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Sept. 29, 1925. 1,555,633.

L. BURCH ET AL

SECRET SIGNALING SYSTEM

Filed Dec. 9, 1922 2 Sheets-Sheet 1

Fig. 1.

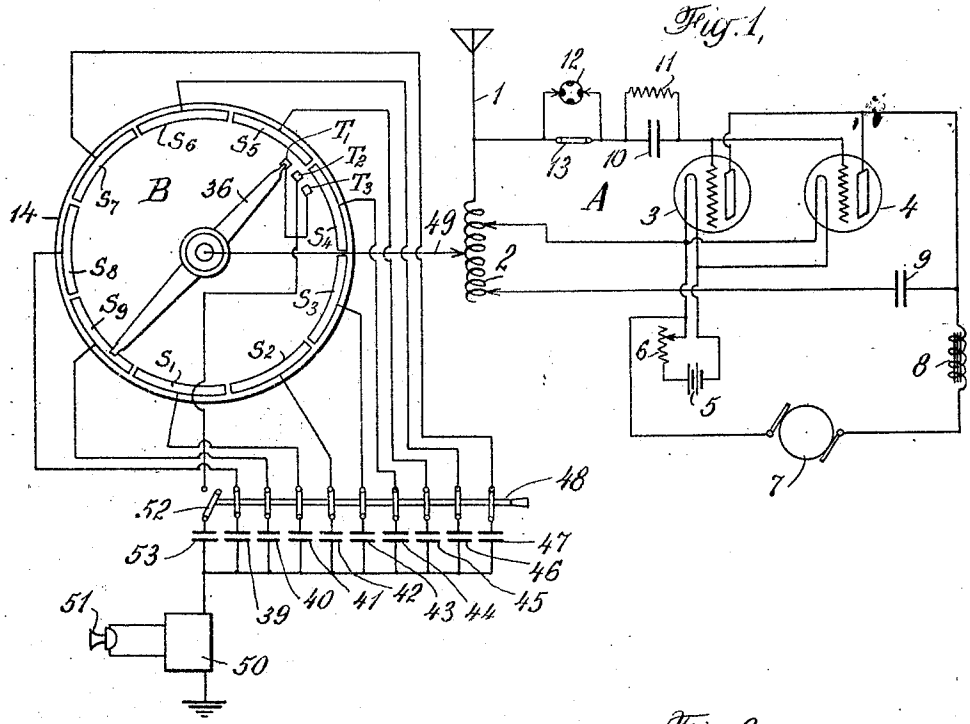
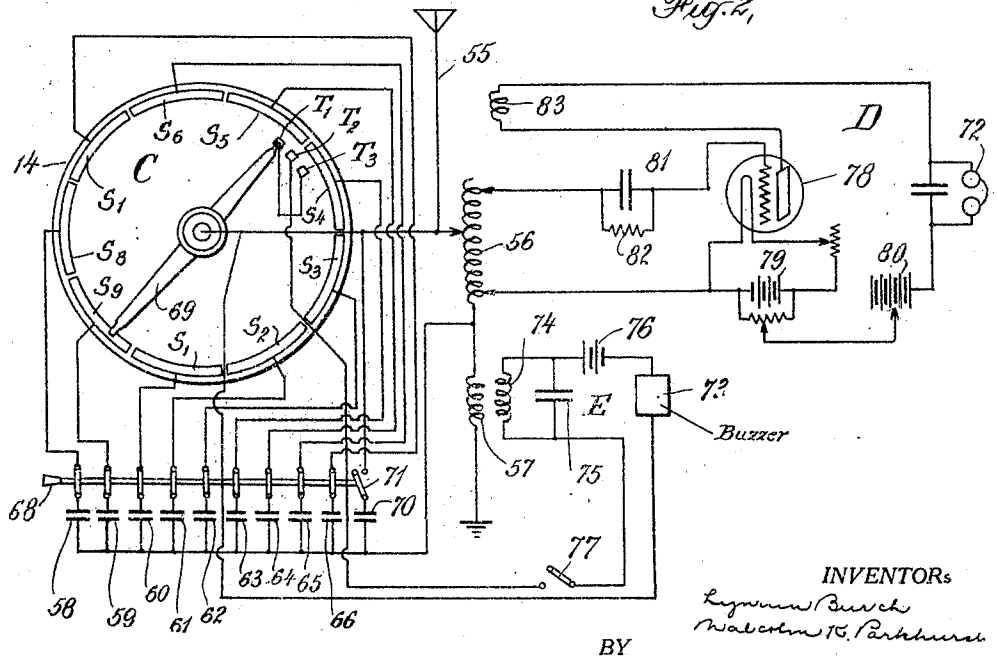


