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APPARATUS FOR TRANSMITTING TERMS TO A DISTANCE

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2 Sheets-Sheet 1

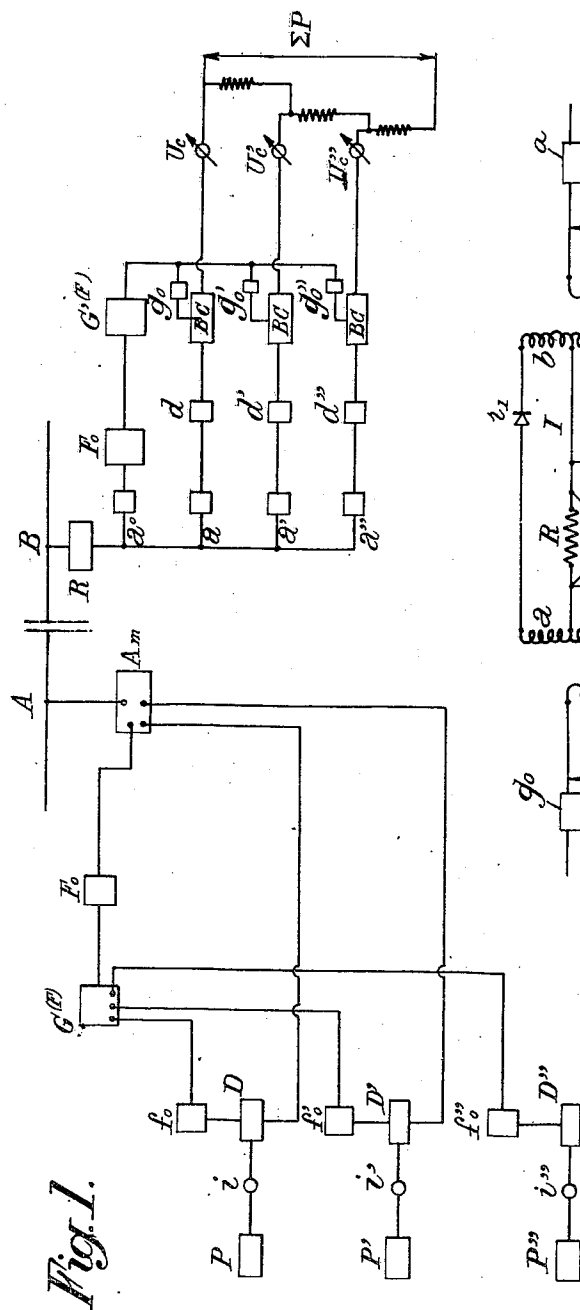


Fig. 1.

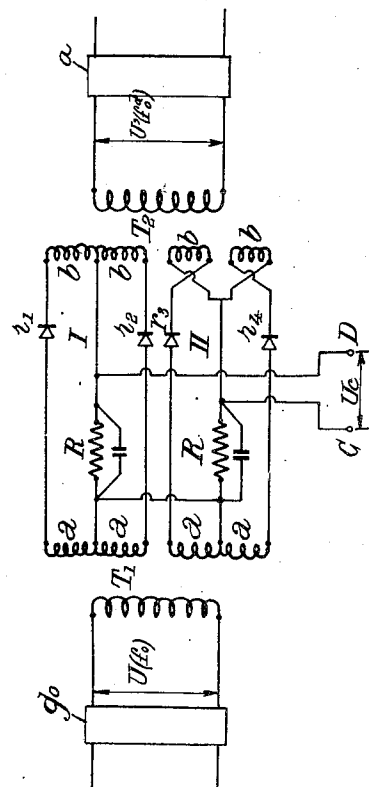


Fig. 2.

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Fig. 3.

