No. 714,116. Patented Nov. 18, 1902.

C. P. STEINMETZ.

SYSTEM OF DISTRIBUTION.

(Application filed Mar. 24, 1902.)

(No Model.)

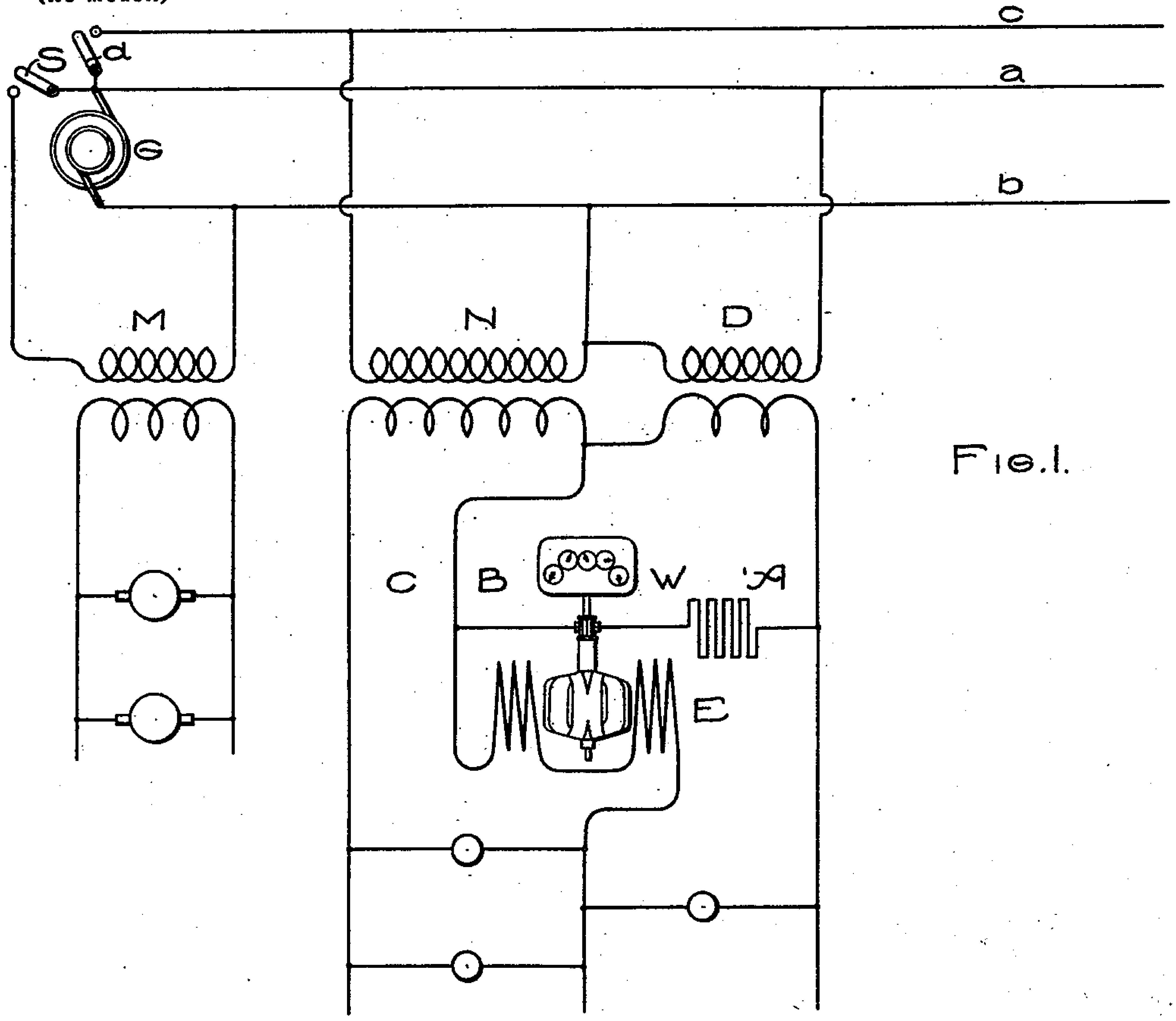

Fig.1.

