(No Model.) 3 Sheets—Sheet 1.

A. MUIRHEAD.

TELEGRAPHY.

No. 435,851. Patented Sept. 2, 1890.

Fig. 1.

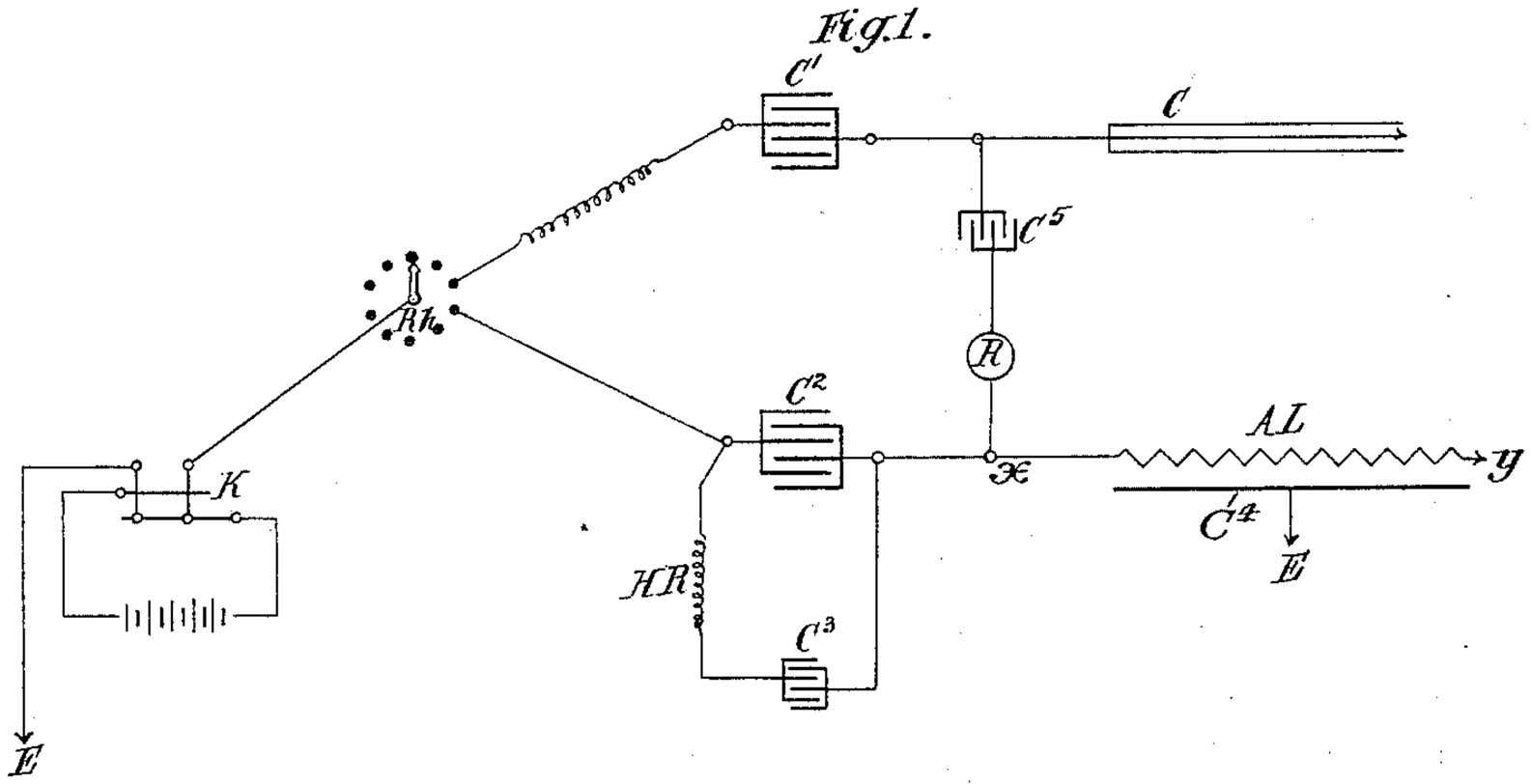


Fig. 2.

