and detecting the signal character voltages at the receiving end of said link, means for producing an alternating voltage of said frequency having maximum value at said phase, a mixing circuit, means for introducing the signal character voltages and said alternating voltage into the mixing circuit to block out spurious additions to the signal voltages after said phase, means for transmitting said signals, means for receiving and detecting the signals, a second generator having a saw-tooth voltage wave of the same form as that at the transmitter but 180° out of phase therewith, and means to combine the detected signal voltages with the voltage of the last-mentioned generator for blocking out spurious additions to the signal characters after said phase.

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