Fig. 2.



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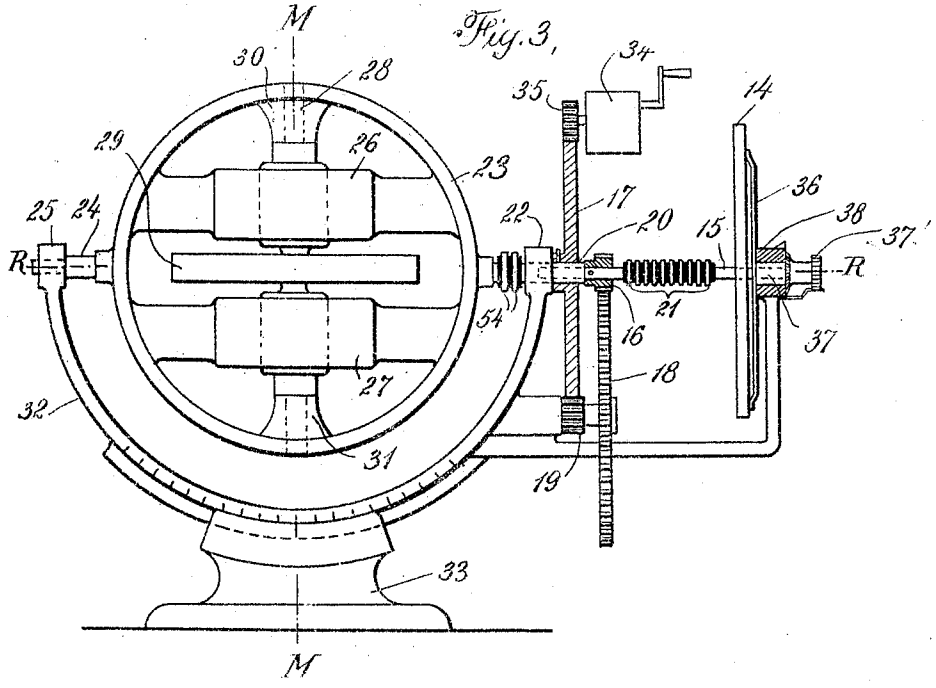
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Fig. 3.



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UNITED STATES PATENT OFFICE.

LYNDEN BURCH, OF BELLEVILLE, NEW JERSEY, AND MALCOLM K. PARKHURST, OF NEW YORK, N. Y.

SECRET SIGNALING SYSTEM.

Application filed December 9, 1922. Serial No. 605,843.

To all whom it may concern:

Be it known that we, LYNDEN BURCH and MALCOLM K. PARKHURST, both citizens of the United States, residing at Belleville, in the county of Essex and State of New Jersey, and New York city, in the county of Bronx and State of New York, respectively, have invented certain new and useful Improvements in Secret Signaling Systems; and we do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to secret signaling systems such as telegraph and telephone systems, and is directed, more particularly, to a system for secret intercommunication between radio stations.

Systems for accomplishing secret radio communication by means of periodic wave length changes at the transmitting station have heretofore been proposed, but in each instance, so far as it has been ascertained, the arrangement has been such that either a comparatively simple receiving apparatus which could be readily constructed and operated by anyone skilled in the art was capable of defeating the purpose of the proposed system; or the receiving apparatus was so complicated as to render it impracticable for tuning.