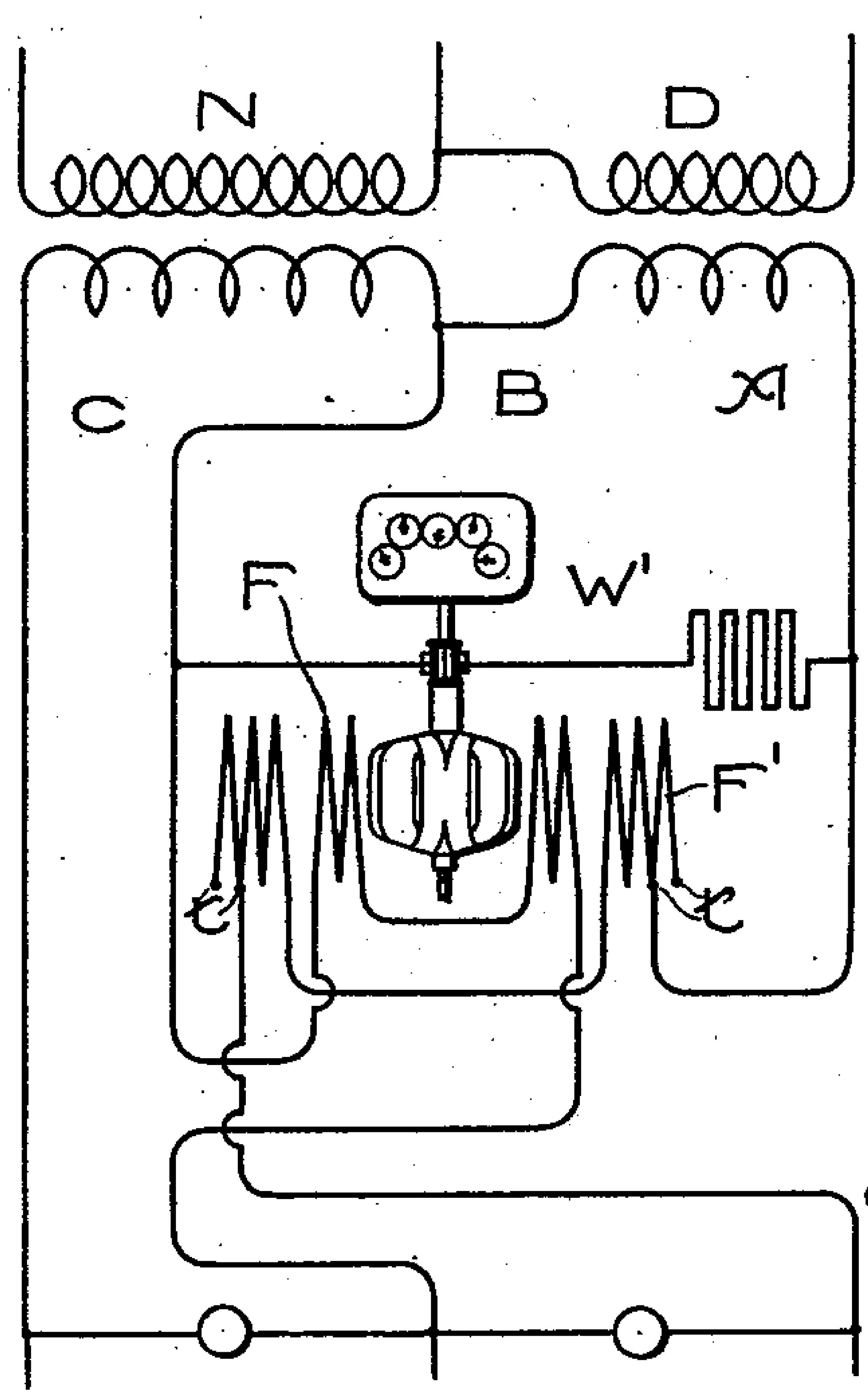

Fig.2.

WITNESSES:
Harry H. Tilden.
Helen Orford

INVENTOR:
Charles P. Steinmetz
by Albert G. Davis
Att'y.

