No. 726,233. PATENTED APR. 21, 1903.

E. THOMSON & F. P. COX.

MULTIPLE RATE METERING.

APPLICATION FILED AUG. 29, 1902.

NO MODEL. 2 SHEETS—SHEET 1.

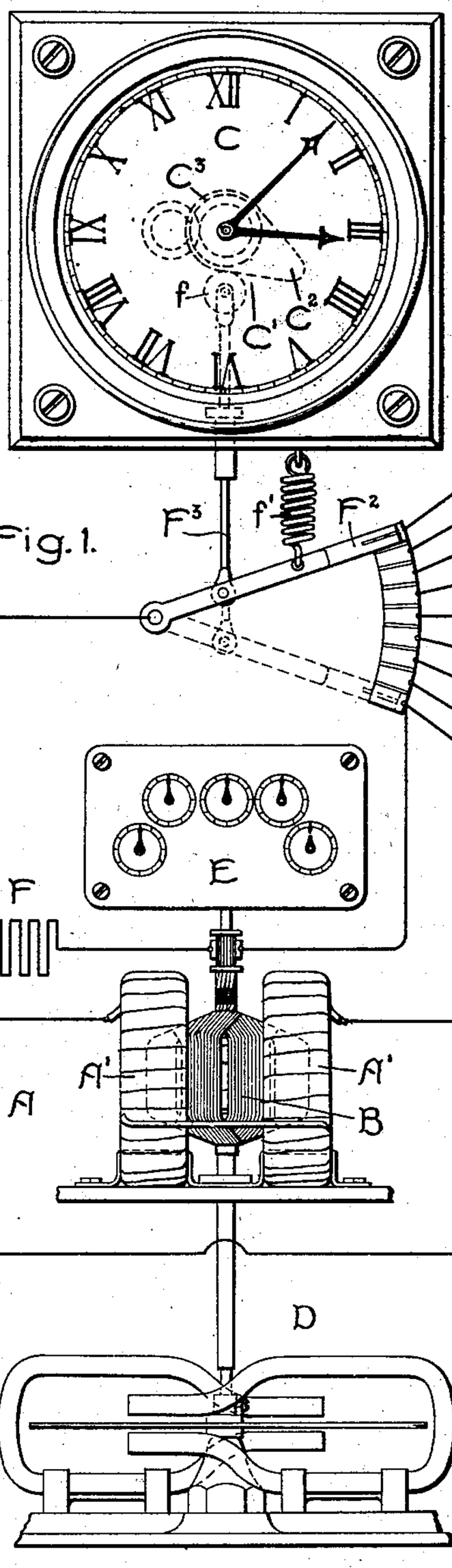

Fig. 1.

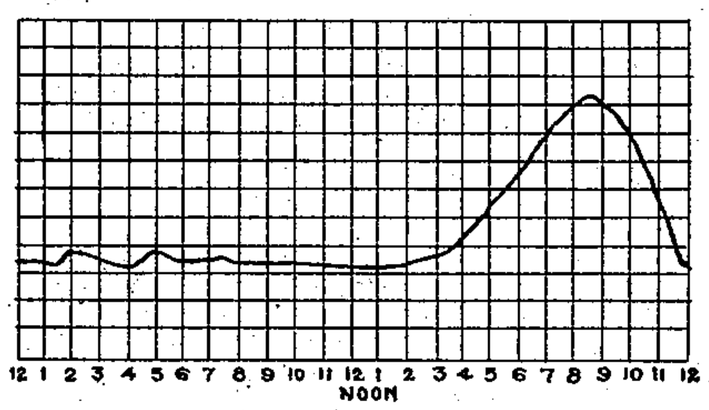

Fig. 2.

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NO MODEL. 2 SHEETS—SHEET 2.

Fig. 3.

