Sept. 3, 1946. E. M. DELORAINE ET AL 2,406,811

FACSIMILE SYSTEM

Filed Dec. 15, 1942 6 Sheets-Sheet 1

Fig. 1.

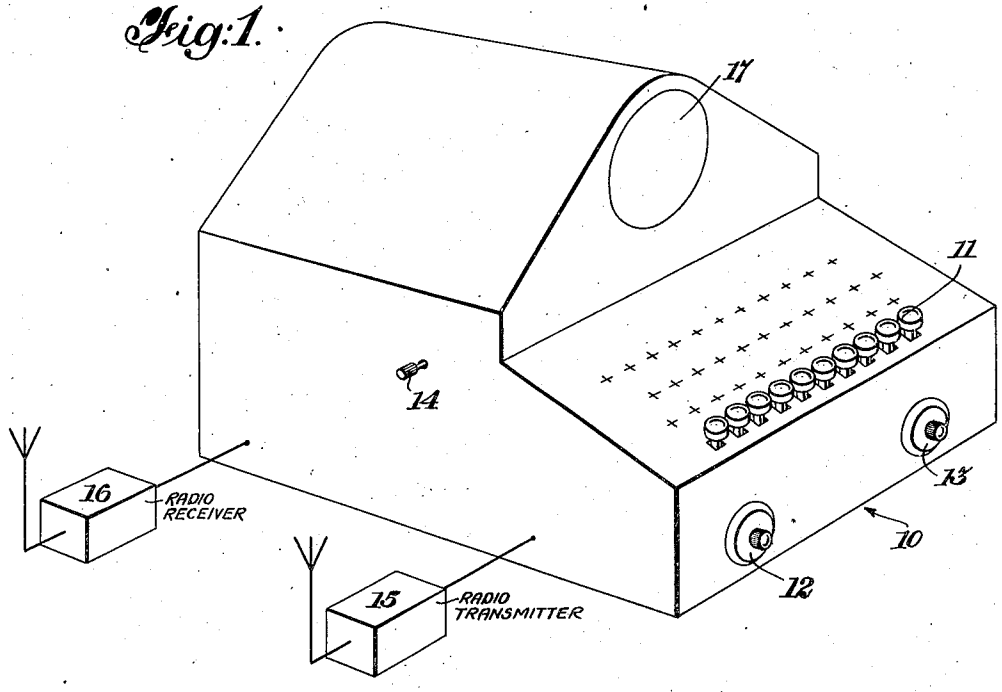
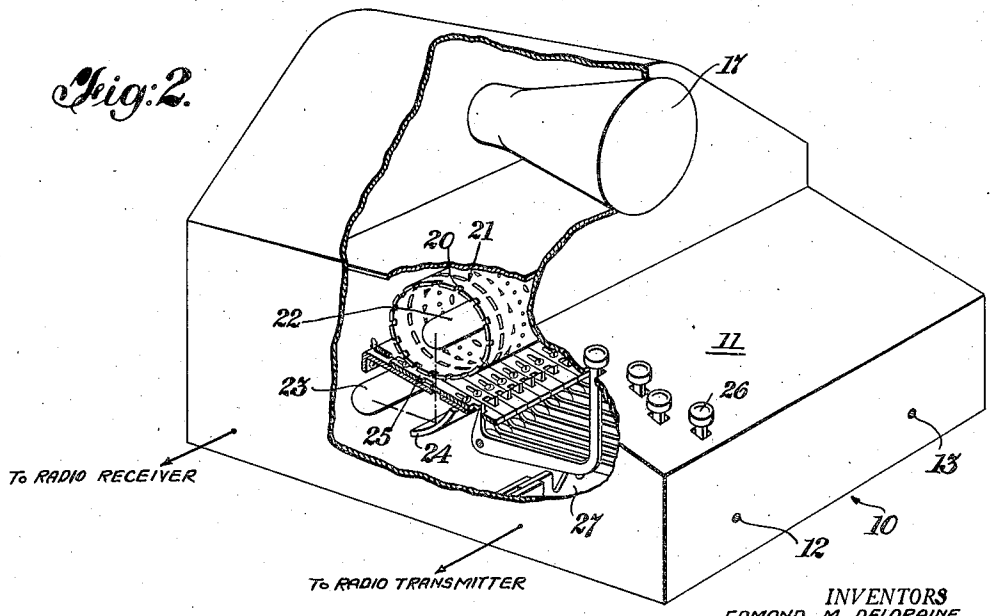


Fig. 2.



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Filed Dec. 15, 1942 6 Sheets-Sheet 2

Fig: 3.