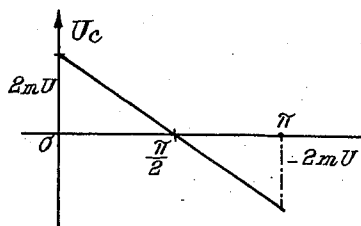
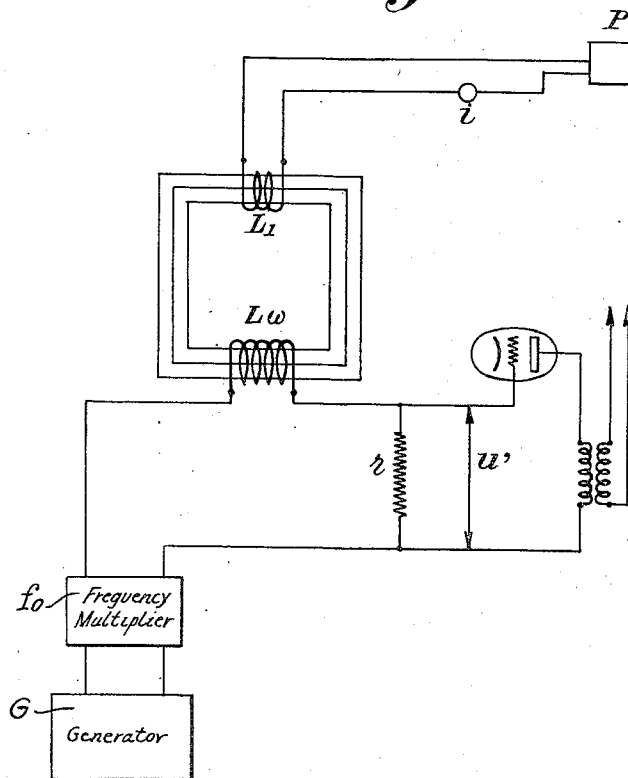


Fig. 4.



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APPARATUS FOR TRANSMITTING TERMS
TO A DISTANCE

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2 Claims. (Cl. 177—351)

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The present invention relates to apparatus for transmitting terms to a distance, the word "terms" designating any magnitude such as a voltage, a current intensity, a frequency, a power, or a nonelectric magnitude such as a temperature, a pressure, a water level, etc., transformed into a voltage, a current intensity, a frequency, etc. And the invention is more especially, but not exclusively, concerned, with telemeasurement methods and apparatus, for instance for transmitting to a distance the values of powers or other magnitudes to be totalized.

The chief object of my invention is to provide an apparatus which is simpler and more accurate than those used up to now.

Preferred embodiments of my invention will be hereinafter described with reference to the accompanying drawings, given merely by way of example and in which:

Fig. 1 is a diagram of a telemeasurement system made according to the invention;

Fig. 2 is a diagrammatical view of a comparator apparatus included in said system;

Fig. 3 is a diagram illustrating the operation of this comparator;

Fig. 4 shows a dephaser included in said system.

It is known that the powers of the various transmitting stations of an electric energy transmission network are transmitted to a central dispatching station, where it is of interest to obtain, in particular, the sum thereof.

In order to obtain this sum easily, the power terms must be, at the receiving station, in the form of direct currents proportional to the powers.

If two conductors are available (a telephonic pair) and if a single term is to be transmitted, the power is taken in the form of direct current at the input and sent into the line. The term in question is received at the other end of the line, either on an indicator (direct current milliammeter or voltmeter graduated in power) or on a resistance, to be added up to other terms. If several terms are to be transmitted through the same telephonic pair, it is no longer possible to utilize the term to be transmitted in the form of a direct current. The method that is employed is then as follows.

The term to be transmitted is transformed into a variable low frequency, say from 25 to 50 periods, for instance by means of rotary apparatus provided with perforations cooperating with photoelectric cells.

The variable frequency wave that is obtained

modulates a musical frequency wave. Therefore, there are as many musical frequency waves as there are terms to be transmitted.

At the receiving station, the musical frequency wave is detected and the low frequency wave is restored. This wave is amplified and applied, either to a tube static system which rectifies both alternations and gives a direct current, or by an electromechanical system. This last mentioned system is constituted by a synchronous motor on the shaft of which is fixed a small direct current generator, which gives a voltage the value of which is proportional to the speed of the motor, that is to say to the variable low frequency.

In both cases, it is necessary to make use of a fixed frequency in order to obtain a false zero, because it goes without saying that the apparatus cannot work at zero frequency. This fixed frequency is 50 periods for the first of the two systems above mentioned, 12.5 periods for the second one. In both cases also, it is necessary, at the receiving end, to return to the low frequency for obtaining the initial term.

Experience has shown that such apparatus are complicated, expensive and do not comply with the requirements of practice.

According to my invention, each term to be transmitted is caused to modify the phase of a wave of given frequency f_0 , in particular of musical frequency, and this in such manner that, for instance, a proportionality law:

$$\varphi = kp$$

is obtained, in which φ is the phase, p the term to be transmitted and k a constant.

I transmit, through any suitable means, this wave, of f_0 frequency and having its phase modified as a function of the measured term p , to the receiving station (for instance through a wire or a telephonic pair, a carrier current, radio electric means) and I apply it, at the receiving station, to a phasemeter or phase comparator apparatus which indicates the phase difference with respect to a wave of the same frequency produced at said station and the phase of which is fixed.

