Dec. 7, 1948. D. SARNOFF 2,455,443

SECRET RADIO SIGNALING SYSTEM

Filed Oct. 12, 1945 5 Sheets-Sheet 1

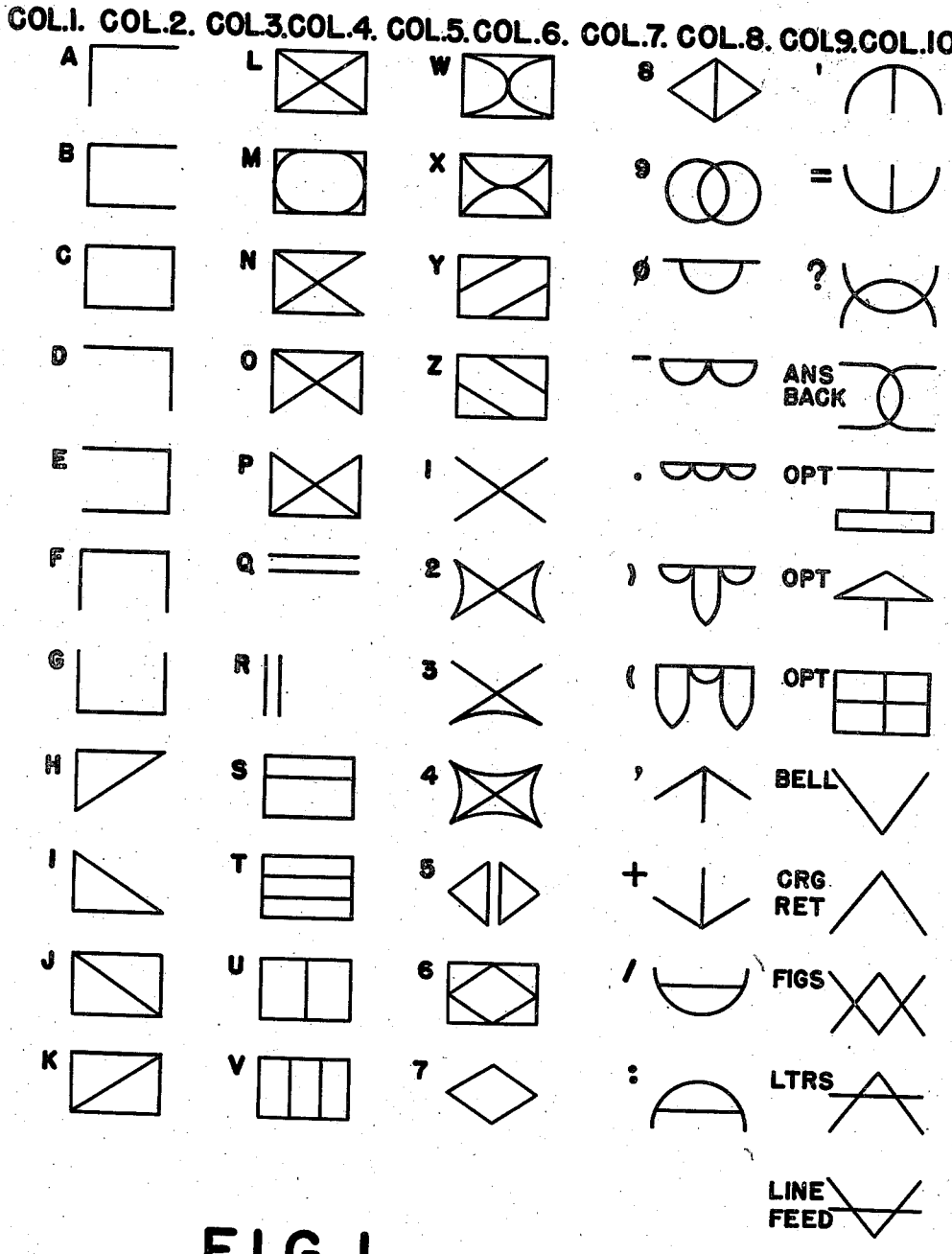



FIG. 1.

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SECRET RADIO SIGNALING SYSTEM

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FIG.2.