UNITED STATES PATENT OFFICE.

CHARLES P. STEINMETZ, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

SYSTEM OF DISTRIBUTION.

SPECIFICATION forming part of Letters Patent No. 714,116, dated November 18, 1902.

Original application filed March 6, 1899, Serial No. 707,879. Divided and this application filed March 24, 1902. Serial No. 99,618. (No model.)

To all whom it may concern:

Be it known that I, CHARLES P. STEINMETZ, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Systems of Distribution, (Case No. 2,790, division of my prior application, Serial No. 707,879, filed March 6, 1899,) of which the following is a specification.

In alternating-current systems of distribution for lighting purposes it is usually impracticable to employ a network owing to the comparatively long distances between the installations of the various consumers. For this reason it is customary to supply each consumer or group of consumers with a transformer of a size corresponding to the maximum load which may be put upon it. I find that even under the best conditions the load on such transformers is exceedingly variable, being practically nothing during the day-time and seldom reaching a maximum even in the evening. The core loss of the transformers therefore forms a comparatively large percentage of the energy supplied, and thus makes the "all-day" efficiency of the installation very low. Various means have been proposed for obviating the difficulties above mentioned; but, so far as I am aware, they are open to serious objections, either from a commercial or an engineering standpoint. In many cases the transformers are operated from sundown to midnight and disconnected during the remainder of the day. This has the obvious disadvantage that the circuits are dead at all other times than between sundown and midnight. Automatic devices have also been used for cutting in and cutting out transformers in various combinations unnecessary here to mention. These are expensive, complicated, and unreliable.

My present invention aims to reduce the core loss of transformer installations without at the same time incurring the disadvantages above referred to and depends for its effectiveness upon the fact that in private dwelling-houses, stores, and the like by far the greatest number of lights or other translating devices is needed in the evening, comparatively few lights being used during the day-time. I therefore divide the secondary wiring into two circuits, to one of which is connected all of those lights which are used only during the night-time and to the other the lights which are used during the day-time or during the day and night both. Each of these circuits is supplied from a transformer of a size corresponding to the maximum load on the circuit which it feeds. Instead of maintaining the secondary circuits distinct from each other I find it convenient to consolidate two of the mains into a single conductor, which acts as a common return for the currents carried by the two circuits, thus forming a species of three-wire system which differs, however, from the ordinary Edison three-wire system as generally used in that the current in the common return is the sum and not the difference of the currents flowing in the outside mains. The primary windings of the transformers are similarly connected, the three mains being carried back to the station. In one of the mains a switch is inserted, so as to cut out the night-transformer during the interval between midnight and the following sunset.

According to the arrangement above described the night-transformer is run at a comparatively high efficiency and is cut out of circuit while there is no call for current, thus saving a large amount of energy which would otherwise be wasted in the transformer. The other transformer, which I term the "all-day" transformer, is maintained in circuit day and night, and being of small size dissipates but a small amount of energy, at the same time supplying the small demand for light in those places which require light both day and night—as, for instance, in cellars, vaults, and other dimly-lighted or unlighted places.

My invention, furthermore, comprises a system of multiple-rate metering to be used in connection with transformer installations of the character described, but which is also applicable, as will be readily understood, to many other systems of distributing electricity.

The details of my invention will be fully described in the following specification, while its scope will be clearly and particularly pointed out in the appended claims.

Figure 1 illustrates diagrammatically a system of distribution embodying my invention. Fig. 2 is a modification of the same.

Referring to Fig. 1, G illustrates a source of alternating current—as, for instance, an alternating-current generator. Three mains *a b c* lead therefrom, the mains *a b* being permanently connected to the terminals of the source G and the main *c* to one of the terminals through a switch *d* of any suitable form. The all-day transformer D is connected across the mains *a b*, while the night-transformer is connected across the mains *b c*. It will thus be observed that the all-day transformer D is always in circuit, while the night-transformer N may be cut in or out by operating the switch *d*. The secondaries of the transformers D and N are connected in series with terminals of like polarity together. From the common point between the secondaries and from the two remaining terminals are led the secondary mains A B C. Those lights or other translating devices which are to be used only at night are connected between the secondary mains of the night-transformer N, while the lights which are to be used or may be used at any time during the whole day of twenty-four hours are connected between the secondary mains of the all-day transformer D. The current which flows in the return-conductor B is the sum of the currents supplied to the translating devices at any one time.

