No. 799,555. PATENTED SEPT. 12, 1905.

B. GÁTI.

TELEGRAPHY.

APPLICATION FILED MAY 9, 1904.

2 SHEETS—SHEET 1.

Fig:3.

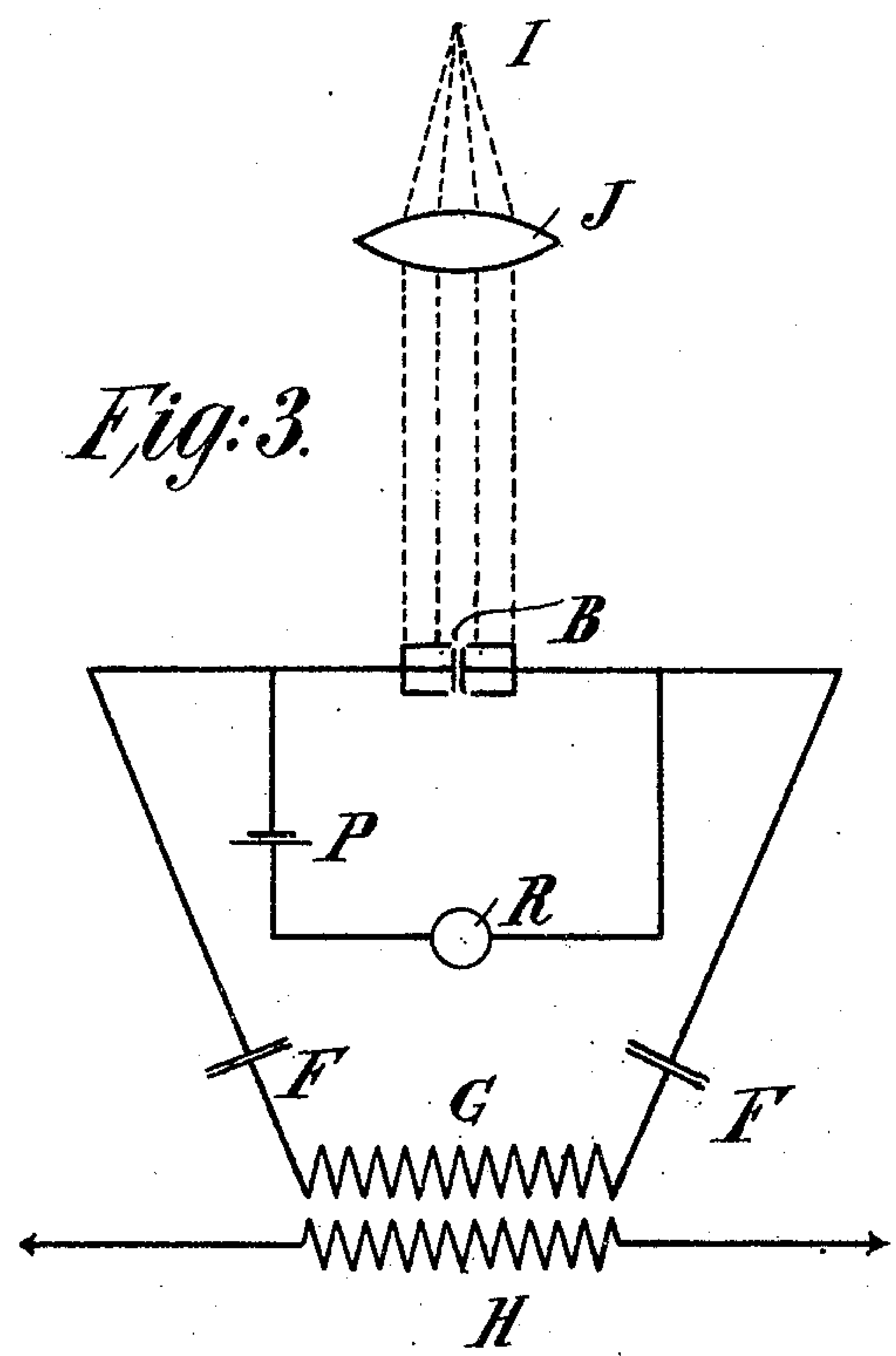


Fig:1.

