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L. RELLSTAB

SUBMARINE AND LONG DISTANCE TELEPHONE SYSTEM AND METHOD OF OPERATING THE SAME

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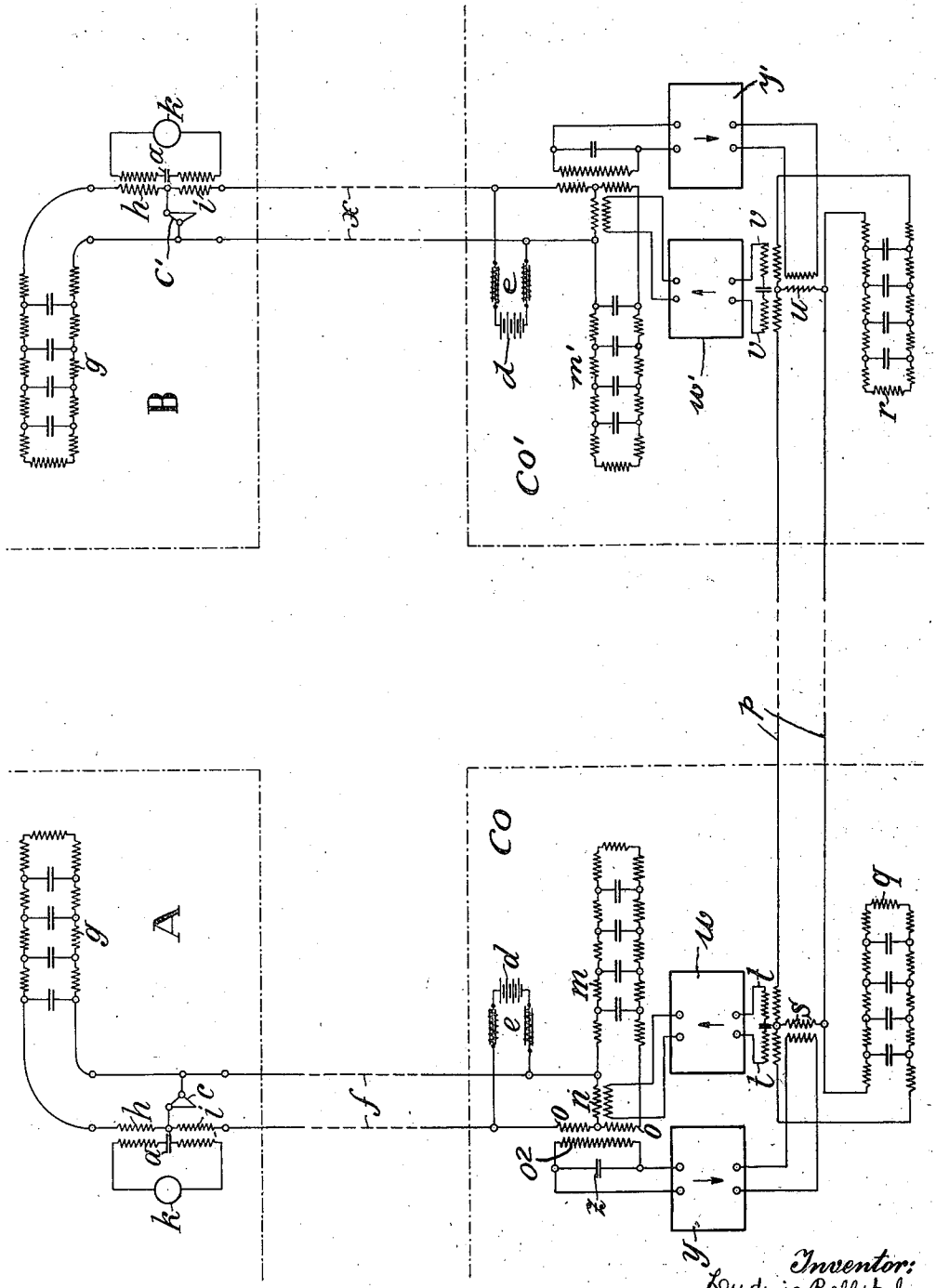

Inventor:
Ludwig Rellstab
by Brown & Mayer
Attorney:

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UNITED STATES PATENT OFFICE.

LUDWIG RELLSTAB, OF ZEIST, NEAR UTRECHT, NETHERLANDS, ASSIGNOR TO NAAMLOOZE VENNOOTSCHAP DE NEDERLANDSCHE THERMO-TELEPHOON MAATSCHAPPIJ, OF UTRECHT, NETHERLANDS, A CORPORATION OF NETHERLANDS.

SUBMARINE AND LONG-DISTANCE TELEPHONE SYSTEM AND METHOD OF OPERATING THE SAME.

Application filed July 8, 1922. Serial No. 573,671.

To all whom it may concern:

Be it known that I, LUDWIG RELLSTAB, a citizen of Germany, and residing at Zeist, near Utrecht, in the Netherlands, have invented certain new and useful Improvements in Submarine and Long-Distance Telephone Systems and Methods of Operating the Same (for which I have filed an application in Germany March 5, 1921), of which the following is a specification.