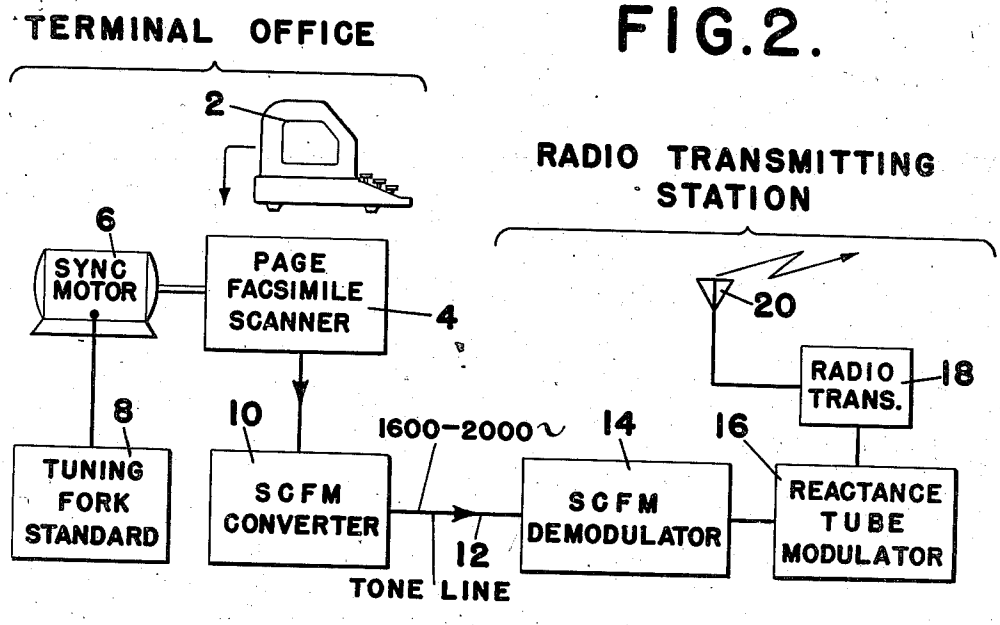
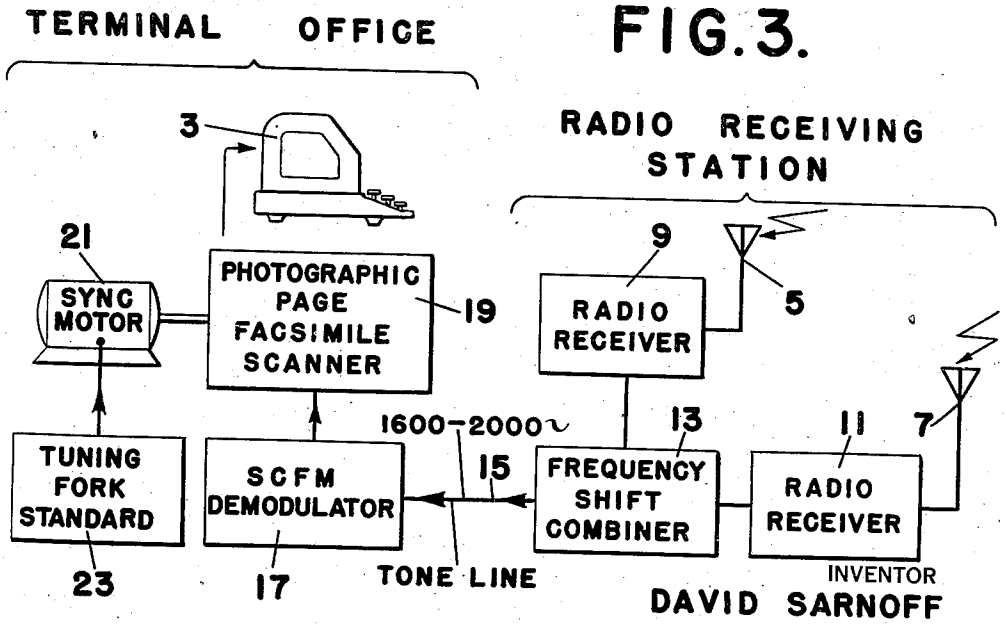



FIG.3.




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SECRET RADIQ SIGNALING SYSTEM