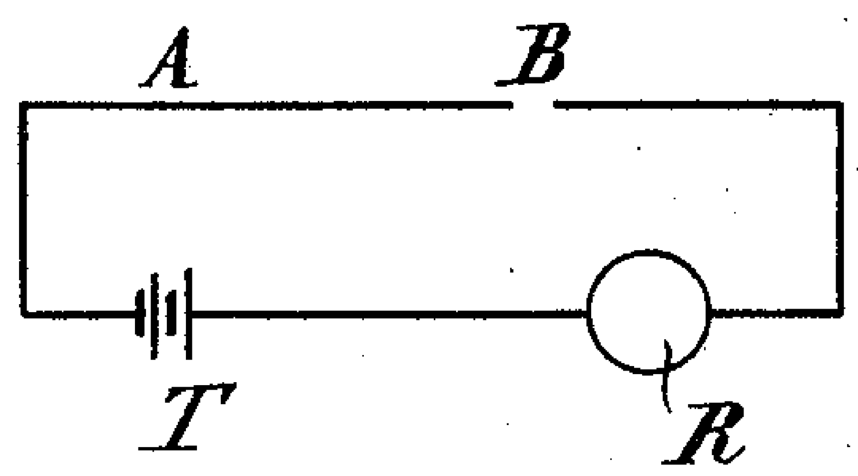
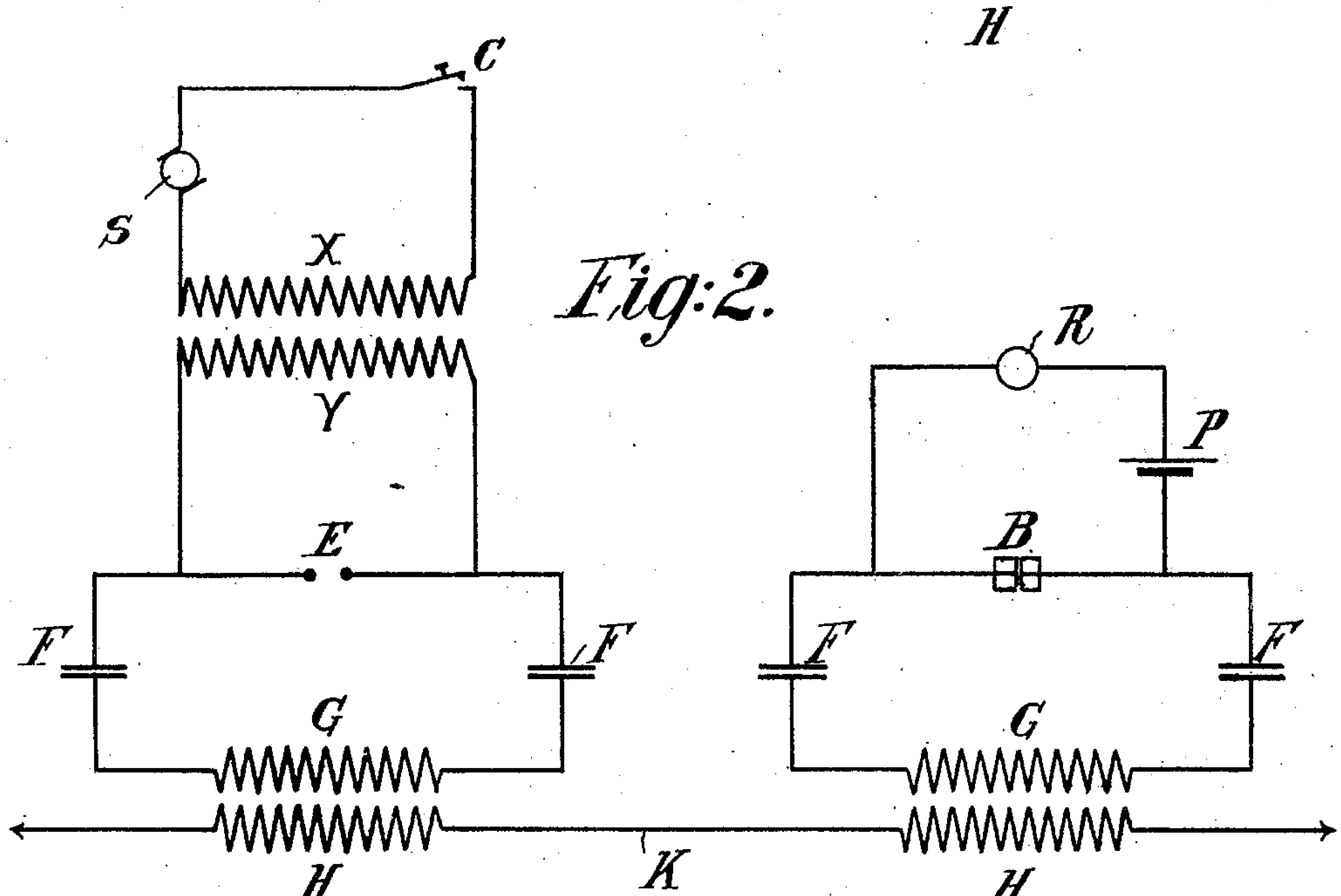