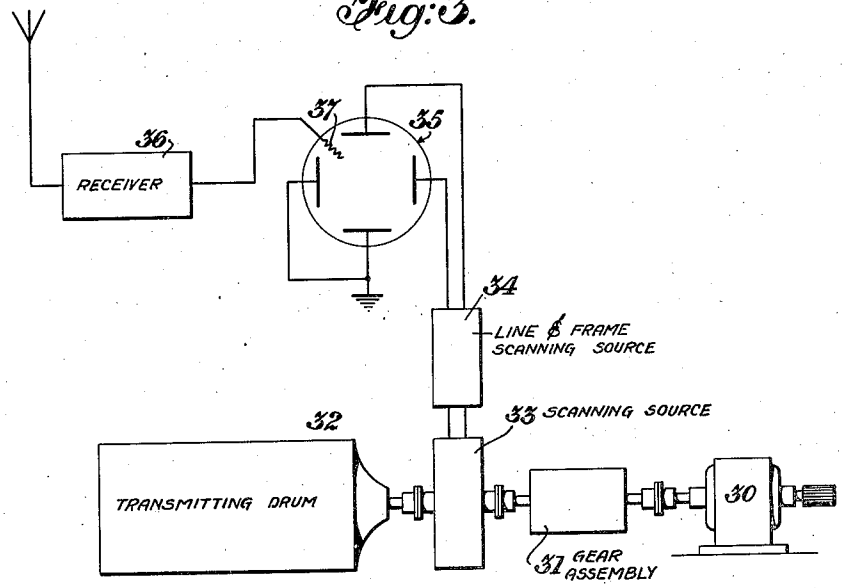
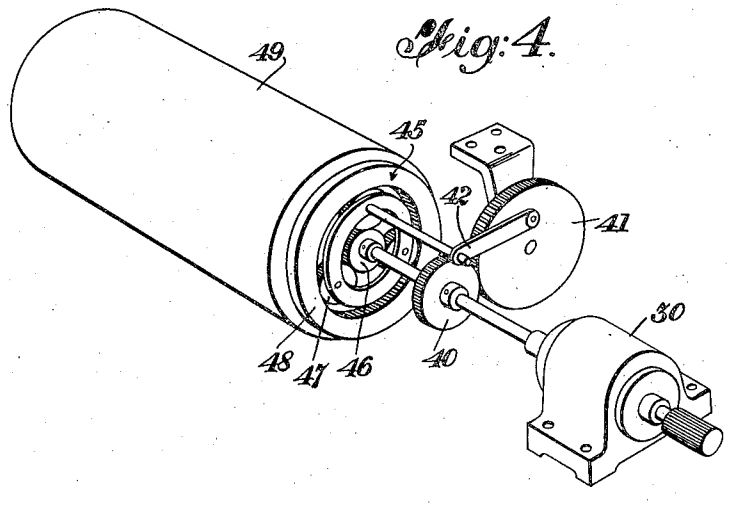


Fig: 4.



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Filed Dec. 15, 1942 6 Sheets-Sheet 3

Fig. 5.

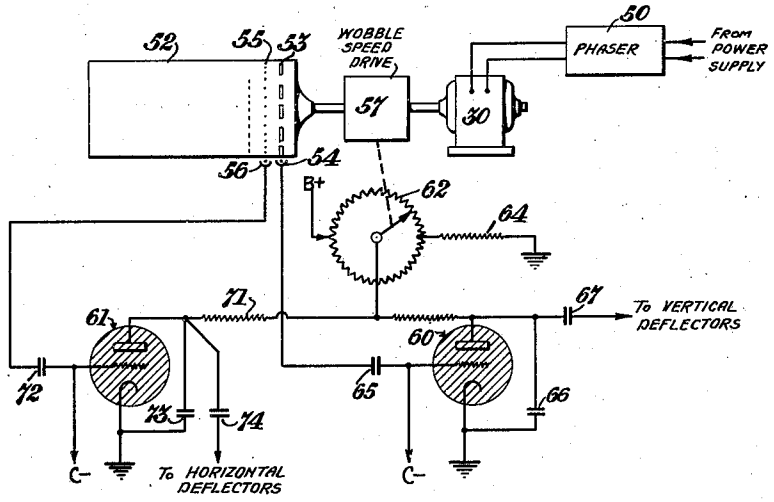
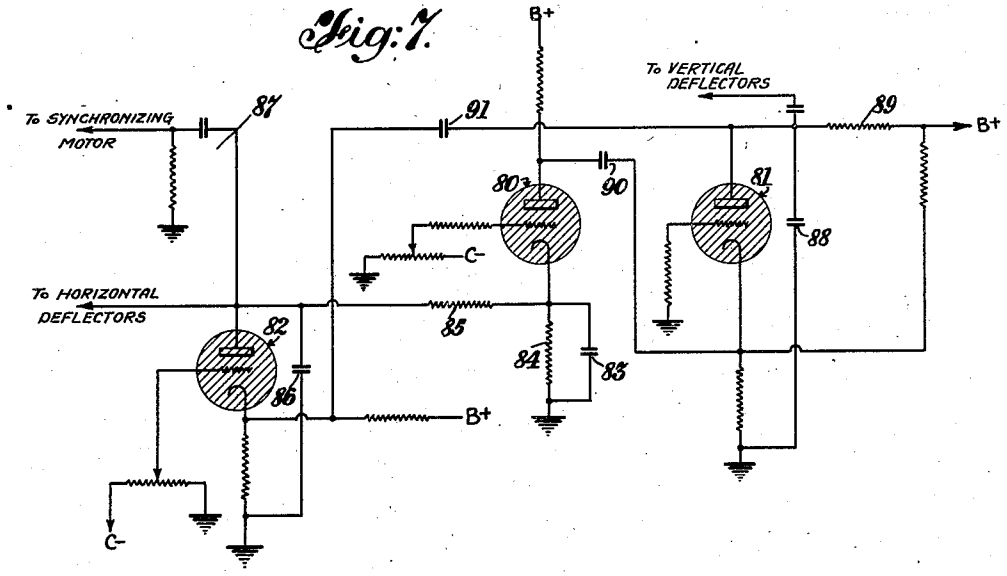


Fig. 7.



