(No Model.)

M. I. PUPIN.

TRANSFORMER FOR TELEGRAPHIC, TELEPHONIC, OR OTHER ELECTRICAL SYSTEMS.

No. 519,347. Patented May 8, 1894.

Fig. 1,

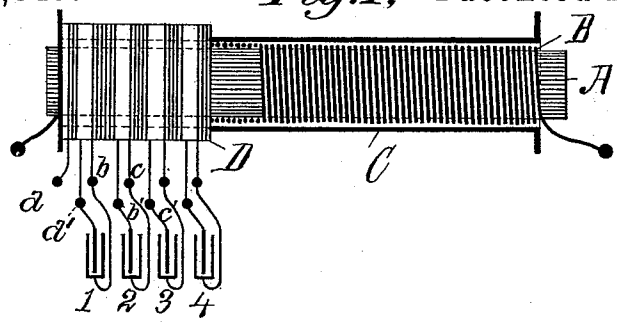


Fig. 2,

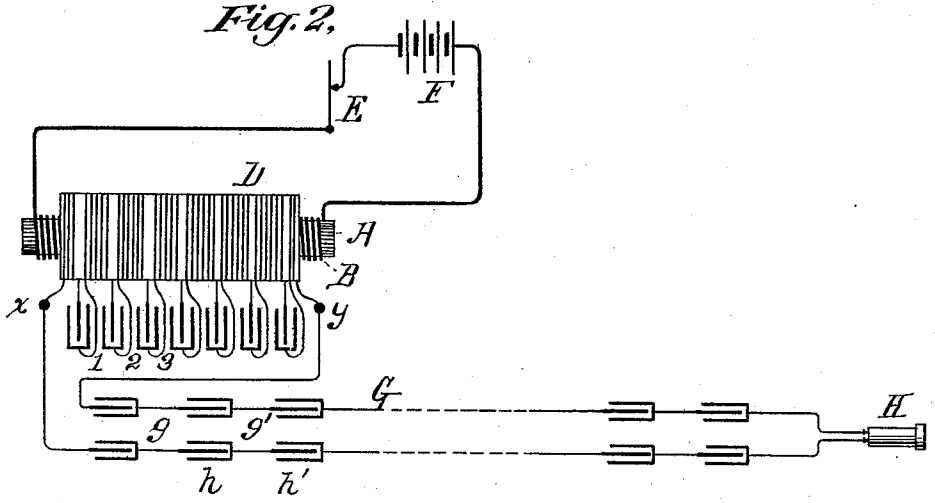
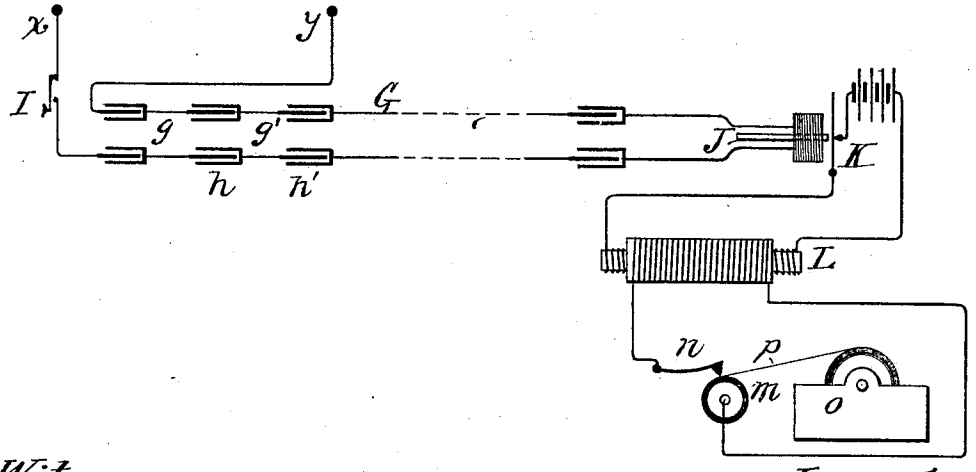


Fig. 3,



Witnesses:-

W. H. Maynard

H. R. Moller.

Inventor:-

Michael I. Pupin

by Parker Benjamin

his Attorney.

THE NATIONAL LITHOGRAPHING COMPANY,
WASHINGTON, D. C.

UNITED STATES PATENT OFFICE.

MICHAEL I. PUPIN, OF NEW YORK, N. Y.