According to the former type of arrangement referred to, the transmitting station was designed to operate on two wave lengths alternately, and the receiving station was provided with a receiving apparatus capable of responding to two wave lengths simultaneously. Receiving apparatus of that character is very easy to construct, and it is therefore a simple matter for would-be eavesdroppers to defeat the purpose of such a system. The second type of arrangement referred to is merely an extension of the first, and differs therefrom only in that a larger number of wave lengths were transmitted in seriatim. Receiving apparatus of the latter character was designed to be responsive to all of the several transmitted wave lengths concurrently. Receiving apparatus of this character, where a large number of wave lengths are employed, is extremely complex and difficult to adjust. In fact, it amounts practically to an aggregation of receiving stations equal in number to the number of wave lengths employed. For example, if say six wave lengths were employed, it was necessary to provide receiving apparatus which was practically equivalent to six separate receiving stations, all of which were necessarily operated simultaneously. With a greater number of wave lengths a still more complex receiving equipment was of course necessary. Those skilled in the manipulation of radio receiving apparatus will readily appreciate the practical difficulty involved in the operation of such receiving equipment.

It is accordingly the principal object of the present invention to provide an efficient secret signaling system, and more especially a secret radio signaling system, which is comparatively simple in structure and manipulation but highly effective in accomplishing secret communication.

In pursuance of the foregoing object a further object is to provide means whereby mechanisms at two or more distantly separated stations which are not interconnected mechanically or electrically can be operated and maintained in substantially exact synchronism.

The invention resides, generically, in the utilization of gyroscopes or other equivalent mechanisms which are responsive in operation to the rotation of the earth for maintaining synchronizing mechanisms or the like in synchronous cooperation.

More specifically the principal feature of the invention consists in the provision of gyroscopically-controlled periodically changing signaling devices at each of two or more signaling stations as, for instance, radio stations, whereby the several stations are maintained in synchronous cooperative relation and whereby secret communication may be maintained between the stations.

As applied to secret radio communication, the invention in its preferred embodiment contemplates the provision at distantly separated transmitting and receiving stations of switching or other means for periodically changing the operating wave length and gyroscopically-controlled mechanisms at both stations for maintaining the switch or other wave length changing means in substantially exact synchronism so that the receiving station is able to uninterruptedly receive in-

coming signals on periodically changing wave lengths from the transmitting station.

It is a well-known phenomenon that a gyroscope having two axes of rotation at right angles, if properly positioned with relation to the axis of rotation of the earth, will, in effect, make exactly one revolution in twenty-four hours about one of its axes. This phenomenon is due to the fact that the gyroscope rotor when rotating tends to constantly maintain its axis of rotation parallel to any plane in space in which it may be when set in rotation, while the rotation of the earth carries the supporting structure of the gyroscope completely around one of its axes once in the course of a complete revolution of the earth, or, in other words, once in twenty-four hours. This slow rotation of the gyroscope about what will, for convenience, be termed the secondary axis, is then a function of the earth's rotation, and is at the same rate of speed irrespective of the place where the gyroscope may be located.

The present invention utilizes this gyroscopic phenomenon for controlling the operation of duplicate wave length changing switches at the transmitting and receiving stations in such a way that the tuning of the receiving apparatus is changed periodically in substantially exact synchronism with the periodic changes of operating wave length at the transmitting station.

Another feature of the invention relates to the means employed for initially synchronizing the receiving station with the transmitting station. This consists of an arrangement at the transmitting station for periodically transmitting a characteristic tuning signal and an arrangement at the receiving station for locally duplicating the tuning signal or signals in duration and period, but, preferably, not in tone. Both the incoming and local tuning signals may be heard at the receiving station when the two stations are not synchronized, but the arrangement is such that when the two stations are synchronized the incoming and local tuning signals occur simultaneously and are therefore not capable of being distinguished from one another. This initial synchronization is brought about through the medium of an adjustable contactor forming a part of the wave length changing switch at the receiving station.