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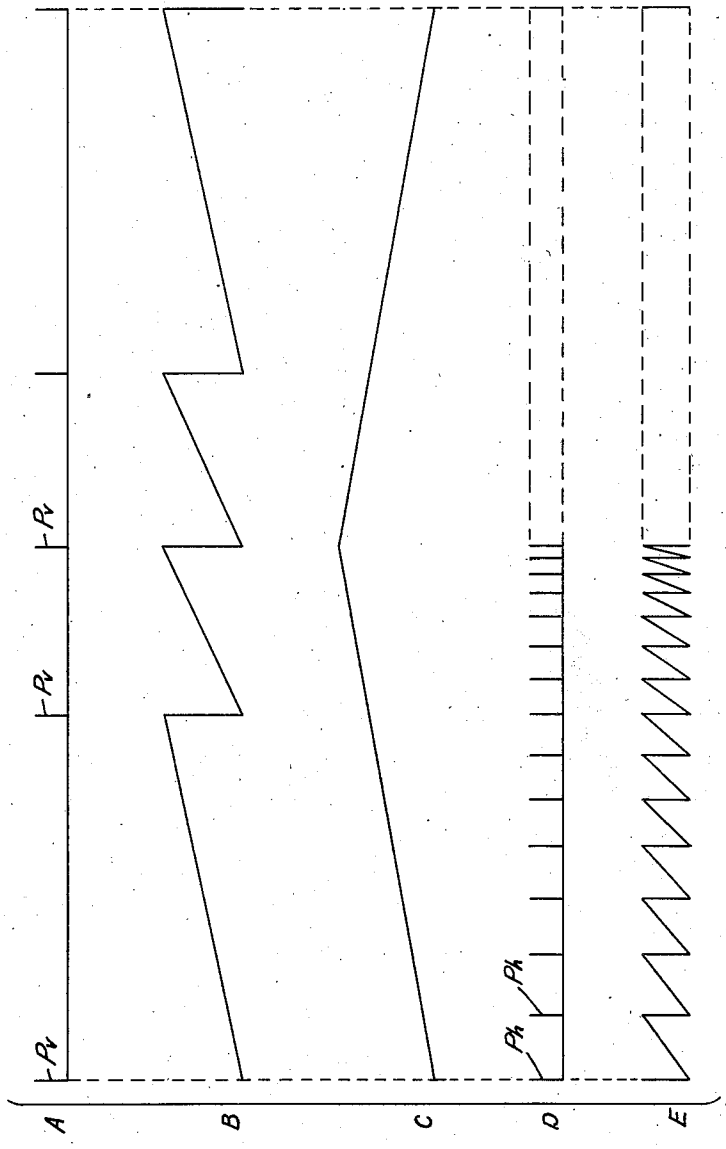
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Sept. 3, 1946. E. M. DELORAINE ET AL 2,406,811

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Filed Dec. 15, 1942 6 Sheets-Sheet 4

Fig:6.



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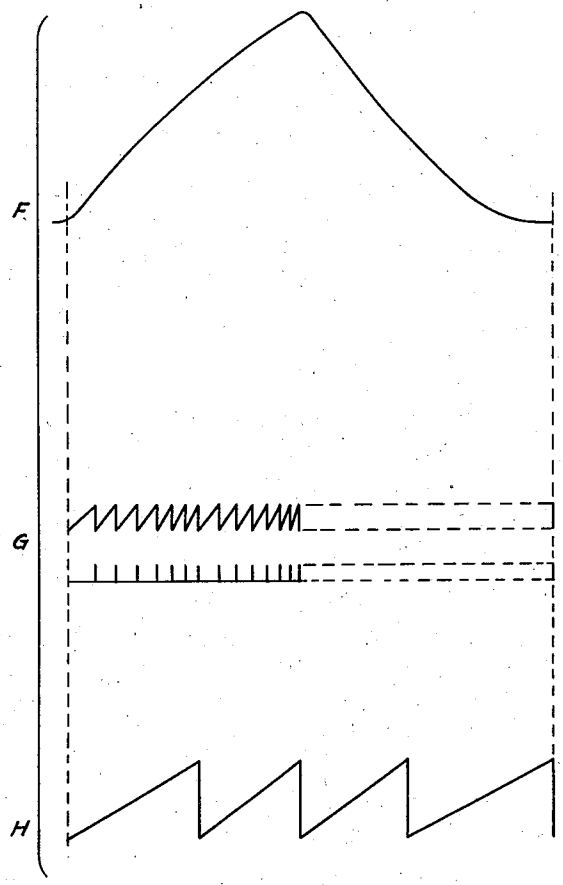
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Sept. 3, 1946. E. M. DELORAINE ET AL 2,406,811

FACSIMILE SYSTEM

Filed Dec. 15, 1942 6 Sheets-Sheet 5

Fig. 8.