My invention relates to improvements in submarine and long-distance telephone systems and the method of operating the same. In submarine telephone systems intensifiers or amplifiers can be provided only at the terminals of the cable, and they can not be mounted within the cable itself, because they require a continuous supply of energy and supervision. By providing Pupin coils the cost of the cable is increased and in addition the cables are more rapidly worn out, the said coils being disposed internally of the covering of the cable. For these reasons Pupin coils have been provided in submarine cables only in exceptional cases.

If amplifiers are provided only at the terminals of the cable, the sound transmitting current must be much stronger at the input end of the cable than at the output end thereof, and for speaking over long distances a considerable quantity of energy must be supplied to the transmitter. When generating and modulating a part or all of the said energy at the station of the subscriber, objectionable effects on the subscriber's receiver can not easily be avoided. Heretofore the means provided to obviate this objection aimed at compensation of the effects of the energy of the transmitter current on the receiver of the speaking subscriber, for example by means of a subsidiary or balancing circuit connected to the subscriber's line and by differential connection of the coupling members of the transmitter or receiver and the line and balancing circuit. However, such means fail in case of high energy, because the subsidiary conductor or balancing circuit can never be made equal to the actual line, the actual line being subject to variation in capacity, resistance and leaking by changes of temperature.

The object of the improvements is to obviate as far as possible the said objections in long-distance telephones, and with this object in view my invention consists in transmitting the telephone sounds by means of two different forms of energy, the microphone battery of the speaking subscriber generating the ordinary currents, which are transmitted to and through the cable to the distant terminal office thereof or the telephone central office to which the receiving subscriber's station is connected, and which are transformed in the said office according to the principles of high-frequency telephony, so that the sounds are transmitted from the said office over the subscriber's line to the receiving apparatus by high frequency means. When speaking in the opposite direction conditions are reversed.

In addition in my improved system disturbing noises caused by foreign influences are reduced, which noises have ordinarily low-frequency character and are not reproduced by the high-frequency apparatus.

For the purpose of explaining the invention an example embodying the same has been illustrated in the accompanying drawing, in which a diagram of the apparatus and circuit connections is shown.

In the said drawing two subscribers' stations, A and B, are shown, connected by line circuits f and x respectively, to terminal offices or telephone exchanges CO and CO′ between which extends a submarine cable or long distance telephone line p. The microphone c of the subscriber A is supplied with energy from a battery d located at the telephone office CO through a choking coil e and the subscriber's line f. When speaking the subscriber causes alternating current to be generated, substantially equal parts of which are transmitted to the subscriber's line f and a subsidiary circuit g equivalent to the subscriber's line. Therefore, the induction in the differentially connected transformers h and i is compensated, so that it has only slight effect on the thermic telephone k connected in the secondary circuit. The said secondary circuit also includes a condenser a the capacity of which is $\frac{1}{10}$ microfarad and which represents a resistance of about 1000 ohm as against low-frequency currents, so that the thermic tele-

phone is not excited by the currents of the speaking subscriber, even if the microphone c is very powerful.

At the telephone office CO the subscriber's line f is compensated by a subsidiary circuit m, and a set of coils n, o, o' is connected between the subscriber's line f and the subsidiary line m. The function of the said coils is known to those skilled in the art, the coils o—o' being opposite in effect with respect to their common secondary o^2 as regards currents generated in coil n, but cumulative as regards currents through the line f originating at station A.

The differentially connected transformers o, o' act through secondary o^2 on a low-frequency intensifier or amplifier y of high amplifying power and high energy discharge, the energy of which is used for overcoming the impedance of the cable line. The long distance cable p is compensated at both terminals by subsidiary balancing circuits q and r as is known in the art. Between q and p at the transmitting terminal and between p and r at the receiving terminal differentially connected groups of coils s, t, t' and u, v, v' respectively are provided. The alternating currents from the speaking subscriber's microphone at station A, amplified as described at y flow through the cable p in the form of low frequency currents, and they pass through the transformers v, v', the secondary voltages of which are added to each other, and so are repeated into the high-frequency generator and amplifier w, which intensifies the oscillations and produces a high-frequency alternating carrier current the frequency of which is far above the frequency of acoustic oscillations. The said high-frequency current is modulated to oscillate with reference to its amplitude at the rate of the currents from the speaking subscriber's station, and in this form it is transmitted to and through the line x of the receiving subscriber, B, which is connected in the same way as the line f of the transmitting subscriber. The high-frequency current acts, by means of the transformers i and h, on the thermic telephone k and causes therein the reproduction of the sounds, the thermic telephone having the property of transforming a modulated high-frequency current into low-frequency acoustic oscillations.