Fig:2.



Witnesses
Edwin D. Bartlett
Albert Gease.

Inventor
Béla Gáti
per Herbert Sefton-Jones
Attorney.

No. 799,555. PATENTED SEPT. 12, 1905.

B. GÁTI.

TELEGRAPHY.

APPLICATION FILED MAY 9, 1904.

2 SHEETS—SHEET 2.

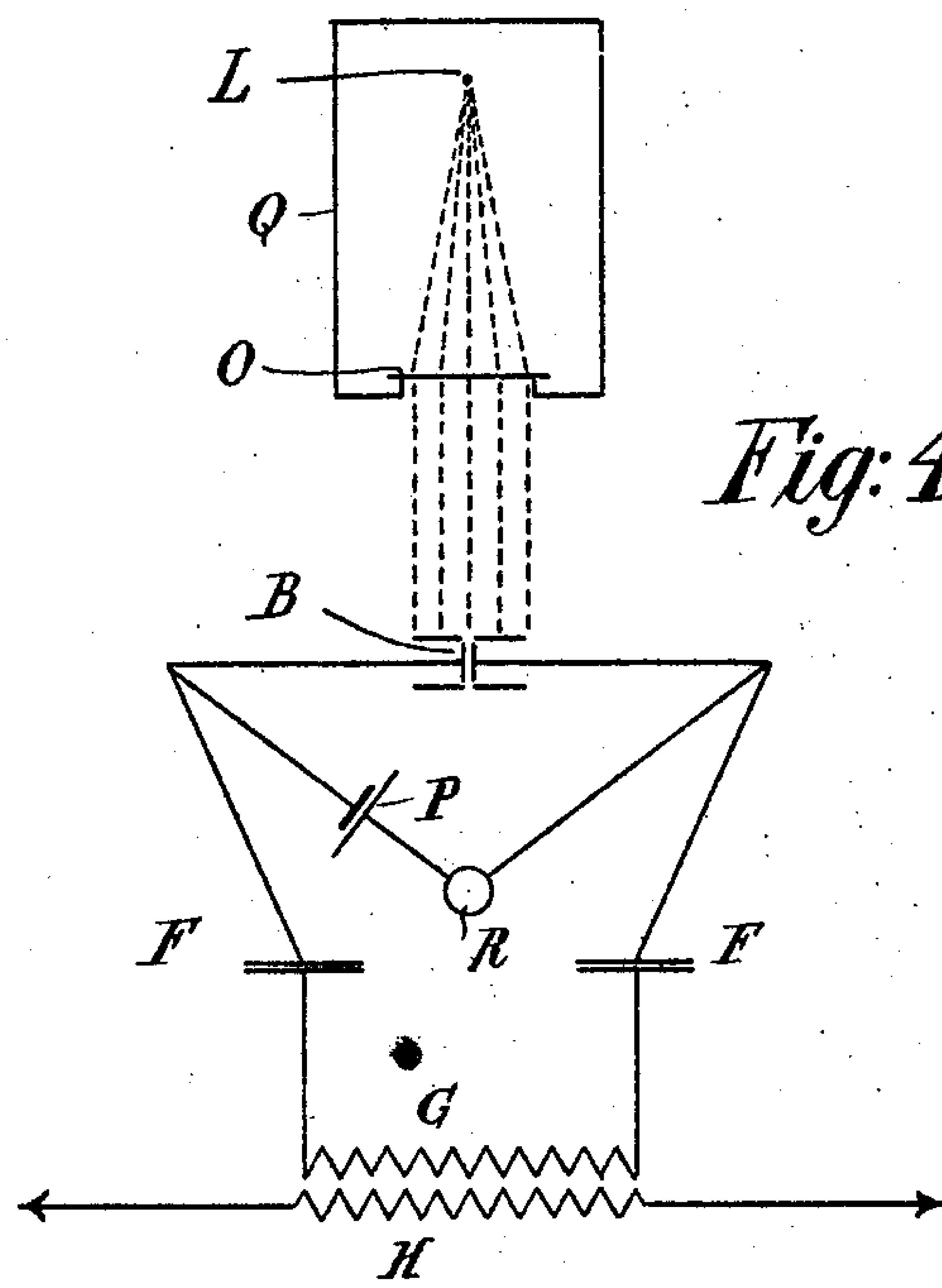
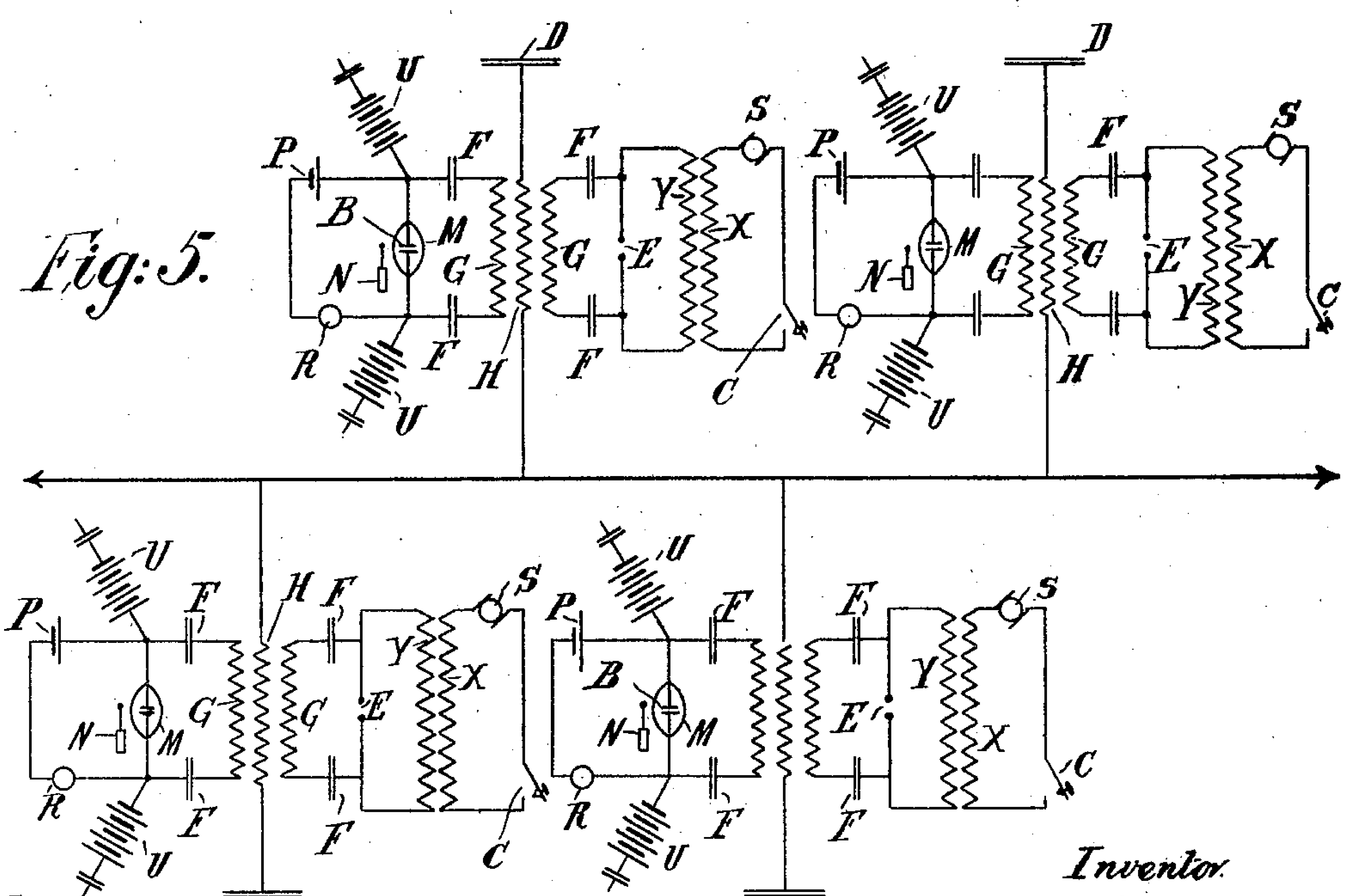