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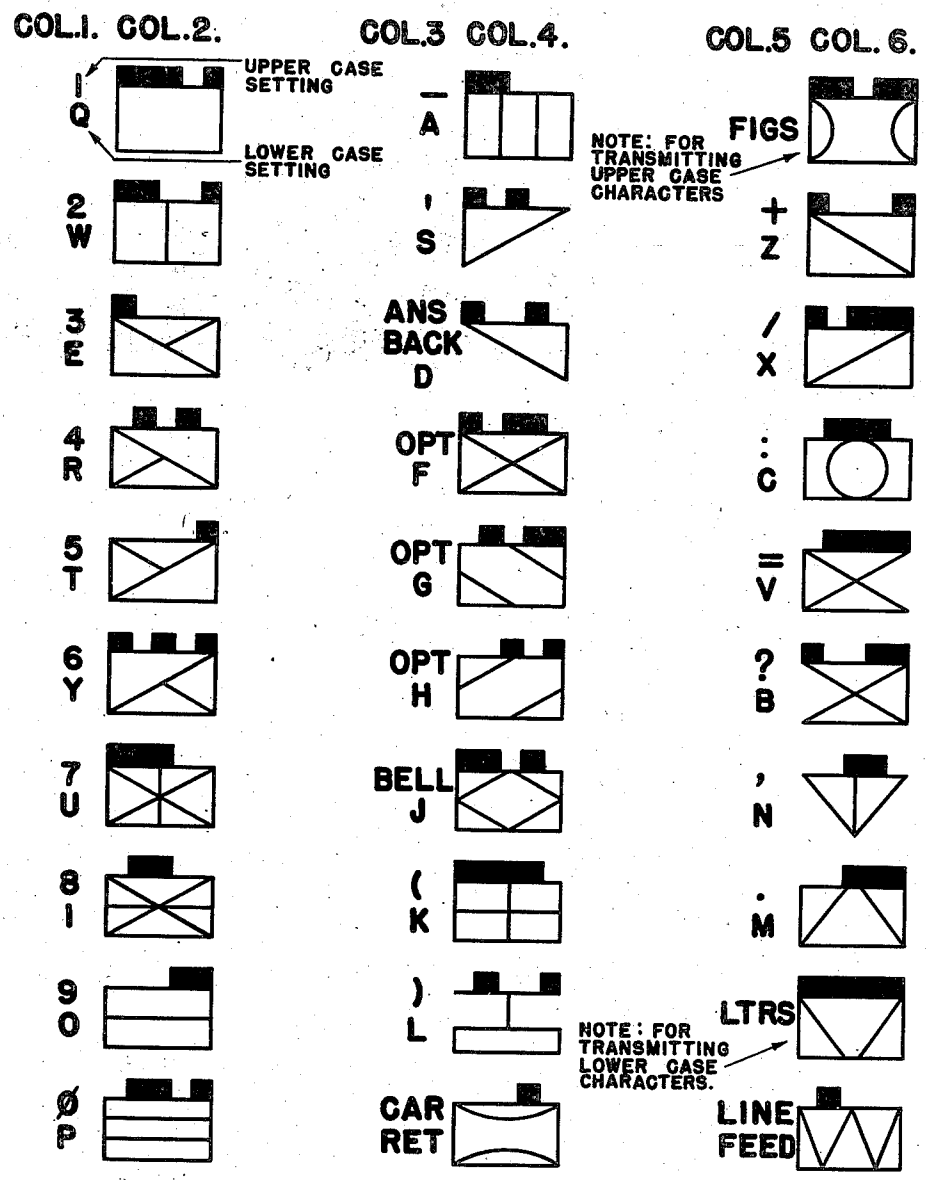



FIG. 4.

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SECRET RADIO SIGNALING SYSTEM

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FIG. 5.