The invention is not limited in its utility to radio signaling systems, but is equally useful in other types of signaling systems as, for instance, in the multiplex printing telegraph art, wherein a plurality of messages are transmitted over a line simultaneously, and in which systems the transmitting and receiving stations are, at present, maintained in synchronism by means of tuning forks.

The preferred embodiment of the invention as applied in a secret radio signaling system is described in detail hereinafter and illustrated in the accompanying drawings which form a part of this specification.

With reference to the drawings,

Fig. 1 is a circuit diagram of a radio telephone transmitter in accordance with the invention;

Fig. 2 is a circuit diagram of a radio telephone receiver which is adapted to cooperate with the transmitter of Fig. 1; and

Fig. 3 is a side elevation partly in cross section of a switching mechanism including a gyroscope adapted for periodically changing the operative wave length at both the transmitter and receiver.

The transmitting station of Fig. 1 comprises an antenna ground circuit 1 including a loading inductance coil 2, a generator of undamped oscillations A, and a continuously operable wave length changing switch B.

The oscillation generator A includes two three-element vacuum tubes 3 and 4 connected in parallel and each comprising a filament, a grid and a plate. A battery 5 supplies current through the rheostat 6 for heating the filaments of both tubes, and a direct current generator 7 is connected in the filament-plate circuit for supplying space current to the tubes. A choke coil 8 is inserted in the filament-plate circuit for smoothing out irregularities in the current from the generator 7. Condenser 9 functions as a by-pass for high frequency currents in the filament-plate circuit. The inductance coil 2 is common to both the filament-plate circuit and the filament-grid circuit, and operates as a feed-back connection whereby the circuit is rendered oscillatory. The function of the grid condenser 10 is to negatively bias the potential of the grid; and grid leak resistance 11 operates to prevent the accumulation of an excessive potential on the grid.

An interrupter or chopper 12 is inserted in the grid conductor 10, but is normally shunted by switch 13. The interrupter 12 is designed to interrupt the grid circuit at a suitable tone frequency for the purpose of transmitting audible tuning signals, as will be referred to hereinafter.

The wave length changing switch B, shown schematically in Fig. 1 and in considerable detail in Fig. 3, comprises a commutator 14, having, in this instance, nine insulated metal segments S_1 to S_9 inclusive, and three smaller segments T_1, T_2 and T_3, which may be conveniently referred to as tuning segments.

Referring to Fig. 3, the commutator 14 is rigidly secured to shaft 15, to which is also secured a pinion 16. Shaft 15 is driven by gear 17 through the medium of the intermediate gear 18 and pinion 19. A suitable gear speed ratio between gear 17 and pinion 19 and likewise between gear 18 and pinion 16 is 1:40, and the resultant ratio between

gear 17 and pinion 16 is 1:1600. Gear 17 is rigidly secured to shaft 20, which is bored at its end to form a bearing for shaft 15 which is journaled therein.

Ten metallic collector rings 21 are shown mounted on shaft 15. These are, of course, insulated from each other and from the shaft. Each of nine of these collector rings is individually connected to a segment S_1, S_2, etc., and the remaining collector ring is connected to the tuning segments T_1, T_2 and T_3 in parallel. These connections are not shown, but it will be understood that suitable conductors for this purpose may be readily provided.

Shaft 20 is journaled in bearing 22 and is secured to the rotor ring 23 of the gyroscope. Shaft 20 and the bearing stud 24, which is journaled in bearing 25, are coaxial with what was referred to hereinbefore as the secondary axis of rotation of the gyroscope. This axis is identified by the reference letters R—R.

A pair of electric motors 26 and 27 have their armatures mounted on a shaft 28, on which is also mounted the gyroscope rotor 29. Shaft 28 is journaled in bearings 30 and 31, forming a part of the rotor ring 23. A pair of collector rings 54 are provided for effecting electrical connections to the motors 26 and 27.

