W. E. ATHEARN.

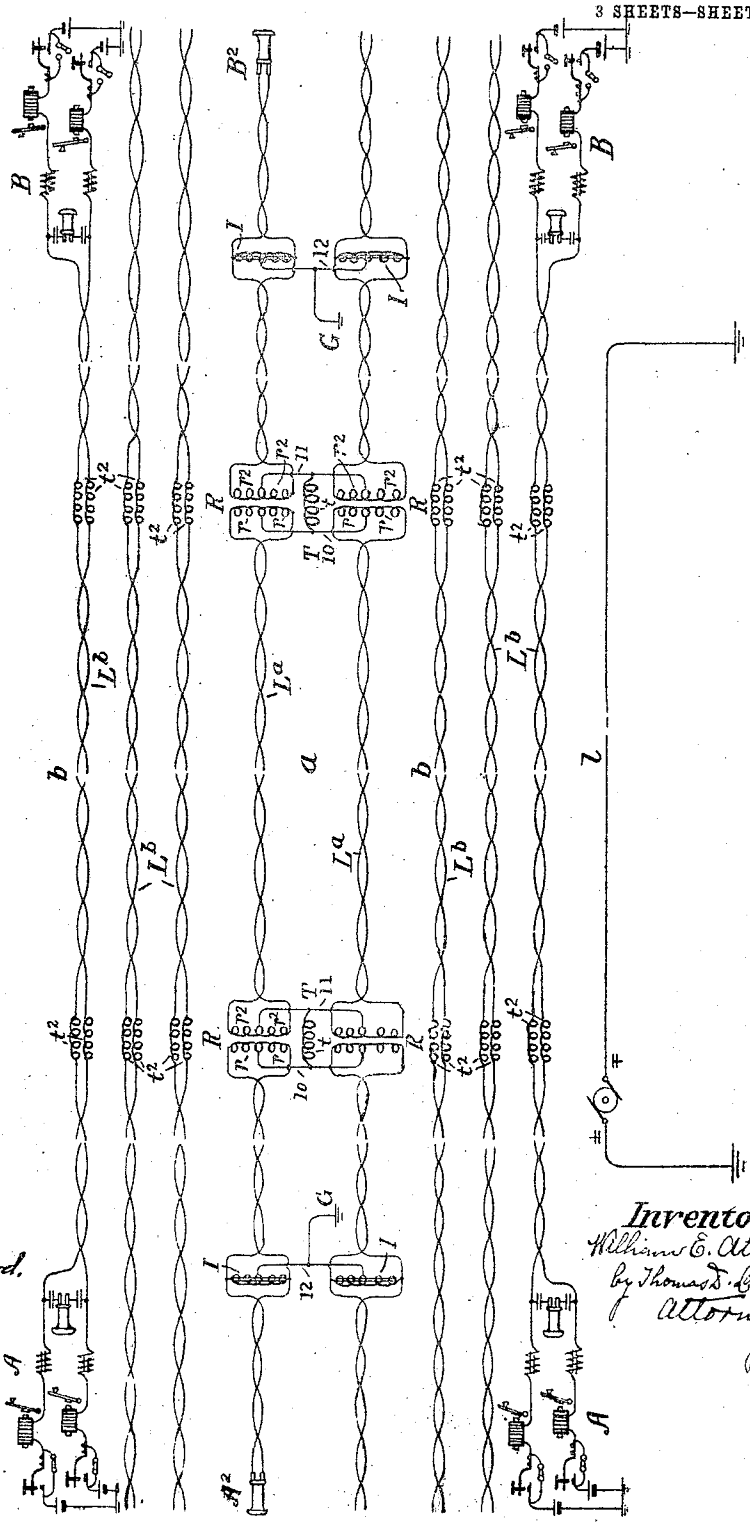
ELECTRICAL CONDUCTING SYSTEM.

APPLICATION FILED APR. 29, 1908.

940,655. Patented Nov. 23, 1909.

3 SHEETS—SHEET 1.

Fig. 1.



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3 SHEETS—SHEET 2.

Fig. 2.

