Aug. 12, 1947. H. E. HALLBORG ET AL 2,425,616

FACSIMILE SYNCHRONIZING SYSTEM

Filed June 19, 1943 3 Sheets-Sheet 1

Fig. 1.

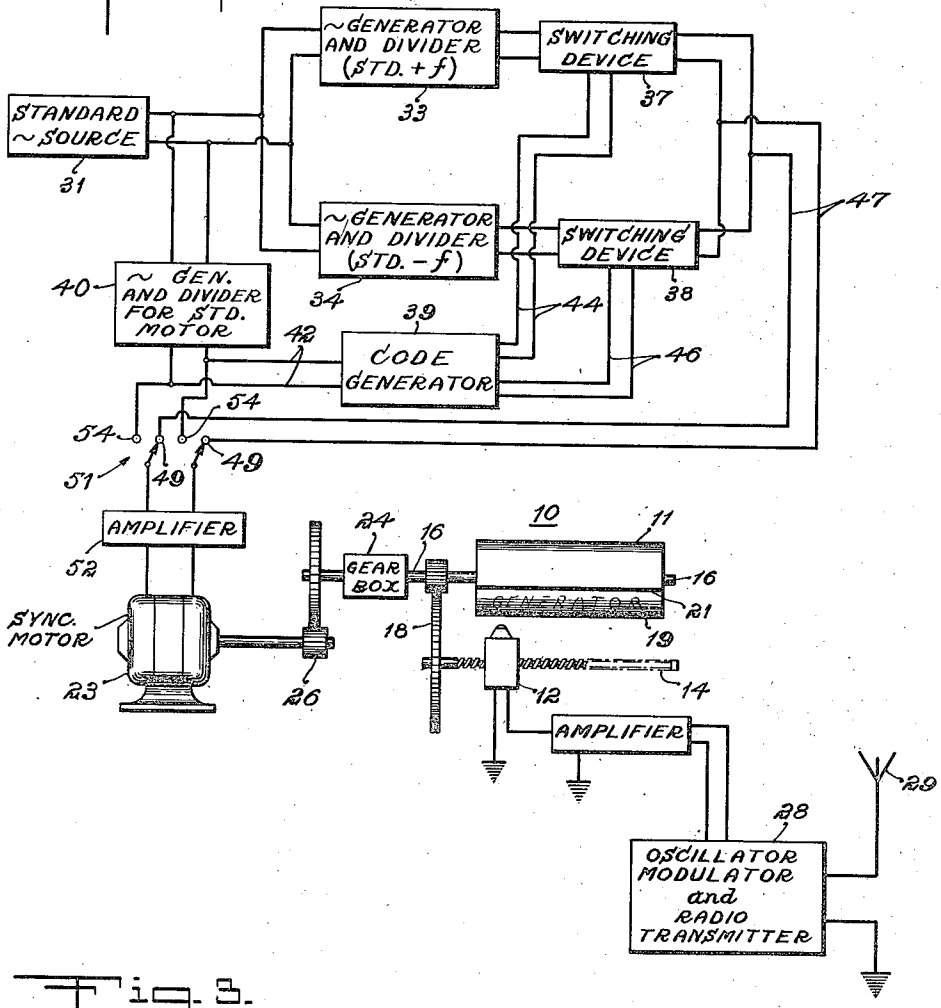
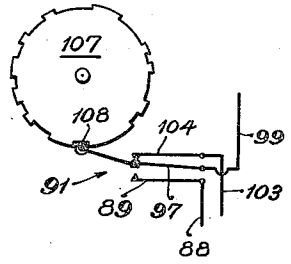


Fig. 3.



