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2,403,059

SECURITY TELEFACSIMILE SYSTEM

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Fig. 1.

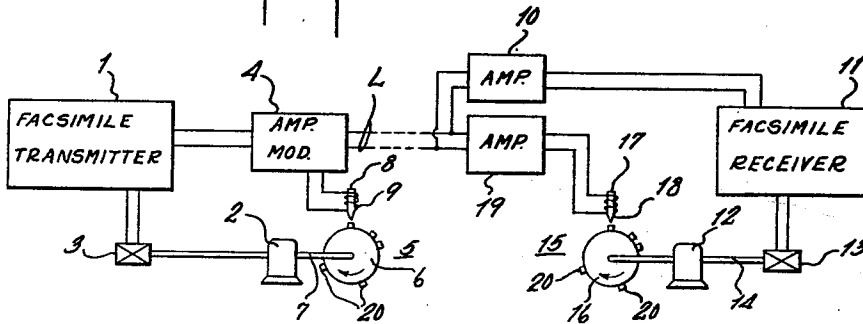
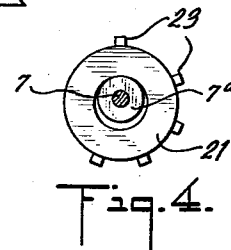
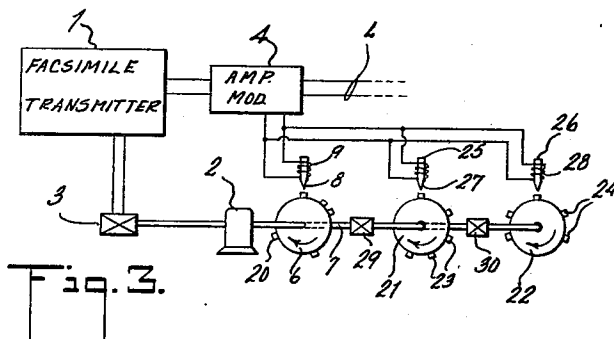
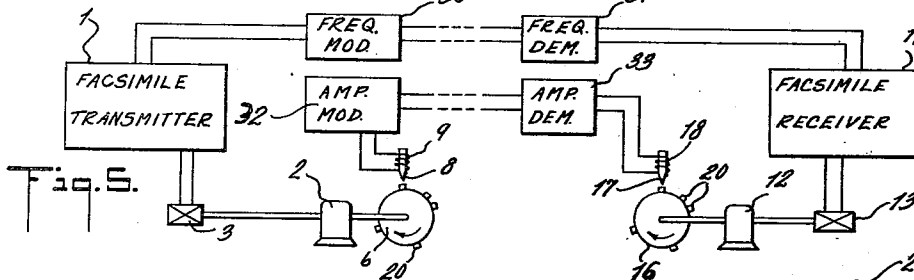
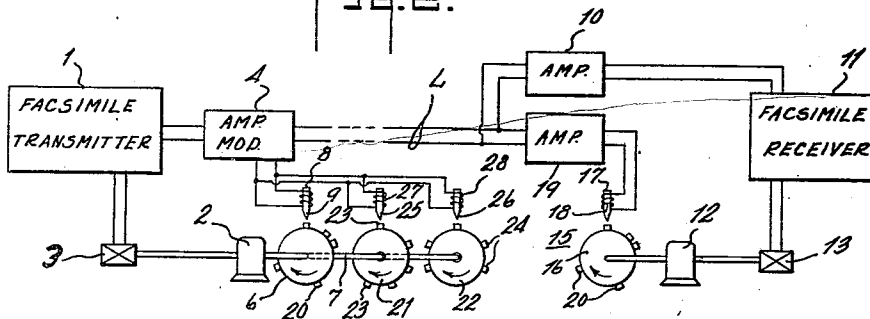


Fig. 2.



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SECURITY TELEFACSIMILE SYSTEM

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This invention relates to telefacsimile systems and more particularly to methods and means for transmitting and receiving facsimile subject matter or the like with secrecy.

A principal object of the invention is to provide method and means for practically preventing synchronism of an unauthorized receiver with a transmitter.

Another object is to provide methods and means for maintaining secrecy in a signaling system wherein the receiving means is provided with a synchronizer device which is adapted to be operated under control of received synchronizing signals.