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FACSIMILE SYSTEM

Filed Dec. 15, 1942 6 Sheets-Sheet 6

Fig: 9.

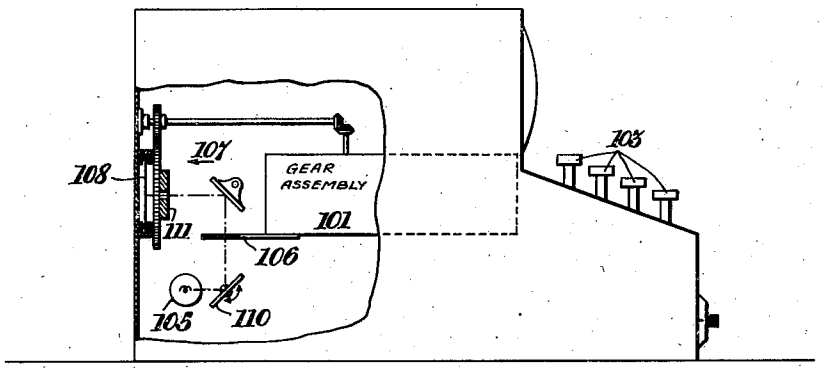
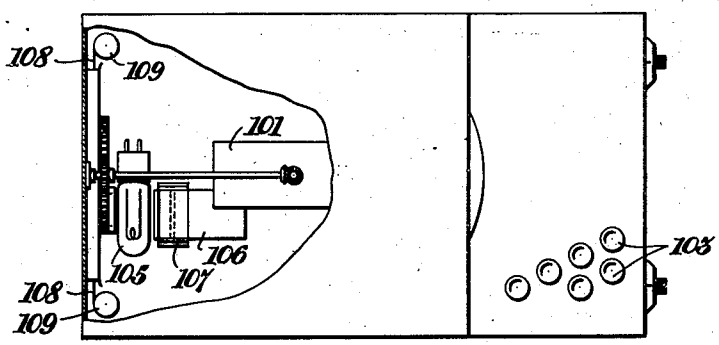


Fig: 10.



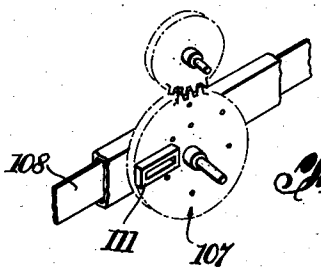


Fig: 10a

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UNITED STATES PATENT OFFICE

2,406,811

FACSIMILE SYSTEM

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Application December 15, 1942, Serial No. 469,056

8 Claims. (Cl. 178—6.7)

1

This invention relates to communication systems and more particularly to radio communication systems of the built-up character or simulated facsimile type.

It is often necessary to provide a system in which communication can be maintained despite relatively high level interference. In the time of war, high level interference may be in the form of intentional jamming by enemy stations. At the same time it is quite necessary to maintain communication despite these attempts of the enemy to disrupt the same. As a general rule telegraph communications are easier to read through interference than the voice signals. However, the telegraph signals may be jammed by transmitter stations sending out impulses or by repeater stations serving to repeat the ordinary transmitted signals at relatively high levels.

It is a principal object of our invention to provide a communication system which will be effective even in the presence of high level interference.

It is a further object of our invention to provide built-up character systems in which the received signals are rendered effective by visual indicating or recording means.

It is a still further object of our invention to provide a system wherein the transmitted signals are successively sent a plurality of times at the transmitter and are received in a cumulative manner at the receiver to produce an effective high level indication of the wanted signals.

In accordance with our invention we provide a transmitter, preferably one sending signals a plurality of times in succession, the impulses each representing a portion of a desired character. At the receiver these signals are translated and visually reproduced on an oscillograph screen or a recording medium, the transmitted characters being impressed one on top of another at the receiver to provide a cumulative effect. Since the interference signals are not transmitted to provide such a cumulative effect, the interference will form only a bright background but will not prevent the signals being read through this background screen.

A better understanding of our invention and the objects and features thereof may be had from the particular description of a few embodiments thereof made with reference to the accompanying drawings, in which:

Fig. 1 is a diagrammatic view illustrating a possible form of transmitter-receiver equipment;

Fig. 2 is a schematic showing of the transmitting apparatus of Fig. 1 with the cover removed;

2

Fig. 3 is a schematic diagram of the transmitter-receiver apparatus explaining operation thereof;

Fig. 4 is a diagram of a possible drive mechanism for providing variable speed drive for the transmitting equipment;

Fig. 5 is a schematic circuit diagram illustrating a scanning mechanism for reproducing the wobbled frequency signals;

Fig. 6 is a set of curves explaining the operation of the circuit of Fig. 5;

Fig. 7 is a further circuit diagram showing a modified form of transmitter and receiver driving control;

Fig. 8 is a set of curves illustrating the operation of the circuit of Fig. 7;

Figs. 9 and 10 are schematic sectional, elevation and plan views, respectively, of a modified form of transmitter-receiver equipment in accordance with our invention; and

Fig. 10*a* is a detail of mechanism shown in Fig. 10.