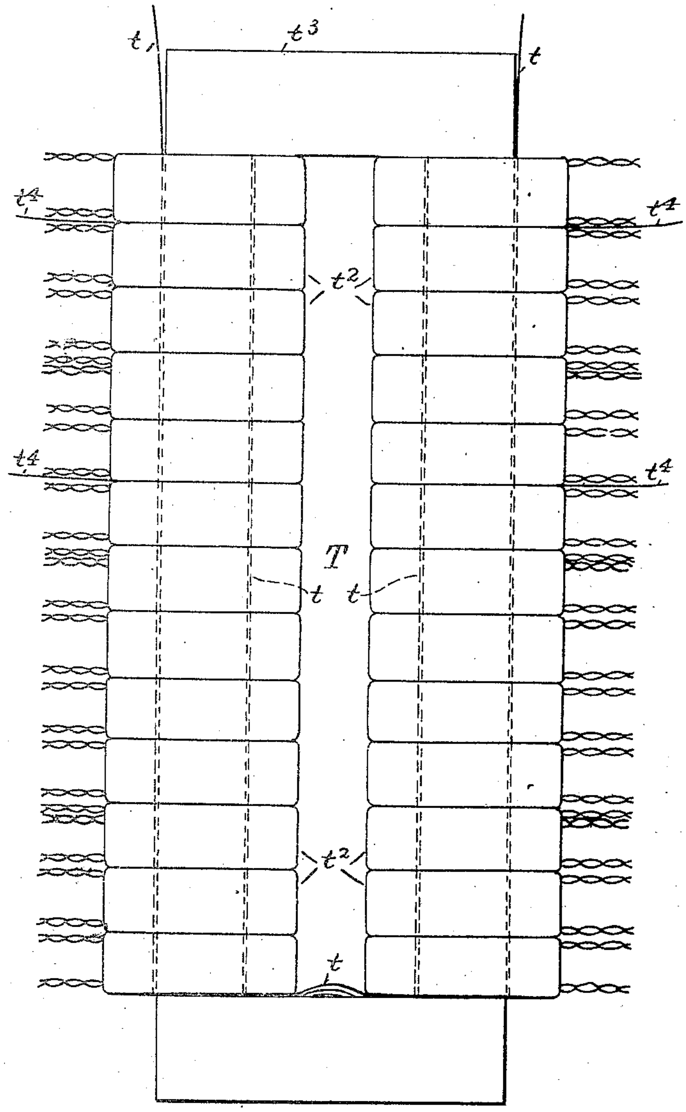
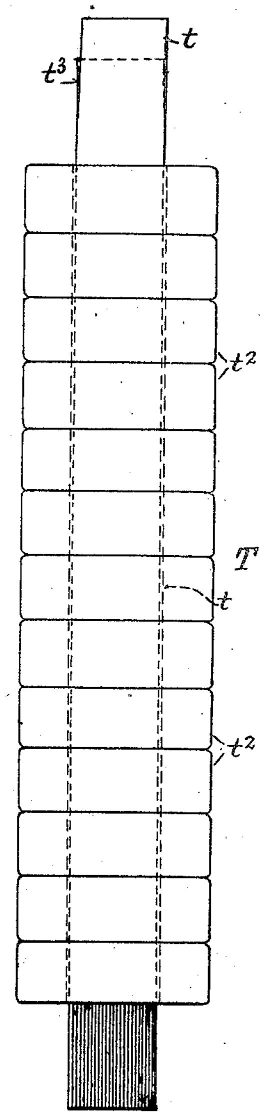


Fig. 3.



