Apr. 10, 1923. 1,450,966

H. A. AFFEL

SYNCHRONIZING SYSTEM

Filed Sept. 30, 1919 2 sheets-sheet 1

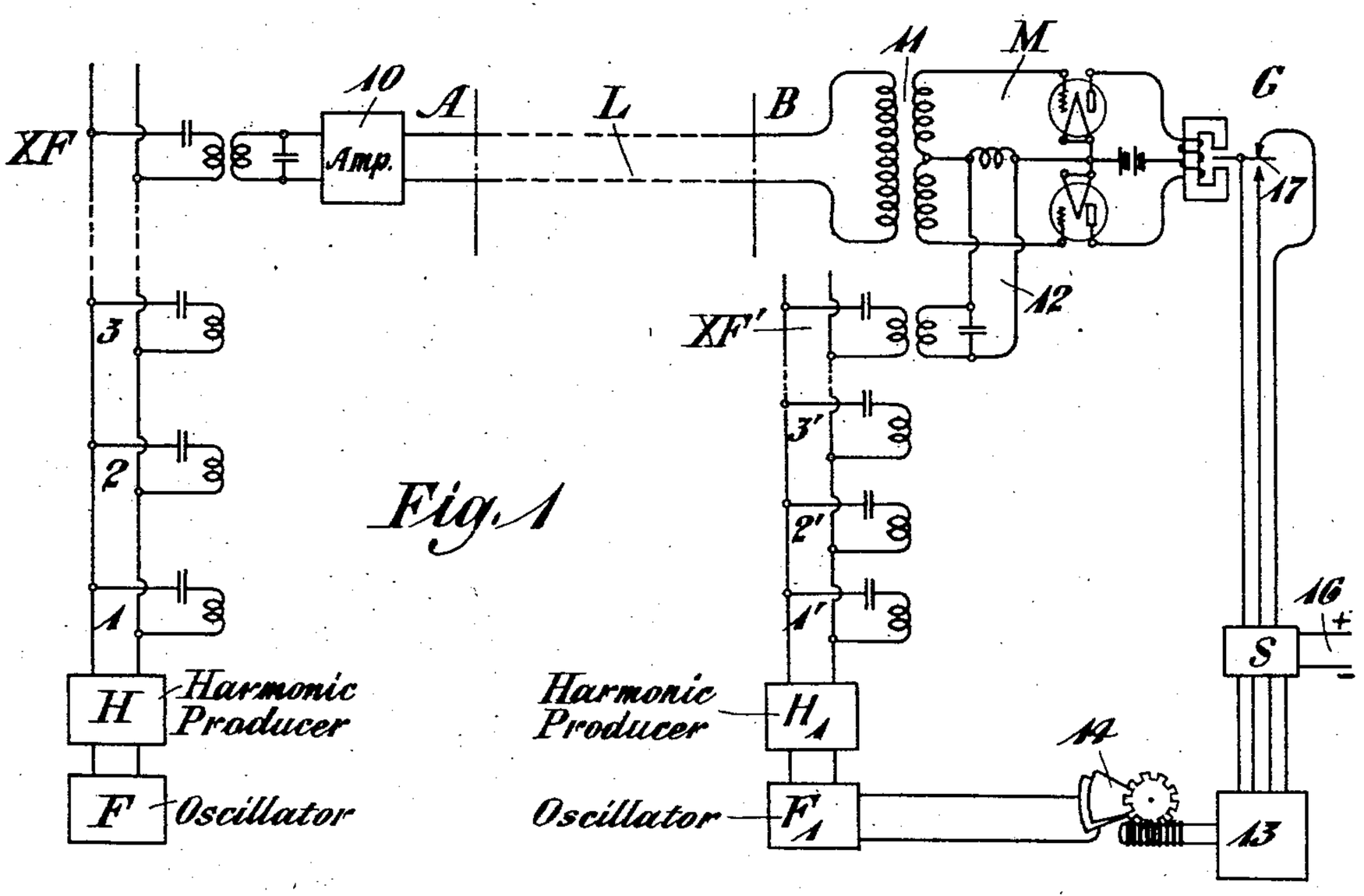

Fig. 1

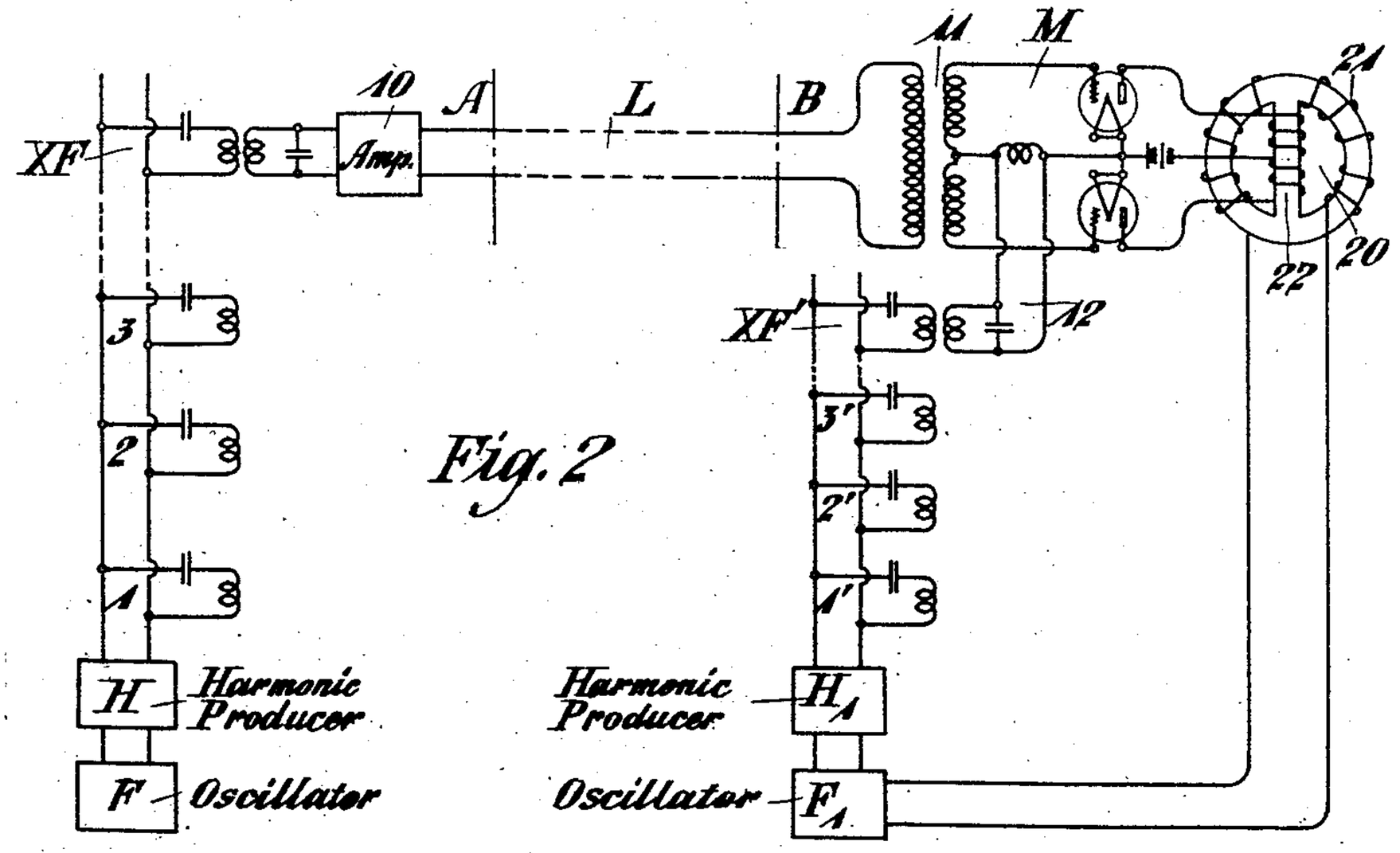

Fig. 2

INVENTOR.
H. A. Affel
BY C. C. Rose
ATTORNEY

Apr. 10, 1923. 1,450,966

H. A. AFFEL

SYNCHRONIZING SYSTEM

Filed Sept. 30, 1919 2 sheets-sheet 2

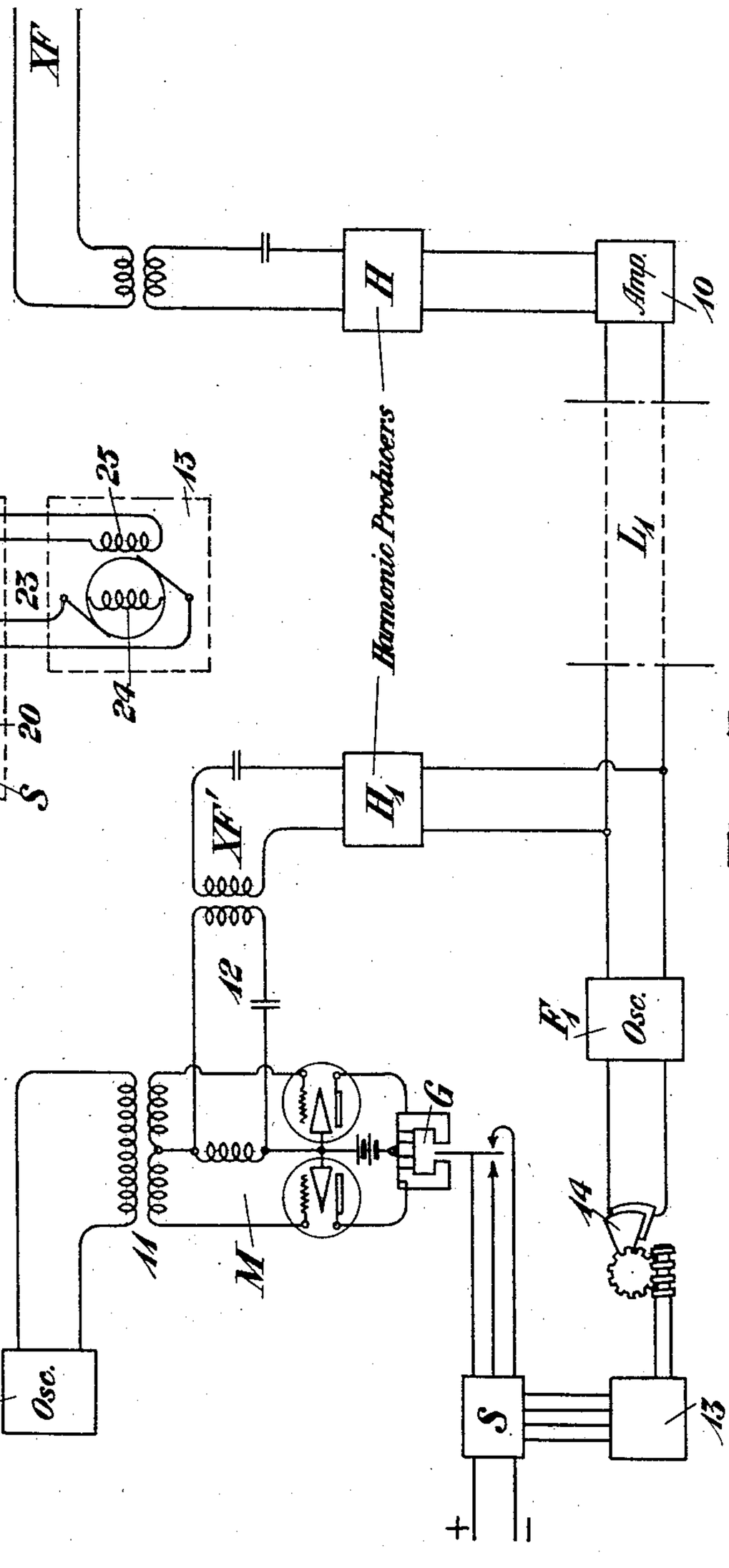

Fig. 3

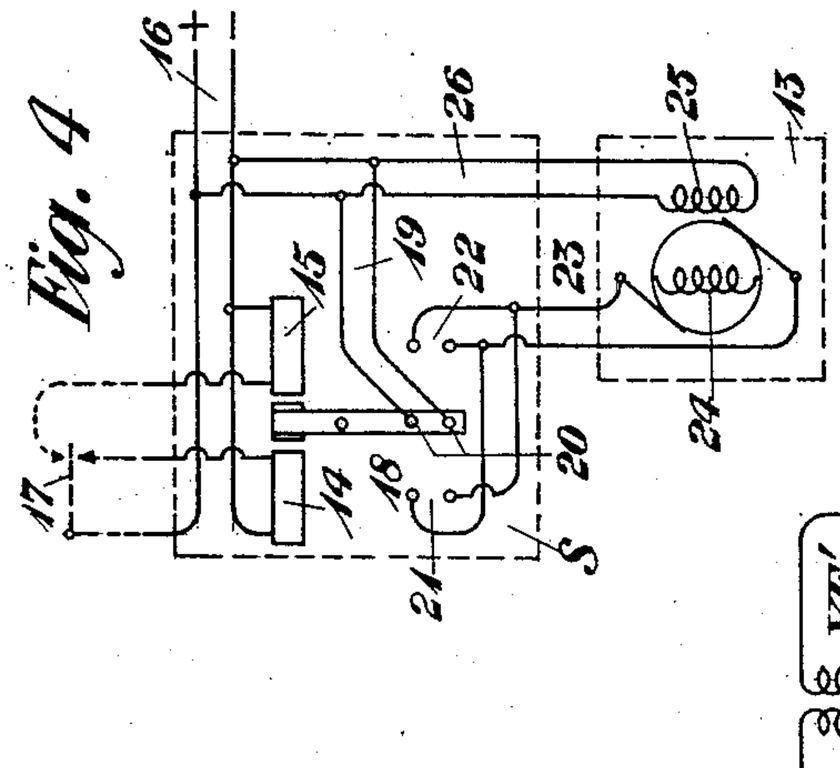

Fig. 4

INVENTOR.
H.A. Affel
BY
ATTORNEY.

Patented Apr. 10, 1923. 1,450,966

UNITED STATES PATENT OFFICE.

HERMAN A. AFFEL, OF BROOKLYN, NEW YORK, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

SYNCHRONIZING SYSTEM.

Application filed September 30, 1919. Serial No. 327,459.

To all whom it may concern:

Be it known that I, HERMAN A. AFFEL, residing at Brooklyn, in the county of Kings and State of New York, have invented certain Improvements in Synchronizing Systems, of which the following is a specification.