Turning first to Figs. 1 and 2, 10 represents a casing covering a form of transmitter-receiver apparatus which may be used in accordance with our invention. This housing 10 includes a transmitter portion comprising keyboard 11, control knobs 12 and 13, the purpose of which will be stated later, and a knurled knob 14 which may be used for starting the drive motor for the transmitter equipment when a synchronous motor is used. The transmitter preferably is in the form generally similar to that disclosed in the copending application of E. M. Deloraine, Serial No. 415,554, filed October 18, 1941, but somewhat simplified in form so that it may be made in a simple, portable transmitter-receiver equipment. This arrangement comprises a drum 20, Fig. 2, rotated by some means not shown. On drum 20 are arranged perforations 21 which each represent a series of signal elements forming a particular character to be transmitted. Within drum 20 is provided a photo cell 22 and externally of the drum is provided a light source 23 and reflecting mirror 24 serving to draw the light from 23 generally toward photo cell device 22. The light, however, is prevented from impinging on cell 22 by reason of shutters 25 controlled by selectively operated keys 26. Preferably, drum 20 is maintained continuously in rotation at a speed several times higher than the normal operating cadence of the keys 26. Thus, upon depression of any selected key 26 the drum will rotate a plurality of times sending in succession repeated series of

impulses representing the character to be received.

In order that only one key may be depressed at one time, we provide any known form of blocking mechanism 27 which may prevent depression of any other key while one is in the depressed position. This mechanism may, for example, comprise a row of balls of such dimension that depression of one key pushes the balls together so that no other key can be depressed until the first depressed key has been released and returned to its normal position. Alternatively, known forms of notched bar commonly used in printing telegraph equipment may be provided as a keyboard blocking mechanism.

The photo cell 22 may be connected to a radio transmitter 15, Fig. 1, from which the impulse trains defining the characters are transmitted for radiation. Likewise, the equipment may be provided with a radio receiver 16 coupling to receiver equipment in casing 10 designated in Fig. 2 by the rectangular block 28. A visual reproducing arrangement such as a cathode ray screen 17, Fig. 1, may be provided for reproducing the received pulses from a distant station.

Turning to Fig. 3, a better understanding of the transmitter and receiver equipment may be had. In this figure is shown a motor 30, which may be a synchronous motor or any other suitable type, coupled through a gearing mechanism 31 to transmitting drum 32. A scanning control arrangement 33 is operated in timed relation with the transmitting drum 32. This scanning control mechanism may be of several different types to be later explained. The output from scanning control 33 operates the horizontal or line and the vertical or frame scanning source 34 from which the scanning waves are applied to cathode ray tube 35 of the receiver coupled to the output of receiver 36. The output of receiver 36 is applied to a control grid 37 to control the intensity of the cathode ray beam in accordance with the input signals.

Thus, if signals are being received at 36 from some distant station, motor 30 is operated to drive scanning control 33 at the same speed as the transmitter drum. Line and frame scanning waves are generated at 34 and applied to the deflector plates of 35. As the scanning takes place, the cathode ray beam is altered in intensity by signals impressed on grid 37. Since the scanning is approximately synchronized with the transmitted signals, the character will be reproduced repeatedly in superposed relation on the cathode ray screen. The cumulative effect of the received signals will cause the character to be produced in brightened outline against any background of interference which may appear on the screen but which is not cumulative.

The gear assembly 31 may be ordinary reduction gearing for driving the transmitter drum at a lower speed than motor 30 or may be a type of variable speed gearing producing a variation in speed of rotation of drum 32. By varying the speed of rotation of drum 32 during each rotation or over several cycles of rotation and correspondingly varying the scanning control for the associated receiver mechanism, the signals may be cumulatively applied to a screen at a variable rate of speed while interfering signals regularly repeated would not be cumulatively applied. Accordingly, by wobbling the speed of rotation of the drum through a desired cycle, interference by jamming may be greatly reduced.

The arrangement for varying the speed of the

transmitter drum may comprise, by way of example, a gear assembly such as shown in Fig. 4. In this arrangement motor 30 operates to drive gears 40 and 41 at a desired reduced speed. A differential gear mechanism is shown at 45 consisting of a central sun gear 46, a planetary gearing system 47 and an outer ring gear 48. Sun gear 46 is coupled to the shaft of gear 40 and the supporting spider for planetary gears 47 is coupled by link 42 to gear wheel 41. Ring gear 48 is coupled to the drum 49. Thus, a wobble is effected in the speed of rotation of drum 49 due to the movement of the planetary gearing 47 through the gear segments 44.