The entire mechanism of the gyroscope and wave length changing switch so far described is carried by the semi-circular yoke 32, which in turn is mounted on the pedestal 33, and is angularly adjustable thereon, as may be inferred from the calibrations on the yoke.

In accordance with one of the well-known laws governing the action of gyroscopes, the rotor 29, when rotating at a considerable speed, will tend strongly to maintain its axis of rotation parallel to any plane in which it may happen to be initially set. If then the axis R—R is set approximately parallel in all planes to the axis of rotation of the earth, the rotor ring 23 will in effect make exactly one revolution about the axis R—R in the time required for the earth to make one revolution, that is substantially twenty-four hours. As a matter of fact, assuming the axis R—R to be set exactly parallel to the axis of rotation of the earth, the rotor ring remains in a fixed relative plane while the rotation of the earth carries the yoke 32 and pedestal 33 around the axis R—R. The term "fixed relative plane" is intended to convey the idea of a plurality of parallel planes. This action of the gyroscope, however, is not apparent to the observer, and for all practical purposes it may be said that the ring 23 rotates about the axis R—R once for each revolution of the earth. It follows then that since a gear ratio of 1:1600 is interposed between the rotor ring 23 and the commutator 14, the latter will rotate at the rate of 1600 revolutions in twenty-four hours or 1.111 R. P. M., and since the commutator in this instance is provided with nine segments, there will be $9 \times 1.111 = 9.999$, or approximately ten wave length changes per minute.

On account of the large gear ratio employed, a very considerable torque is required to turn the shaft 20, and a gyroscope of considerable proportions would be required to supply such a torque. Therefore, in order to make it possible to utilize a relatively small gyroscope, it is proposed to use an auxiliary driving motor as, for instance, a spring motor 34, which engages gear 17 through the medium of pinion 35. The auxiliary motor 34 is preferably designed to apply just enough force to the gear 17 to balance the load so that the gyroscope has practically no load to carry. Thus the size of the gyroscope may be reduced to a minimum and its function may be substantially that of a governor only. While the auxiliary motor 34 is very desirable, it does not constitute an absolutely essential element of the invention.

Contact wiper arm 36 is insulatively secured to the sleeve 37, which is bored to receive the right hand end of shaft 15, the latter being journaled therein, and is provided with a knob 37′ whereby the contact wiper arm 36 may be manually rotated relative to the commutator 14. This provision for adjusting the contact wiper arm is useful more particularly at the receiving station for effecting initial synchronism, but it may also be employed to good advantage at the transmitting station, although it is not indispensable there.

Referring again to Fig. 1, the transmitting wave length changes are effected by periodically varying the reactance of the antenna ground circuit 1, and for this purpose condensers 39 to 47 inclusive of different capacities may be conveniently utilized. Each of these condensers is connected through a blade of switch 48 to a commutator segment S_1, S_2 . . . S_9 respectively, these connections being made through the medium of corresponding collector rings 21 (Fig. 3) and suitable brushes which are not shown. A conductor 49 establishes a connection between contact wiper arm 36 and inductance coil 2. If the invention be applied to radio telephony, any suitable modulator or system of modulation as, for instance, a magnetic modulator 50, may be inserted in the ground lead of the antenna ground circuit together with a microphone 51, which would ordinarily be provided in conjunction therewith.

From the foregoing description it will be quite readily understood that in operation the commutator 14 is rotating at a uniform speed under the control of the gyroscope and

that one end of the contact wiper arm engages the segments S_1, S_2, etc., successively, thereby connecting in the condensers 39 to 47 in seriatim, and accordingly changing the operating wave length periodically. In normal operation switches 48 and 13 are set in the positions shown.

It is, however, necessary to initially synchronize the receiving station with the transmitter, and for this purpose the three tuning segments T_1, T_2 and T_3 are provided. These tuning segments may be connected into the antenna ground circuit in series with condenser 53 by throwing switch 48 into a position wherein switch blade 52 engages its fixed contact. With switch 48 thus thrown into its off-normal position, it will be seen that for each revolution of the commutator, three impulses are transmitted into the ether, one for each segment T_1, T_2 and T_3. If switch 13 is open, the high frequency waves constituting each of these three impulses are chopped into audible frequency groups, as is sometimes done in the case of undamped wave telegraphy.