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Filed June 19, 1943 3 Sheets-Sheet 2

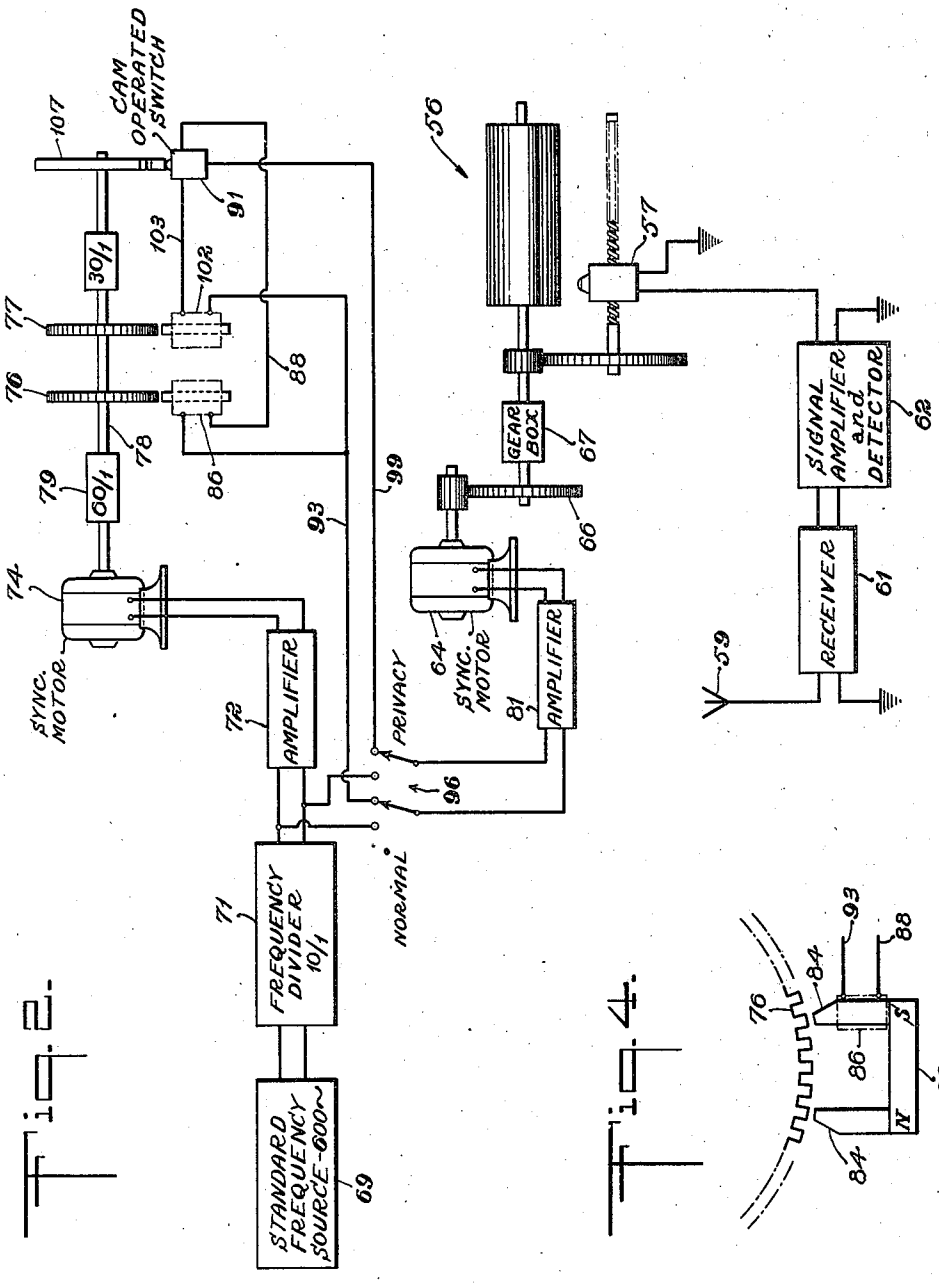


Fig. 2.

Fig. 4.

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FACSIMILE SYNCHRONIZING SYSTEM

Filed June 19, 1943 3 Sheets-Sheet 3

Fig. 5.