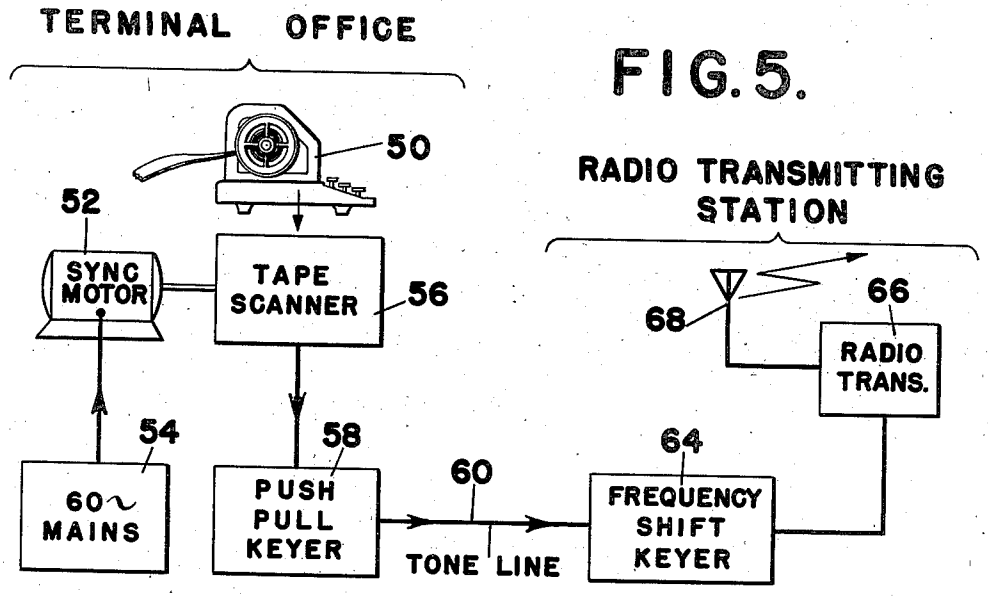
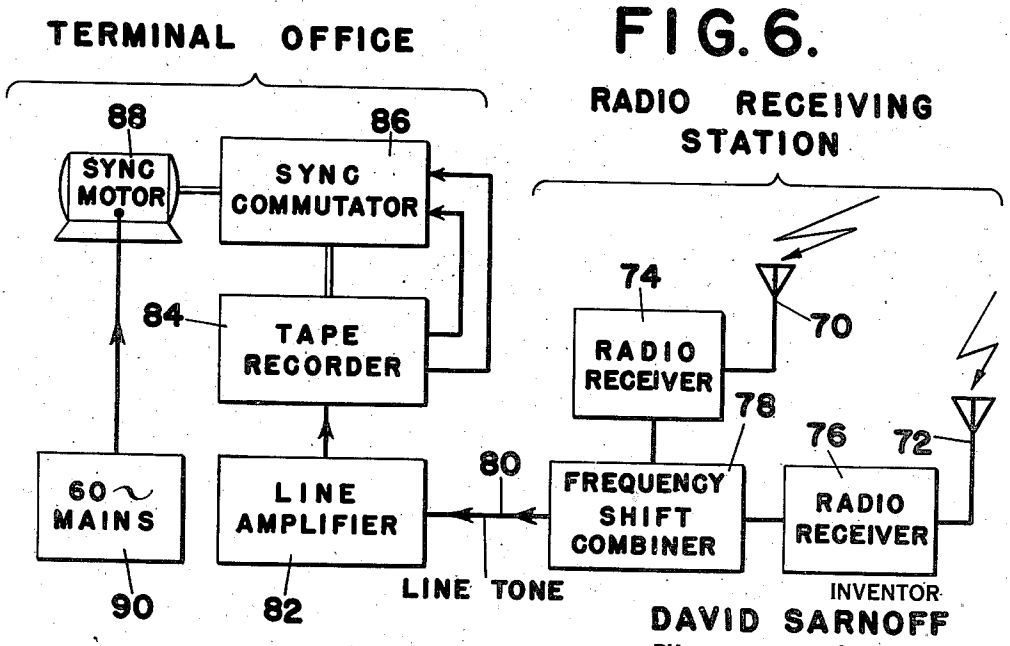



FIG. 6.




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SECRET RADIO SIGNALING SYSTEM

Filed Oct. 12, 1945

5 Sheets-Sheet 5

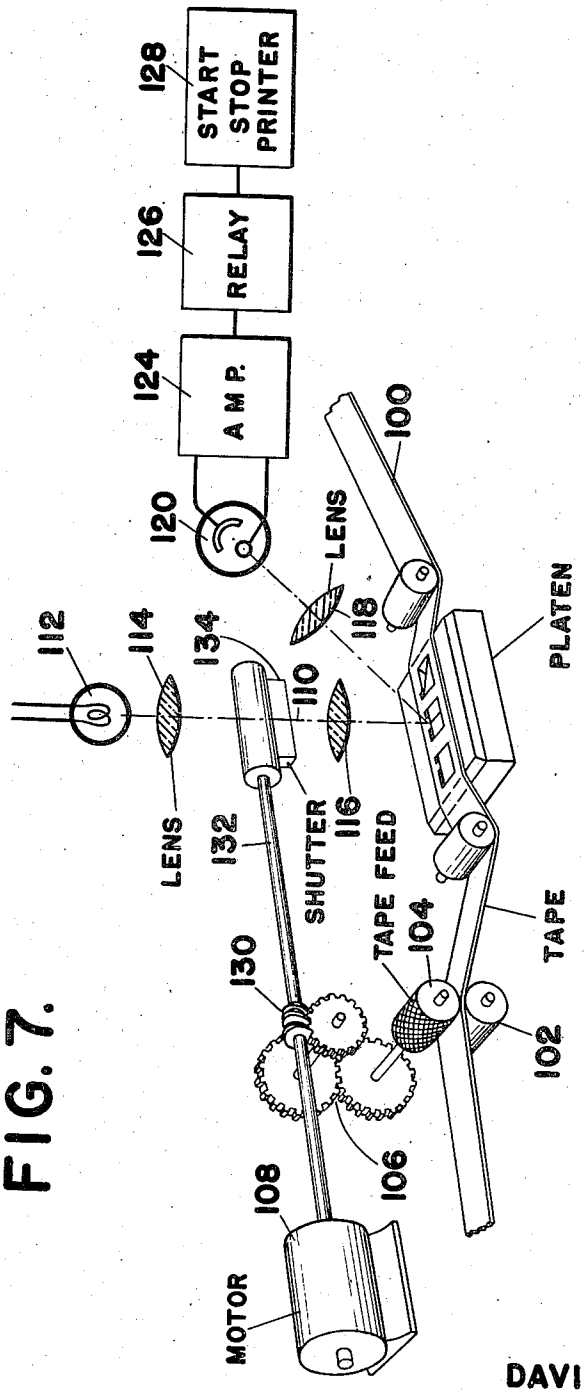



FIG. 7.

