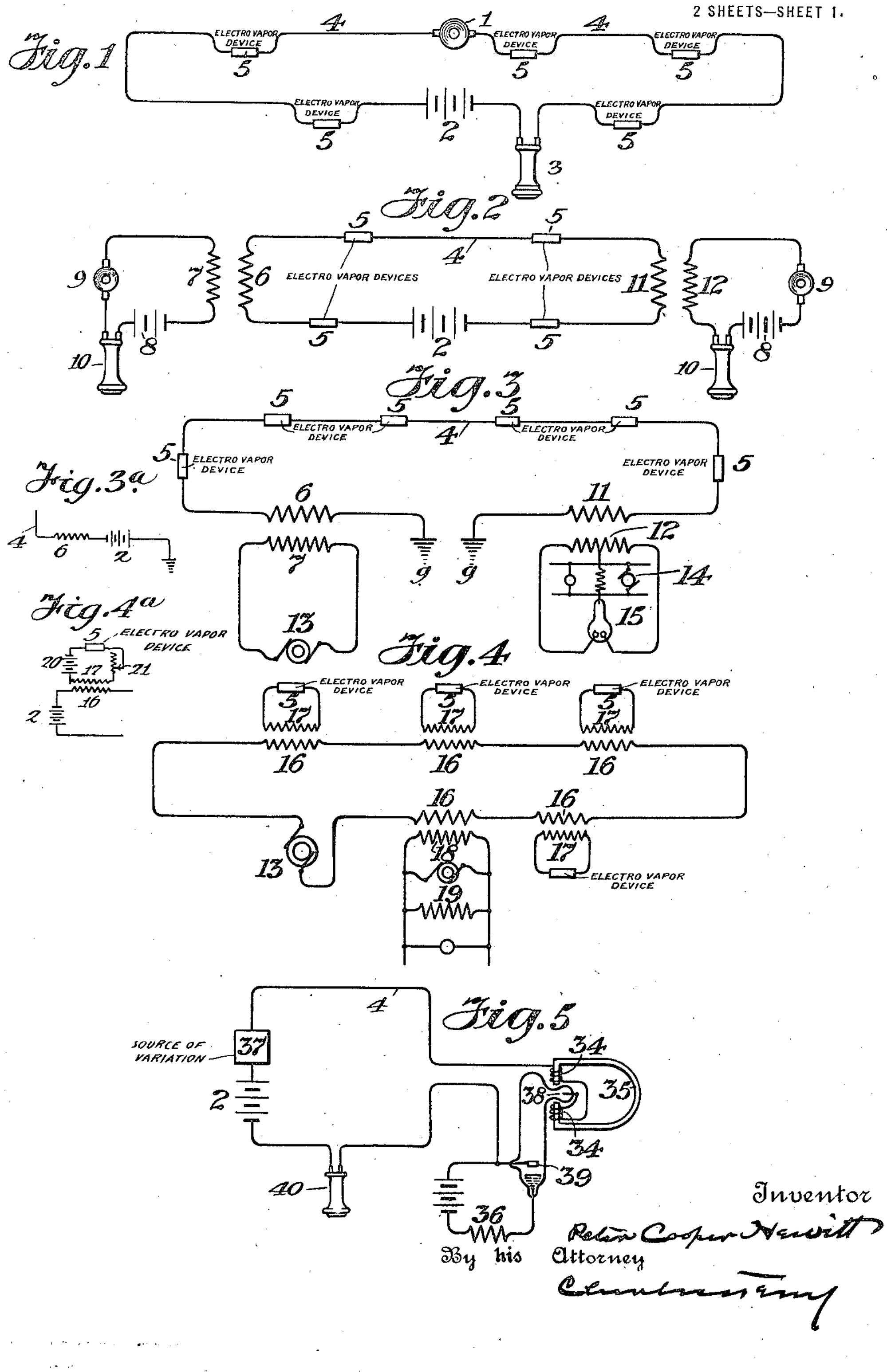
P. C. HEWITT.

ELECTRIC CIRCUIT.