It is clear that in place of this type of gearing mechanism, any desired form of gear arrangement may be used. Furthermore, as desired, the variation in drum rotation speed may be achieved by supplying motor 30 from a variable frequency source, if the motor is a synchronous motor type, or by varying the load on motor 30 if the motor is of the type whose speed varies with loads such as an induction motor or a series repulsion motor. This variation in load may, for example, be obtained fastening to the shaft of motor 30 a known form of drag mechanism commonly called the Hammond wheel and exciting the poles of the Hammond wheel by means of a variable potential.

Transmitter drum 32 is preferably made of very light material and may constitute merely an opaque film with the signal elements photographically reproduced thereon as transparent rectangles. Since the transmitter drum is very light in weight a relatively small motor is required to drive it at the desired high speeds. Likewise, the inertia of the drum will be small so that variations in the motor speed will be transmitted to the drum without undue lag due to acceleration. Furthermore, by using transparent film different sets of character elements may be substituted having differently shaped characters so that should the enemy capture one of the transmitter equipments and begin sending signals to confuse the messages, it is merely necessary to change to a drum having differently shaped characters in order that the true message can be distinguished from the false message from the enemy station.

The scanning control mechanism for the receiver equipment may take any of several forms. In Fig. 5 is illustrated one form of system which will serve to reproduce the scanning waves necessary for reception. In this arrangement motor 30 is supplied with energy from any power supply source through a phasing mechanism 50. The wobbled speed drive mechanism is shown at 41 driving drum 52. Since the transmitter equipment will normally be disconnected at the time reception is occurring, the transmitter drum 52 may be provided with additional means for producing the scanning voltages needed for reception. At one end the drum 52 is provided with a single perforation 53 effective for producing frame synchronizing pulses through a pickup cell 54, shown externally of the drum for convenience, and a plurality of other perforations 55 effective through pickup cell 56 also shown outside the drum, for producing synchronizing pulses for the line scanning mechanism. The frame or vertical synchronizing pulses are indicated at PV, curve A, and the lines or horizontal synchronizing pulses at PH, curve D of Fig. 6. Since drum 52 is rotated at a variable speed, the pulses produced through 53 and 55 will be variably spaced in time in accordance with the speed of the drum rota-

tion. Accordingly, it is necessary to provide an arrangement whereby the saw-toothed scanning voltages may be caused to reach substantially the same amplitude in variable periods of time.

The scanning generators comprise tubes 60 and 61 serving to produce the frame or vertical scanning pulses and the line or horizontal scanning waves, respectively. These tubes are preferably of the gas discharge type known under the trademark name of "Thyratron." A positive voltage is supplied from B+ through rheostat 62 and rotating arm 63 to the plate of tube 60. Arm 63 in cooperation with rheostat 62 provides a variation in B supply potential as indicated in curve C of Fig. 6. The midpoint of rheostat 62 opposite to the B supply, is grounded through a resistor 64. The grid of tube 60 is maintained at a slightly negative bias so that normally no current traverses the tube. Positive voltage from B over rheostat 62 and arm 63 serves to charge a condenser 66. This condenser charge slowly builds up after the manner shown in curve B of Fig. 6. Pulses PV of curve A of Fig. 6 illustrates the pulses produced in cell 54 showing the variable spacing due to variation in speeds of rotation of the drum. When one of the pulses PV from cell 54 is applied to the grid of tube 60 over coupling condenser 65, tube 60 becomes conductive serving to discharge condenser 66 producing the straight portion of the saw-tooth wave as shown in curve B of Fig. 6. This pulse passes quickly and condenser 66 again begins to charge. However, arm 63 has rotated to a different position on rheostat 62 and therefore larger voltage is applied for charging condenser 66. The charge, therefore, builds up much more rapidly to a fixed level as shown in the second saw-tooth wave of curve B, at which time the tube is again discharged by the succeeding applied pulse PV. After passing the voltage maximum point of curve C, the voltage is again reduced causing the successive saw-teeth to again increase in length as shown in curve B after which the entire cycle is repeated. The saw-tooth voltage generated in tube 60 and the wave generated in unit 62, 63 is applied over a resistance 71 to the anode of tube 61 and to condenser 73. Also the pulses PH as shown in curve D produced at pick-up cell 56 are successively applied over coupling condenser 72 to the grid of tube 61. The voltage applied over 71 to condenser 73 charges this condenser and because of the increasing voltage the energization is brought to the same level in spite of the shorter periods between the applied pulses from 56. Thus, a variable saw-tooth wave for line scanning such as shown at curve E of Fig. 6 is produced. The output of tube 60 is applied over condenser 67 to the vertical deflector plates of the indicator device and the output waves from tubes 61 are applied over coupling condenser 74 to the horizontal deflectors of the indicator.

It will be readily appreciated that since motor 30 at the receiver is being driven at substantially the same speed as the motor at the transmitter, and the variable speed drive for both is made substantially identical, it will only be necessary to adjust the phase of energy supplied to this motor with respect to that at the transmitter in order that the letters may be properly reproduced on the screen. For this reason, the phaser 50 is supplied and may be adjusted at the transmitter by knob 12, Fig. 1.