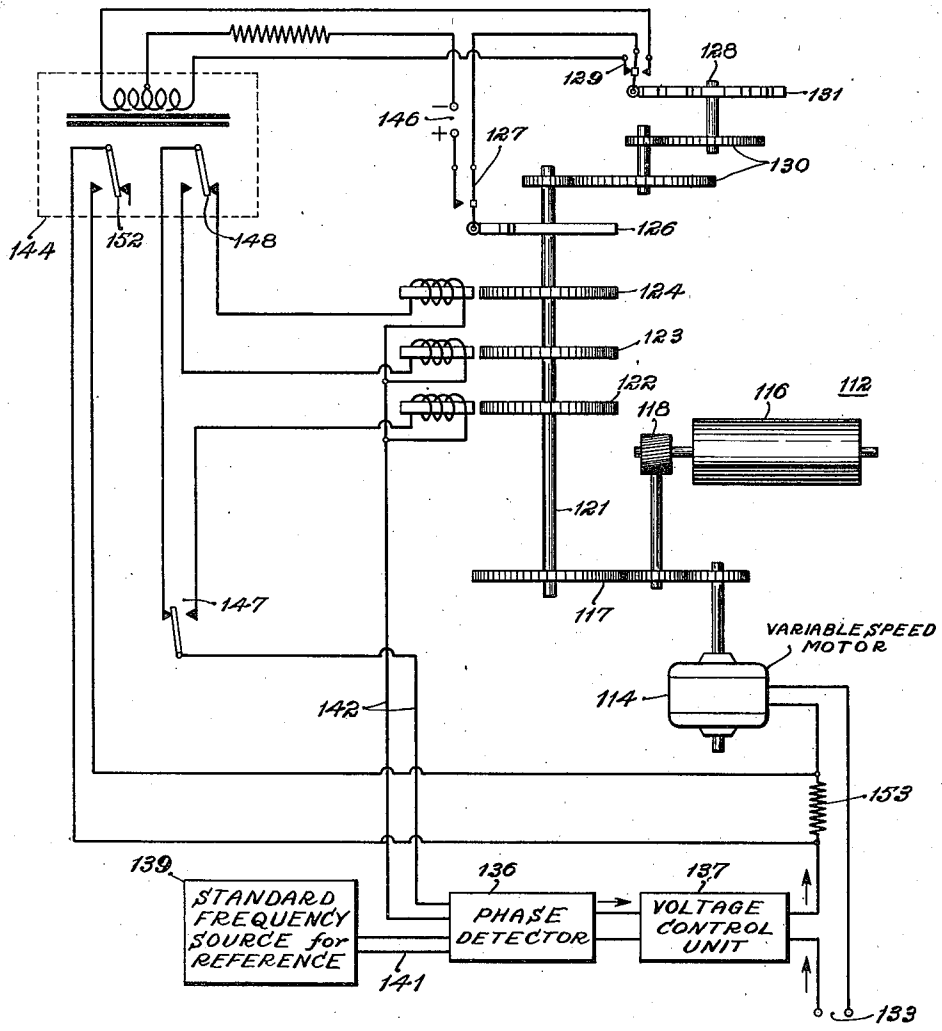
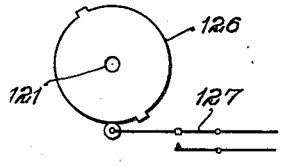


Fig. 6.



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UNITED STATES PATENT OFFICE

2,425,616

FACSIMILE SYNCHRONIZING SYSTEM

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Application June 19, 1943, Serial No. 491,537

7 Claims. (Cl. 178—69.5)

1

The present invention relates to communication systems, and more particularly to systems for sending and receiving facsimile signals in secrecy. More specifically, the present invention relates to a secret communication system wherein variable speed mechanisms are provided at the transmitting and receiving stations, which mechanisms are caused to have substantially identical speed variations.