APPLICATION FILED JAN. 30, 1917. RENEWED OCT. 16, 1919.

1,328,327. Patented Jan. 20, 1920.

2 SHEETS—SHEET 1.



Inventor

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By his Attorney

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2 SHEETS—SHEET 2.

Fig. 6

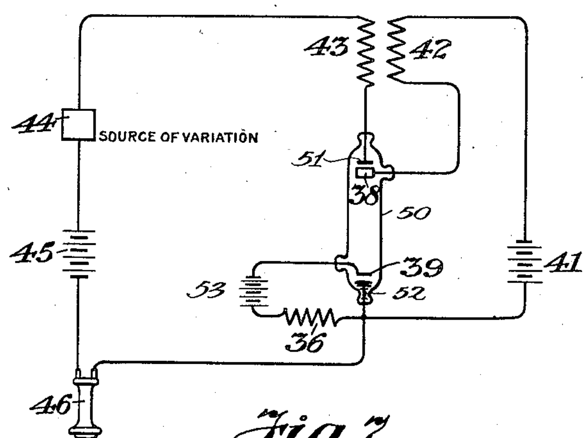


Fig. 7

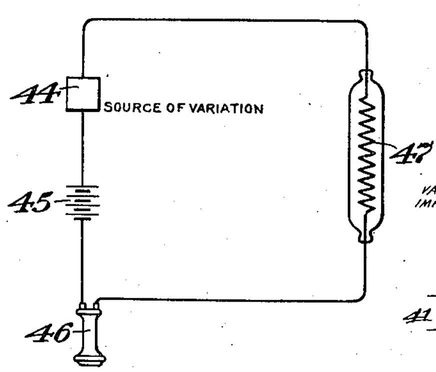


Fig. 9.

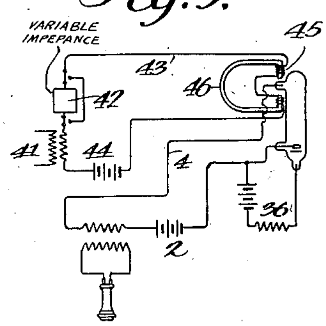
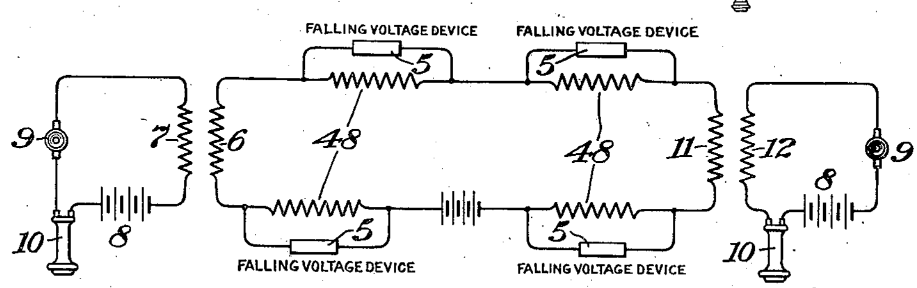


Fig. 8



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UNITED STATES PATENT OFFICE.

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ELECTRIC CIRCUIT.

1,328,327. Specification of Letters Patent. Patented Jan. 20, 1920.

Continuation in part of application Serial No. 775,632, filed June 25, 1913. This application filed January 30, 1917, Serial No. 145,378. Renewed October 16, 1919. Serial No. 331,244.

To all whom it may concern:

Be it known that I, PETER COOPER HEWITT, a citizen of the United States, and resident of Ringwood Manor, county of Passaic, State of New Jersey, have invented certain new and useful Improvements in Electric Circuits, of which the following is a specification.

An electric current traversing an ordinary electric circuit tends to vary proportionately with variations of the impressed electromotive-force. Variations in energy produce variations in impedance, and the greater and more rapid the variations, the greater becomes the impedance effect.

In many classes of circuits it is desirable to modify, minimize or avoid such impedance or its effect, as, for instance, in telephone circuits and long lines.