This invention relates to means for producing synchronism and isochronism between the alternating currents supplied from independent sources.

One of the features of the invention resides in the provision of means whereby the current supplied from one alternating current source may be automatically maintained at the same frequency and in the same phase relation with respect to currents supplied from another source.

Another feature of the invention resides in the provision of means whereby the frequency and phase angle of a locally supplied alternating current adapted to be used in connection with the production of carrier frequencies for a multiplex system may be maintained in the same relation with respect to a carrier current received from a distant signaling station.

The above features, as well as other features of the invention more fully appearing hereinafter, are realized in the arrangements set forth in the following description and illustrated in the accompanying drawing, Figures 1, 2 and 3 of which constitute circuit diagrams of different embodiments of the invention, and Figure 4 of which is a diagram of one of the switching arrangements employed in connection with the invention.

Referring to Figure 1, F designates a source of alternating current which may be, for instance, a vacuum tube oscillator. If this source is to be used in connection with a multiplex carrier system, the various carrier frequencies of the system may be produced from the fundamental frequency supplied by the oscillator F, by impressing the oscillations upon a harmonic producer H, which is an apparatus of well known character. This apparatus may be, for instance, a distorting tube arrangement of a type well known in the art. As a result of the action of the harmonic producer, harmonics of the fundamental frequency supplied to the oscillator F are furnished to the output circuit and the first, second and third harmonics, respectively, may be selected by means of the tuned circuits designated 1, 2 and 3.

At the receiving station B, a similar oscillator F_1 may be provided for supplying the same frequency as that supplied by the oscillator F, at the station A. In practice, although the two sources may be adjusted to supply the same frequency, there will be a tendency for one or the other to slowly change its frequency, so that the phase relation between the wave supplied will gradually change and utilmately a material difference in frequency will occur.

It is one of the purposes of the present invention to overcome this difficulty, so that the phase relation and frequency relation may be maintained the same between the two sources.