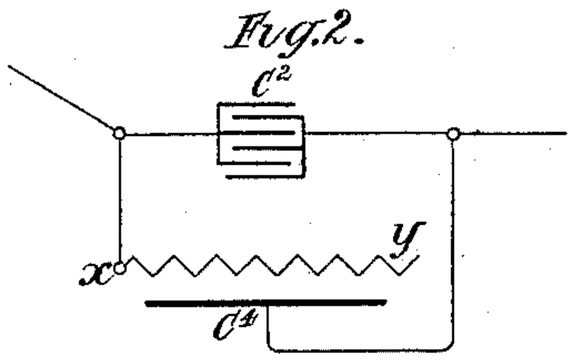
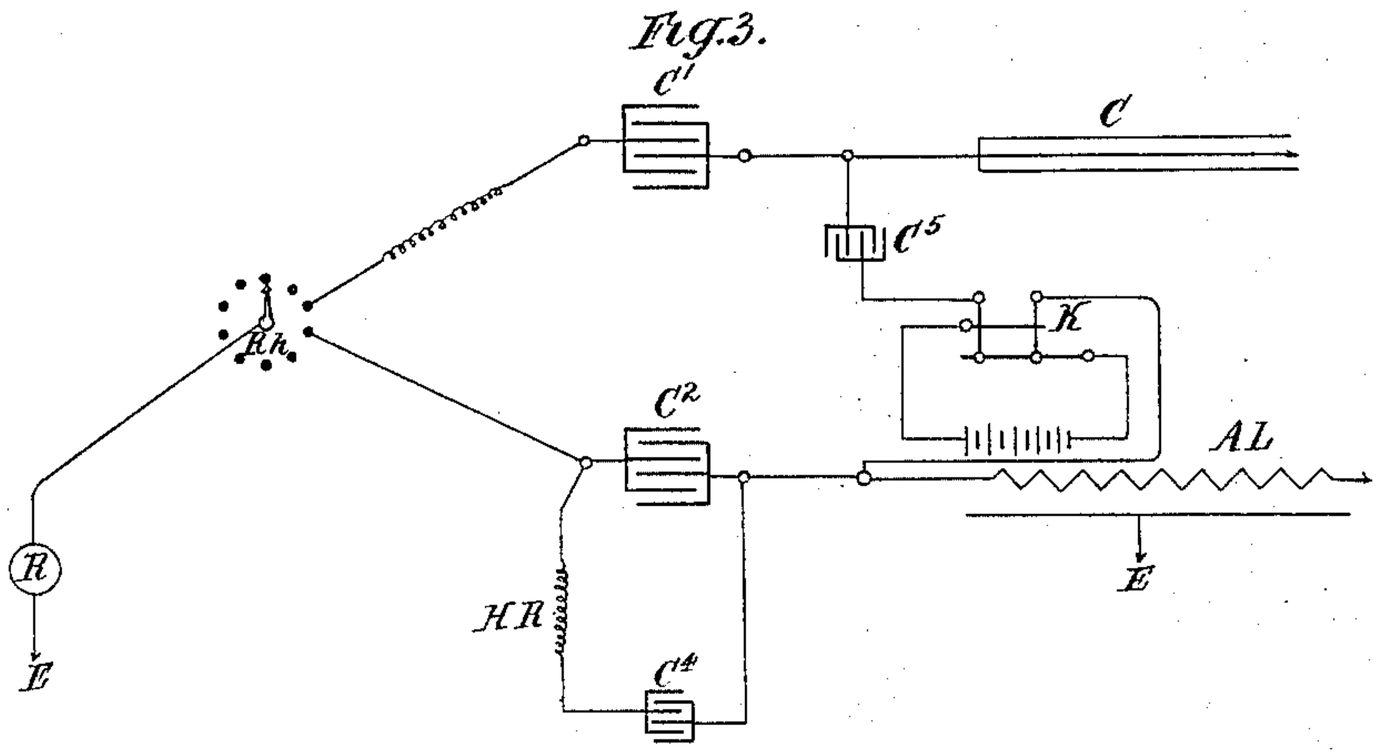


Fig. 3.



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(No Model.) 3 Sheets—Sheet 2.

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Fig.4.