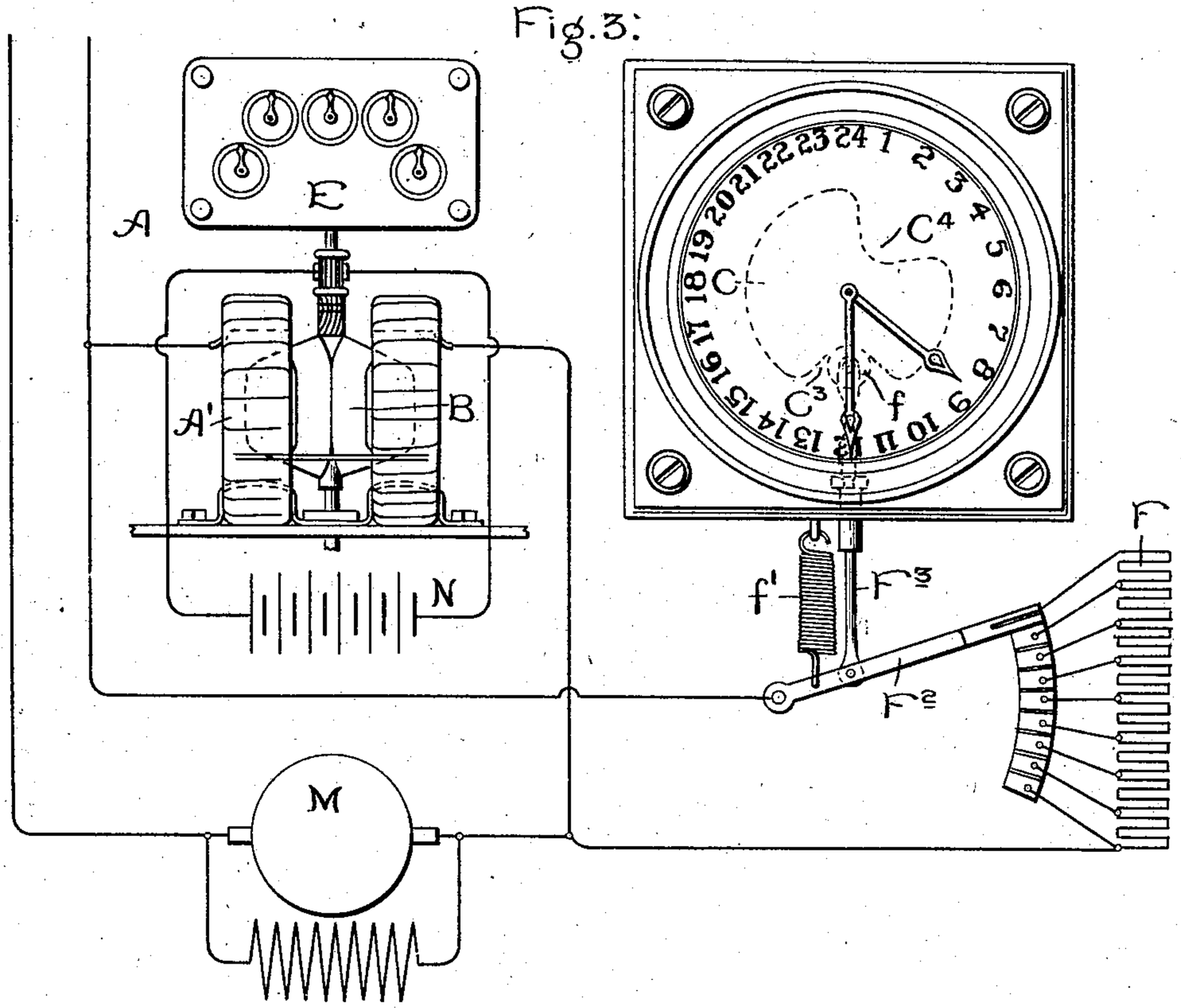


Fig. 3a.