The frequency supplied by the source F_1 may be impressed upon a harmonic producer H_1, similar to the harmonic producer H, so that harmonics of the fundamental frequency will result. Of these harmonics, the first, second and third may be selected by means of the tuned circuits designated as 1′, 2′ and 3′, respectively, for use as carrier currents of a multiplex system. These harmonics, as well as the corresponding harmonics supplied at the station A, may be transmitted over a common transmission line, such as, for instance, the line L, in a well known manner. The details of the multiplex apparatus whereby this may be accomplished form no part of the present invention, however, and are accordingly not illustrated.

In order to maintain the proper frequency and phase relations between the source F and F_1, one of the harmonics of the fundamental frequency produced by the source F may be selected by means of the tuned circuit XF and supplied to an amplifier 10, associated with the line L. This amplifier may be of any well known type, such as, for instance, a vacuum tube amplifier. The selected harmonic, after being amplified, is transmitted over the line L to the receiving station B, where it may be impressed upon a modulating apparatus M. This modulating apparatus may be of any well known type, but as illustrated is a duplex vacuum tube modulating apparatus of the type disclosed in the U. S. patent to John R. Carson, No. 1,343,307, of June 15, 1920. The harmonic supplied to this modulator from the

circuit XF is applied to the modulator through the transformer 11.

A corresponding harmonic from the source F_1 may be selected by means of a tuned circuit XF′ and supplied to the modulator M, over a circuit 12. The output circuit of the duplex modulator M includes a differential galvanometer switching arrangement G, having two windings included in the two halves of the modulator. These windings are normally balanced, so that if the harmonics supplied through the transformer 11 and the circuit 12 are of the same frequency and are in proper phase relation, the currents flowing through the two halves of the winding of the galvanometer switch G will be equal and opposite, so that the armature of the galvanometer will remain in a neutral position. If one of the oscillators F or F_1 begins to gain or lose with regard to the other, the harmonics supplied through transformer 11 and circuit 12 will begin to get out of phase, so that the galvanometer switch G is unbalanced and the armature is thrown in a corresponding direction.

A switching arrangement S is provided and is arranged to be controlled by the galvanometer switch G, so that a motor 13 may be operated to adjust a variable condenser 14 or the like, for regulating the frequency of the oscillator F_1.

The switch S is shown in more detail in Figure 4 and comprises a pair of magnets 14 and 15, supplied with current from a circuit 16, the circuit of one or the other of these magnets being closed by the armature 17 of the galvanometer switch G. An armature 18 is controlled by the magnets 14 and 15 and normally this armature is in a neutral position. Upon the actuation of one of the magnets, 14 or 15, the armature may be thrown to the right or left, thereby supplying current over a circuit 19, contacts 20 carried by armature 18 and contacts 21 or 22, to a circuit 23 leading to the armature winding 24 of the motor 13. The connections of the contacts 21 and 22 are reversed, so that the polarity of the current supplied to the armature winding 24 will be reversed, depending on which way the armature 18 is thrown, which in turn depends upon the action of the armature 17 of the galvanometer switch G. The field winding 25 of the motor is supplied with current over a circuit 26.

If now, the two harmonics supplied over transformer 11 and circuit 12 are slightly out of the proper phase relation, the galvanometer switch G will throw its armature into one position or the other, so that one of of the magnets, say 14, of the switching arrangement S is energized. The armature 18 is then operated to close the circuit 19 over contacts 20 and 22, thereby causing the motor 13 to revolve in such a direction as to adjust the condenser 14 to change the frequency of the oscillator F_1 to bring the harmonics back into proper phase relation again.

In Figure 2 a modified arrangement is illustrated, which enables the control of the oscillator F, through electrical means without the use of any mechanical switching apparatus. Instead of controlling the frequency of the oscillator F, by means of a condenser as in Figure 1, a variable inductance element 20 is provided for this purpose. This inductance includes a winding 21 included in the oscillation controlling circuit 23 of the oscillator F_1, and a saturating winding 22 which is composed of two halves, so that one half is included in each of the output circuits of the tubes of the modulator M.