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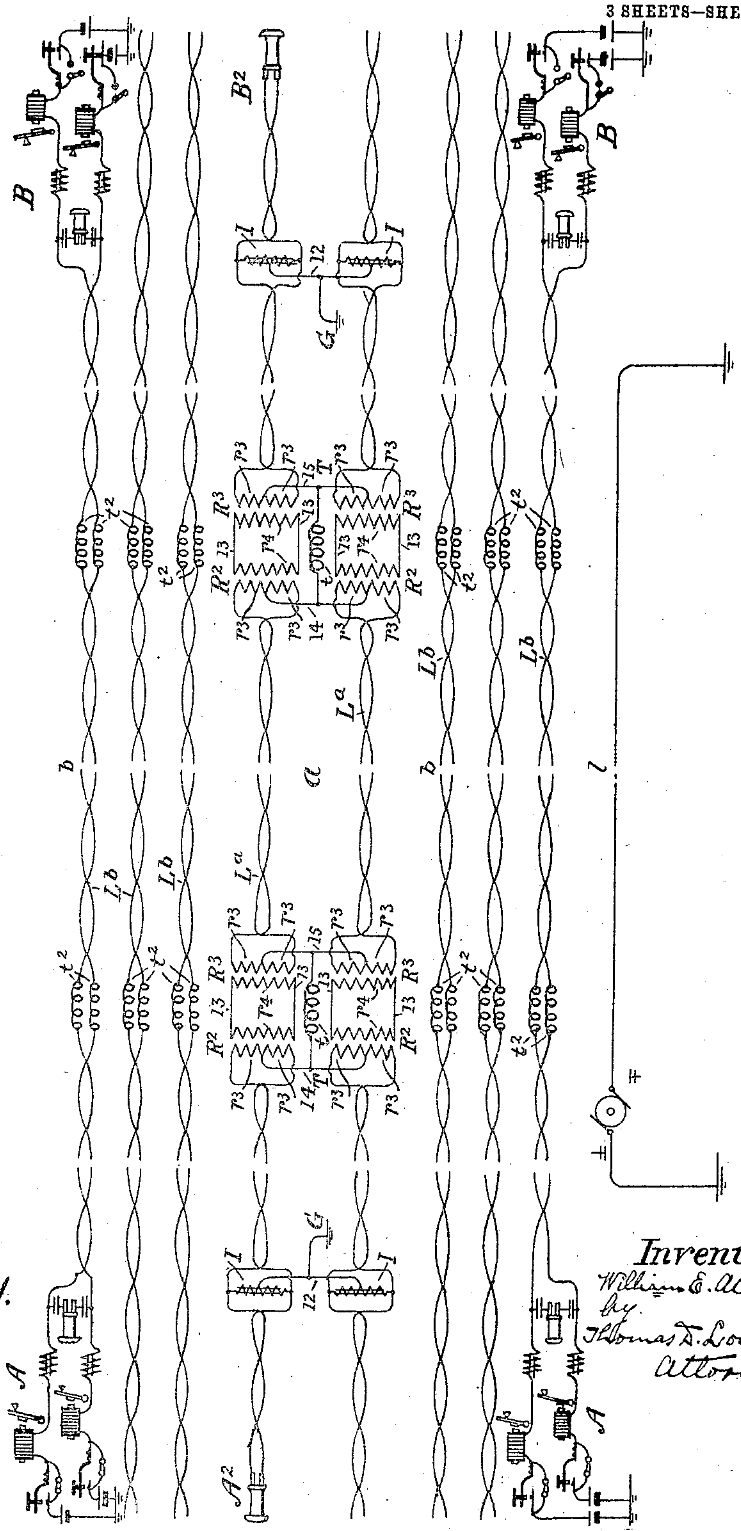
3 SHEETS—SHEET 3.

Fig. 4.



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UNITED STATES PATENT OFFICE.

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ELECTRICAL CONDUCTING SYSTEM.

940,655. Specification of Letters Patent. Patented Nov. 23, 1909.

Application filed April 29, 1908. Serial No. 429,974.

To all whom it may concern:

Be it known that I, William E. Athearn, residing at New York, borough of Brooklyn, in the county of Kings and State of New York, have invented certain Improvements in Electrical Conducting Systems, of which the following is a specification.