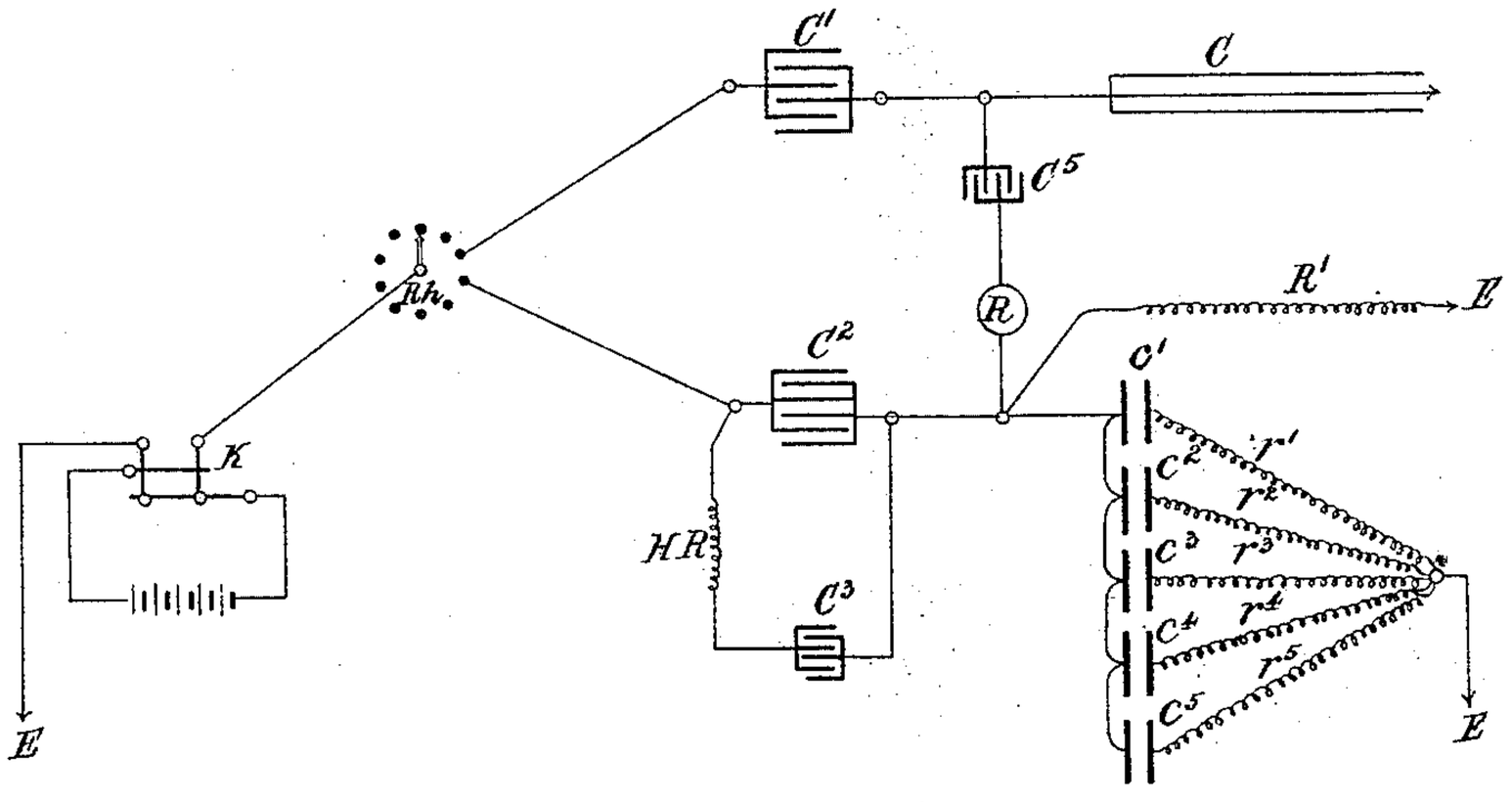