Another object is to provide methods and means for maintaining secrecy in a telefacsimile system or the like wherein synchronization of the receiver and transmitter is effected by an inherent frequency component of the transmitted facsimile signal.

A feature of the invention relates to an improved secrecy telefacsimile system employing a modulated audio frequency carrier for the signals.

Another feature relates to the means for transmitting simultaneously with a desired synchronizing signal, one or more arbitrarily chosen frequencies having no readily determinable relation to the synchronizing frequency.

A further feature relates to the means for transmitting simultaneously with a desired synchronizing signal, one or more arbitrarily chosen frequencies which can be independently varied during transmission of the message without affecting the synchronization of an authorized receiver.

A still further feature relates to the novel organization, arrangement and relative interconnection of parts which cooperate to form an improved secrecy signal transmission system especially suitable for facsimile transmitters and the like.

Other features and advantages not specifically enumerated will be apparent after a consideration of the following detailed descriptions and the appended claims.

In the drawing which shows by way of example several embodiments of the invention,

Fig. 1 is a schematic diagram of a telefacsimile system according to the invention.

Fig. 2 is a modification of Fig. 1.

Fig. 3 is a modification of Fig. 2.

Fig. 4 is a schematic view of one typical form of "random" coupling according to the invention.

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Fig. 5 is a schematic diagram of a modification of the invention.

Inasmuch as telefacsimile systems and apparatus are well-known, only those parts which are necessary to an understanding of the invention are illustrated in the drawing. While the invention will be described as applied to certain types of signaling systems, it will be understood that the inventive concept can be equally well applied to other types of signaling systems. The invention may be embodied in a system of the type wherein the telefacsimile signals or other message signals themselves, are used as a synchronizing control to maintain a receiver in synchronism with a transmitter. Such a system is disclosed in Patent No. 2,015,742 to Austin G. Cooley.

Referring to Fig. 1 of the drawing, the block 1 represents schematically any well-known form of facsimile transmitting machine usually comprising a rotatable drum around which is wrapped the subject matter to be transmitted. This subject matter is arranged to be scanned in successive elemental areas to produce corresponding electric currents as is well-known in the art and as described for example in said Patent No. 2,015,742. There is provided a motor 2 which drives the scanning mechanism of machine 1 through suitable gearing 3. The facsimile signals from machine 1, usually in the form of relatively low frequency current variations, are impressed upon a suitable amplifier modulator 4. Modulator 4 is also supplied with an audio frequency carrier under control of a generator 5. Preferably, this generator consists of a toothed magnetic rotor 6 fastened to shaft 7 which is driven at the required speed by motor 2. Associated with rotor 6 is a magnetic pole member 8 having an energizable or pick-up winding 9 which is connected to the modulator 4. Consequently, the output of modulator 4 will consist of a carrier wave determined by device 5, the amplitude of the carrier waves being modulated in accordance with the signals from machine 1. Preferably the generator 5 is such that the rotor 6 can be readily removed and replaced by another rotor for purposes to be described.

At the receiving station schematically shown in the right-hand portion of Fig. 1, the modulated carrier wave received from the line or transmission channel L is amplified in a suitable amplifier 10, the output of which is used to control a reproducing light source or other well-known recording element in the facsimile receiving machine 11. The receiving machine may comprise a scanning drum adapted to be rotated

about its own axis and advanced bodily along its axis in any well-known manner. If desired, the drum may be merely rotated about its own axis and the reproducing light source or the like may be advanced longitudinally as described in said Patent No. 2,015,742. For a detailed description of a typical drum scanning arrangement that may be used, reference may be had to Patent No. 2,138,784 to Austin G. Cooley.

For the purpose of operating the scanning mechanism of machine 11, there is provided a motor 12 which may be of the induction type and coupled through suitable gearing 13 to the scanning mechanism of machine 11. In order to maintain synchronism, the driving shaft 14 has coupled thereto a synchronizing motor 15 comprising a toothed magnetic rotor 16 and a magnetic pole member 17 having an energizing winding 18. Winding 18 is adapted to be energized by part of the received carrier from line L after passing through a suitable amplifier 19. Preferably the rotor 16 is readily removable so that it can be replaced with another rotor to correspond with a change of rotor 6 at the transmitter.