Older privacy systems have one or more of the following limitations; they require inherent change in equipment, require a wide frequency band for transmission, intermittent transmission is necessary, power is wasted in spurious signals, critical adjustments are required, the quality of the received subject made is below normal standards. Moreover, these older systems are not suitable because of multi-path effects where transmission over a long radio circuit is necessary.

The secrecy system disclosed herein may be added to existing equipment substantially without change in the scanning and recording circuits or in the method of transmission normally employed. Secrecy systems in accordance with the invention are relatively simple in operation and give a high degree of privacy at a comparatively low cost for equipment and operation. A system embodying this invention may be operated normally after performing a simple switching operation at each circuit terminal. No power is wasted unnecessarily in spurious signals.

In brief, the operating speed of both an image or facsimile signal generator and an image or facsimile signal recorder are varied in accordance with a prearranged plan or code. This may be done conveniently by a switch or cam at both the transmitting and receiving stations for varying the rotational speed of the mechanical power source at arbitrarily selected time intervals whereby unauthorized persons not knowing and having the means for changing the speed of operation of their receiver in accordance with the transmitter speed changes cannot synchronize their receiver to reproduce anything which is intelligible.

The principal object of the present invention is to provide novel methods of and apparatus for preventing the intelligible reception of facsimile signals by anyone except authorized persons.

Another object of the present invention is to provide a facsimile recorder having means for varying the degree of departure from normal synchronous operation in a predetermined manner.

A further object of the present invention is

2

to provide a novel arrangement for obtaining changes in the speed of a facsimile machine in accordance with a predetermined code.

Other and more specific objects of the invention will become apparent and suggest themselves to those skilled in the art to which the invention is directed upon reading the following specification and claims in connection with the drawings in which:

Fig. 1 is a schematic block diagram of a facsimile transmitting station embodying the invention;

Fig. 2 is a diagrammatic showing of a receiving station in accordance with the invention;

Figs. 3 and 4 are side elevational views of details of Fig. 2;

Fig. 5 is a diagrammatic showing of a facsimile station embodying the invention in a modified form; and

Fig. 6 is a fragmentary view in side elevation of a detail of Fig. 5.

Referring to Fig. 1, there is shown a transmitting station having a facsimile scanner indicated generally by reference character 10, and comprising a copy holding drum 11 and a facsimile signal generating device, such as a scanning head 12. The scanning head 12 is advanced axially of the drum 11 by a lead screw 14 driven from the drum shaft 16 by a gear and pinion combination 18. It will be understood that the scanner 10 may be of any known type employing either the rotating copy holding drum 11, shown by way of example, or a continuous sheet or web in which the signal generating device 12 reciprocates line by line over the web. The copy holding drum 11 has a message sheet 19 secured thereon in any suitable manner, for example, by a clamping device indicated conventionally at 21. Facsimile signals representing a message or picture inscribed or otherwise provided on the message sheet 19 will be generated when the copy holding drum 11 is rotated with respect to the scanning head 12. The drum 11 and the lead screw 14 are driven from a motor 23 through a change speed device such as a gear box 24, and, if desired, through a combination 26, shown conventionally, or a worm and worm wheel combination as shown by Fig. 5 of the drawings. The gear box 24 provides a convenient means for changing (usually reducing) the speed of the motor 23 to the desired operating speed of the scanning drum 11. The motor 23 as will hereinafter appear is preferably an alternating current synchronous motor.

A conventional radio transmitter 28, comprising the conventional oscillator and modulator,

radiates signals from an antenna 23 which signals contain the intelligence derived from scanning the message sheet 19. It will be understood, however, that any communication channel such as a wire line, for example, may be substituted for the radio link 29.