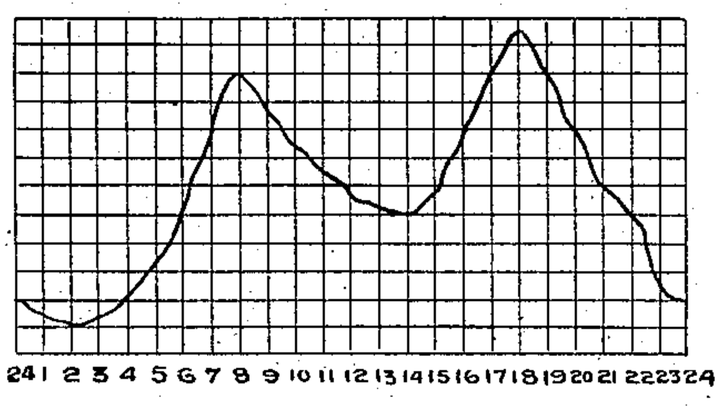
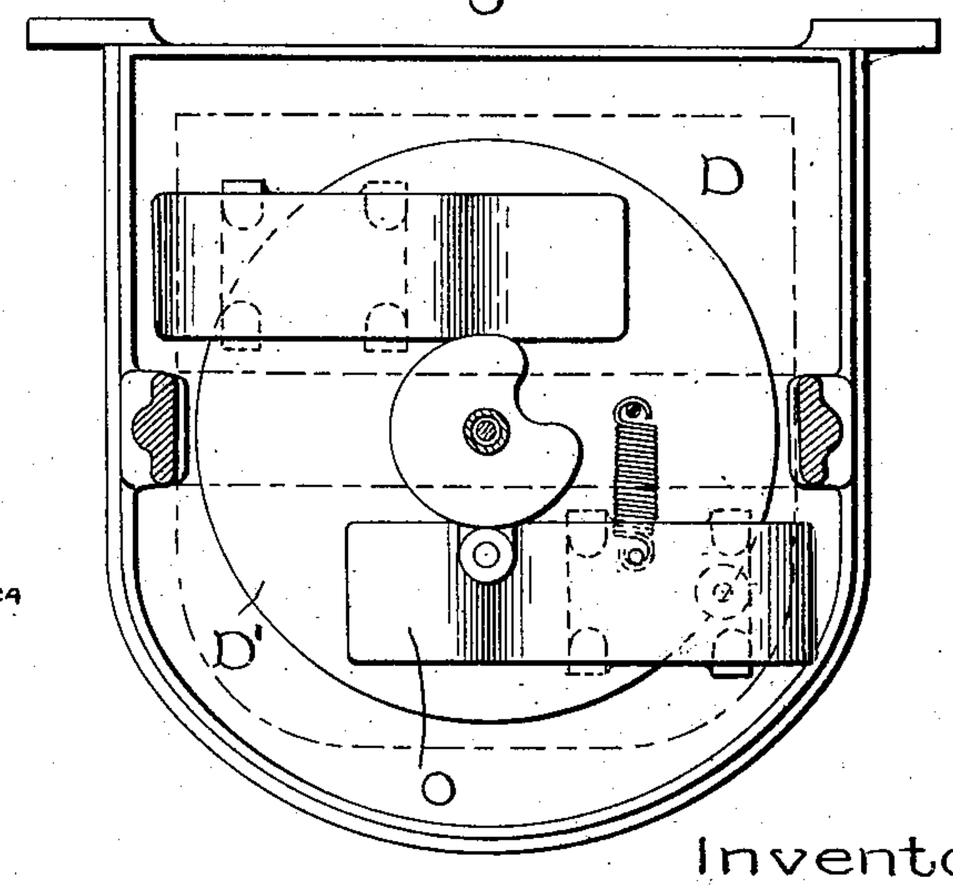


Fig. 4.



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UNITED STATES PATENT OFFICE.

ELIHU THOMSON, OF SWAMPSCOTT, AND FRANK P. COX, OF LYNN, MASSACHUSETTS, ASSIGNORS TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

MULTIPLE-RATE METERING.

SPECIFICATION forming part of Letters Patent No. 726,233, dated April 21, 1903.

Original application filed February 25, 1899, Serial No. 706,774. Divided and this application filed August 29, 1902. Serial No. 121,453. (No model.)

To all whom it may concern:

Be it known that we, ELIHU THOMSON, residing at Swampscott, and FRANK P. COX, residing at Lynn, in the county of Essex, State of Massachusetts, citizens of the United States, have invented certain new and useful Improvements in Multiple-Rate Metering, of which the following is a specification.

Our present invention relates to electric metering; and it consists of the adaptation of any well-known form of meter, the specific construction of which for the purposes of this invention is immaterial, to a more equitable method of registration than those with which we are now acquainted.

In the art of electric measurement of energy two systems in addition to the older one of directly indicating the current-flow in either watts or amperes have come into use. The old system is to measure the energy in watt hours or ampere hours, as may be desired, and to make to the consumer a charge based directly upon the consumption. To encourage the use of current at times when the station is not fully loaded and as nearly as possible equalize the total load, thus diminishing the cost of energy and increasing the efficiency of the boilers, engines, and generators, which, as is well known, are best adapted to maintain their full load, (or work at highest efficiency when run near full load,) the two other systems have been devised. One of these methods is to use a two-rate meter, which by various contrivances unnecessary here to detail is adapted to register at a given rate during part of the day and at a lower or higher rate during another part of each twenty-four hours.

Various forms of this device have been elaborated, some of which indicate the two charges on different dials, and some of which simply shift mechanism of one sort or another, so as to effect a direct change in the registration, measuring all of the energy upon a single set of dials.