Heretofore, where synchronizer devices such as 5 and 15 have been employed, the rotors have been designed with the poles or teeth 20 equally distributed around the rotor so as to produce a synchronizing signal wherein all the impulses are of equal duration and are of uniform recurrence. As an example of such a system reference may be had to U. S. Patent No. 1,590,270. In such prior systems, it is relatively easy therefore for an unauthorized person to pick up the transmitted facsimile signals and to determine the frequency of synchronization. This is possible, because in the prior arrangements the synchronizing signal will be revealed by its regularity and substantially single frequency characteristic. In accordance with the present invention, the synchronizing rotors 6 and 16 are provided with the same number of teeth or poles 20, but these teeth are arbitrarily grouped and distributed around the rotor. While Fig. 1 shows the rotors with five teeth, two of which are close together and the other three relatively widely spaced, it will be understood that any other number and arbitrary distribution of the teeth around the rotor may be employed, provided the distribution in the transmitting and receiving rotors is substantially identical. In any event the teeth are so arranged that the spacing between successive teeth progressively varies around the rotor circumference so that synchronism cannot be obtained at a receiver which employs a rotor having equally spaced teeth. Preferably the rotor teeth are arranged so that no regular or uniform teeth spacing occurs over a major part of the rotor circumference. In order that the receiving rotor 16 and the transmitting rotor 6 may correspond as to number and arrangement of teeth they may both be cut during the same cutting operation by the same cutting or punching tool or the like. Thus in the case of laminated rotors the laminations may all be cut at the same time for both the transmitting and receiving rotors with the teeth integral therewith. If desired however one may start with uniformly spaced teeth rotors and remove in any suitable manner the requisite number of teeth at arbitrary intervals with the understanding that the transmitting and receiving rotors are substantially alike. It will also be understood that it is not necessary that all the teeth have

the same peripheral width or pitch so long as the impulses transmitted by the transmitter rotor arrive at the receiving rotor in the proper phase relation with respect to the corresponding teeth on the receiving rotor while rotating, that the said impulses tend to pull the receiving rotor into step or to maintain it in step with the transmitting rotor. When the rotor 16 at the receiver has substantially the same number and arrangement of teeth as the rotor 6 at the transmitter, the proper synchronism is obtained and it is extremely difficult for unauthorized receivers to reproduce an intelligible facsimile.

In order to increase the secrecy factor, one or more additional rotors may be used at the transmitter so that there are impressed upon the line or communicating channel L two or more sets of impulses, but only one of which may be used for synchronization. Such an arrangement is shown in Fig. 2 wherein the parts similar to those of Fig. 1, bear the same designation numerals. In Fig. 2, the shaft 7 in addition to carrying the true synchronizing rotor 6, also carries two other toothed rotors 21, 22, which have their poles or teeth 23, 24, distributed around the respective rotors in different arbitrary arrangements, the distribution being different from the distribution of the teeth on the true synchronizing rotor 6. Each of the rotors 21, 22, has associated therewith a pick-up arrangement in the form of respective magnetic poles 25, 26, and windings 27, 28, which also feed the modulator 4. Consequently, there is impressed upon the line L in addition to the true synchronizing frequency determined by the rotor 6, other sets of impulses determined by the rotors 21 and 22. At the receiver the mechanism is provided with a synchronizing motor 15 having a rotor 16 identical with the true synchronizing rotor 6. Consequently, the rotor 16 will respond only to the frequency and distribution of synchronizing impulses corresponding to rotor 6. The remainder of the system is the same as that of Fig. 1 and further description thereof is not necessary. However, in order to prevent unauthorized interception and reproduction, the rotors 21 and 22 should be coupled to shaft 7 by some kind of coupling having random "play" therein, so that the currents induced in windings 27 and 28 will not be of constant frequency or constant impulse distribution with respect to the scanning rate, but rather of random or fortuitous impulse distribution with respect to time. One manner of accomplishing this is to provide a gearing between each of the rotors 21, 22, and shaft 7, which gearing has considerable "play" between the meshing teeth. Another way is shown in Fig. 4 wherein the shaft 7 has fastened thereto a friction disc 7a upon which is loosely fitted the rotor 21 so that there is a slight clearance between the rotor 21 and the driving disc 7a. However, the rotor 21 normally rests on the disc 7a and is rotated by the frictional engagement therewith, and because of the slip between the members 7a and 21, the latter is rotated at a fortuitous speed. Other equivalent methods may be used for energizing the windings 27 and 28 with fortuitous impulses.