Normally the currents through the two halves of winding 22 neutralize each other, so that a definite inductance is included in the oscillation circuit 23 of the oscillator F_1 and consequently the oscillator F_1 generates oscillations of a definite frequency. If this frequency is the same as that generated by the oscillator F, the harmonics supplied to the modulator M through transformer 11 and circuit 12 will be of the same frequency. Consequently the two halves of the winding 22 will be balanced if the harmonic waves have the proper phase relation. If, however, this phase relation tends to vary, as would be the case if one of the oscillators should gain or lose in frequency with respect to the other, the winding 22 would become unbalanced and would change the inductance in the circuit 23, so that the oscillator F_1 would tend to again step in phase with the oscillator F.

In the previously described arrangements two generators of the same frequency were maintained both synchronous and isochronous. Figure 3 shows an arrangement whereby a generator of one frequency may be caused to maintain a definite frequency relation to a generator of another frequency. In this figure F_1 designates an oscillator supplying alternating currents to a line L at a terminal station of which the currents may be amplified by an amplifier 10. A desired harmonic frequency may then be obtained by impressing the fundamental amplified frequency on the harmonic producer H, the desired harmonic being selected by a tuned circuit or the like, XF.

The frequency of the oscillator F_1 may be controlled by a generator of higher frequency, F″, which supplies oscillations to modulator M through transformer 11. A harmonic frequency of the fundamental supplied by the oscillator F_1 may be obtained by means of the harmonic producer H_1 and the desired harmonic may be selected by the circuit XF′ and impressed

upon modulator M through circuit 12. If the frequency of the harmonic corresponds to that supplied by oscillator F'' and bears the proper phase relation thereto, no effect will be produced upon the galvanometer switch G. Should the harmonic frequency lose or gain with respect to the frequency supplied by oscillator F'', the galvanometer switch G will be actuated to close one or the other of its contacts, thereby causing the operation of the switch S with the resultant functioning of the motor M to adjust the condenser 14 until the frequency of the oscillator F_1 is brought into proper relation to that of oscillator F''.

It will be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated without departing from the spirit of the invention as defined in the following claims.

What is claimed is:

1. The method of synchronization which consists in producing a first frequency, generating a second frequency, producing a harmonic from said second frequency, said harmonic having a frequency in the neighborhood of the first frequency, beating said first frequency with said harmonic and controlling said second frequency by the resultant difference frequency.

2. The method of synchronization which consists in producting two frequencies which are to be synchronized, deriving harmonics from each of said frequencies, beating the harmonics together to produce a difference frequency, and controlling one of the frequencies to be synchronized in accordance with the difference frequency.

3. In a synchronizing system, means to produce a first frequency, means to produce a second frequency to be synchronized therewith, a duplex balanced modulating arrangement, means to impress said frequencies upon said modulator through circuit connections which are conjugately related, and apparatus controlled by said modulator for operating the means to produce one of said frequencies to vary said frequency.

4. In a synchronizing system, means to produce a frequency with which another frequency is to be maintained in synchronism, means to generate a second frequency, means to produce harmonics of said second frequency, one of said harmonics being in the neighborhood of said first frequency, a balanced duplex modulator, means to impress said first frequency and the corresponding harmonic upon said modulator through circuit connections which are conjugately related, and means controlled by said modulator for operating the means for generating said second frequency to vary said frequency.

5. In a synchronizing system, means to generate two frequencies which are to be synchronized, means to produce harmonics of each frequency, a duplex balanced modulator, means to impress harmonics of each frequency upon said modulator through circuit connections which are conjugately related, and means controlled by said modulator operating upon the means for generating one of the frequencies to be synchronized to vary said frequency.

6. In a synchronizing system, means to produce a frequency with which another frequency is to be synchronized, means to generate a second frequency, means to produce a harmonic of said frequency, said harmonic having a frequency in the neighborhood of the first frequency, means to beat said first frequency with said harmonic to produce a difference frequency, and means controlled by said difference frequency for operating the means to generate the second frequency to vary said second frequency.

7. In a synchronizing system, means to generate two frequencies to be synchronized, means to produce harmonics of each frequency, means to beat the harmonic of one frequency with the corresponding harmonic of the other frequency to produce a difference frequency, and means controlled by said difference frequency to operate the means for generating one of the frequencies to be synchronized to vary said frequency.

In testimony whereof, I, have signed my name to this specification this 29th day of September, 1919.

HERMAN A. AFFEL.