It is generally possible to make the all-day transformer of very small size, thus saving the amount of energy almost equal to that which would be saved if a single large transformer were used during the night-time only and cut out at other times. In a transformer system of the character described it is obvious that the circuit on a night-transformer is inoperative during the day-time. This would ordinarily appear objectionable to the customer, and if no compensating advantages were presented it would seem preferable to him that all lights or translating devices should be placed on the circuit which is always alive, thus defeating any attempted saving in core loss. I have therefore found it advisable to charge for current on the all-day circuit at a higher rate than for current on the night-circuit.

The additional expense incident to the use of translating devices on the all-day circuit will thus result in a reduction of the number of such devices to a minimum, thus allowing the use of a smaller transformer for the all-day circuit, which is always operative and in which the transformer-core loss is always going on. At the same time a maximum number of translating devices is placed on the night-circuit, thus saving an amount of energy corresponding to the loss which would take place if the circuit were energized during the no-load hours.

The method of charging above described is the direct opposite of the two-rate system now well known, in which current is charged for at lower rates during the day-time, when the station-load is small, than during the night, when it is high. The objects to be obtained in the two systems of metering are different, and therefore not inconsistent.

The system of metering devised by me aims to prevent waste of energy in an electrical distribution system, while the principal object sought for by the employment of a multiple-rate system of the ordinary kind is an equalization of load on the system. In the two-rate system already mentioned lower rates are charged during the day as an inducement for the customer to use current at the time when the load on the station is small. So far from being inconsistent are these systems that I find it advisable to supply motor-loads from the source of supply G during the day-time, while the load on the station is small, and to supply this current at a reduced rate. In the drawings, M illustrates a transformer supplying motors or other translating devices and connected through a switch *s* with the source of supply G. Owing to the reduced rate at which this current is supplied, I find it advisable in most instances that the circuit should be opened at night, when the motor-load or demand for motor-current is a minimum.

In connection with the system of distribution described, and shown in the drawings, I have provided a system of multiple-rate metering which automatically records, according to the predetermined rates, the amount of energy used in both circuits.

In Fig. 1 I have shown an arrangement suitable for metering at different rates the energy expended in the all-day circuit and the night-circuit. For this purpose a single recording wattmeter W is employed, with its current-coils E connected in series with the common return B of the two circuits and its armature connected in shunt across the mains A B of the all-day circuit, which, as before explained, are always energized. If the electromotive forces of the night-circuit and of the all-day circuit are equal, it will be evident that the energy expended in the two circuits will be metered at the same rate, since a given amount of current flowing in the night-circuit represents the same amount of energy as a like flow of current in the all-day circuit. In order, therefore, to cause the wattmeter to register energy in the night-circuit at a lower rate than in the all-day circuit, I make the two circuits of different electromotive force, that of the night-circuit being higher than that of the all-day circuit in proportion to the reduction of the rate desired. Thus if it be desired to charge for energy on the night-circuit at half the rate for that on the day-circuit it is only necessary to make the electromotive force on the night-circuit twice that of the all-day circuit. Under these conditions a given amount of current flowing in the night-circuit represents twice the expenditure of energy corresponding to the same amount of current in the all-day circuit. The wattmeter, which gives the same registration for the current in the common return B, regardless from which circuit the current is supplied, consequently registers energy in the night-circuit at half the rate that it registers energy in the all-day circuit, and this because of the fact that the speed of the meter is proportional to the current in the field-coil. Instead of the form of meter shown any other suitable form of meter may be employed.