Various means have been devised in an attempt to neutralize, overcome or do away with impedance. The methods and apparatus heretofore devised for such purpose have dealt with a condition where the current flow varies directly with the electromotive-force or applied difference of potential.

My invention is based upon the discovery that a composite circuit may be constructed in which the current flow is not in proportion to the applied electro-motive-force, (as it is in an all-metallic conductor) and in which the resistance of a portion of the composite circuit varies in reverse order to the energy absorbed by impedance. As a result it is possible to produce a circuit wherein the current flow is not directly proportional to the voltage, and the voltage drop varies less or more than would be the case for the same current variations over the ordinary metallic circuit, and the ratio of energy dissipated is not the same as in such metallic circuit.

The invention contemplates a composite electrical circuit consisting of members in certain of which the resistance tends to remain constant and is so under normal conditions, the current flow tending to vary directly with the impressed electromotive-force, and another member or members electrically connected therewith wherein the resistance tends to be variable under the influence of difference of energy transmitted and the current passed is not proportional to the voltage. In one member the resistance tends to be constant and the voltage variable with varying current; in the other the resistance is variable.

The energy dissipating ability of one member is that of a true conductor, while the energy dissipating ability of another member follows a different law.

In an electrical system variation of energy dissipation is a function of varying resistance, varying voltage or varying current or any of them.

It follows from this that given a circuit in which the resistance can be varied in some ratio with respect to varying energy, it becomes possible to produce a circuit in which impedance effects such as the inductance and the capacity effects may be given other relative values for carrying energy than those of an ordinary circuit consisting simply of a true conductor.

My invention provides for such modification of the characteristics of a circuit by inserting at intervals resistance paths which have the quality of varying in resistance when transmitting variations of energy. I am able to do this by utilizing the electrical characteristics of certain bodies such, for instance, as a conducting gas or vapor as a part of the electrical circuit. When the means consists of a conducting vapor, it may be held in an air-tight container constructed to secure the essential requirements of gas purity and proper gas or vapor density, and it may be rarefied as required to be adapted to particular uses to which it is to be placed and be modified as to size and shape, and the gas contained as well as have its normal action modified by magnetic and by electrostatic action by the electric energy of the circuit, or be influenced by another circuit.

In certain cases this special conductor may be contained in an independent circuit inductively, electrically or electro-magnetically associated with the principal circuit as, for instance, by means of a transformer, the main circuit being the primary and the special conductor being included in the secondary circuit. In other cases, it may be used directly in the main circuit and connected around an impedance device in the line, or it may be located directly in the main line and form a part thereof.

In the accompanying drawings, Figure 1 shows a telephone circuit having capacity, inductance, resistance, a source of energy, and vapor devices; Fig. 2 is the same as Fig. 1 except that the telephone variations are impressed upon the line inductively; Fig. 3 is a power transmission line; Fig. 3ª is a modification of Fig. 3; Fig. 4 is a further modification of Fig. 3; Fig. 4ª is a modification of Fig. 4; Fig. 5 illustrates a simple embodiment of the invention herein described and claimed; Fig. 6 illustrates an arrangement whereby electrostatic effects are substituted for magnetic affects; Fig. 7 shows a hot wire in place of the gas or vapor device, or rather a device having a falling voltage characteristic appearing in the other figures of the drawing; Fig. 8 illustrates a modification; and Fig. 9 shows an arrangement for controlling the electric device by electric elements located in a separate circuit.

Referring to Fig. 1, 1 represents a telephone transmitter or other suitable means for varying the currents derived from a battery 2, or other suitable source of currents. 3, represents a receiving device such as a telephone receiver, or other apparatus, operated by the transmitted currents. The circuit connections between the device 1, and the device 3, comprise sections, 4, and sections, 5. The sections 4, are ordinary metallic conductors or what may be conveniently termed true conductors. The sections 5, include the vapor devices in which the resistance tends to be variable under the influence of different amounts of energy transmitted, and wherein the current passed is not proportional to the voltage, as hereinbefore described. Assuming the circuit arrangement of Fig. 1 is a telephone line, and that speech is to be transmitted from a point in the line at the transmitter 1 to the receiving device 3, the speech to be transmitted will be impressed on the line 4 through the medium of the transmitter 1 which has a variable resistance. The variations in this resistance cause the current flowing in the circuit from the battery 2 to vary. Increase of current in the circuit causes a decrease of voltage drop across the device 5, which causes a greater increase of current in the circuit from the source. The impeding effect of the resistance of line 4 on the variations is thus counteracted to the desired extent by the characteristics of devices 5, and the variations will be reproduced in the receiver 3.