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Patented Dec. 7, 1948

2,455,443

# UNITED STATES PATENT OFFICE

2,455,443

## SECRET RADIO SIGNALING SYSTEM

David Sarnoff, New York, N. Y., assignor to Radio Corporation of America, a corporation of Delaware

Application October 12, 1945, Serial No. 622,043

2 Claims. (Cl. 178—22)

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This invention relates to an improved method of and system for secret signaling.

Many systems and methods have been proposed for obtaining secrecy in radio telegraphic signaling. They include the telegraphic transmission of messages in accordance with a secret code; interlacing, at the transmitter, telegraphic elements of several messages and later, at the receiver, unscrambling the received multiplexed signals; rapid switching of successive portions of a message from one signaling channel to another at predetermined, variable rates; mixing code characters, such as may be used to actuate a teletypewriter, with telegraphic elements derived from a tape in which a masking signal has been punched; and others.

The degree of secrecy attainable with such arrangements of the prior art is not high, for they can be, and actually have been solved with relative ease to yield the supposedly secret messages. In addition, when employing long distance radio circuits as the link between transmitter and receiver, such systems are particularly susceptible to inaccuracies brought about by static and fading. Static impulses produce false markings and, similarly, fading conditions cause dropouts or spaces. The end result of both static and fading is, therefore, to produce erroneous characters which are indistinguishable from desired signal transmissions.

To overcome these faults is the principal purpose of this invention. More specifically, it is an object of the invention to provide a secret signaling system which shall be exceedingly difficult to decipher and which shall be substantially free of errors heretofore caused by fading, static or other unfavorable conditions in the transmitting medium.

Briefly, in accordance with the invention, a standard keyboard transmitter at a sender's office is designed to print pictorial characters or other arbitrarily chosen symbols rather than the usual letters of the alphabet. Messages consisting of the printed symbols are then transmitted by facsimile or by television over a radio circuit, which may be operated by a public carrier, to the receiving point. There, the pictorial representations reproduced by facsimile or television, are read and translated. Translation is effected, in accordance with one modification of the invention, by means of a complementary typewriter or printer wherein hand operated keys are marked with the symbols, but the type printed is normal.

By pre-arrangement between sender and addressee the secret combination of symbols can be changed as often as desired so as to enhance secrecy, even as against the carrier. Although static, fading and similar adverse signaling conditions may produce distortions in the pictures reproduced at the receiving end of the system, each picture, representing a letter or word of the message, will be clearly identified as a whole, thereby enabling the printing of correct signal elements. In this way, errors normally caused by static and similar troublesome conditions are circumvented.

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In a modification of the invention, which will be described in greater detail later, relatively obscure differences between pictorial representations are utilized to cause automatic translation or printing of the transmitted message. In the event that the received pictures are disfigured by reason of poor signaling conditions, each picture, nevertheless, is clearly recognizable in its entirety and may be repaired by means of suitable templets before use in mechanism for automatically printing the messages from the corrected, accurate, radio facsimile copy.

In the more detailed description of the present invention which follows, reference will be made to the accompanying drawings wherein:

Figure 1 is a special code devised for use in the present invention. Unlike symbols or pictorial representations thereof represent different units of intelligence, such as letters of the alphabet, to be transmitted in secrecy;

Figures 2 and 3 are schematic representations, respectively, of page facsimile radio transmitting and receiving stations of a secret signaling system which makes use of a code such as illustrated in Figure 1;

Figure 4 illustrates a secret code especially designed to enable automatic translation and printing of secret messages, although it should be understood that messages in the code of Figure 4 may be translated in accordance with the procedure employed in connection with Figures 1, 2 and 3;

Figures 5 and 6 are, respectively, schematic diagrams of transmitting and receiving apparatus for messages sent by a secret code such as shown in Figure 4; and

Figure 7 is a simplified, diagrammatic showing of apparatus for automatically translating a message, composed of the secret symbols of Figure 4, into normal print.