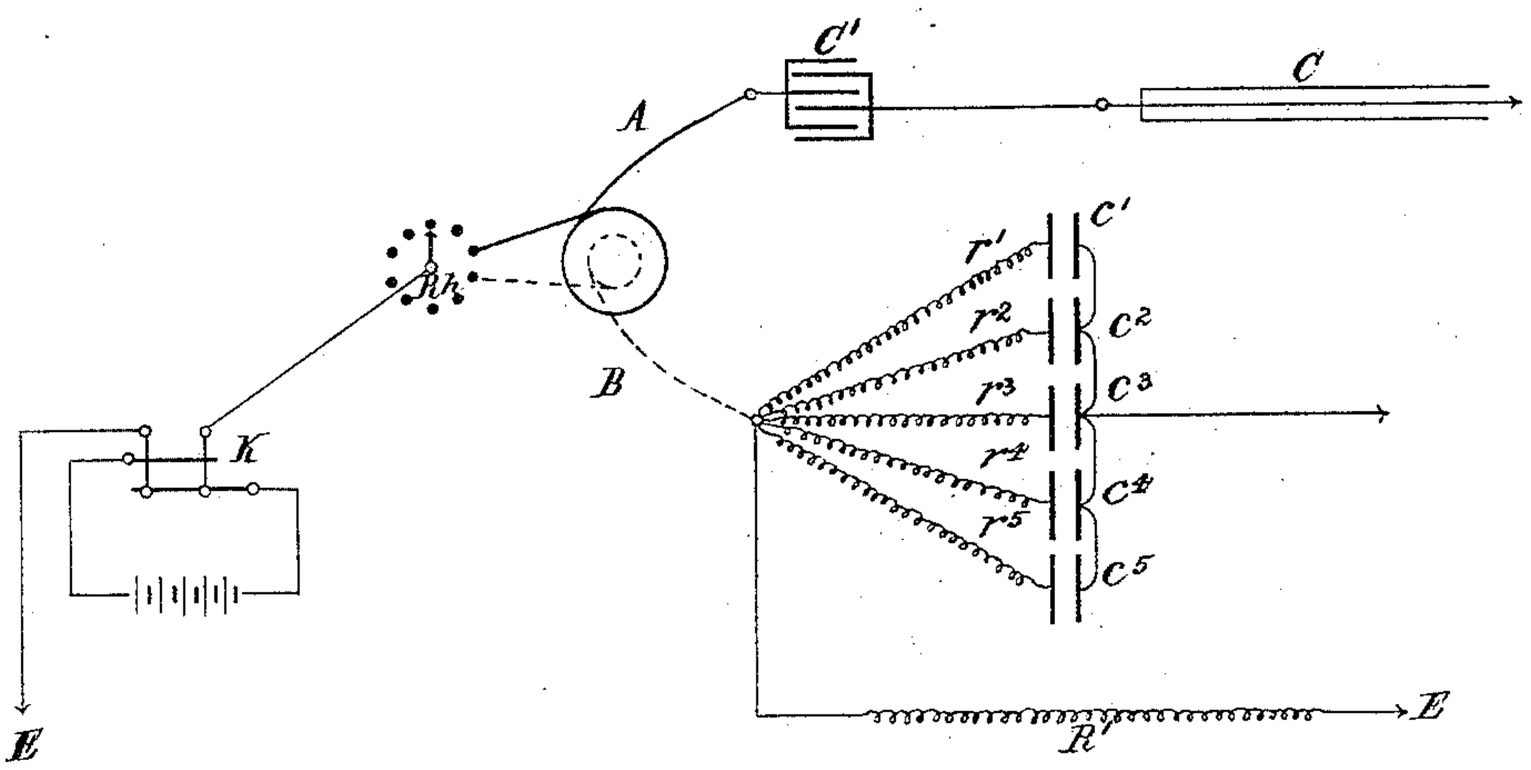