As an additional secrecy factor, the rotors 21 and 22 of Fig. 2, may be coupled to the shaft 7 by variable gear transmissions. Such an arrangement is shown in Fig. 3 wherein the parts corresponding to those of Fig. 2, bear the same designation numerals. In this figure, the rotor 21 is coupled to the shaft 7 by a manually variable

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gear ratio 29 of any well-known construction. Likewise, the rotor 22 is coupled to the shaft 7 by another manually variable gear ratio 30. In this embodiment, the rotors 21 and 22 are likewise attached to their respective shaft portion 7 by means of a variable frictional coupling such as that shown in Fig. 4. Preferably, the gearing arrangements 29 and 30 are such that the speed of rotation of the rotors 21 and 22 may be manually varied at any time during the transmission of the message without affecting the speed of rotation of the true synchronizing rotor 6.

In all the foregoing embodiments, as an additional precaution the scanning drum or other movable scanning element of the transmitter 1 may be driven at a variable speed so that received copy will be distorted in scale unless matched gearing is used at transmitter and receiver. The gearsets may be made readily changeable for altering the coding. The ratio between scanning rate and synchronous rotor speed may be changed at will in the same manner, further complicating the problem of synchronizing an unauthorized receiver. Thus the gearing 3 which connects the driving motor 2 to the rotatable scanning element of the facsimile transmitter and also gearing 13 at the receiver, may be of any well-known variable ratio type, so that the speed of rotation or speed of movement of the scanning element varies from instant to instant according to a definite law. Consequently, the signals from the photo-electric cell of the facsimile transmitter will have a varying scanning frequency and it will not be possible for an unauthorized receiver to determine from these signals the actual speed of the transmitting scanner element. Of course at the receiver, the gearing 13 should be correlated with the gearing 3 so that the scanning drums or movable scanning elements of the machines 1 and 11 are driven at the same speed at any given instant.

While in the foregoing, specific apparatus has been mentioned, it will be understood that various changes and modifications may be made therein without departing from the spirit and scope of the invention. Thus, while the synchronizing impulses are produced by a mechanically rotating member 6, it will be understood that any equivalent electrical means may be employed for generating the synchronizing impulses in cyclically repeated groups but with the individual impulses of the groups arbitrarily spaced. Likewise, while in the systems of Figs. 1, 2 and 3, the current from the device 5 is also used as the carrier for the facsimile signals, it will be understood that the current from the device 5 may be applied to the line L as a separate synchronizing signal. Thus the output of machine 1 may consist of an audio frequency carrier having a random carrier frequency as above mentioned, modulated in accordance with the lights and shades of the successive elemental areas of the subject matter being transmitted. At the same time, the arbitrary synchronizing signals from device 5 are impressed upon the channel L. In such an arrangement preferably the signals from the device 5 are diverted into a separate synchronizing circuit at the receiver in which event the amplifier 10 may be provided with a filter, demodulator or the like to prevent the passage to the receiving machine of the synchronizing signals generated by the device 5. It will be understood of course that instead of transmitting the picture signals and the synchronizing signals over the same line these signals may be transmitted over separate respec-

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tive channels or lines as is well-known in the art. While in the foregoing, the signal from the generator 5 and the signal from the machine 1 are transmitted in the form of an amplified modulated carrier wave, it will be understood that either or both signals may be transmitted by so-called "frequency modulation" as is well-known in the art. In that event, the receiver will also be equipped with frequency demodulators for detecting the frequency modulations corresponding to the synchronizing signal and the frequency impulses corresponding to the facsimile signals. Thus as shown in Fig. 5, the picture current signals from the transmitter machine 1 are applied to any well-known form of frequency modulator 30 whereby the varying amplitude picture signals are translated into corresponding variable frequency signals which preferably are of substantially uniform amplitude. These frequency modulated signals are transmitted to the receiver and are demodulated in any well-known form of frequency demodulator 31, the output of which is suitably amplified and applied to the recording lamp or other element of machine 11. The synchronizing signals picked up in the winding 9 are applied to an amplitude modulator 32 and are transmitted over the transmission channel to an amplitude demodulator 33, the output of which after suitable amplification energizes the winding 18 to control the speed of the driving motor 12. It will be understood of course that in Fig. 5, the picture signals and the synchronizing signals instead of being transmitted over separate channels may be transmitted over the same channel. It will also be understood that in any of the foregoing arrangements, it is not necessary that the picture signals be transmitted in the form of a modulated audio frequency carrier since they may be transmitted directly over the transmission channel as for example over a cable by D. C. transmission. Likewise, the output of machine 1 may be used to modulate directly a radio frequency carrier in which event the transmission channel will be a suitable radio channel. In this event, the arbitrary synchronizing signals may be transmitted over the same radio channel or they may be transmitted as an audio frequency signal over an audio frequency channel.