Circuits for telephonic and telegraphic communication, or other lines over which electrical signals are transmitted under comparatively low potentials, are liable to be subjected to the inductive influence of such alternating current power circuits as are used for the propulsion of heavy railway trains at high speeds. These power systems frequently operate with excessive currents and at a relatively low frequency, say twenty-five cycles, and have been found sometimes to set up in adjacent conductors electromotive forces often amounting to from one hundred and fifty to three hundred volts and sometimes reaching eight hundred volts. Under such conditions a grounded telegraphic circuit, as usually organized, is rendered inoperative, the induced twenty-five cycle current, even if not under much pressure, causing the relay armatures to so vibrate that the Morse signals are rendered unintelligible. With metallic circuits, as those of the telephone, no matter how carefully they are transposed, they still may be seriously affected when the induced electromotive force reaches about two hundred volts, since it then begins to discharge at the lightning arresters, and to the disturbance thus produced is added the hazard of fire from insufficient insulation and of painful shocks to subscribers and operators. To prevent these difficulties, it has been proposed to diminish the inductive effects by applying to the disturbed conductors opposing electromotive forces generated in the plural secondary windings of one or more properly designed induction coils, there being one of these secondary windings connected in each signaling conductor, while a primary winding for inducing in the secondaries the neutralizing electromotive forces is in a circuit under the same inductive influence as said signaling conductors. To attain the best results the resistance of the primary circuit of each induction coil must be low, and therefore the primary winding consists of a conductor of relatively large cross section. To continue this low resistance throughout the circuit of the primaries, the conductors making up the remainder of this neutralizing circuit must also be of small resistance, and since, as already pointed out, their exposure must be the same as that of the lines in which disturbances are to be abated, it has been found convenient to set aside from the latter a sufficient number to give the requisite conductivity, connecting these in multiple to each primary winding and grounding their extremities outside the affected district to permit a flow of the primary neutralizing current. It will be evident that the lines thus employed are useless for the purposes for which they were intended, since their connection with the single primary winding makes them in effect a single conductor and the ground connections carry off the signaling as well as the neutralizing currents. There must consequently be counted against this system, in addition to the comparatively small investment in induction coils, charges for the neutralizing conductors amounting to at least twenty-five per cent. of the expenditure for those protected. Though a gain is made, it is at a heavy cost, and the purpose of the present invention is to minimize this loss in conductors.

With this end in view, my invention consists in a means of utilizing for transmission the primary conductors, and abating therein the effect of the directly induced electromotive forces which develop in the secondary conductors the neutralizing electromotive forces.

In the accompanying drawings, Figure 1 illustrates diagrammatically one embodiment of my invention; Fig. 2 is a front elevation of a transformer adapted for use in the system; Fig. 3 is a side elevation of said transformer, and Fig. 4 is a diagram showing another arrangement of the system from that of Fig. 1.

Similar characters are applied to like parts throughout the figures of the drawings.

Referring particularly to Fig. 1, a grounded power conductor *l*, for high potential, low frequency alternating current, is shown extending in proximity and substantially parallel to a number of conductors L^a, L^b, which it is desired to employ for telephonic and telegraphic communication. It may be assumed that the conductors L^a, L^b, are practically equidistant from l. In the present instance the conductors are arranged in twisted pairs, and are therefore adapted for metallic telephone circuits, but they may be also used independently of their application to telephone purposes or simultaneously therewith for grounded telegraph circuits, in the latter case either singly or in pairs by the well-known composite or simplex methods. The current traversing the power conductor will induce in the signaling lines electromotive forces, tending to produce the disturbing currents and discharges previously mentioned.

To render a portion of the lines available for signaling, they are divided into two groups a and b, the conductors therein being designated as L^a, L^b, respectively. I have shown three times as many conductors in the group b as in a, with the former distributed upon opposite sides of the last named group. In practice, as has already been pointed out, the distance of each pair of conductors in both groups from the disturbing conductor would be substantially the same, all the signaling conductors, for example, being contained in a cable. In group a the conductors L^a are multipled together and have connected with them in series a single low resistance primary winding t of at least one induction coil or transformer T. At points beyond the ends of the power conductor the line conductors of group a are connected to ground or other common return at G, G through apparatus which will be later considered, since it does not enter into the operation of that portion of the system now being described. Each transformer has a plurality of secondary windings t^2, each consisting of a pair of conductors and preferably equaling in number the pairs in the line group b. The design of the transformer is governed by the following general considerations: The passage of the disturbing current through the conductor l will induce in each of the signaling conductors L^a and L^b substantially equal electromotive forces. In the primary group a this electromotive force will cause a flow of current through the circuit completed by the common return, which, traversing the primary windings t of the transformers, generates an electromotive force in each of the secondary windings t^2. The secondary windings are so related to the primaries and so connected to the conductors L^b, that the transformer electromotive force of the secondary conductors opposes that directly induced by the power conductor. Then by supplying each secondary coil with a greater number of turns than its primary to provide for losses in the primary conductors and in transformation, this secondary electromotive force may be made practically to nullify the disturbing electromotive force. Complete compensation cannot be obtained by such a transformer, because of differences in wave form and phase between the directly induced and secondary electromotive forces in the conductors L^b caused by characteristics of the transformer. This effect, however, may be minimized by the use of an efficient transformer and by keeping down the resistance of the primary circuit, the latter condition being obtained by the large primary winding and the multipling with it of a number of the line conductors L^a. The number of transformers used depends upon the length of the groups of lines to be protected and the magnitude of the electromotive force induced, since each of said transformers will carry its proportionate part of the total voltage, and to distribute this among a plurality of transformers increases the factor of safety in case of accident. In the present instance two of these are shown, and the primary windings of these transformers may be considered to separate the conductors L^a into three sections.