Fig.5.



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(No Model.) 3 Sheets—Sheet 3.

A. MUIRHEAD.

TELEGRAPHY.

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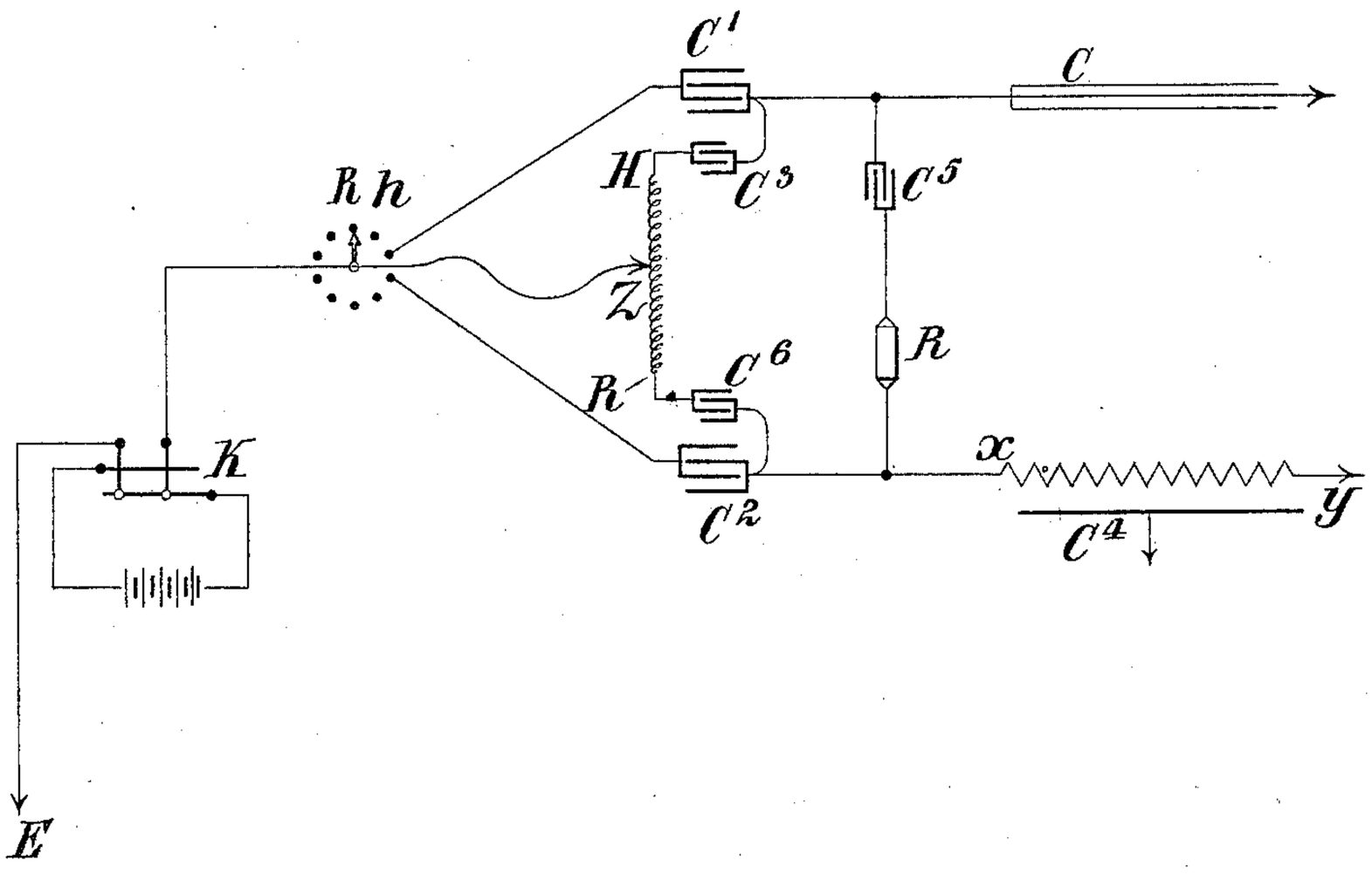
Fig. 6.



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THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

UNITED STATES PATENT OFFICE.

ALEXANDER MUIRHEAD, OF LONDON, ENGLAND.

TELEGRAPHY.

SPECIFICATION forming part of Letters Patent No. 435,851, dated September 2, 1890.

Application filed March 6, 1888. Serial No. 266,367. (No model.)

To all whom it may concern:

Be it known that I, ALEXANDER MUIRHEAD, doctor of science, telegraph engineer, a subject of the Queen of Great Britain, and a resident of London, England, have invented new and useful Improvements relating to Electric Telegraphs, of which the following is a specification, reference being had to the accompanying drawings.

My invention relates to duplex electric telegraphs; and its main object is to diminish the cost of the apparatus required for working long submarine cables upon systems such as that known as the "Muirhead double-block" system. In the said double-block system and in analogous systems it has been customary to employ an artificial line and to arrange condensers or sets of condensers between the key and the actual line or cable and between the key and the artificial line. It has, moreover, been usual to make an artificial line with a total capacity equal to or nearly as great as that of the cable, and in which the ratio of the resistance to the capacity is the same as that of the resistance of the cable to the capacity of the cable.

I have discovered that a sufficiently-near balance to permit of efficient duplex working can be obtained with an artificial line of much less total capacity than that of the cable. To effect this result, I in some cases increase the resistance of the artificial line in such a manner that although the capacity thereof is less than that of the cable the product of the resistance and the capacity of the artificial line are equal to the product of the resistance and capacity of the cable. For example, I substitute for the artificial line heretofore employed an artificial line consisting of "Muirhead's inductive resistance," so constructed that its strip-resistance is greater in proportion to its capacity than in apparatus of the same kind or class heretofore constructed. In other cases I substitute for the artificial line heretofore employed a compensating circuit composed of a series of condensers of which the total or collective capacity is less than the total capacity of the cable, (say, for instance, about one-third of the capacity of the cable,) and which are arranged in combination with suitable resistances, the said series of condensers and resistances being connected to one of the main condensers. Moreover, I employ a supplementary condenser and a high resistance in combination with one of the condensers or sets of condensers above mentioned composing the double block, or I employ other suitable means for establishing a balance under the conditions of cable and artificial line herein specified.