Fig: 4.

Fig: 5.



Witnesses

Edwin D. Bartlett

[illegible]

Inventor

Béla Gáti

per Herbert Sefton-Jones

Attorney

UNITED STATES PATENT OFFICE.

BÉLA GÁTI, OF BUDAPEST, AUSTRIA-HUNGARY.

TELEGRAPHY.

No. 799,555. Specification of Letters Patent. Patented Sept. 12, 1905.

Application filed May 9, 1904. Serial No. 207,107.

To all whom it may concern:

Be it known that I, BÉLA GÁTI, electrical engineer, of Hotel Metropole, Budapest, Austria-Hungary, have invented Improvements in Telegraphy, of which the following is a specification.

Existing telegraphic systems are, so to speak, exclusively based upon the magnetic action of the electric current. The variation of the current strength—that is, the increase thereof from zero to a certain value or the decrease thereof from a certain value to zero in a wire coil—causes the variation of the magnetism. By means of the magnetism mechanical devices are actuated, and thereby the signals are produced at the distant station. The requisite current strength, the corresponding magnetism, and the actuation of the mechanical devices are comparatively easy to obtain with simple telegraphy, but with multiplex telegraphy many complications arise, and in consequence thereof the permanent maintenance of any quadruplex system is difficult, while for cable transmission such systems can only be used with great difficulty. According to the present invention these difficulties are obviated by employing in place of the magnetic action of the current the ionizing action thereof. In order to render the means employed for this purpose intelligible, it is necessary to more particularly describe the phenomena based upon ionization. If a substance is resolved into its ions and positive ions travel in one direction and negative ions in another direction, it is said that the substance conducts electricity. With solid bodies the movement of the ions cannot be shown. With liquid bodies this is easier; but with gases the ion movements can be followed, as in the case of ion-rays, cathode-rays, anode-rays, &c. The resolution of a body into its ions can be brought about by a variety of causes, such as electric potential differences, light-waves, electromagnetic waves, ion-rays, cathode-rays, anode-rays, Röntgen-rays, N-rays, radium-light, ultraviolet light, chemical action, caloric action, &c. There is, so to speak, hardly any phenomenon under the influence of which a substance would not commence to be resolved into its ions. In the following I will consider the case in which any solid substance and a gas are so grouped that the solid substance is readily resolved into its ions, but the gas with difficulty.