In Fig. 2 I have shown a different arrangement for metering energy in the night and in the all-day circuits at different rates. In this case the two transformers supplying the consumption-circuits have the same ratio of transformation, so as to give the same electromotive forces in the two circuits. A single wattmeter W′ is employed, as before, but the connections for the same are differently made. The armature of the meter, as in the first instance, is connected across the mains A B of the all-day circuit. One of the field-coils or sets of field-coils F is connected in series with the common return B, while the other field-coil F′ is connected in series with the main A of the all-day circuit. As thus arranged it will be evident that when current flows in the all-day circuit it will pass through all of the field-coils of the meter, while when current flows in the night-circuit current will pass only through those coils of the meter which are in series with the common return B. If the turns of the two sets of field-coils have an equal effect upon the armature, it will be evident that current in the all-day circuit will be metered at a rate twice that of the current in the night-circuit. If it be desired to change the relative rates of metering for the two circuits, it is only necessary to change the relative number of turns of the two sets of field-coils connected, respectively, in series with the common return B and the main A of the all-day circuit. As illustrating how this change may be made I have shown in Fig. 2 the coil F′ of the meter as provided with a plurality of terminals t, so that by connecting the main A to different terminals the number of effective turns of the coil F′ may be varied. The relative rates of metering in the two circuits are approximately in the proportion of the total number of active field-turns to the number of turns in the common return alone. By suitably adjusting this relation of turns the respective rates of metering may be made anything desired.

By the employment of the above-described system of distributing and metering electricity I have found that by far the largest part of the iron losses of the transformers may be saved, and since this loss constitutes a large percentage of the station output a considerable reduction in price may be made for those lights which are operative only in the evening. Even with such a reduction in charges the saving effected is generally more than sufficient to compensate for the expense and inconvenience of an additional primary wire.

Although the system of metering which I have described above is particularly useful in connection with alternating-current systems of distribution already described, it will of course be evident that it is in no respect limited thereto, but in its broader features is equally applicable to other systems of distributing current, and I intend hereinafter to lay claim broadly to this system of metering regardless of the particular nature of the system of distribution in connection with which it is employed.

Having thus described my invention, what I claim as new, and desire to secure by Letters Patent of the United States, is—

1. The combination with a plurality of electric circuits provided with a common return-conductor, of a meter having a plurality of field-coils less in number than the total number of supply-conductors, one of which field-coils is inserted in the common return.

2. The combination with a plurality of electric circuits provided with a common return-conductor, of a meter having a plurality of field-coils less in number than the total number of supply-conductors, one of which field-coils is inserted in the common return, and the other coils respectively in other conductors of the supply-circuit.

3. The combination with three conductors one of which acts as a common return for current flowing in the other two, of a recording-meter provided with two field-coils one of which is connected in series with the common return and the other in series with one of the other conductors.

4. The combination with three conductors one of which acts as a common return for the other two, of means for maintaining substantially equal electromotive forces between the common return and the other two conductors respectively, and an electric meter provided with two coils one of which is connected in series with the common return and the other with one of the remaining conductors.

5. The combination with three conductors one of which acts as a common return for the other two, of means for maintaining substantially equal electromotive forces between the common return and the other two conductors respectively, an electric meter provided with two coils one of which is connected in series with the common return and the other with one of the remaining conductors, and means for varying the ratio between the effective ampere-turns of the two field-coils.

6. The combination with three conductors one of which acts as a common return for the other two, of means for maintaining substantially equal electromotive forces between the common return and the other two conductors respectively, an electric meter provided with two coils one of which is connected in series with the common return and the other with one of the remaining conductors, and means

for varying the number of turns of one of the field-coils.

7. The combination with a plurality of electric circuits provided with a common return-conductor, of a meter having a plurality of field-coils one of which is inserted in the common return.

8. The combination with a plurality of electric circuits provided with a common return-conductor, of a meter having a plurality of field-coils one of which is inserted in the common return, and means for varying the ratio between the effective ampere-turns of the coils.

9. The combination with a plurality of electric circuits provided with a common return-conductor, of a meter having a plurality of field-coils one of which is inserted in the common return, and means for varying the number of turns of one of the coils.

10. The combination with a plurality of electric circuits provided with a common return-conductor, of a meter having a plurality of field-coils one of which is inserted in the common return, and means for varying the magnetizing-power of one of the coils.