TRANSFORMER FOR TELEGRAPHIC, TELEPHONIC, OR OTHER ELECTRICAL SYSTEMS.

SPECIFICATION forming part of Letters Patent No. 519,347, dated May 8, 1894.

Application filed February 10, 1894. Serial No. 499,716. (No model.)

To all whom it may concern:

Be it known that I, MICHAEL I. PUPIN, of the city, county, and State of New York, have invented a new and useful Improvement in Transformers for Telegraphic, Telephonic, or other Electrical Systems, of which the following is a specification.

My invention relates first to the construction of the transformer, and second, to the combination of such a transformer with a line conductor having in circuit telephone or telegraph instruments, or both. When the secondary coil of an induction transformer consists of a large number of turns of wire, it then possesses defects which materially impair its efficiency. First, its electrostatic capacity checks the separated electrifications in their exit from the coil. Second, the normally large self induction gives the secondary coil too large a time constant and renders it very inefficient when acted upon by electromotive forces of high frequencies. This evil is especially serious in case of induction transformers which are used in connection with telephone transmitters, because the self induction of the secondary coils of such transformers tends to weaken the upper harmonics and so to distort the voice. If, however, the secondary coil of such a transformer be divided into a number of preferably equal parts or sections, and these placed in series and in inductive relation by disposing condensers between the successive sections, then I have discovered that both the capacity effect of the coil can be reduced to any desirable limit, and the time constant may also be made as small as may be wished. If such a transformer be combined with a line conductor also divided into sections, arranged in inductive relation and in series, or in other words, provided with condensers between the sections, and if both the line and the transformer coil be properly tuned then the rapidity of transmission may be exceedingly great, the number of messages which may be transmitted over such a line is independent of electrical conditions, simultaneous telephony and telegraphy is practicable, and a telephonic current will control a recording telegraphic receiver.

Referring to the accompanying drawings: Figure 1 is a partial longitudinal section showing the construction of my transformer. Fig. 2 shows said transformer connected with a telephone line. Fig. 3, shows the arrangement of the same line for both telegraphic and telephonic purposes.

Similar letters and figures of reference indicate like parts.

In Fig. 1, A is the core of the transformer, preferably of fine iron wire, which is surrounded by the primary coil B. Inclosing the primary coil B is a spool C, upon which is wound the secondary coil D. Said secondary coil is divided into a number of preferably equal parts or sections as $a\ a'$, $b\ b'$, $c\ c'$, &c. Between these parts are interposed the equal or nearly equal condensers, 1, 2, 3, 4, so that the said sections and the said condensers are connected in series. The size of the various coils and condensers determines the time constant of the whole secondary coil D. It is not, of course, essential to divide the secondary coil into equal parts, or to insert equal condensers in order to shorten the time constant, for the latter will always be between the shortest and longest time constant of the various parts. So also the various sections of the coil can be connected partly in series and partly in parallel, or any like adjustment be made.

I will now describe the arrangement of my said transformer in combination with a telephone line. It is to be understood that the line conductor here illustrated is not specifically claimed in this application, because it forms the subject matter of another application for Letters Patent, Serial No. 493,651, already filed by me December 14, 1893, and now pending. Referring to Fig. 2 in circuit with the primary B. of the transformer is a telephone transmitter E of any suitable construction and a source of electricity F.

The terminals of the secondary D are connected with the line conductor G, which is made up of sections as $g\ g'$, between which sections are interposed the condensers h, h', &c.

H is a telephone receiver in circuit.

The arrangement of the line for telegraphic or combined telephonic and telegraphic purposes is represented in Fig. 3. The line terminals at $x\ y$ are connected to the terminals of the secondary coil D as in Fig. 2. At I is a telegraphic key. At the distant station is

arranged a relay connected with the line. This may be of any desired form and operate either to open and close a circuit or to produce variations of current strength therein. Thus there may be an electro-magnet J connected to line and operating the diaphragm of a telephone transmitter K in local circuit with the primary of an induction coil L, the secondary of which coil is in circuit with the metal drum *m* and the marking point *n*. Over the drum may be drawn by clockwork *o* or any other suitable means a strip of chemically prepared paper *p* which will be marked wherever the current passes through it as it is carried between the point *n* and drum *m*. The paper is of course moved along at a uniform rate of speed. The impressed electromotive force in the primary circuit of the transformer at the transmitting end, may be caused by the telephone transmitter E set in operation by the voice or by any sounding apparatus such as an organ reed in front of it or by an alternating current dynamo. The induced current on the secondary is interrupted in the usual way to send Morse signals for example by the key I. It is advisable that the periodicity of the impressed electromotive force be as nearly equal to the periodicity of the circuit as practicable. If the secondary of the transformer is tuned to a high pitch and the line be also tuned to the same high pitch, then any known means for very rapid telegraphy, such as the Wheatstone system may be employed, and the number of messages that can be transmitted will be limited only by the mechanism of the transmitting and receiving devices, and not by any electrical conditions. When an alternating current generator is employed to feed the primary of such a transformer, then the primary coil also may be divided into a suitable number of parts in the same way as the secondary with condensers in like manner interposed. This is especially desirable when the primary has large self-induction. The metallic return shown in Figs. 2 and 3 is not essential, as the line can be grounded in the usual way.