It should be further noted that since the transmitted and received characters are being sent at a variable speed any interference signals received will appear to be moving relatively to these frequency scanned signals and therefore will be readily distinguished from the proper received signal.

If synchronous motors are not used, then a second control such as a motor speed control may be necessary at the receiver as well as the phase control so that motor speed driving the drum at the receiver may be coordinated properly with the transmitter drum. Such control may be effected by control knob 13 shown in Fig. 1, in any known manner. The proper speed and phase adjustment may be visually determined by adjusting the controls until the received characters are stationary on the screen.

In Fig. 7 is shown a still different circuit arrangement which may be used to provide the horizontal and vertical deflector waves and also provide for a variable frequency supply to drive the scanning motor at the desired variable speed in accordance with the line by scanning frequency. The control circuit of Fig. 7 does not depend on rotation of the transmitter drum for control of the scanning, and so the motor need not be operated during periods of reception. In this circuit there are provided three gaseous discharge tubes 80, 81 and 82. A positive voltage is applied at tube 80 and the grid of this tube is negatively biased at the desired negative potential. We may assume first that tube 80 is conductive. As the current flows through tube 80 a charge is built up on condenser 83 tending to oppose the flow of current through tube 80 to the cathode. When this potential has built up to a sufficient extent the current in tube 80 is reduced to such a low value that it is no longer sufficient to maintain ionization. The condenser 83 then discharges through resistor 84. The charge and discharge curve for the condenser 83 is indicated by the curve F of Fig. 8.

Variations in plate potential of tube 80 are applied over coupling condenser 90 to the normally positively biased cathode of tube 81. Condenser 88 is meanwhile charging over resistance 89. When the combined effect of the charge at 88 applied to the anode of tube 81, and the negative potential charge applied to the cathode becomes sufficiently high, tube 81 becomes conductive. This then discharges condenser 88 causing the anode voltage of tube 81 to drop to a value insufficient to maintain discharge. The subsequent charge of condenser 88 takes place producing the succeeding saw-tooth oscillation. This oscillation is charged in duration depending upon the voltage applied over 90, being shortened when this voltage increases, and lengthened as this voltage decreases. The resultant curve H of Fig. 8 shows a possible saw-tooth variation which may serve as the vertical scanning wave for the receiver system.

The voltage of condenser 83 is applied over a resistance condenser network 85, 86 to the anode of tube 82. As condenser 86 becomes charged, the potential therein builds up as shown by curve G, Fig. 8, until tube 82 becomes conductive, whereupon tube 82 quickly discharges reducing the plate voltage to a value insufficient to maintain discharge. The cycle is then repeated, condenser 86 in this case charging up more quickly due to the higher voltage supplied from condenser 83 so that the period of successive saw-tooth oscillations varies as potential. The time constant of circuit 85, 86 is made to be very much smaller than the time constants of circuit 83 so that a plurality of variable saw-tooth waves of

the form shown in curve G are produced serving to provide the line scanning waves for the horizontal deflections of the indicator.

At the same time these saw-tooth waves may be translated over an integrating circuit 87 serving to produce pulses for controlling the frequency of the supply for driving the synchronous motor of the system. The impulses may be applied to a known form of inverter circuit to produce sine wave energy to serve as motor supply.

A coupling condenser 91 is provided between the output of tube 81 and the positively biased cathode of tube 82. This assures the proper timing of the line scanning waves so that they will commence at the beginning of this frame scanning.

Accordingly, with this system, there is produced not only the vertical and horizontal scanning frequencies but also an additional frequency which may serve to drive the motor at a variable speed. All of these voltages are properly timed with respect to one another since they are all derived from the same common source. In order to adjust the speed of operation, the variation in the bias of tube 80 may be effected. Likewise, proper phasing of the signals may be achieved by controlling the time constants of the circuits of tube 82. Control knobs such as shown at 12 and 13 of Fig. 1 may serve this purpose.

It will be understood that other forms of reproducing mechanism than those illustrated may be provided, if desired. Instead of a cathode ray oscillograph any known form of oscillograph which will operate with sufficient rapidity may be substituted. In this case the vertical and horizontal scanning waves will be applied to the proper control elements to achieve the reproduction of signal characters in the manner required. Likewise, instead of using a luminous cathode ray screen, it is clear that the signals may be reproduced on photoelectric sensitive film. For this purpose it might be preferable to provide sensitized paper of the type commonly used in making photographic proofs since permanency of the records is not necessary and development of the film on paper is not necessary.

In Figs. 9 and 10 is illustrated an arrangement modified to provide recording of the signals on photographic paper instead of on a luminous cathode ray screen. In this arrangement the unit comprises a transmitter which may have a gear assembly 101 similar to that shown in Fig. 4. At the receiver end is provided a light source 105. The received signals serve to control a light valve which may, for example, comprise a mirror 110 controlled by the received signals serving to deflect the light to an opening 106 in response to received signals. The light passing through opening 106 is applied to a suitable scanning mechanism 107 which may be in any of the known forms such as a Nipkow disc. Alternatively rotating mirrors or a mirror oscillograph may be used. A slotted mask 111 may serve to let light through only one disc opening at a time. The light from this scanning source is applied to a paper 108 mounted on a carrier 109. This carrier is provided with known forms of stepping mechanism to advance the paper periodically. Thus, if the average character repetition is 21, the paper may be stepped forward one for every 21 repetitions.