The page facsimile system of Figures 2 and 3 makes use of a secret code such as shown in Figure 1 wherein each unit of intelligence to be

transmitted is delineated by a separate and distinct symbol or pictorial representation. In columns 1, 3, 5, 7 and 9 of Figure 1 are shown the units of intelligence to be transmitted, such as letters of the alphabet, numerals, etc., and the symbols representing them are shown adjacent in the even numbered columns. Thus, for example, the letter "C" is represented by a rectangle, letter "R" by a pair of vertical parallel lines, number 7 by a rhomboid, etc.

The coded copy of the message to be sent in secrecy is prepared by a printer or typewriter illustrated diagrammatically at 2 in Figure 2. The key caps of printer 2 bear the marks appearing in the odd numbered columns of Figure 1. The type faces on the keys of typewriter 2 are so set up, however, that in one case position the secret symbols of the even columns of Figure 1 are printed; whereas, in the other case position, normal printing, such as appears in the odd columns of Figure 1, takes place when the typewriter is operated.

When sending a secret message, printer 2 is actuated so that the name and address of the addressee and also, if desired, of the sender, are typed in normal print on a page inserted in the typewriter. To print the body of the message in accordance with the secret code of the even columns of Figure 1, the operator merely shifts case, by depressing the case shift lever, and then operates the key levers in the usual way.

After the typist has prepared the coded copy, it is transmitted by page facsimile over the radio circuit. When received at the distant receiving terminal, such as diagrammatically illustrated in Figure 3, the radio facsimile copy may be delivered by the public radio carrier to the addressee, at whose office the secret, coded message is translated. Translation is effected by means of a typewriter 3 having the secret symbols or pictorial representations marked on its key caps and corresponding letters or other normal units of intelligence on its type faces. To heighten secrecy, the sender and addressee may change codes in accordance with prearranged, confidential schedules.

The set of pictorial representations of Figure 1, it should be clearly understood, is only illustrative. Many others can be devised and these may, of course, include actual pictures of different animate and inanimate objects. The representations chosen, however, should be such as can be used on type face and, when scanned, should be satisfactory for transmission over the radio circuit.

Returning to Figure 2 of the drawings, after the page copy of the secret message has been prepared in printer 2, it is transferred to a page facsimile scanner 4. The latter is driven by a synchronous motor 6 provided with motive power derived from a tuning fork standard 8. Preferably the amplitude modulation output of the scanner is converted to sub-carrier frequency modulation by a suitable converter 10 for transmission over a control tone line 12 which may be replaced, if desired, by an ultra high frequency radio relay.

At the output end of tone line 12, the frequency modulated sub-carrier is demodulated in a demodulator 14. The demodulated waves are used to control a reactance tube modulator 16 which causes a shift in frequency of the radio frequency carrier wave generated in radio transmitter 18. The carrier frequency may be shifted, for example, ±2 kilocycles and radiated to the distant radio receiving system of Figure 3.

At the radio receiving station such as shown schematically in Figure 3, a two unit frequency diversity receiving system intercepts the frequency shifted carrier radiated by the transmitting antenna 20 of Figure 2. The two unit diversity receiving system includes the separated receiving antennas 5 and 7 and radio receivers 9 and 11. The outputs of the latter are employed in a frequency shift combiner 13 to produce a frequency shifted subcarrier which is transmitted over a tone line 15 into the receiving terminal office. There the sub-carrier is demodulated by means of a suitable demodulator 17. The varying amplitude D. C. output of the demodulator is used to control a photographic facsimile page recorder 19 driven by synchronous motor 21. The latter is supplied with synchronous power derived from a tuning fork standard 23.

The facsimile copy is then delivered to a customer's office where a printer or typewriter 3, as before described, is provided for deciphering the secret, page facsimile message.

For more detailed descriptions of scanning machines and related apparatus which may be used at the transmitting terminal of Figure 2 and to photographic facsimile recording apparatus which may be used at the receiving terminal of Figure 3, reference is made to the book entitled "Radio Facsimile," dated October 1938 and published by RCA Institutes Technical Press. Particular reference is made to pages 139, 144, 151, 172, 239, 240 and 241 thereof. For a detailed description of a suitable sub-carrier frequency modulation system for radio facsimile, reference is made to an article by R. E. Mathes and J. N. Whitaker entitled "Radio Facsimile by Sub-Carrier Frequency Modulation" appearing at page 131 of the RCA Review for October 1939. Systems wherein the outputs of diversity receivers are reduced to on-off keying by means of frequency shift combiners are described in U. S. Patents Nos. 2,067,432 and 2,070,418 issued to H. H. Beverage and in the copending application of R. E. Schock et al., Serial No. 632,978, filed Dec. 5, 1945. A suitable frequency modulated sub-carrier demodulator such as used at 14 in Figure 2 and at 17 in Figure 3 is described in U. S. patent to W. H. Bliss No. 2,350,869.