In Fig. 2, a source of current is represented at, 2, connected in the circuit, 4, 5. 6, represents the secondary of an induction coil, the primary of which is connected through a source of current, 8, with a telephone transmitter or other current varying device, 9, and a receiving device, 10. At some other portion of the circuit a similar transforming device having its primary, 11, connected in the circuit, 4, 5, and its secondary, 12, connected in a circuit containing another current-varying device, 9, and a source, 8, and receiving device, 10, are shown. In this embodiment, the variations of the transmitter resistance 9 cause variations in the current of its local circuit 7, 8, 10 which causes a variation in the voltage across the transformer secondary 6. These variations of voltage add to or subtract from the voltage of the battery 2 causing the current flowing in the battery 2 to vary and these variations of current are increased by the devices 5 in the same manner as in Fig. 1. Variations in the line circuit 6, 4, 5, 11, 2 are reproduced in the transformer secondary 12 and utilized in the receiver 10. The operation is the same when speech is transmitted in the reverse direction.

In Fig. 3, the circuit, 4, 5, is shown as being grounded at g, g, the earth forming a portion of the return conductor. In this circuit, transformers 6, 7, and 11, 12, are shown. In connection with the primary, 7, there is shown a source, 13, of alternating or varying currents. The transformer, 11, 12, has its secondary connected at an intermediate point with one side of a consumption circuit, 14, containing any desired devices, the other side of the consumption circuit being connected with one terminal of one electrode of a vapor device, 15, two terminals thereof being connected, respectively, with conductors leading to the respective terminals of the coil, 12. In the arrangement of apparatus here shown, the energy from the source of variable or alternating current 13 is transferred to the line 4, 5 through the transformer coils 7, 6. The energy in passing over the line 4, 5 is successively subjected to the impeding effects of the sections 4 and the impedance-modifying effects of the devices 5 and delivered to the work circuit 14 through the transformer 11, 12 and the rectifying device 15.

In Fig. 4, the source, 13, is shown as being connected through primary coils, 16, the secondary coils, 17, of which are connected through circuits containing vapor devices, 5, whose resistance varies in the manner above described. An additional primary, 16, is shown, having a secondary, 18, the terminals of which are connected through devices, 19, of any desired character, as shown. For reinforcing and modifying current in the line, it will be understood that sources of energy supply may be associated with the devices 5; in Figs. 3 and 4, shown at 2 in Fig. 3ª and the secondaries 17, in Fig. 4, shown at 2 and 20 in Fig. 4ª. Owing to the variation of the resistance of the secondaries under variation of current in the line, the secondaries 17 may have a variable impedance without energy supply in the circuit of the secondary. In the power circuit shown in Fig. 4 the energy from the source 13 is transmitted through the line 4 and coils 16 to the transformer 16, 18, of the work circuit 19. The devices 5 are connected to the line inductively through the transformers 16, 17 and the modifying effect of the devices 5 on the line current takes place through said transformers.

In Fig. 5, there is shown a source, 2, of electric currents and a device, 37, for producing variations therein. A conductor from the device, 37, leads through two coils, 34, upon the poles or projections of the poles of a magnet, 35, which varies the voltage drop over the device, which poles are presented to an extension, 38, of the vapor device containing an electrode with which a coil, 34, is connected. An electrode, 39, is connected with the return conductor of the first circuit through a receiving device, 40, affected by variations of current. A keep-alive circuit, 36, of any convenient arrangement is also shown. The operation of the circuit shown in Fig. 5 will be readily understood from the description already given of the general system of Fig. 1. The operation of the particular arrangement of device and magnet is fully set forth in the last eight paragraphs of the present specification.