I proceed in the same manner for the other term or terms to be transmitted, making use of other transmission frequencies.

Preferably, the phasemeter or phase comparator apparatus above referred to are arranged in such manner as to give a direct current substantially proportional to phase φ , these phasemeters being constituted in particular by thermionic rectifiers or contact rectifiers such as those de-

scribed in the French applications filed in the name of "Union d'Electricite" respectively on April 14, 1942, for "Improvements brought to methods and devices of the kind of those for measuring or comparing sinusoidal functions, in particular with a view to actuating apparatus for the selective protection of transmission networks," on September 10, 1943, for "Improvements brought to methods and apparatus for measuring or comparing periodic functions, in particular for the selective protection of networks," and, on November 20, 1945, as a certificate of addition to the second of these two applications, the characteristics of which phasemeters are hereinafter indicated.

My apparatus is for instance made as follows:

At the transmitting station a pilot generator G supplies oscillations of, say, 50 cycles.

At the receiving station a generator G' is provided to supply oscillations of the same frequency.

These two stations are interconnected through a line AB.

At the transmitting station, an amplifier-transmitter Am is connected to point A of the line. In this transmitter Am, various oscillations, supplied at the transmitting station, are caused to modulate a carrier wave which, after amplification, is transmitted from A to B. Between generator G and transmitter Am, there is provided a frequency multiplier F₀ which transforms, for instance, the 50 cycles oscillation from G into a 2000 cycles oscillation.

Oscillations from generator G are further supplied to frequency multipliers f₀, f'₀, f''₀ the respective outputs of which are connected to phase shifters D, D', D'' which are thus fed, for instance with frequencies of, for instance, 500, 1000, and 1500 cycles, respectively.

These phase shifters are controlled by electric factors (direct or alternating currents, voltages; etc.) supplied by the apparatus P, P', P'', respectively, which supply the "terms" to be transmitted to the receiving stations. For instance, these apparatus P, P', P'' supply direct currents illustrated by ammeters i, i', i'', respectively, to control the phase shifting effects in devices D, D', D''. The outputs of these devices are connected to the input of transmitter Am so as to modulate the carrier wave sent from this transmitter through line AB.

At the receiving station, the system includes a receiving and demodulating device R having its input connected with point B of the line and the output of which delivers the modulating waves from F₀, D, D', and D'' respectively. On the output of R are mounted, in parallel, filters a₀, a, a' and a'' corresponding to the 2000, 500, 1000 and 1500 cycles frequencies. The output of filter a₀ is connected with a frequency divider F'₀ which delivers oscillations at a 50 cycle frequency. The output of this frequency divider is coupled with an oscillation generator G', adjusted to give a 50 cycles frequency wave, whereby this generator G' is kept strictly in phase with generator G. The output of generator G' is connected through a frequency multiplier g₀, g'₀, g''₀, respectively, with one input of each of three static phasemeters BC, BC' and BC'', of the type above mentioned, whereby these inputs are supplied with oscillations of 500, 1000 and 1500 cycles frequencies, exactly in phase with the oscillations delivered by frequency multipliers f₀, f'₀, f''₀ at the transmitting station.

The other input of each of these phase meters

is connected to the output of each of the three filters a, a', a''. Between each filter and the corresponding phase meter, there is interposed a phase shifting device d, d', d'' adjusted to take into account the phase differences introduced by the delays of transmission through the line and the filters.

The voltages U_c, U'_c, U''_c obtained at the outputs of the phase meter BC, BC', BC'' are proportional to the values of the "terms" supplied by apparatus P, P', P''.

These voltages can be summed up, as shown by Fig. 1, to give a value ΣU proportional to the sum of the terms in question.

This system works in the following manner:

The terms to be transmitted from one station to the other, for instance p, p', p'' supplied by apparatus P, P', P'', control phase shifters D, D', D'' so that the oscillations of 500, 1000 and 1500 cycles frequencies supplied by D, D' and D'' have, with the oscillations of the same frequencies supplied by frequency multipliers f₀, f'₀, f''₀ respective phase differences proportional to values p, p', p''. In other words, if I call φ the phase difference between the outputs of f₀ and D, φ' that between the outputs of f'₀ and D', and φ'' that between the outputs of f''₀ and D'', I have $\varphi = kp$; $\varphi' = kp'$; $\varphi'' = kp''$, k being a constant coefficient.

At the receiving station, generator G' is kept, as above explained, in phase with G. Therefore the oscillations at the outputs of g₀, g'₀ and g''₀ are in phase with those supplied by f₀, f'₀ and f''₀ and of the same frequencies, respectively.