It will be seen that the above system will adapt the conductors L^b for both metallic circuit telephone and grounded circuit telegraph purposes between stations of which two are indicated at A and B on each of two lines, since both the unneutralized parasitic electromotive force and the resulting current are small; but obviously the conductors L^a, multipled together and connected to the transformer primaries and to ground, are not capable of use for signaling purposes.

I will now describe my means for restoring to the primary conductors their efficacy for transmission. In this system there are two more important features, these being that each of the lines or circuits of group a are rendered electrically continuous independently of the associated lines in said group and of the windings of the transformers, and that there is provided for the neutralizing primary current a path to the common return which shall exclude operating currents. In the system as illustrated, I secure the continuity of each pair of conductors by associating their successive sections independently of the primaries of the transformer through repeating coils R having electrically symmetrical sectional windings r, r, and r^2, r^2. The opposite extremities of the primary t of each transformer T are joined in multiple with the centers of the windings of all the repeating coils connected to the same pair of line sections, that is, to points at the junctures of the coil sections r, r, and r^2, r^2, by conductors 10 and 11, respectively. Electrical signaling impulses of a pulsatory or alternating character, such as telephone currents, originated, for example, at a station A^2, flow in both sides of the first section in the circuit furnished by a pair of conductors L^a, passing serially through the coil windings r, r, and inducing similar currents in the associated windings r^2, r^2. Transmission will thus continue throughout the circuit to station B^2, each winding r, r acting as the primary and r^2, r^2 as the secondary of the induction coil the relation being reversed when the transmission occurs in the opposite direction. The induced primary current, which is to be used in the production of the compensating secondary currents, traverses each pair of line conductors L^a in parallel, inward through both sections of the winding r, r of the first repeating coil, conductor 10, the primary t of the first transformer, conductor 11, outward by the repeating coil winding r^2, r^2, and so on through the line, this being reversed for each alternation. As this primary current due to the power conductor is equal and opposite in both sides of the line pair and in both sections of the repeating coil windings, it will be balanced and without effect upon the operating current.

To furnish a selective ground connection for the neutralizing current, I have shown bridged across each line pair beyond the opposite extremities of the distributing conductor l, a suitable impedance coil I with its center united to the ground G by a conductor 12. To the telephone currents passing in the same direction through their entire length these coils present so high an impedance as to be practically opaque or exclusive thereto, but for the induced current flowing in opposite directions through the halves, they act differentially and become readily permissive. In this manner operating currents are confined to the metallic circuit in which they are originated, while the primary neutralizing current circulates in the conductors L^a in parallel and through the common ground return.

From what has been stated, it will be seen that I have provided a method whereby the group of conductors L^a not only performs its function of protecting the companion group L^b against inductive disturbances, but which also permits a not greatly affected transmission of signaling currents through the first group. There yet remains to be considered the effect upon the system of the electromotive force which produces the primary neutralizing current. If this were equal to the inductively impressed electromotive force it might, under some conditions of circuits and exposure, be so great as to lead to the disruptive discharges and to cause fires and shocks as has been described. But the transformers, by the self-induction of their primaries will generate a counter electromotive force opposing the impressed electromotive force and approaching it in magnitude, the difference being the voltage necessary to send the transformer magnetizing current through the primary circuit. As the transformers are designed to operate efficiently and the resistance of the primary circuit is comparatively small, the resultant electromotive force will be too low to be detrimental. The group a of signaling conductors will therefore be as fully protected against induction as is the group b.