In the accompanying drawings, Figure 1 is a preliminary diagram. Fig. 2 shows diagrammatically a sending and a receiving station connected by line-wires for simple telegraphy. Figs. 3 and 4 show ways of ionizing the gases in the gap at the receiving-station. Fig. 5 shows four stations of a multiplex system connected to a single line-wire.

Referring to the diagram Fig. 1 of the drawings, the electric potential difference at the terminal of a current source T would begin to resolve the solid part of the circuit A into its ions, and in the circuit of the current source an electric current would ensue if the gas at the gap B were also resolved into its ions by any means. If, for example, the gas at B were subjected to the action of radium, the gas would be resolved into its ions and electricity would begin to flow in the circuit. It would, for example, put a relay R in action and by it any recording apparatus could be operated, so that if the radium were made to act during a longer or shorter time, corresponding to certain telegraphic symbols, the recording instrument on the receiver would record the corresponding symbols. Instead of radium or radio-active substance any other ionizing means can be employed, or two or more such may be employed in combination. In practical application several ionizing means are generally employed, and one of these depends regularly upon the electromagnetic wave.

Fig. 2 shows an arrangement for effecting telegraphy by the use of a gap in which the gases are made conducting by electromagnetic waves resulting from waves transmitted through a wire from a sending-station. S is any suitable source of alternating or oscillating currents. C is a key, and X the primary of an induction-coil in circuit with the source S through the key. The terminals of the secondary winding Y are connected to sparking points E. F F are condensers, connected on the one hand to the points E and on the other hand to the terminals of a coil G. H is a coil in the line-wire K, arranged to have waves induced in it by waves in G. At the receiving-station there are corresponding coils G H and condensers F F, the latter in this case being connected to the terminals of a gap B. A local circuit, including a battery P and a relay or indicating apparatus R, is also connected to the terminals of the gap. When the key C is depressed, an alternating current passes through coil X, exerting a high inductive action on the coil Y, and sparks are produced at E. Hence oscillations of current of high frequency take place in G, causing waves in H, which pass in both directions along the line K. The coil H at the receiving-station is made to resonate with these waves, causing waves in the circuit G F B F at the receiving-station, whence oscillations are produced at the gap B, and the gases at the gap may thus be ionized, allowing a current to pass from battery P through signaling-relay R.