In some cases the condenser employed in combination with the compensating circuit above described may be dispensed with, a differential receiving-instrument being used, one wire of which is connected directly to the compensating circuit and the other to the condenser which is in connection with the cable. In such cases the values of the condensers and resistances forming the compensating circuit must be determined, so as to produce the same electrical effect as that obtained by means of a compensating circuit such as that above described combined with a main condenser.

In the accompanying drawings, Figure 1 is a diagram showing an arrangement of apparatus working upon the double-block system of duplex telegraphy, with condensers in the sending and receiving circuits and having my present improvements embodied therein or incorporated therewith. Fig. 2 is a diagram illustrating a modification of my present invention. Figs. 3, 4, 5, and 6 are diagrams illustrating further modifications thereof.

Like letters indicate corresponding parts throughout the drawings.

Referring to Fig. 1, C is the cable. A L is the artificial line, which consists, as above stated, of Muirhead's inductive resistance, x y being the resistance strip or conductor, and C^4 the induction plate or surface.

C' C^2 are the main condensers, arranged, respectively, between the said key K and the said cable and between the said key and the artificial cable A L.

R h is a rheostat of low resistance placed between the key K and the condensers C' C^2.

C^3 is a supplementary condenser connected to the condenser C^2, and H R is a set of coils of high resistance inserted between terminals of the said condensers C^2 C^3. I sometimes substitute for the condenser C^3 and resistance H R a circuit composed of Muirhead's inductive resistance, as shown in Fig. 2, wherein x y is

the resistance strip or conductor of the said inductive resistance, and C^4 is the induction plate or surface. A receiving-instrument R and a condenser C^5 are inserted between the real and artificial cables.

The following is a practical example of the conditions under which I can advantageously use an artificial line of less capacity than the cable—that is to say, assuming the cable C, Fig. 1, to have a capacity of one thousand microfarads and a resistance of seven thousand five hundred ohms, a balance is established with the artificial line of total capacity of five hundred microfarads and a resistance of fifteen thousand ohms under the following conditions, viz: the condenser C′ having a capacity of eighty microfarads, the condenser C^2 a capacity of 38.23 microfarads, and the condenser C^3 a capacity of 3.3 microfarads, and H R thirty-one thousand ohms, a resistance of about twenty ohms being inserted between C′ and the rheostat R *h*. When the artificial line is of very high resistance, it may be advantageous in certain cases to transpose the key K and receiving-instrument R, as shown in Fig. 3.

Fig. 4 shows an arrangement of apparatus similar to that shown in Fig. 1, with the following exception, viz: I dispense with the artificial cable and substitute therefor a compensating circuit comprising a series of condensers c' c^2 c^3 c^4 c^5 of relatively small capacity, which are all connected to the main condenser C^2 and to earth, resistances r' r^2 r^3 r^4 r^5 being interposed between the several condensers of the said series and the earth. The condenser C^2 is, moreover, in some cases connected to earth through a resistance R′.

Fig. 5 shows one arrangement in which a differential receiving-instrument is employed. A B indicate the two wires or coils of the said receiving-instrument, whose relative electromagnetic effect upon the index of the instrument can be varied. The wire A is inserted between the condenser C′ and the rheostat R *h*. I dispense with the main condenser C^2 and with the supplementary condenser C^3 and resistance H R, (shown in the preceding figures,) and I connect one end of the wire B to the rheostat R *h* and the other end thereof to the condensers c' c^2 c^3 c^4 c^5 and resistances r' r^2 r^3 r^4 r^5, the said condensers being connected to earth, and in some cases I also connect the said wire B to earth through a resistance R′. It is evident that the values of these condensers and resistances must differ from the values of those used in combination with the condensers C^2, as in Fig. 4.

The condensers c' c^2 c^3 c^4 c^5 and resistances r' r^2 r^3 r^4 r^5 may in any case be arranged either as shown in Fig. 4 or as in Fig. 5—that is to say, the resistances may be between the condensers and the earth or between the condensers and the receiving-instrument.