To avoid confusion in the diagram, the primary and secondary windings of the transformers T appear as separated from one another. Such a transformer as might actually be used is shown in Figs. 2 and 3 of the drawings. Here a rectangular core t^3, built up of laminæ of soft iron, has upon its opposite longer sides the primary winding t distributed uniformly. This primary is furnished by three hundred and fifty turns of insulated copper tape, having sectional dimensions of seventy-two thousandths of an inch by one and three-tenths inches and a total resistance of about four-tenths of an ohm. Over this the plural secondaries t^2 are placed side by side on both cores, each having the same number of turns of paired windings as the primary and being of number twenty insulated copper wire, each of these wires presenting a resistance of approximately five and seventy-five hundredths ohms. Taps t^4 are brought out from the primary winding, whereby the number of turns may be reduced by amounts varying up to about fifteen per cent. of the total to give the desired ratio of transformation. The repeating coils and impedance coils need not be particularly described, as standard apparatus may be employed.

It will be understood that my improved system may be modified in many respects without departing from the spirit of the invention.

In Fig. 4 I have indicated diagrammatically an arrangement in which, instead of a single repeating coil at each transformer T to continue a signaling circuit from line section to line section of each pair of primary conductors, two repeating coils R^2 and R^3 are used. Each coil has one sectional winding r^3, r^3 joined in series with the conductors of one line section, while the other windings r^4, r^4 are placed in series with one another by conductors 13, 13. The primary t of each transformer is united at one extremity by a conductor 14 with the juncture of the windings r^3, r^3 of the coils R^2, while the opposite end of the primary is similarly connected by a conductor 15 to the windings r^3, r^3 of the coils R^3. As in the organization of Fig. 1, the neutralizing primary current flows through the conductors of each line pair in parallel, inward through the winding r^3, r^3 of coil R^2, conductor 14, primary of the transformer, conductor 15, outward by winding r^3, r^3 of coil R^3 and on through the circuit as has been previously traced, and then upon alternation in the opposite direction. The signaling currents circulating in a line section traverse the winding r^3, r^3 of coil R^2 serially, inducing like currents in the winding r^4, and this flows in the circuit formed therewith by the conductors 13, 13 and winding r^4 of coil R^3, the last-named winding repeating into the winding r^3, r^3 of coil R^3. Save as indicated, this arrangement operates in the same manner as that of Fig. 1.

In my application, Serial Number 429,973, filed April 29th, 1908, I have claimed a method described but not claimed herein.

I claim:

1. An electrical signaling system comprising groups of lines, an induction coil having a primary winding connected to the lines of one group and secondary windings joined to the lines of a second group, and means for preserving the electrical continuity of each line of the primary group independently of the associated lines.

2. The combination with conducting circuits, of an induction coil having a winding connected to the circuits and dividing them into sections, and means for transmitting electrical impulses from section to section independently of the induction coil.

3. An electrical system comprising a plurality of conductors, a transformer having a primary winding and a plurality of secondary windings, a portion of the conductors being connected in parallel to the primary winding and other conductors united separately to the secondary windings, and means outside the transformer for permitting the flow of current through each of the conductors united to the primary winding.

4. The combination with a plurality of conductors and a common return conductor, of an induction coil having a primary winding connected in parallel with a plurality of the conductors and dividing them into sections and being provided with secondary windings joined to other conductors, repeating coils for electrically associating the conductor sections at opposite sides of the primary winding, and connections from the primary conductors to the common return conductor, said connections acting selectively with respect to the currents passing through the winding of the induction coil and those transmitted by the repeating coils.

5. In a signaling system subjected to induction from a source external thereto, the combination with two groups of conductors, of a transformer having a primary winding connected in one group of conductors, a secondary winding connected in the other group, said transformer being organized to generate under the influence of the external source upon the primary conductors an electro-motive force in the secondary winding opposing that caused by the external source, means for securing independent paths for the signaling currents through the primary conductors, and ground connections for induced currents from the primary conductors, said ground connections being situated at opposite sides of the transformer and being impassable to the said signaling currents.

In testimony whereof, I have signed my name to this specification in the presence of two subscribing witnesses, this 23rd day of April 1908.

WILLIAM E. ATHEARN.

Witnesses:
ROBERT FOSTER JANES,
SYLVANUS H. COBB.