In Fig. 6 a falling voltage device is shown at 50, one electrode, 51, is connected through a source of variation 44 to one pole of a source of current, 45. The other pole of this source is connected through a receiving device 46 to the other electrode, 52. A keep-alive circuit may be employed consisting in this instance of a source of current, 53, and a resistance or reactance device, 36, connected between the electrode 52 and another electrode 39. To supply the electrostatic condition, there is provided a source of energy 41 connected on one side with the electrode 52 and on the other with a terminal 38 arranged in proximity to the electrode 51. In Fig. 6 the operation is similar to Fig. 5, but in this case electro-static force instead of magnetic force is impressed on the vapor path to secure the desired characteristics. The resistance of the tube is increased by the potential from the battery 41 applied to the electrode 38 and then varied by the variations from the source 44 transmitted through the transformer 43, 42 as variations of potential on the electrode 38, the transformer coils 43, 42 being so connected that increase of current in 43 will be accompanied by a decrease of resistance in the vapor path and vice versa.

In Fig. 7 a typical circuit is shown in which is included a source of variation 44, a source of current 45, a receiver, 46, and a device comprising in this instance an inclosed material, 47, the resistance of which has a falling electromotive characteristic. The operation is obvious from the description of the other figures, particularly Fig. 1.

Fig. 8 shows several of the falling voltage devices 5 connected in series in a closed circuit, but each shunted by a resistance or reactance device 48. A transmitter 9, receiver 10 and battery 8 are connected through a coil 7 in inductive relation to a coil 6 in the first named closed circuit. At a distant point a coil 11 is included in this circuit, and this is in inductive relation to a coil 12 connected in series with a receiver 10, a source of current 8 and a transmitter 9. In the telephone line of Fig. 8 variations are impressed on the line in the same manner as in Fig. 2, the reactance devices 48 providing a means of adjusting the current of devices 5 with reference to the line current.

Fig. 9 represents a modification similar, in general character, to that of Fig. 5, except that the variations in resistance of the device are brought about by acting upon the magnet in a separate circuit not including the said device, but affecting the resistance thereof. In this figure, 41 represents a source of variations, 42 a variable device which may or may not be included in circuit 43, leading from a source 44, through the coils 45, of the polar extensions of the magnet 46. The poles of this magnet act on the variable resistance device which is connected in an independent circuit as shown. The operation of this arrangement will be clear from the described operation of the preceding figures of drawing, taken in connection with the statements made in the five following paragraphs and particularly the fifth of said paragraphs.

It will be apparent from the various figures of the drawings and from the specification, that the possibilities of the application of the invention are extremely varied, but such variations all rest upon the fundamental device herein described.

On consideration of Ohm's equation in connection with the present system, it must be borne in mind that the resistance of the special conductor differs from that of the ordinary metallic conductor in that it may not remain constant with variations of energy so that any or all of the three members in the equation $C=\frac{V}{R}$ may become a variable, and as a result any selected one may be made to vary or be a constant within limits while any two may vary in different degrees with respect to each other. Owing to these possibilities the energy radiated or dissipated from a portion of the circuit may be given many values within wide limits. It will be understood that in the equation $C=\frac{V}{R}$ the character C represents current strength, V, voltage or electromotive-force, and R, resistance.

Thus the characteristics of a circuit consisting essentially of a normal or "true conductor", such as copper, may be modified by including therein sections having characteristics other than those of such true conductor.

The variable resistance characteristics of certain forms of matter, when passing different amounts of electrical energy, may be modified by means external to it. This is particularly manifest in an attenuated gas or vapor wherein many of the electrical resistance phenomena may be modified by electromagnetic and electrostatic influence, including certain phenomena at the positive end of a conducting vapor or gas. These modifications are more pronounced at low densities. As an illustration, if a magnet be approached near a vapor device passing current, the voltage required to pass unit current will be increased, and the voltage required to pass current may diminish as the current increases, and the device may have a falling voltage characteristic. Under these conditions, the voltage required to pass unit current—and, therefore, the apparent resistance—will be increased in some direct proportion as the magnetic effect is increased, and will be decreased in some direct proportion as the current is increased.