Another system which has been developed is the so-called "maximum-demand" system of bookkeeping, which consists in its essence of making a certain fixed charge proportioned to the maximum energy which may be consumed in a given branch circuit at any time and over and above that another charge proportioned to the actual energy consumed. There are inherent inequitable features in each of these systems. The maximum demand, for instance, may be established for any month or other period by factors which do not give a true measure of the probable demand for current which the station must supply to the branch circuit under consideration. For instance, in some forms of such devices an accidental short circuit or a very unusual supply of current taken for only a brief period may be registered as a basis for the fixed charge referred to, although such a demand may not occur again for months or years, and this leads to dissatisfaction on the part of the customer and is manifestly unfair. The charge also has no relation to the station-load and being the same no matter at what time the demand occurs has no tendency to encourage consumption at times of small station-load. Similarly, two-rate meters as heretofore developed have in a measure been open to some objections. For example, the change of rate is made at a certain definite time, (where it is effected by clockwork attached to each meter,) and this time should vary at different seasons of the year, whereas the mechanism of a clock is such that the period of high charge is not ordinarily susceptible of variation. Furthermore, the change in the rate of registration is effected all at once, so that during the transition from light load at the station to full load, which is always more or less gradual, the consumer is paying either at a less rate or a greater one than is equitable either to him or to the station.

It is to the class of two-rate meters that our invention is most nearly allied. It differs, however, from all others with which we are acquainted in that it takes into account the error last specified—that is, it effects a registration at a rate varying from hour to hour with the load upon the station. It consists, therefore, not only in the special appa-

ratus illustrated in our drawings, but in the improvement in the art of registration or recording the consumption of electrical energy, which consists in varying from time to time the rate of registration and making this variation such that the rate of registrating is dependent upon the load upon the central station in more or less direct proportion thereto. Claims to the latter, however, only are made in the present application, the apparatus claims being made in the parent application, of which this is a division.

To effect the purposes of the invention just indicated, we have devised the arrangement of apparatus shown and described in this case; but we do not wish to limit ourselves to any particular type of apparatus, because, so far as we are aware, we are the first to progressively change the rate of registration in the way just indicated and wish to make broad claims to this feature of invention. As an embodiment of the invention, therefore, the apparatus illustrated in the drawings is to be considered. It consists in general of an ordinary recording-wattmeter, to which is connected a suitable rate-varying means, such as a resistance, over the contacts of which a switch-arm is moved by a cam driven by clockwork mechanism, so that at the time when the least load comes upon the station the greatest resistance will be in circuit with the meter, and this resistance will be progressively varied, decreasing as the load comes on and increasing as it falls off. It is manifest that by varying the shape of the cam which controls the motion of the resistance-switch this change may be made anything desired. We have so far described it as used in an electric-lighting plant; but in some other classes of distribution—for instance, in an electric railway—there may be more than one peak to the load. In such cases the cam should be so shaped that the resistance would be properly varied for each one of the peaks and to the degree to which the peak indicates an increase of load. For instance, in an electric railway it is common to have large demand for current from seven to nine o'clock in the morning, when people are going to their customary employments, a similar or smaller peak at the middle of the day, and another and heavier peak than either of these at the close of the day's business. Of course it is plain that the proportioning of the cam could be made such as to take these changes into account; but in a lighting system where the peak of the load occurs from five to eight or nine o'clock in the evening only one change need be made. If, for example, in a given station the load comes on quite gradually, the shape of the cam could be made such as to cut out the resistance quite gradually, and if the load falls off more rapidly the shape of the cam may be adapted to compensate for this. In other words, our invention will be found of general applicability to any class of recording electrical measuring instrument in which the load factor at the station is to be taken into account, and to this extent we consider the claims which we make generic.

In the drawings, Figure 1 shows a watt-meter with the invention applied thereto. Fig. 2 is a chart of the load curve of the station. Fig. 3 shows a recording-ammeter with another form of the invention. Fig. 3^a is a diagram like Fig. 2, to which the form of meter shown in Fig. 3 is adapted. Fig. 4 is a modified arrangement for effecting the registration.

In Fig. 1, A is a watt-meter, with the fields A′ A′ connected in series with and an armature B connected across the lines of a branch circuit including the lamps L, which may represent any load whatever. E is the counter, F the usual resistance in series with the armature, and D the damping mechanism. All of these parts are well known. F′ is a rate-varying means, consisting of a resistance, in this case shown in series with the armature. It is cut into and out of circuit progressively by the movement of the switch-arm F^2. A spring f' holds the arm at the maximum-resistance position during the greater part of the revolution of the cam C′. This cam is driven so as to rotate once in twenty-four hours by means of gearing C^3, driven from a clock C, and is provided with a projecting portion or toe C^2, operating a cam-roller f and depressing the rod F^3, connected to the resistance-arm. Of course a twenty-four-hour clock may be employed instead of the twelve-hour clock shown, as illustrated in connection with the modified form of the invention shown in Fig. 3.