The novel means of this invention for insuring secrecy and now to be described are independent of the conventional facsimile station equipment just described. A standard frequency source 31, which serves as a reference frequency for the transmitter, is of any suitable type and produces a substantially constant tone frequency of the order of 600 cycles per second, for example. It will be understood, however, that any desired tone frequency may be employed, although the frequency of 600 cycles is herein selected and assumed as the "standard" since it is a multiple of the usual power supply frequency of 60 cycles for which readily available equipment is manufactured. The output of the standard frequency source 31 is applied to two frequency dividers and frequency generators 33 and 34, which serve in the illustrative example of Fig. 1 not only to produce a sub-multiple of the output frequency of the standard source 31 but to change the frequency of the sub-multiple in a predetermined manner. For example, the device 33 may produce a frequency of 60 cycles plus another frequency f. The device 34 may produce a frequency of 60 cycles minus the same frequency f. This frequency f is selected to be within the range of stable operating frequencies of the motor 23 and may, for example, be 1 per cent of the selected submultiple of the frequency of the source 31. Practically any speed change may be utilized up to the limit of synchronous response by the motor. The output of the generator and dividers 33 and 34 will then be 61 and 59 cycles respectively. The generator and divider devices 33 and 34 are connected to switching devices 37 and 38 respectively which are controlled by a device which may be a code generator 39 and preferably is of the nonrepeating type; that is to say, the group of code pulses produced by the code generator 39 are not repeated in normal operation during a transmission or a series of transmissions from the radio transmitter 28. The code generator 39 preferably provides cut-off bias for the switching devices 37 and 38, and its operation is timed from the standard frequency source 31 through a frequency generator and divider 40 over a connection 42. It will be understood that the code generator 39 may be connected directly to the standard source 31, if desired, rather than to the frequency generator and divider 40 as shown. The code generator 39 may be a counter controlled or a cam controlled electronic device, or it may comprise a rotary cam and switch such as is shown by way of example in Fig. 3 of the drawings. The switching devices 37 and 38 may be repeaters or amplifiers biased to cut-off over connections 44 and 46 from the code generator 39 or electromagnetic relays held in an inoperative condition at times by the code generator. The latter cuts off switching device 37 when switching device 38 is operative and vice versa. The output terminals of the switching devices 37 and 38 are connected by way of conductors 47 to a pair of terminal studs 49 on a double throw switch 51. The switch arms of this switch are connected by way of an amplifier 52 to the scanner drive motor 23.

If desired, the switch 51 may be provided with additional switch arms and studs in any well

known manner to cut out the code controlled frequency changing equipment, shown at the top of Fig. 1. When the switch arms of the switch 51 are in their left hand position in contact with studs 54 to connect the motor and amplifier 52 directly to the rated motor frequency source, namely, standard source 31 and divider 40, ordinary operation is obtained so that intelligible copy may be received by ordinary receivers within the transmitting range of transmitter 28. It will be understood by those skilled in the art that the source 31 may be a commercial power source where the transmitter and receivers can be connected to the same commercial power network to insure synchronism. Also, dividers 33, 34, and 40 may be a single unit if desired.

A description of the operation of the equipment shown by Fig. 1 in conjunction with a similarly equipped receiving station will be described in detail following a description of Fig. 2 which shows, by way of example, a receiving station equipped with apparatus necessary for the intelligible reception of signals transmitted by a transmitter embodying the invention, such, for example, as that shown by Fig. 1 of the drawings.

Referring to Fig. 2, reference character 56 indicates a recording scanner which is or may be similar to the transmitting scanner 19 of Fig. 1, the principal difference being that a copying head 57 is substituted for the scanning head 12 of Fig. 1. Radio signals are intercepted by an antenna 59 connected to a radio receiver 61. A signal amplifier and detector combination 62 serves to amplify picture signals which are supplied to the copying head 57 in known manner. A synchronous motor 64, which may be similar to the motor 23 of Fig. 1 drives the recorder 56 through a gear and pinion combination 66, shown conventionally, and the gear box 67. If desired, a worm and worm wheel combination, as shown on Fig. 5 of the drawings, may be substituted for the gear and pinion 66.