The receiving station shown schematically in Fig. 2 includes a tuning switch C, which may be structurally the same as the wave length switch B of Figs. 1 and 3; and a detector circuit D, which may be of the simple single tube regenerative type shown, or of any other suitable type, as will be readily apparent. The antenna ground circuit 55 includes a variable inductance coil 56, and may include a second coil 57 which functions in connection with the operation of initially synchronizing the receiving station with the transmitter. The tuning of this receiving circuit in accordance with the periodic changes of wave lengths transmitted is accomplished by connecting condensers 58 to 66 inclusive, in seriatim, in parallel with the inductance coil 56.

Each of the last-mentioned condensers is connected through a blade of switch 68 to one of the segments S_1, S_2, etc., and it will be readily apparent from an examination of the circuit that each of these condensers is brought into operation when its corresponding segment is engaged by the contact wiper arm 69. The capacity of condenser 70 is suitable for tuning the circuit for the reception of the previously-mentioned tuning signals. In order to receive these signals, switch 68 is thrown out of the normal position in which it is shown into its off-normal position, wherein switch blade 71 engages its fixed contact and whereby condenser 70 is connected in circuit. The periodic tuning signals from the transmitting station may then be heard in the telephone 72. For the purpose of synchronizing the tuning switch C with the wave length changing switch D at the transmitting station, an auxiliary buzzer circuit E is provided at the receiving station. This comprises a buzzer 73 having an audible tone frequency, a suitable inductance coil 74 in inductive relation to the coil 57, a condenser 75, and a battery or other source of current 76. A switch 77 is provided for closing the buzzer circuit. With the latter switch closed, the buzzer circuit is extended to the tuning segments T_1, T_2, T_3, and thence through the contact wiper arm, and is closed each time the contact wiper arm engages one of the tuning segments. Since there are three tuning segments, the buzzer 73 is operated three times in succession for each revolution of the commutator 14. It will now be quite readily apparent that if the wave length changing switch B at the transmitter and the tuning switch C at the receiver are not synchronized, both the incoming tuning signals and the locally generated tuning signals which are set up by the buzzer 73 will be heard in the telephone 72. By turning the knob 37' (see Fig. 3) the contact wiper arm 69 at the receiving station may be rotated until the local tuning signals and the incoming tuning signals are exactly blended. When thus adjusted, the two stations will be in substantially exact synchronism, and the switches 68 and 77 at the receiving station and switches 48 and 13 at the transmitting station may be restored to their normal positions. The two stations will then remain in exact synchronism indefinitely, due to the exact control of the gyroscopes.

The detector circuit D comprises a three-element vacuum tube 78, a filament battery 79, a filament-plate circuit battery 80, a grid condenser 81, a grid leak resistance 82, and a tickler coil 83. This is a simple circuit of the well-known regenerative type, and it is thought that its operation will require no explanation.

An attempt has been made herein to illustrate and describe this invention in its simplest terms. It will no doubt be recognized by those skilled in the art that in practice it might be expedient to elaborate somewhat upon the circuit shown. For instance, it will be readily recognized that more than one adjustment might be desirable at both the transmitter and receiver. This would probably require one or more additional commutators and associated contact wiper arms on the shaft 15 at each station. Furthermore, the receiving station would in all probability be provided with two or more stages of amplification.

Means other than gyroscopes which are capable of utilizing the rotational effect of the earth for the purpose of maintaining synchronism as, for instance, a pendulum, are considered for the purpose of this invention as being equivalent to a gyroscope.

Many modifications of the present invention will be readily apparent to those skilled

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in the art, and it is not desired that the invention be construed as limited except by the scope of the appended claims.

We claim:

1. In a signaling system, transmitting apparatus, receiving apparatus, and means including a gyroscope for mutually synchronizing the operation of said transmitting and receiving apparatus.