Likewise, the oscillations at the outputs of groups a—d, a'—d' and a''—d'' are in phase with those supplied by D, D' and D'' and of the same frequencies, respectively. Therefore the voltages at the outputs of phasemeter BC, BC', BC'' are proportional to φ , φ' , φ'' respectively and therefore to p, p', p''.

Some indications will now be given concerning phase meters or comparators BC, BC' and BC'' and phase-shifters D, D', D' and d, d', d''.

Concerning the phase meter or comparator, it is advantageously constituted by means of the thermionic or contact rectifier arrangements provided in the above mentioned prior French patent applications, taking care, preferably, that the curve that represents U_c as a function of φ is a straight line, as illustrated by Fig. 3, tension U_c being therefore proportional to the terms that are transmitted.

I have shown, on Fig. 2, a comparator BC such as described in said prior applications. It essentially includes two cells I and II provided with rectifiers r₁, r₂, r₃, r₄ and fed from transformers T₁ and T₂ to which are applied the two voltages from the outputs of g₀ and d respectively, said cells being such that, in one of them, voltages a and b are added to each other, and, in the other, they are subtracted from each other. Load resistances are provided at S. This comparator gives, across terminals C, C', the desired voltage U_c.

Concerning phase-shifter D, it may bring into play, under the influence of the terms P to be transmitted: either variations of self-inductance, or variations of capacity, or both.

On Fig. 4, I have shown an embodiment of such a phase shifter which can be adopted in the case of term p being measured by a direct current i.

This phase shifter D, supposed to receive the volt-

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age, of frequency f_0 , given by the following formula:

$$u = U \cos \omega_0 t$$

includes an electric circuit K connected with the output of the corresponding frequency multiplier f_0 and including, in series therein, a winding L_ω . This winding is mounted around a portion of a magnetic circuit M another portion of which is surrounded by a winding L_1 inserted in the output circuit of the corresponding apparatus P which supplies the direct current (indicated by ammeter i) the value of which is to be transmitted. A resistance r is inserted in electric circuit K.

The grid circuit of an amplifier tube T is connected to the terminals of resistance r and the plate circuit of this tube is connected to the input of transmitter Am through a transformer Q.

I obtain, at the output of circuit K, across the terminals of a resistance r , a voltage:

$$u' = U' \cos (\omega_0 t - \varphi)$$

By suitably calculating the magnetic circuit, it is possible to obtain for the phase difference φ the desired law of proportionality.

Concerning the phase-shifter at the receiving station, it will be of an analogous type, being adjusted in such manner that voltage U_c is zero when the power that is transmitted, that is to say voltage P, is zero. The voltage of wave f_0^d will then be in phase difference of $\pi/2$ with the voltage of wave f_0 ($\varphi=0$). This phase-shifter will be adjusted once and for all.

My system has, over those used at the present time for the same purpose, many advantages, in particular that of avoiding the necessity of passing through the intermediate of a variable low frequency, and consequently that of eliminating any apparatus concerning low frequencies and in particular permanently rotating mechanical systems.

In a general manner, while I have, in the above description, disclosed what I deem to be practical and efficient embodiments of my invention, it should be well understood that I do not wish to be limited thereto as there might be changes made in the arrangement, disposition and form of the parts without departing from the principle of the present invention as comprehended within the scope of the accompanying claims.

What I claim is:

1. An apparatus for transmitting a term to a distance which comprises, in combination, an

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oscillation generator at each of the transmitting and receiving stations, means for synchronizing said generators to keep their respective oscillations in phase, a phase shifter of the static type at the transmitting station connected with the generator at this station, said phase shifter being responsive to variations of the term to be transmitted so as to supply at its output a wave the phase difference of which with the input wave is a function of the value of this term, means for transmitting this output wave to the receiving station, and static comparator means at the receiving station for directly indicating the phase difference between the modified wave thus transmitted thereto and the synchronized wave supplied at this station.

2. An apparatus for transmitting a term to a distance which comprises, in combination, an oscillation generator at each of the transmitting and receiving stations, means for synchronizing said generators to keep their respective oscillations in phase, a phase shifter of the static type at the transmitting station connected with the generator at this station, said phase shifter being responsive to variations of the term to be transmitted so as to supply at its output a wave the phase difference of which with the input wave is a linear function of the value of this term, means for transmitting this output wave to the receiving station, and electronic comparator means at the receiving station for directly indicating the phase difference between the modified wave thus transmitted thereto and the synchronized wave supplied at this station.

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