As another precaution against unauthorized intervention and reception, the main driving motors 2 may be provided with manually variable means so as to adjust during transmission, the speed of the various components in an arbitrary manner at the transmitter. However, as a result of the special synchronizing arrangements disclosed, the receiving motor 12 will be maintained in synchronism with the arbitrarily varied speed of the driving motor 2 at the transmitter.

As a final precaution the subject matter which is being transmitted may be prepared so that it is substantially free from regular lines or patterns from which an unauthorized recipient might determine the manual adjustment of the speed of his receiver to correspond with the regular pattern. Thus in the case of printed or typewritten matter the individual letters normally constituting a line can be printed in irregular line formation so that a minimum regular line pattern appears therein.

What we claim is:

1. In a secrecy signaling system of the type having a signal transmitter and a signal receiver which are to be maintained in motional synchronism; a synchronizing impulse producer at the transmitter, means to rotate said producer to

generate synchronizing impulses having non-uniform spacings between successive impulses, an impulse responder at the receiver, and means to transmit and apply said synchronizing impulses to said impulse responder, said responder locking itself in synchronism with the impulse producer only in response to said non-uniformly spaced impulses.

2. In a secrecy signaling system of the type having a signal transmitter and a signal receiver which are to be rotated in synchronism, a continuously rotating synchronizing impulse producer at the transmitter having a series of impulse producing elements which are spaced to produce impulses with non-uniform time intervals therebetween when the said impulse producer is rotating at substantially uniform speed, a continuously rotating synchronizing impulse responder at the receiver having impulse responding elements corresponding in number and spacing to the elements of the said impulse producer, and means to transmit and apply the impulses from said impulse producer to said impulse responder, said responder locking itself in synchronism with the producer only in response to said non-uniformly spaced impulses.

3. Means for synchronizing between signaling devices comprising a generator for transmitting synchronizing impulses having non-uniform spacing between successive impulses, and a synchronous motor responsive only to said non-uniformly spaced impulses to lock itself in synchronism with said generator.

4. Means for synchronizing between signaling devices comprising a generator for transmitting synchronizing impulses having non-uniform spacing between successive impulses, and a synchronous motor responsive only to said non-uniformly spaced impulses to lock itself in synchronism with said generator both the generator and motor having toothed rotors with the same number and non-uniform spacing of poles.

5. The method of secret signaling between a signal transmitter and a signal receiver which are to be operated in synchronism which includes the steps of generating at the transmitter a secret synchronizing signal in the form of series of impulses having non-uniform impulse spacings therebetween, locking the receiver into synchronism with the transmitter only in response to said non-uniformly spaced impulses, transmitting simultaneously with the synchronizing impulses one or more other series of non-signaling impulses, each of said other series being constituted of a succession of impulses having non-uniform spacings which spacings are different from the spacings of the impulses of said synchronizing signal, at least one of said other series of impulses being generated at a random frequency or impulse distribution with respect to time.

6. The method of secret signaling between a signal transmitter and a signal receiver which are to be operated in synchronism which includes the steps of generating at the transmitter a secret synchronizing signal in the form of series of impulses having non-uniform impulse spacings therebetween, locking the receiver into synchronism with the transmitter only in response to said non-uniformly spaced impulses, transmitting simultaneously with the synchronizing impulses one or more other series of non-signaling impulses, each of said other series being constituted of a succession of impulses having non-uniform spacings which spacings are different from the spacings of the impulses of said synchronizing

signal, and varying the rate of generation of said other sets of impulses during transmission of the signaling impulses.