I have thus made clear the propagation of sound waves or oscillations originating as low frequency current waves at station A, through the intervening line f and cable p, and their transmission through line x to station B as modulations on a high frequency carrier current supplied at the terminal amplifier and generator w'. It is apparent from the arrangement shown in the drawing that voice waves originating at the transmitter c' at station B will be propagated in the same manner through line x, the low frequency amplifier y' at terminal CO′ and the cable p to the terminal office CO, where through coils t, t', (cumulative in effect for cable currents) they will be repeated into the high frequency generator-modulator-amplifier unit and will thence be transmitted as modulations on a high frequency carrier current through the subscriber's line f to the station A, where they will affect the thermic receiving telephone. Thus, a two way system is provided, in which currents are transmitted in each direction through successive links or sections (land line—cable—land line) at different frequencies, opposite currents in either land line, i. e. currents for sending and for receiving respectively, being of different and separable frequencies, and all currents through the cable (or equivalent long distance line) being of low or voice frequency, but great power.

By reason of my improved system I am enabled to use at the subscriber's stations microphones of any power without providing amplifiers, batteries, and the like, the advantages of the intensifiers provided in the central offices as CO and CO′ being fully availed of by the subscribers.

Irregular sounds produced on the subscribers' lines are not heard at all or only weakly, because the thermic telephone which operates without direct current supply does not respond efficiently to low-frequency currents. In the improved system only a weak heating current need be provided in connection with the thermic telephone. On the other hand the high-frequency currents can be strong, without reacting on the long-distance line, because any high-frequency current which might pass through the coils o, o', o^2 into the low frequency amplifier y, or y' as the case may be, having imperfect differential action, are intensified to a minimum degree and thereafter are entirely annihilated within the long-distance line p by damping.

Preferably a condenser z of a capacity of $\frac{1}{10}$ microfarad is connected in shunt across the low-frequency intensifier y, which does not materially reduce the low-frequency currents, it representing as against such currents a high resistance of about 1000 ohms, while as against high-frequency currents it acts as a short-circuit of 10 ohms.

With this system I am enabled more thoroughly to keep apart the transmitted low-frequency current and the received high-frequency current, than is possible with ordinary telephone systems. The long-distance line p as well as the subscribers' lines f and x being balanced by subsidiary circuits q, r and q, m, g', m', respectively, the separation of the outgoing and received currents is particularly complete.

When it is desired to use my invention on long-distance lines equipped with Pupin coils or amplifiers, no difficulty arises, provided that the said means are disposed between the ends of the long-distance line itself.

The advantages of my improved system are available also for long-distance land lines, though they are less conspicuous in such use than in use with submarine cables.

I claim:

1. In a telephone system two local or subscribers' stations each containing a microphone transmitter and a high frequency wave receiver, and a wire circuit connecting them for conversation composed of three links or sections, the two end links communicating directly with the respective local stations, and an intermediate trunk line having inductive terminal connections with the end links, said inductive connections including a low frequency amplifier for the input from each end link into the trunk line, and a high frequency generator and modulator unit for the output from each end of said trunk line into the corresponding end link, whereby voice waves originating in the transmitter at each local station will pass thence through the corresponding end link and its low frequency output amplifier into and through the trunk line at the same low frequency, and at the distant end thereof will be transformed into corresponding low frequency modulations on a high frequency carrier current and so propagated in the distant end link to be detected and rendered audible by the subscriber's or local station wave receiver connected thereto, the currents transmitted and received respectively through each end link or subscriber's line being of different character and frequency, and non-interfering, and all power for amplifying and transforming being supplied at the two ends of the intermediate link.

2. The system claimed in claim 1 in which the inductive terminal connections are repeating coils differentially connected as between each land line or end link and the respective low frequency amplifiers and high frequency generators and intensifiers, and as between the same and the ends of the trunk line, whereby low frequency and high frequency currents are kept separate, and low frequency current will not be repeated back into the originating line, nor high frequency currents back into the trunk.

3. The system claimed in claim 1 in which the inductive terminal connections are repeating coils differentially connected as between each end link and the respective low frequency amplifiers and high frequency generators and intensifiers, and as between the same and the ends of the trunk line, with a low capacity condenser connected in shunt of the repeating coil winding on the input side of the low frequency amplifier to short circuit high frequency currents that pass through said repeating coil.

4. The system claimed in claim 1 with inductive terminal connections consisting of repeating coils differentially connected as between each land line or end link and the respective low frequency amplifiers and high frequency generators and intensifiers, and as between the same and the ends of the trunk line, and artificial balancing lines at both ends of the trunk line, each artificial line or balancing circuit containing a corresponding balancing winding of the terminal repeating coils.

5. A telephone system comprising a cable with terminal offices containing the terminals of subscribers' lines, a low frequency amplifier connected for input, and a high frequency generator, modulator and amplifier unit connected for output, at each end of the cable, a subscriber's line terminating at each of said central stations, a subscriber's station on each line, having a microphone transmitter and a high frequency receiver, a source of current at each terminal office connected to supply energy over the line for the subscriber's transmitter, and differential repeating coil connections between each line and cable including the said amplifier and said high frequency unit, respectively.

In testimony whereof I hereunto affix my signature in presence of two witnesses.

LUDWIG RELLSTAB.

Witnesses:

H. Y. KUYPERS,

T. V. SHANGENDYK.