The operation of the parts shown in Fig. 1 is as follows: As the clock rotates the cam C′ rotates with it, and when the toe C^2 is in line with the rod F^3 all of the resistance F′ is cut out, the meter recording at its normal rate. This is from about seven to nine o'clock in the particular combination of apparatus shown and coincides with the peak of the load as shown in Fig. 2. A little later, when lights are turned out, the switch begins to cut in more of the resistance F′, until finally all of it is in circuit and the meter records at its minimum rate. This condition is maintained in the particular case illustrated until a little after three p. m., when the resistance again begins to be cut out. The shape of the cam corresponds in a general way to the shape of the average load-curve shown in Fig. 2, so that the meter-reading instead of being $\int ECdt$ or $\int Cdt$ becomes $\int ECf(L)dt$ or $\int Cf(L)dt$, or even $\int ECLdt$ or $\int CLdt$, where E, C, and t are electromotive force, current, and time, respectively, and L is the station-load—that is to say, our improved meter integrates not the quantities usually measured, but the same quantities modified by a continuous function of the load on the station.

In Fig. 3 we show the same invention as applied to a recording-ammeter measuring the current supplied to the motor M, the am-

meter having its fields in series and its armature separately excited from the battery N or other source of constant potential. In this case the resistance F is included in a shunt around the meter, and here the cam C works in the reverse way, the larger part of the cam being concentric when the least resistance is in the shunt. It is manifest, of course, that some resistance must always be in the shunt when its circuit is closed in order to permit the meter to operate. When the depression C^3 coincides in position with the roller *f*, a greater amount of resistance is included in the shunt and a larger proportion of the total current is forced through the ammeter, which accordingly registers at a greater rate, while when the depression C^4 reaches the roller the shunt is open-circuited and the meter records at its maximum rate, all of the current passing through it.

Fig. 3^a is a chart showing a station-record different from that shown in Fig. 2. It is supposed to represent an electric-railway distribution in which there are two peaks to the load, one occurring in the morning and the other in the afternoon. With such a load-curve and with the twenty-four-hour clock (shown in Fig. 3) the particular form of cam shown can be employed. We prefer to use a twenty-four-hour clock, as the cam can be mounted directly upon the hour-shaft.

In both forms of the invention just described resistances have been used as the rate-varying means, and in practice this will be found to be preferable. Other arrangements might, however, be used, and in Fig. 4 we have indicated one such modification. In this figure we have shown how one of the magnets O of the damping mechanism D may be mounted upon a pivot, and when the meter rate is to be increased be swung by the action of the cam communicated through any convenient intermediate mechanism, such as the cam-roller shown, toward the shaft of the motor, thus diminishing its pull upon the damping-disk D. We do not regard this as so good a form of the invention, because it introduces the probability of error in the calibration of the meter; but it might be usefully employed. All of the forms of the invention which we have shown are to be regarded as examples, and many others might be conveniently devised which we do not undertake to show; but any apparatus which embodies the idea of progressively changing the rate of registration of a recording electric meter of any type so as to increase this rate at the time of large load and diminish it when the load falls off we regard as within our invention. In alternating-current systems, for example, we might use impedances or changes of inductive relation in coils as the rate-varying means; but these arrangements are apparent to engineers.

This application is a division of our pending application, Serial No. 706,774, filed February 25, 1899.

What we claim as new, and desire to secure by Letters Patent of the United States, is—

1. The improvement in the art of recording electric energy, which consists in progressively and automatically varying the rate of registration to accord with the station-load curve.

2. That improvement in the art of recording the electric energy delivered to a circuit, which consists in progressively and automatically increasing the rate of registration as the average load comes on at the station and decreasing the rate as said load falls.

3. The method of registering current or energy in a branch circuit, which consists in automatically integrating the same as modified by a continuous function of station-load curve.

In witness whereof we have hereunto set our hands this 26th day of August, 1902.

ELIHU THOMSON.
FRANK P. COX.

Witnesses as to signature of Elihu Thomson:

DUGALD MCK. MCKILLOP,
JOHN J. WALKER.

Witnesses as to signature of Frank P. Cox:

DUGALD MCK. MCKILLOP,
ALEX. F. MCDONALD.