7. In a facsimile signaling system, a facsimile transmitter machine, a facsimile receiver machine, each of said machines having members arranged to be operated in synchronism, an impulse type current generator associated with the transmitter for generating cyclically recurring series of synchronizing impulses with successive impulses of each series spaced non-uniformly but with each series having the same number of impulses, and an impulse type synchronizing motor associated with the receiver and responsive to said synchronizing impulses for converting said impulses into corresponding cyclically recurring series of electro-mechanical impulses having the same number and impulse spacing as the first-mentioned series.

8. In a facsimile signaling system, a facsimile transmitter machine, a facsimile receiver machine, a rotatable impulse generator associated with said transmitter, a synchronous motor associated with said receiver, said impulse generator arranged to generate recurring series of impulses with successive impulses spaced non-uniformly but with each series having the same number of impulses, and said synchronous motor having its stator and rotor designed so that it runs in synchronism with said generator only when it receives said impulses of non-uniform spacing.

9. In a signaling system of the type having a signal transmitter machine and a signal receiver machine to be maintained in secret synchronism, means to maintain said secret synchronism including a toothed magnetic rotor and an associated magnetic stator for each machine, the teeth on the transmitting rotor being non-uniformly spaced so as to produce synchronizing impulses with non-uniform spacing therebetween, and the teeth on the receiving rotor being likewise non-uniformly spaced to correspond with the spacing on the transmitting rotor, said receiving rotor being locked in synchronism only in response to the receipt of said non-uniformly spaced synchronizing impulse.

10. In a signaling system of the type having a signal transmitter machine and a signal receiver machine to be maintained in secret synchronism therewith, means to maintain said secret synchronism including a rotary inductor at the transmitter for producing series of impulses with the spacing between successive impulses non-uniform, and a similar rotary inductor at the receiver arranged to be locked in synchronism with the transmitter inductor only in response to said non-uniformly spaced synchronizing impulses.

11. A signaling system according to claim 10 in which the rotary inductor at the transmitter has a toothed rotor with the teeth non-uniformly spaced, and the rotary inductor at the receiver has a toothed rotor with the teeth non-uniformly spaced and corresponding to the spacing of the teeth in the transmitting inductor rotor.

12. In a system of the character described, a transmitter having a motor for operating the same to produce message signal impulses, a rotary inductor driven by said motor for producing cyclically recurring series of synchronizing impulses with successive impulses non-uniformly spaced and with each series having the same number of impulses, and at least one other rotary inductor also driven by said motor and producing non-

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signaling impulses with successive impulses non-uniformly spaced and with the spacing different from that of the synchronizing impulses.

13. A system according to claim 12 in which said non-signaling impulses are generated at a random impulse distribution.

14. In a facsimile signaling system a movable scanning member, means to move said member in a scanning motion and for varying the speed of said member from time to time during scanning, a synchronizing impulse generator associated with said scanner for generating synchronizing impulses in cyclically recurring series with the impulses having non-uniform spacings therebetween but with each series having the same number of impulses.

15. In a facsimile signaling system a rotatable scanning drum, a motor for driving said drum, means between said motor and drum for varying the speed of the drum from time to time during scanning, a synchronizing impulse generator locked to the speed of said motor and arranged to generate synchronizing signals in the form of cyclically recurring series of current impulses having non-uniform spacings therebetween but with each series having the same number of impulses.

16. The method of secret signaling between a transmitter and a receiver each of which has elements to be operated in synchronism which in-

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cludes the steps of transmitting the signals from the transmitter to the receiver by frequency modulation, secretly synchronizing the transmitter and the receiver by transmitting secret synchronizing signals in the form of a series of current impulses having non-uniform spacings therebetween, and locking the receiver in synchronism with the transmitter only in response to said non-uniformly spaced impulses.

17. The method of secret signaling according to claim 16 in which the synchronizing signals are also transmitted by frequency modulation.

18. In a facsimile signaling system, the method of synchronizing a facsimile transmitting machine with a receiving machine while maintaining secrecy of transmission, which includes the steps of transmitting synchronizing signals between the machines in the form of cyclically recurring series of current impulses with non-uniform spacings therebetween but with each series having the same number of impulses, and simultaneously transmitting over the same channel as the synchronizing signals other non-synchronizing and non-signaling impulses having random frequency and non-uniform spacings between impulses which frequency and spacing are different from those of the synchronizing signal impulses.

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