Any desired number of condensers and resistances may be employed in the aforesaid series.

It is evident that by the improvements above described I provide for greatly diminishing the cost of the apparatus, as I am enabled to employ apparatus of much less capacity than has heretofore been used in duplex telegraphs on submarine cables. Moreover, a diminished capacity is required in a series of condensers and resistances such as that above described as compared with an artificial line of ordinary construction.

I wish it understood that for the purpose of my present invention I include under the term "artificial line" a compensating circuit consisting of condensers and resistances arranged as shown in Fig. 4 or in Fig. 5, as well as the Muirhead's inductive resistance shown in Figs. 1 and 3, and also any equivalent devices or arrangements.

I find the arrangement shown in Fig. 6 to be an advantageous equivalent of the condenser C^3 and high resistance H R shown in Figs. 1, 3, and 4—that is to say, two condensers C^3 C^6 are joined up in connection with the block-condensers C′ C^2, as shown in Fig. 6, and the high resistance above mentioned with reference to Fig. 1 is replaced by a set of slides of high resistance H R, connected with the condensers C^3 C^6. The index or movable or sliding contact Z of the slides is connected directly to the key K or to the index of the rheostat R *h*. By varying the position of Z upon H R the difference in the rates of flow of the two sets of condensers C′ C^3 and C^2 C^6 can be more gradually effected than by the single circuit of C^3 and H R. (Shown in Figs. 1, 3, and 4.)

Moreover, I wish it understood that I am aware of the existence of the following - ters Patent of the United States for du x telegraphy, viz: No. 234,490, November 16, 1880; No. 327,097, September 29, 1885, and No. 329,477, November 3, 1885, granted to myself, and No. 284,498, September 4, 1883, granted to Smith and Taylor, and I do not make any claim in my present application for any of the inventions described in the specifications of the aforesaid prior patents.

What I claim is—

1. In a duplex electric telegraph working on the double-block or an analogous system, an artificial line or compensating circuit having a capacity much less than that of the actual cable and a resistance correspondingly greater than the conductor of the cable, combined with a supplementary or adjusting circuit comprising an adjustable condenser and an adjustable high resistance or the electrical equivalent thereof, substantially as hereinbefore described, for the purpose specified.

2. In a duplex electric telegraph working upon the double-block or analogous systems, and in which condensers are employed in both the sending and receiving circuits, an artificial line consisting of Muirhead's inductive resistance, having a total capacity much less than that of the actual cable and resisttance correspondingly greater than that of

the conductor of the cable, substantially as and for the purpose above specified.

3. In a duplex electric telegraph working on the double-block or analogous systems, the combination, with the cable C, the condensers C′ C^2, the key K, and a receiving-instrument, of a Muirhead's inductive resistance, the resistance strip or conductor x y of which is connected to one terminal of the condenser C^2 and the induction plate or surface C^4 of which is connected to earth, substantially as and for the purpose set forth.

4. In a duplex electric telegraph working on the double-block or analogous systems, the combination, with the cable C, the condensers C′ C^2, the key K, and a receiving-instrument, of a Muirhead's inductive resistance, the resistance-strip x y of which is connected to one terminal of the condenser C^2 and the induction plate or surface C^4 of which is connected to earth, and an adjusting-circuit connected to the terminals of the said condenser C^2, substantially as and for the purposes set forth.

5. The combination, with the cable C, the condenser C′, the key K, and a receiving-instrument, of the condensers c' c^2 c^3 c^4 c^5 and resistances r' r^2 r^3 r^4 r^5, substantially as and for the purposes set forth.

6. The combination, with the cable C, the condenser C′, the key K, and a receiving-instrument, of the condensers c' c^2 c^3 c^4 c^5, the resistances r' r^2 r^3 r^4 r^5, and the resistance R′, substantially as and for the purposes set forth.

7. The combination, with the cable C, the condenser C′, the key K, and a receiving-instrument, of the condensers c' c^2 c^3 c^4 c^5, the resistances r' r^2 r^3 r^4 r^5, and the condenser C^2, substantially as and for the purposes set forth.

In testimony whereof I have hereunto signed my name in the presence of two subscribing witnesses.

ALEXANDER MUIRHEAD.

Witnesses:
DAVID YOUNG,
C. JUNGE.