It is not difficult to show by the following calculations that for obtaining the coherer action (if only electromagnetic waves be employed as the ionizing means) very high speeds of vibration are required. According to Drude, the number of gas molecules in one cubic centimeter at $0°$ centigrade temperature and seven hundred and sixty millimeters barometric pressure amounts to 2.4×10^{19}. A calculation may be made with reference to the "Karoly" coherers, which have hitherto been considered the most sensitive. These coherers consist of two steel needles, which are crossed, the distance between them at the point of crossing being very small, usually from 0.1 to 0.0001 of a millimeter. (See *Mathematical and Physical Papers*, 1903, page 127, of the Mathematical and Physical Society of Budapest.) The volume of the gas between the two contacts of such a coherer may be taken to be $0.001\times0.001\times0.001$ cm. $=10^{-9}$ cm. Assuming there are 2.4×10^{10} molecules and that each molecule consists of one thousand positive and one thousand negative electrons, there have to be taken into account 2.4×10^{13} electrons. In order to establish an electric current, according to Drude, at least 1.2×10^{5} molecules must be resolved into their ions, and consequently 2×10^{8} electrons must be produced, for which purpose a wave with at least 10^{8} vibrations will be necessary even if it be assumed that each wave separates at least one negative and one positive electron, while it is possible that a number of waves may pass through the gas without separating electrons. The length of the wave with the number of vibrations 10^{8} with a wave speed of 3×10^{10} centimeters is 3×10^{2} centimeters. It is therefore tolerably small. The propagation of such a wave could only be effected with certainty if with such lengths the electric factors of the conductors (such as resistance, dispersion, leakage, self-induction, and capacity) could be assumed to be stable, which is of course not possible. It is therefore necessary with the existing system of conductors to adopt longer waves. For this purpose it is necessary to employ other ionizing means than that of the electromagnetic wave alone. Electrical potential difference must be employed on account of the inclusion of the relay in the receiving-circuit. Of the other ionizing means the ion-rays and the light-rays have proved to be the best. With caloric action the reduction of the gas molecules to their ions is very rapid, and it can therefore hardly be used for this purpose. The simpler the ion-rays or light-rays are the more reliably can their action be regulated. Most kinds of radium-light are mixed lights, (ion-rays, Röntgen rays, &c.,) and consequently the adjustment for these is difficult. The stronger the secondary ionizing means is the greater can be the volume of gas employed. The distance apart of the terminals of the conducting part of the circuit can be made greater, and the disturbing effect of the caloric action can be reduced. With a greater distance the number of gas molecules will be greater, and more energy will be required for ionizing them. This can be remedied by reducing the number of gas molecules contained in the volume—*i. e.*, by attenuating or partially exhausting the gas. If, for example, by the attenuation of the gas or by increasing the action of the ionizing means the effect is obtained that for producing the conduction of the current, for instance, only 10^{4} ions need to be produced instead of 2×10^{8} ions, then for producing this number electromagnetic waves of 10^{4} vibrations can be used with certainty. The corresponding wave length will be about 3×10^{6} centimeters, a length within which on the one hand the electric factors of the conductor are tolerably constant and on the other hand such vibrations can be produced more easily and with a less tension. In the apparatus used at the receiving-station there must therefore be used an additional ionizing means which is always acting on the gases in the gap B, but which, with the potential due to the battery for actuating the relay, is not sufficient to produce ionization of the gases at the gap unless aided by electromagnetic waves received from the line.

Fig. 3 shows how violet and ultraviolet light may be applied to the gases at the gap B for the purpose of assisting in the ionization. The rays of violet and ultraviolet light from a source at I—such, for example, as a mercury-vapor lamp, an arc-lamp, or a magnesium-burner—are condensed on the gap B by a quartz lens J and so act on the gases that the waves produced in the circuit G F B F by the waves coming from the line will be able to complete the ionization.

Fig. 4 shows how cathode-rays, Röntgen rays, or the like from a source at L can be caused to act on the gap through an aluminium plate O. A metallic casing Q may be used to prevent any electromagnetic waves from the source L from acting on the gases in the gap B. If radium or a radio-active substance is to be used as the additional ionizing means, it is simply necessary to bring that substance into the neighborhood of the gap B. Electric potential difference can also be used as the additional ionizing means, as is illustrated at each station in Fig. 5. (Explained below.) The potential difference may be produced between plates in the gap by batteries U, the outer terminals of which are connected to condensers. The batteries U U have no circuit except through their insulation resistance, so that no appreciable current can flow from them across the gap. The batteries, in fact, act somewhat like charged condensers. The scientific reason for the ionizing action of the batteries so connected cannot be given; but it is a fact that the desired action is obtained, as has been experimentally proved.

If the gases at the gap are to be attenuated, they may be inclosed in tubes, as at M in Fig. 5, and vibrators of any known type (indicated diagrammatically at N) may be used for causing the terminals of the gap to vibrate. The use of vibrators is particularly desirable when one of the ionizing means is electrical potential difference acting between metallic terminals, because in such case after the cessation of the waves the gas might still remain conducting. Further, in consequence of the electric current passing through the gas at the gap ions of the adjacent conductors will probably become mixed with the gas ions, so that after the ionization has been started a less degree of energy will be required for its maintenance. Hence the vibrating of the contacts is desirable in this case in order, for instance, to increase the gap from 0.001 centimeter to 0.01 centimeter, whereby the current-circuit would be interrupted and the action of the conducting-ions would be stopped. With carbon terminal electrodes such vibrating should not be necessary; but it should always be employed when metallic electrodes are used.