If desired, the secret message, typed on pages by means of printer 2, may be transmitted by radio television to a television receiver located near the translating typewriter 3. In that event, the operator of typewriter 3 would translate the secret symbols as they appear on the television screen.

Automatic translation and printing of messages, made secret in accordance with principles previously expounded upon in connection with Figures 1, 2 and 3, will now be described with the aid of, and reference to, Figures 4, 5, 6 and 7. The automatic system involving these figures will enable one to dispense with the services of the typist heretofore required to operate the translating typewriter diagrammatically illustrated at 3 in Figure 3.

For automatic operation, a special formation of secret symbols is provided so that scanning will produce an equal length code suitable for automatic translation at the receiving end of the system. The secret facsimile code of Figure 4 illustrates, by way of example, a simple line formation which, when photoelectrically scanned, will produce the equivalent of an equal length teleprinter baud code for start-stop printer use. It will be noted that along the tops of the secret

characters or symbols of colums 2, 4 and 6, "pips" are positioned which represent the marking elements of the five unit start-stop Baudot teleprinter code. The marking and spacing elements shown are those necessary for selection purposes. The space between characters must be such that it will equal two bauds, as will be explained more fully later.

The units of intelligence to be transmitted appear in columns 1, 3 and 5 of Figure 4, and the corresponding secret facsimile symbols are immediately adjacent in columns 2, 4 and 6. It will be recognized that the signaling elements of Figure 4 are arranged in the sequence generally adopted for teletypewriters.

Since a slip or tape facsimile system lends itself more readily to automatic translation requirements, a slip or tape typewriter 50 is provided as diagrammatically shown in Figure 5. Typewriter 50 is constructed so that the key caps are marked with normal units of intelligence such as appear in the odd columns of Figure 4 and the type faces are embossed with the symbols of columns 2, 4 and 6. It should be noted that by depressing the key cap marked "FIGS," upper case settings, such as the numerals of column 1 of Figure 4, will be reproduced by the printer at the receiving end. Actuation of the key lever bearing the designation "LTRS" (see column 5, Figure 4) will cause transmission and printing of lower case characters, such as the letters of column 1, Figure 4, at the receiving terminal. In other words, the same facsimile symbols are transmitted for either upper or lower case marks, shift from one case to the other being accomplished by actuation of the keys marked "FIGS" or "LTRS" at the transmitting typewriter 50.

The entire message is printed, on the tape or slip fed to printer 50, in the form of the secret symbols of Figure 4. The printed tape is then transferred to the tape scanner 56 of Figure 5 and photoelectrically scanned. Synchronous motor 52, powered from 60 cycle mains, drives the tape-scanner. For a more detailed description of a suitable tape-facsimile scanning system which may be used at this point, reference is made to page 271 of "Radio Facsimile" previously referred to.

As indicated in Figure 5, the control voltage output of scanner 56 is used to operate a push-pull tone keyer 58. The keyed tone output is fed over a tone transmission line 60, or by way of a radio relay link, if desired, to a frequency shift keyer 64 in turn controlling the output of a radio transmitter 66. The carrier wave radiated by antenna 68, connected to radio transmitter 66, is shifted in frequency, in accordance with the output voltage of scanner 56, by keyer 64. This shift in frequency may be any desired amount such as ±425 cycles per second.

The frequency shifted radio carrier wave, radiated by antenna 68 of Figure 5, is received at the radio receiving station of Figure 6. The latter includes spaced receiving antennas 70, 72 feeding super-heterodyne radio receivers 74 and 76. The detected outputs of the receivers 74 and 76 are reduced to on-off keying of a suitable tone frequency, alternating current by means of the frequency shift combiner 78. The on-off keyed tone is transmitted to the receiving terminal office of Figure 6 over a control link which may be an ultra high frequency radio circuit or, as illustrated, a wire tone line 80.

At the receiving terminal of Figure 6, the incoming on-off keyed tone is amplified by line amplifier 82 and fed, in amplified form, to tape recorder 84. As more fully described in a paper entitled "Tape Facsimile Synchronizing Systems" by Henry Shore and James N. Whitaker at page 270 of "Radio Facsimile," previously referred to, recorder 84, briefly, comprises a revolving spiral member and a signal controlled recording bar. The bar, or moving element of the recording head, is arranged to press a white record tape and a carbon slip together in a pattern which results in an exact facsimile of that which obtains in the scanning process carried on at the tape scanner 56 of Figure 5.

Also, as shown in Figure 6 and as more fully described in "Radio Facsimile" at page 281, the tape recorder of Figure 6 is provided with a special synchronizing commutator 86 and is driven by synchronous motor 88 powered from 60 cycle alternating current mains 90.