2. In a signaling system, signal transmitting apparatus, and a gyroscope for controlling the operation of said transmitting apparatus.

3. In a signaling system, receiving apparatus, and a gyroscope for controlling the operation of said receiving apparatus.

4. In a signaling system, signaling apparatus, and means for periodically changing the operating characteristics of said apparatus, said means including a gyroscope.

5. In a signaling system, a high frequency transmitting station having means for periodically changing its operating frequency, a high frequency receiving station for cooperating with said transmitting station having means for periodically changing its operating frequency, and means controlled by the rotation of the earth for synchronizing the operation of said first and second means.

6. In a signaling system, a transmitting station, a receiving station, and means controlled by the rotation of the earth for maintaining said stations in communicative relation to each other.

7. In a wave signaling system, a high frequency transmitting station, a high frequency receiving station, means at each of said stations for periodically changing their respective operating frequencies, means for initially synchronizing said receiving station with said transmitting station, and means responsive to the rotation of the earth for controlling both of said first-mentioned means whereby said stations are maintained in synchronism.

8. In a wave signaling system, a high frequency station, means for periodically changing the operating frequency of said station, and means responsive to the rotation of the earth for controlling the operation of said first means.

9. In a signaling system, a transmitting station, a receiving station, said stations being adapted to cooperate only when one is operatively adjusted with respect to the other, means for continuously varying the operative adjustment of said stations, and controlling means for said first means whereby said stations may be continuously maintained in cooperative adjustment.

10. In combination with signaling apparatus, means operable for controlling the operation of said signaling apparatus in a predetermined manner, and means responsive to the rotation of the earth for maintaining the operation of said first means at a uniform time rate.

11. In combination with signaling apparatus, means operable for controlling the operation of said signaling apparatus in a predetermined manner, and means including a gyroscope for maintaining the operation of said first means at a uniform time rate.

12. In combination with signaling apparatus, means operable for controlling the operation of said signaling apparatus in a predetermined manner, and means responsive to the rotation of the earth for controlling the operation of said first means in accordance with a predetermined time factor.

13. In a signaling system, signal propagating means, means for changing the character of the propagated signals in accordance with a predetermined time factor, and means responsive to the rotation of the earth for controlling said first means in accordance with said time factor.

14. In a signaling system, signal propagating means, means for changing the character of the propagated signals in accordance with a predetermined time factor, and means including a gyroscope for controlling said first means in accordance with said time factor.

15. In a signaling system, high frequency signal propagating means, means for changing the frequency of the propagated signals in accordance with a predetermined time factor, and means including a gyroscope for controlling said first means in accordance with said time factor.

16. In a signaling system, a plurality of high frequency stations, means for periodically varying the operating frequency of said stations, and means responsive to the rotation of the earth for synchronizing the periodic variations of said stations.

17. In a signaling system, a transmitting station having means for generating and transmitting signaling waves of a plurality of frequencies, a switching mechanism at said transmitting station for periodically changing the frequency of the signaling waves, a receiving station having means for receiving and indicating the signaling waves from said transmitting station, a switch mechanism at said receiving station for periodically changing the tuning of said receiving means, said switching mechanisms when operated in synchronism being adapted to maintain said stations in communicative adjustment, and means whereby said switching mechanisms are mutually controlled by the earth, in its rotation, and thereby maintained in synchronism.

18. In a signaling system, a transmitting station having means for generating and transmitting signaling waves of a plurality

of frequencies, a switching mechanism at said transmitting station for periodically changing the frequency of the signaling waves, a receiving station having means for receiving and indicating the signaling waves from said transmitting station, a switching mechanism at said receiving station for periodically changing the tuning of said receiving means, said switching mechanism when operated in synchronism being adapted to maintain said stations in communicative adjustment, and means including a gyroscope at each of said stations for maintaining said switching mechanisms in synchronism.