By the arrangements above mentioned simple telegraphy can be effected. For multiplex telegraphy it is necessary to use various frequencies of electromagnetic waves for communicating between the respective stations. Fig. 5 shows four complete stations I, II, III, and IV connected to a single line K. If station I transmits electromagnetic waves of a frequency of 10^4 and if the coil H of station III resonates to these waves, then signals can be transmitted from I to III and from III to I. The coils of the sets II and IV may be set to resonate to a different frequency of wave, (for instance 10^5,) and the waves from stations I and III will then not affect them. In this way a large number of stations may be connected with one line over which they can all communicate without interference one with another. It is true that in addition to the main vibrations also higher vibrations will be produced in the coils; but as we are not bound to such narrow limits as in wireless telegraphy the number of vibrations can be chosen with much greater differences, and consequently the working will be more reliable. The sizes of the coils will vary according to the length of the conductors. In an article commencing on page 957 of the *Annalen der Physic* (Vol. 11, Series 4, 1903) it is shown that there are two main vibrations, one principally dependent upon the conducting length of the coil and the other upon the wave length of the system comprising the circuits (I and II, for example) with the connecting-wire K. It depends mainly upon financial considerations to which of these the apparatus is to be adjusted. With short distances the wave length of the system can be the main value, while with greater distances the wave length due to the length of the conducting length of the coil may predominate. The existence of the circuits III and IV will, it is true, have a disturbing effect upon the calculations for circuits I and II; but the necessary corrections can always be made in advance, as will be well understood, by means of experiments carried out with suitably-diminished electrical factors, (resistance, leakage, self-induction, capacity.)

Capacities D may be connected with the lines for establishing the equilibrium which would be disturbed by connecting the wave-producing apparatus with the lines. Their values can be calculated from formulæ which are known to physicists and are given, for instance, in the *Annalen der Physic*, (Vol. 11, Series 4, 1903,) in the article above referred to, (page 957 *et seq.*) The capacities D may be in connection with the earth, or if two line-wires are available one can be used, as D, or, again, in the case of cables the sheathing of the cable may supply the capacity, as will be well understood.

As with overland single lines the dispersions or leakage vary considerably, the system cannot be well applied to greater distances than with existing lines. It is, however, very advantageous for cables where the dispersion is small and constant. It is true that large dimensions are necessary and that, for instance, a coil for a cable of one thousand kilometers will occupy a considerable space; but if it be considered that the wave length does not depend very much upon the diameter of the wire and that consequently wires of 0.2 millimeters can be used it will be seen that the cost of the coils will be very small notwithstanding the large dimensions.

The gases at the gaps B can be replaced by non-conducting but ionizable liquid or solid bodies. In such cases, however, the adjustment is very difficult, because the laws relating to the ionization of such bodies are not nearly so well known as those relating to gases, although there are already some wave-indicators known the adjustment of which is easily made even when the material to be ionizated is fluid. These can be employed, therefore, if desired, as coherers in the receiving-circuits.

What I claim is—

1. In a telegraphic system, apparatus comprising a coherer in which is a small gap with a fluid between the terminals thereof, a cir-

cuit in connection with the terminals of the coherer including a source of electric current and a relay, additional ionizing means adapted to constantly act on the fluid in the gap but with insufficient intensity to produce ionization, and means whereby electric waves can be made to act on the fluid in the gap for producing ionization.

2. In a telegraphic system, the combination with a line-wire, of a plurality of transmitting instruments connected to said wire each of said instruments including means for transmitting electric waves of approximately a certain frequency through the wire, a plurality of receiving instruments connected to said wire each comprising a coil adapted to resonate to electric waves of approximately a certain frequency, and a circuit including a source of electric current, a relay, a gap with a fluid between the terminals thereof, means tending to ionize the fluid in the gap, and means whereby the waves received from the line are caused to act on the fluid in the gap for producing ionization.

In testimony that I claim the foregoing as my invention I have signed my name in presence of two subscribing witnesses.

BÉLA GÁTI.

Witnesses:
LOUIS VANDOR,
ANDREW KELEMEN.