Long telephone lines act in consequence of their distributed capacity like lines of low impedence, that is to say, a comparatively speaking low electromotive force at the transmitting end can produce a large current at that end, but a very small part of this initial large current reaches the receiving end of the line. This effect is well known and is attributed to the attenuating effect of the line. Owing to this attenuating power of the line, it becomes necessary to work with transmitters which are capable of sustaining a large current in the secondary core of the transformer, that is to say, the number of turns in the secondary coil must be kept low. Briefly stated, long distance telephone lines are worked to-day on the principle of large current and low voltage. But in a long distance line of very high impedence but no attenuating power, it is desirable to work with high electromotive forces and small currents. Hence, the induction transformer of the transmitter must have a much larger number of turns in the secondary, than the transformer now in use. But on account of the well known fact that high self induction kills upper harmonics, it is evident that a large number of turns in the secondary cannot be employed unless some device is introduced which will diminish the tendency of the self induction of the coil to weed out the upper harmonics. This is accomplished by dividing the secondary coil into sections and interposing condensers as hereinbefore described, so that thus I may use very high electromotive force without weakening of the upper harmonics. It will be seen therefore that by this invention I may operate a long distance telephone line on the opposite principle from that now followed; that is instead of using low electromotive forces and large currents, I may employ high electromotive forces and small currents.

I claim—

1. A transformer having one of its coils divided into sections, the said sections being connected in series and in electrostatic inductive relation and each section being tuned to a certain predetermined periodicity.

2. A transformer having its secondary coil divided into sections, and condensers connected in series and interposed between said sections and each section being tuned to a certain predetermined periodicity.

3. A transformer having its primary coil in circuit with a source of electricity and a means of varying the electrical condition of said circuit, and its secondary coil connected to a line conductor, the said secondary coil and line conductor being each divided into sections, the said sections being placed in series and in electrostatic inductive relation.

4. A transformer having its primary coil in circuit with a source of electricity and a means of varying the electrical condition of said circuit and its secondary coil connected to a line conductor, the said secondary coil and line conductor being each divided into sections the said sections being placed in series in electrostatic inductive relation and each tuned to a certain predetermined periodicity.

5. A transformer having its primary coil in circuit with a source of electricity and a means of varying the electrical condition of said circuit and its secondary coil connected to a line conductor and condensers, the said secondary coil and line conductor being each divided into sections, and connected in series with said condensers: and the said sections being tuned so that the total periodicity of the secondary coil and line conductor shall equal or very nearly equal a certain predetermined periodicity.

6. In combination a transformer having its primary coil in circuit with a source of electricity and a telephone transmitter, and a secondary coil divided into sections disposed in series and in electrostatic relation: a line

conductor also divided into sections disposed in series and in electrostatic inductive relation, and a telephone receiver connected with said line conductor.

7. In combination a transformer having its primary coil in circuit with a source of electricity and a telegraphic transmitter and a secondary coil divided into sections disposed in series and in electrostatic inductive relation, a line conductor also divided into sections disposed in series and in electrostatic relation, and a telegraphic receiver connected with said line conductor.

8. In combination, a transformer having its primary coil in electrical circuit with a telephone, and its secondary coil divided into sections disposed in series and in electrostatic inductive relation and a telegraphic transmitter and receiver connected with said line conductor.

9. In combination a transformer having its primary coil in circuit with a source of electricity and a means of producing periodic electrical vibrations, and a secondary coil divided into sections disposed in series and in electrostatic inductive relation, a line conductor also divided into sections disposed in series and in electrostatic relation and a telegraphic transmitter and receiver connected with said line conductor.

MICHAEL I. PUPIN.

Witnesses:
H. R. MOLLER,
E. MARTIN.