A standard frequency source 69 supplies a substantially constant frequency alternating current voltage to a frequency divider 71, the output of which is a sub-multiple of the frequency produced or generated by the standard frequency source 69. The frequency of the standard source may conveniently be 600 cycles per second with the frequency divider having a ratio of 10 to 1 so that the output of the latter to an amplifier 72 is 60 cycles, a frequency which is suitable for operating a synchronous motor 74. This motor may be of the small synchronous clock drive type which is readily obtainable commercially. Tone wheel rotors 76 and 77 of a pair of induction generators are carried by a shaft 78 which is driven from the motor 74 through a speed reducing gear box 79. The speed at which the shaft 78 is to be driven depends upon the frequency of the output of the induction generators 76 and 77 assuming a given number of teeth on their rotors. The output frequency of these generators preferably is such that their output may be amplified in an amplifier 81 and applied to the terminals of the synchronous motor 64. For example, if the motor 74 is a 60 cycle two pole clock motor, the speed reducing gear should have gear ratio of 60 to 1 so that with 59 teeth on the rotor 76 and the 61 teeth on the rotor 77, these two inductor generators will provide output voltages at 59 and 61 cycles respectively which is 1 per cent above and 1 per cent below the frequency of the output of the divider 71.

The stators of the inductor generators are

similar, and generator 76 is shown more in detail by Fig. 4 of the drawings. It is seen to comprise a permanently magnetized yoke 83, and the two polar tips 84 are separated by a distance equal to several times the pitch of the teeth on the rotor. A winding 86 surrounds a portion of the magnetic circuit, for example one of the pole tips, and one of its terminals is connected by way of a conductor 88 to a contact 89 of a cam operated switch 91 in the manner shown diagrammatically on Fig. 2 of the drawings and more in detail by Fig. 3. The remaining terminal is connected to a conductor 93 which connects with one stud 94 of a double pole double throw switch 96. The corresponding stud of the switch 96 is connected to the tongue 97 of the switch 91 by way of a conductor 99. The winding 102 of the generator 77 is connected by a conductor 103 to contact 104 of the switch 91. The remaining terminal of the winding 102 is connected to the conductor 93. With the switch 96 in its right hand position, as shown, the receiver will operate in conjunction with a transmitter such as the one shown in Fig. 1 to give a legible record.

The cam 107 which operates the cam switch 91 is provided with notches 108 cut in accordance with a predetermined code to match the code of the similar device employed at the transmitter, for example, the device 39 of Fig. 1.

In operation of the system so far described, the transmitting station, which may be provided with a code wheel arrangement as shown in Figs. 2 and 3 of the drawings or with a code generator 39, as pointed out above, is placed in operation, with a message sheet 19 bearing subject matter for transmission secured on the drum 11 of scanner 10. The code generator 39 is arranged to operate in accordance with an irregularly occurring code or, if a cam switch type of code device is employed, the cam is selected so as to have irregularly occurring indentations or, conversely, irregularly occurring teeth. The latter arrangement necessitates merely a reversal of the cam switch contacts. If a cam switch and inductor generators are employed, the selective code may be further complicated to prevent its solution by an unauthorized party by increasing the number of the tones generated by adding a cam code wheel and cam operated switch per pair of added frequencies. The code generator at the receiver, which may comprise the cam 107 and the cam operated switch 91, operates to connect either the inductor generator 86 or the inductor generator 102 in circuit at the same time as the switching device 37 or the switching device 38 at the transmitter is in circuit. The speed of operation of the transmitter scanner 10 will then correspond at any instant to the speed of operation of the recording scanner 56, and a legible copy of the transmitted subject matter will be recorded.

The apparatus at the transmitting station may be employed to transmit in a normal manner to any receiving station by placing the switch 51 in its left-hand position. Likewise, the receiver of Fig. 2 may be employed to receive signals from any transmitter station by placing the switch 96 in its left-hand position.