19. In a signaling system, a transmitting station having means for generating and transmitting signaling waves of a plurality of frequencies, means for periodically changing the frequency of the signaling waves, a receiving station having means for receiving and indicating signaling waves from said transmitting station, means for periodically changing the tuning of said receiving station in accordance with the frequency changes of the signaling waves transmitted from said transmitting station, means at said transmitting station for transmitting a tuning signal, and means at said receiving station for adjusting, in accordance with said tuning signal, said means for periodically changing the tuning of said receiving station.

20. In a signaling system, a high frequency transmitting station, means continuously operable during the operation of said transmitting station for periodically changing the frequency of the transmitted signals, a receiving station comprising high frequency signal receiving apparatus, means continuously operable during the operation of said receiving station for periodically changing the tuning of said receiving apparatus whereby said receiving station may be maintained in operative synchronism with said transmitting station, means at said transmitting station for transmitting a characteristic tuning signal at regular intervals, and means at said receiving station for synchronizing said second-mentioned means with said first-mentioned means, said synchronizing means being operable in conjunction with said tuning signal.

21. In a signaling system, a high frequency transmitting station comprising a generator of high frequency signaling waves, a continuously operable permutation switch, circuit connections between said generator and said permutation switch whereby said switch is adapted to periodically change the operating frequency of said generator, and means responsive to the rotation of the earth for maintaining the operation of said permutation switch substantially constant.

22. In a signaling system, a high frequency transmitting station comprising a generator of high frequency signaling waves, a continuously operable permutation switch, circuit connections between said generator and said permutation switch whereby said switch is adapted to periodically change the operating frequency of said generator, and means including a gyroscope for maintaining the operation of said permutation switch substantially constant.

23. The combination with a continuously movable switching device of means including a gyroscope for maintaining said device in operation at constant speed.

24. The combination with a continuously movable switching device of a gyroscope having a major axis of rotation and a secondary axis of rotation, and means responsive to the rotation of said gyroscope on said secondary axis of rotation for maintaining said switching device in operation at constant speed.

25. In combination, a switching mechanism having a fixed contacting member and a movable contacting member, a gyroscope so disposed with respect to the axis of the earth that it will rotate on one of its axes relatively to the earth at a uniform speed dependent upon the rotation of the earth, and means for utilizing said rotation of the gyroscope for imparting a uniform movement to said movable contacting member.

26. In a signaling system, a high frequency transmitting station comprising means for generating high frequency signaling waves, a permutation switch at said transmitting station for periodically changing the operating frequency of said generating means, said switch including means adapted for transmitting characteristic tuning signals at regular predetermined intervals, a receiving station comprising means for receiving and indicating the signaling waves from said transmitting station, a permutation switch at said receiving station for periodically changing the tuning of the receiving means thereat in synchronism with the changes in operating frequency at said transmitting station, said last-mentioned permutation switch including means for indicating synchronism between said stations in accordance with said tuning signals.

27. In a signaling system, a high frequency transmitting station, a high frequency receiving station, a continuously movable switching mechanism at said transmitting station for periodically changing the operating frequency thereof, a continuously movable switching mechanism at said receiving station for periodically changing the tuning of said receiving station in synchronism with the changes in the operating frequency of said transmitting station, said switching mechanism at said transmitting station being operable to effect the transmission of char-

acteristic tuning signals at regular predetermined intervals consonant with the periodic frequency changes at said transmitting station, a local source of tuning signals comprising a circuit and source of current at said receiving station, said switching mechanism at said receiving station being operable to close the circuit of said local source at predetermined intervals and durations corresponding with the intervals and durations of the transmitter tuning signals, means for adjusting the switching mechanism at said receiving station for effecting initial synchronism between said stations, means at said receiving station for detecting and indicating both incoming and local signals, the arrangement being such that when the local tuning signals are indicated at the receiving station simultaneously with the incoming tuning signals, said stations are in synchronism, and means for maintaining said stations in synchronism.

In testimony whereof we affix our signatures.

LYNDEN BURCH.
MALCOLM K. PARKHURST.