11. In a system of distribution the combination of a plurality of supply-circuits one of which is continuously supplied with energy and another of which is supplied with energy periodically, and means for simultaneously recording at different rates the energy consumed in the said circuits.

12. In a system of distribution, the combination of a plurality of supply-circuits one of which is continuously supplied with energy and another of which is supplied with energy periodically, and means for recording at different rates the flow of energy in the two circuits, the flow of energy in the continuously-supplied circuit being recorded at a higher rate than the corresponding record for the periodically-supplied circuit.

13. In a system of distribution, the combination of a plurality of supply-circuits one of which is continuously supplied with energy and another of which is supplied with energy periodically, and means for recording at different rates the flow of energy in the two circuits.

14. In a system of distribution, the combination of a plurality of transformers one of which is continuously in circuit, and another of which is cut out during certain intervals, and means for simultaneously recording at different rates the energy consumed in the permanently-connected transformer-circuit and the periodically-connected transformer-circuit.

15. In a system of distribution the combination of a plurality of transformers one of which is continually in circuit and another of which is periodically cut out of circuit, and means for recording at different rates the flow of energy in the two transformer-circuits, the flow of energy in the circuit of the permanently-connected transformer being recorded at a higher rate than the flow of energy in the periodically-connected transformer-circuit.

16. In an alternating-current system of distribution, the combination of a source of electrical energy, a plurality of transformers one of which is fed from the source by permanently-connected mains and another through a circuit which may be interrupted at will, connections from one terminal of each secondary coil to a common point and mains connected to the common point and to the free terminals of the secondary coils.

17. In an alternating-current system of distribution, the combination of a plurality of supply-mains two of which are for carrying current of the same phase or polarity, means for connecting or disconnecting one of the said two mains to or from the source of supply, a plurality of transformers fed from the two mains aforesaid operating in conjunction with other supply-mains, and a connection from one terminal of each transformer secondary coil to a secondary main and connections from the other terminal of each coil to a common point.

18. In an alternating-current system of distribution, the combination of a plurality of supply-mains two of which are for carrying current of the same phase or polarity, means for connecting or disconnecting one of the said two mains to or from the source of supply, a plurality of transformers fed from the two mains aforesaid operating in conjunction with other supply-mains, a connection from one terminal of each transformer secondary coil to a secondary main, connections from the other terminal of each coil to a common point, and an additional main connected to the common point.

19. In an alternating-current system of distribution, the combination of supply-mains, a plurality of transformers with their primaries connected to the mains, and their secondaries with one terminal of each connected to a common point and with the electromotive forces of the secondaries in opposition, and mains leading from the common point and from the free terminals of the secondaries.

20. In an alternating-current system of distribution, the combination of supply-mains, a plurality of transformers with their primaries connected to the mains, and their secondaries with one terminal of each connected to a common point and with the electromotive forces of the secondaries in opposition, and means for cutting out one of the transformers.

21. In an alternating-current system of distribution, the combination of supply-mains, a plurality of transformers with their primaries connected to the mains, and their secondaries with one terminal of each connected to a common point and with the electromotive forces of the secondaries in opposition, and means for interrupting at will the supply of energy to one of the transformers.

22. The combination of a plurality of supply-circuits, and means for metering at different rates the energy consumed in the different circuits.

23. The combination of a plurality of circuits and means for metering the energy consumed in one circuit at a rate different from that at which the energy consumed in another of said circuits is metered.

24. The combination of a plurality of circuits and a single meter for metering the energy consumed in one circuit at a rate different from that at which the energy consumed in another of said circuits is metered.

25. The combination of a plurality of circuits and means for metering the expenditure of energy in any number of said circuits, the energy expended in one circuit being metered at a rate different from the rate of metering for another circuit.

26. The combination of a plurality of circuits and means for simultaneously metering the expenditure of energy in any number of said circuits, the energy expended in one circuit being metered at a rate different from the rate of metering for another circuit.

In witness whereof I have hereunto set my hand this 22d day of March, 1902.

CHARLES P. STEINMETZ.

Witnesses:

BENJAMIN B. HULL,

HELEN ORFORD.