Fig. 5 of the drawings discloses a modification in which the facsimile scanner 112 is driven by an induction motor 114. This apparatus may be used either at a transmitting or receiving station. The motor 114 drives the copy holding drum 116 of the scanner 112 through gearing 117 and a worm and worm-wheel combination 118. The gearing 117 also drives a shaft 121 on which

are mounted the rotors of inductor generators 122, 123, 124. The shaft 121 also has secured thereto a cam disc 126 which operates a cam controlled switch 127. The proper time phase of switching between the inductor generators 123 and 124 is controlled by the switch 127. A cam operated switch 129 is controlled by a code disc 131 having code teeth cut thereon. This code disc 131 is mounted on a shaft 128 and corresponds in function to the cam 107 of Figs. 2 and 3 of the drawings and is driven at reduced speed relative to disc 126 by gearing 130.

The motor 114 obtains driving power from a suitable alternating current source which may be a standard 110-volt, 60-cycle service outlet connected at terminal points 133. The driving speed of the motor 114 is varied in accordance with the code provided on the code disc 131 by means of a phase detector 136 and a voltage control unit 137. These pieces of apparatus are disclosed and claimed in a copending application of Hallborg et al., Serial No. 491,538, filed June 19, 1943. So much of the description appearing in this copending application as is necessary to an understanding of the present invention will be repeated herein for the sake of completeness of the disclosure. Briefly, the device 136 beats the output of the generators 122 to 124 with the output of the standard frequency source 139 to produce a phase shift in the beat wave. This phase shift produces a proportional change in resistance in the motor circuit resulting in a proportional change in motor speed.

The standard frequency source 139 provides a regulated frequency output which is fed to the phase detector 136 over a connection 141 and inductor generators 122 to 124 are also connected to the phase detector 136 over a connection 142 under control of a polar relay 144, the operating coils of which are connected to the contacts of the cam operated switch 129. A suitable source of operating potential 146 in series with the cam operated switch 127 provides for energization of the relay coils. A manually operable switch 147 interposed in one leg of the connection 142 provides for operating the system as a privacy system or in the normal manner in conjunction with any type of transmitting or receiving station. The tongue 148 of the polar relay, when in its right-hand position (and with switch 147 in the privacy position, as shown), connects the inductor generator 124 to the phase detector 136. This inductor generator 124 is provided with a number of teeth such that it would generate a frequency higher than the frequency of the frequency standard 139 if the shaft 121 were permitted to run at normal speed. With the tongue 148 of polar relay 144 in its left-hand position, and the manual switch 147 in the position shown, the inductor generator 123 is connected to the phase detector 136. The inductor generator 123 is provided with a number of teeth such that it would generate a frequency lower than the normal operating frequency of the motor 114 if the shaft 121 were permitted to run at normal speed.

The inductor generator 122 is provided with a number of teeth such that it will generate a frequency equal to the normal operating frequency of the motor 114 when it is operating at normal speed. Therefore, with the switch 147 in its right-hand position, the motor 114 will operate at a constant speed under control of the output of the standard frequency source 139.

In operation of the apparatus described, the switch 129 will operate to place either of the in-

ductor generators 123 or 124 in connection with the phase detector 136 so as to supply voltage thereto. Assuming that the code disc 131 has moved the switch 129 into the position shown, the tongue 148 of the polar relay will, when switch 127 closes, connect the inductor generator 124 to the phase detector device 136. The momentary increase in frequency will result in instantaneous decrease in the motor speed to the point at which the inductor generator 124 generates precisely standard frequency by reason of a decrease in the supply voltage applied to the motor 114 through the voltage control unit 137. When the cam code disc causes the switch 129 to move to its right-hand position, the tongue 148 of the polar relay will connect the inductor generator 123 to the phase detector 136. An instantaneous increase in the speed of the motor 114 will be produced and maintained until the code disc 131 again operates the switch 129. The tongue 152 of the relay 144 short circuits a resistor 153 which is in series with the motor 114 and assists in obtaining the very rapid increase in speed.

The apparatus described in connection with Fig. 5 is operated in the manner already described in connection with Figs. 1 and 2 of the drawings. For example, at the transmitter station a message sheet bearing a copy for transmission will be placed on the drum 116 and a code disc 131 will be selected and mounted on the driving shaft 128 for the code disc.