If, as shown in Fig. 5, a terminal of a permanent magnet adjacent to the device be surrounded by a coil of wire and be connected in series with the device or be connected in another circuit, as shown in Fig. 9, in such manner that current passing through the coil will tend to demagnetize the magnet, and lessen its action on the device, the total resistance or opposition to the passage of the current presented by the device will be modified by the passing current by modification of the voltage required to pass current through the device, by modification of the magnetic force by the current, and also by the resistance varying inversely with the current passed. Such variable resistance of the device is itself essentially most unstable and may require in circuit with it, certain features of impedance presented by a true conductor, such as impedance 21, Fig. 4ᵃ, and the ratio of the voltage drop over these may be made of such relative value as to produce the required results, and in circuits may be had by suitably positioning the variable resistance devices in the line so that the line presents such impedance.

By means of my discovery it is possible to modify or to compensate for the effects of capacity or inductance in a circuit, or both, resulting from energy variations and so modify the impeding effects of these factors in circuits of considerable length; in other words, by adding to the energy consuming ability of a true conducting circuit, resistance of a different value and characteristics and thereby modifying the characteristics tending to produce impedance or impair wave forms.

A characteristic of a vapor device of variable resistance, is that the capacity and inductance effects are of very different order from those which are inherent in a true conductor. I propose using this phenomenon in connection with a true metallic circuit, and this is one feature of the present invention.

This application is a continuation of my application Serial Number 775,632, filed June 25th, 1913, as to matter common to the two applications.

I claim as my invention:

1. In an electrical system, a gas or vapor electric device, means for passing current through the same, and means for affecting the device by electro-static force and for causing the said force to be diminished by an increased current flow through said device.

2. In an electrical system including a device having a falling voltage characteristic, the method of controlling the current flow therein which consists in affecting the said device by electro-static force and causing the action of the said force to be diminished by increased current flow in said device.

3. In an electrical system, the method of operation, which consists in creating electro-static force in the system, varying said force by changes of current in the system, causing said force to act upon a local path having a falling voltage characteristic, and producing changes of resistance in the local path.

4. The combination of an electric circuit, a source of current therein, a conductor having an inherent falling electromotive force characteristic in said circuit, electro-static means for imparting an additional resistance thereto, and means for varying the effect thereof coincidently and inversely with the variations of the resistance of the conductor.

5. A composite electric circuit comprising a section in which the current flow is approximately proportional to the applied electromotive force, and a section in which the current flow is inversely proportional in some degree to the applied electromotive force, electro-static means for increasing its initial resistance, and means for utilizing this additional range of resistance for occasioning a fall of electromotive force in response to an increased flow of current therethrough.

6. In a telephone system, the combination of a transmitting device, a receiving device and a connecting circuit consisting in part

of a metallic conductor and in part of a device having a falling voltage characteristic, electro-static means for increasing its initial resistance, and means for utilizing this additional range of resistance for occasioning a fall of electromotive force in response to an increased flow of current therethrough.

7. In an electrical system, a gas or vapor electric device, means for passing current through the same, and means for affecting the device by electro-static force and for causing the said force to be diminished by increased current flow through said device.

8. In an electrical system including a device having a falling voltage characteristic, the method of increasing the falling voltage characteristic, which consists in applying an electro-static force to the device and decreasing the said force by increased current flow through said device.

9. In an electrical system, including a translating device, the method of operation, which consists in increasing by electro-static action the electromotive force required to pass current through the said device and decreasing the required electromotive force in response to an increase of current flow therethrough.

10. In an electrical system, the combination with a translating device, of means for increasing by electro-static action the electromotive force required to pass current through the device and for decreasing the required electromotive force in response to an increased current flow therethrough.

Signed at New York in the county of New York and State of New York this 29th day of January A. D. 1917.

PETER COOPER HEWITT.

Witnesses:

RAYNER M. BEDELL,
THOS. H. BROWN.