The messages on the facsimile tape, derived from tape recorder 84 of Figure 6, will be inscribed in the secret symbol code of Figure 4. The tape is then subjected to a local scanning operation to provide equal length band signals, arranged in successive equal time intervals. The equal length baud signals, fed to a five unit start-stop teleprinter, actuate the same causing translation, i. e., printing of the secret message in normal type. An arrangement for scanning the tape and applying the equal length baud signals to a five unit start-stop printer is schematically illustrated in Figure 7.

Before describing Figure 7 in detail, it should be borne in mind that a standard start-stop five unit teleprinter functions at 368 operations per minute. That is, it transcribes and prints 368 seven unit baud groups per minute. Successive equal time intervals are assigned to the seven unit baud groups. Five of the seven units are necessary and used for character selection purposes. The sixth unit of each group is used to provide for the stop function in the printer, i. e., printing and clearance. The seventh provides the start function, i. e., it conditions the printer for the next operation.

Returning now to Figure 7, the facsimile slip or tape record 100, on which the specially formed symbols of Figure 4 have been recorded by recorder 84 of Figure 6, is passed through a scanner, as shown in Figure 7, so arranged as to scan the top portion of each character. Passage of tape 100 through the scanner is effected by the action of the tape feed wheels 102, 104 in turn driven by gearing 106. The latter is rotated by motor 108. A scanning spot 110, produced by light source 112 and a pair of lenses 114 and 116, is directed on the upper portion of each symbol. Light reflections from the tape pass through a lens 118 which concentrates and directs the reflected light upon a photocell 120. Photocell 120 controls the output of a vacuum tube amplifier 124 which controls a polar relay 126. The tongue of the relay is connected to supply suitable voltages of opposite polarity to, and thereby operate, a standard five unit start-stop teleprinter 128.

Drive motor 108 should be designed and operated to pull the tape 100 past the scanning spot 110 so that 368 seven unit baud groups will be scanned per minute. By means of gearing 106, worm 130 and shaft 132, motor 108 is made to rotate a shutter 134. Shutter 134 is so positioned and dimensioned that at the end of five baud units of each seven unit group, the light source will be cut off for one baud length. At the end of that time, it will be observed, light spot 110 will hit a

white space between the characters for a time equal to one baud. These in between character bauds provide, first, the stop function in printer 128 and, second, the start function.

Instead of using a five unit code and printer, a synchronous seven unit printer and a balanced code may be used to good advantage. When using such a balanced seven unit code, the minimum spacing between characters should be three bauds and the maximum seven for single channel operation. For a detailed description of a balanced code seven unit system, reference is made to U. S. Reissue Patent No. 22,394, issued to J. B. Moore et al. For printing apparatus particularly suited to the use of a balanced seven unit code, reference is made to the following U. S. patents issued to J. A. Spencer: 2,153,737, 2,231,397, 2,274,103, 2,336,197.

Obviously, the "pips" giving rise to the impulses for automatic operation may be arranged otherwise than across the tops of the secret symbols as shown in Figure 4 and on tape 100 of Figure 7. It should, therefore, be clear that modifications may be made without departing from the spirit and scope of the invention.

Having thus described my invention, what I claim is:

1. Secret signaling apparatus comprising means for printing on a tape a message in the form of secret symbols, markings on different symbols being arranged in accordance with an equal time interval multi-unit code, different markings representing different units of intelligence to be transmitted, means for transmitting the symbols by facsimile over an alternating current circuit to a distant receiving point, means at the receiving point for reproducing a facsimile copy of the secret symbols from the received currents, means for photoelectrically producing electrical current impulses from the facsimile copy, the impulses being arranged in equal time intervals in accordance with the multi-unit code used during transmission, thereby circumventing errors introduced by the alternating current circuit, a shutter so dimensioned, positioned and actuated as to operate said photoelectric means in such a way as to provide in between character current impulses and means for utilizing the impulses so produced to cause printing of the message in normal type.



2. A secret signaling system comprising, in combination, a typewriter at a transmitting point, said typewriter being provided with keys and type faces such that in one case position, the address of the addressee may be printed in normal type and such that in the other case position, secret symbols are printed, said secret symbols representing different letters of the alphabet whereby a secret message may be printed following the printing of the address of the addressee in normal print, said secret symbols being so chosen as to be satisfactory for clear transmission over a radio facsimile circuit, a radio facsimile system for transmitting messages so typed up to a distant receiving point whereby errors and inaccuracies due to fading conditions and static impulses are avoided, and instrumentalities located at the receiving point for translating the secret symbols as received by radio facsimile into normal type.

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