At the receiver station a suitable type of message blank will be placed on the drum 116 and a code disc 131 identical with that at the transmitter will be used. Phasing or framing of the copy may be accomplished in accordance with well known methods.

Solely by way of example, a typical system operated in accordance with the invention employed a motor 114 with a normal speed of 1760 R. P. M. A gear ratio of

$$\left(\frac{30n}{f_1} \text{ to } 1\right)$$

was provided in the reducing gear, where n was the number of teeth in the reference frequency tone wheel 122, f_1 was the standard reference frequency, and $n-1$ and $n+1$ the number of teeth for producing drum speeds above and below normal by means of inductor generators 123 and 124. The driving ratio of the worm and worm wheel combination 118 was 1 to 30. The driving gear ratio for the worm shaft was 45 to 44. The gear ratio between the motor 114 and the shaft 121 in the specific example now being described has already been given.

Having now described our invention, what we claim as new and desire to have protected by Letters Patent is:

1. In an electrical communication system comprising a movable intelligence transferring member and power drive means for said movable member, means cooperating with said member to generate intelligence signals, a frequency controlled electrical power supply for said power drive means, means to vary the frequency of said supply to produce a change in speed of said power drive means, and code controlled means for controlling said frequency varying means and thereby controlling the speed of said intelligence transferring member so that communication by the intelligence signals at a plurality of different speeds is obtained at predetermined times.

2. A secrecy system comprising a signal translating device, power drive means for said translating device, an alternating current power source having an output of a predetermined frequency, a second alternating current power source having a frequency differing from the frequency of said first named source, and code operated means to connect said power drive means with either of said power sources.

3. A secrecy system comprising a signal translating device, power drive means for said translating device, a stable frequency alternating current power source, an alternating current power source having a frequency higher than the frequency of said stable frequency source, an alternating current power source having a frequency lower than the frequency of said stable frequency power source, code operated means to connect said power drive means with either of said second or third named power sources, and means associated with said stable frequency alternating current power source for controlling said code operated means.

4. In an electrical communication system comprising a movable intelligence transferring member and power drive means for said movable member, means cooperating with said member to generate intelligence signals, a frequency controlled electrical power supply for said power drive means, means to produce a separate alterable frequency, means to compare said separate frequency with the frequency of said supply, means to produce a change in speed of said power drive means in accordance with said comparison, and code controlled means for controlling said frequency varying means and thereby controlling said intelligence transferring member so that communication by the intelligence signals at a plurality of different speeds is obtained at predetermined times.

5. In a facsimile communication system comprising a scanner for generating intelligence signals and power drive means for said scanner, an electrical energy supply for said power drive means, means for providing a supplemental power supply having a characteristic different from a like characteristic of the power supply for said power drive means, means to compare said characteristics, means to produce a change in the speed of said power drive means as a result of said comparison, and code controlled means for controlling said supplemental power supply so that secrecy of communication by the intelligence signals is maintained.

6. In an electrical communication system comprising a movable intelligence transferring member and power drive means for said movable member, means cooperating with said member to generate intelligence signals, a frequency controlled electrical power supply for said power drive means, a generator driven from said power drive means to produce a separate alterable frequency, means to compare said separate frequency with the frequency of said supply, means to produce a change in speed of said power drive means in accordance with said comparison, and code controlled means for controlling said frequency varying means and thereby controlling said intelligence transferring member so that communication by the intelligence signals at a plurality of different speeds is obtained at predetermined times.

7. Apparatus for obtaining privacy of communication comprising a facsimile scanner for generating intelligence signals, electrical means for driving said scanner, a frequency regulated alternating current power supply for said scanner

drive means; means to vary the frequency of said alternating current power supply to produce a change in speed of the scanner drive means, and a code operated switch for controlling said frequency varying means in accordance with a prearranged code.

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