In instances it may be desirable, however, to have the paper stepped forward a number of times during the period of repetition so that the character will be reproduced in clear in at least one of these partial periods. For this purpose the stepping mechanism may be made to step the paper forward the distance of one character at an interval corresponding to one-third of the average character interval. Thus, the paper may be stepped forward one step after each seven repetitions provided their normal numbers of repetitions is 21. Thus, regardless of the typing speed, the central one of these three reproduced images will be clear of interference although there may be some overlapping on the outer two characters.

In a particular test made of apparatus embodying the principles of our invention, it was found that legible signals were reproduced even when the interference level was 15 or 20 times as high as the normal signal level. It is, therefore, clear that the arrangement in accordance with our invention is such that readable signals may be provided despite the presence of high level interference.

While we have described particular embodiments of our invention in connection with specific examples thereof, it is to be clearly understood that many modifications and adaptations of our invention may be made within the spirit of the invention as outlined in the objects of the invention and the accompanying claims without departure therefrom.

What is claimed is:

1. A transmission system comprising transmitter means for transmitting a plurality of times in succession a series of signal elements related to a selected signal character to be transmitted, receiving means, and oscillograph means for superposing and cumulating the successive series of signal elements for reproducing in superposed relation the selected signal character, whereby the effect of interference on the received signals is minimized because the interference does not superpose in time and as a consequence does not cumulate.

2. A transmission system according to claim 1 wherein said transmitter means comprises means provided with different character designations, means for selecting any desired one of said character designations, said selecting means operating at a predetermined time cycle, means operating to transmit said selected designation, and means operating said last named means a plurality of times during said predetermined time cycle.

3. A transmission system according to claim 1 wherein said transmitter means comprises means provided with different character designations, means for selecting any desired one of said character designations, said selecting means operating at predetermined time cycle, means operating to transmit said selected designation, and means operating said last named means a plurality of times during said predetermined time cycle.

4. A transmission system comprising transmitter means for transmitting a plurality of times in succession a series of signal elements related to a selective signal character to be transmitted, said transmitter means comprising means to vary the transmission frequency of said transmitted characters at a predetermined rate, receiver means, and means at said receiver means to vary the characteristics at said receiver corresponding with said predetermined rate to cause superposing and cumulating of the successive series of signal elements to reproduce the selected character, whereby the effect of interference on the received

signals is minimized because the interference does not superpose in time and, as a consequence, does not cumulate.

5. A transmission system comprising transmitter means for transmitting a plurality of times in succession a series of signal elements related to a selected signal character to be transmitted, said transmitter comprising a rotary drum, said drum being provided with sets of perforations representing said series of signal elements for each character to be transmitted, photo-electric means and a cooperating light source cooperating with one another through said perforations, shutter means normally covering said perforations, key means for selectively operating said shutter means to uncover selected ones of said sets of perforations to permit cooperation of said light source and said photo-electric means, and drive means to rotate said drum at a predetermined speed relatively high with respect to the operation time of said keys whereby the character designations are repeated a plurality of times, and receiving means for superposing and cumulating successive series of signal elements to reproduce the selected signal character, whereby the effect of interference on the received signals is minimized because the interference is not superposed in time and, as a consequence, does not cumulate.

6. A transmission system comprising transmitter means for transmitting a plurality of times in succession a series of signal elements related to a selected signal character to be transmitted and receiving means for superposing and cumulating the successive series of signal elements to reproduce the selected signal character, whereby the effect of interference on the received signals is minimized because the interference does not superpose in time and, as a consequence, does not cumulate, said receiver means comprising a light source, means for controlling the light from said source in accordance with the

received signal and means for controlling the position of said light over a predetermined area during a time period equal to the time period of a single series of said signal elements, whereby said signal character is reproduced in said area.

7. A transmission system comprising transmitter means for transmitting a plurality of times in succession a series of signal elements related to a selected signal character to be transmitted and receiving means for superposing and cumulating the successive series of signal elements to reproduce the selected signal character, whereby the effect of interference on the received signals is minimized because the interference does not superpose in time and, as a consequence, does not cumulate, said receiver means comprising a light source, means for controlling the light from said source in accordance with the received signal and means for controlling the position of said light over a predetermined area during a time period equal to the time period of a single series of said signal elements, whereby said signal character is reproduced in said area, light sensitive recording means positioned over said area, and means for advancing said recording means to at least three different recording positions during the time corresponding to the transmission of a succession of signals representing each selected signal character.

8. A method of communication comprising repeatedly transmitting a plurality of times at predetermined variable intervals over a given range of variation a series of signal elements related in shape to a selected signal to be transmitted, receiving said transmitted signal elements, and cumulatively superposing said received signal elements to reproduce the selected signal character whereby the effect of interference is minimized.

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