

A GRAPHIC RECORDING-AMMETER.

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With the advance of the study of quick acceleration, the need was felt for an instrument capable of registering accurately current and voltage readings which fluctuate violently. Such an instrument must be capable of operating satisfactorily on a car moving at a high speed over bad track, and hence subject to vibration and shock. Sudden changes in the quantities measured required that the instrument should have a short period and should be perfectly damped. The swaying of the car, the rapid acceleration and retardation made it necessary that the instrument should be thoroughly balanced. In order to obtain a permanent record with freedom from sticking it was necessary to use ink, since even with the high torque of this instrument a metal stylus or graphite pencil-point would not give good-service.

To secure the required torque, a dynamometer construction is used, in which the current to be measured is carried by the fixed coil and a constant current of small value flows through the moving coil, supplied preferably by a storage-battery.

The moving coil, rectangular in shape, is composed of several turns of wire surrounding an iron core of cylindrical shape, and carries about one ampere; this coil and core are enclosed in the fixed coil. The moving coil is suspended by a controlling spring which holds it in position at the top, and is supported by a small steel shaft at the bottom; this bottom bearing is so made that when the instrument is in use the moving system hangs freely from the controlling spring, and the vertical motion is so limited that excessive vibration cannot take place. Current is led to

the moving coil by two spiral conductors of negligible elasticity in comparison with the controlling spring; the controlling spring can be adjusted by changing its length.

The magnetomotive force in the fixed coil of an ammeter is about 2400 ampere-turns, and in the moving coil about 80 ampere-turns; with this combination, a torque of about 200 gramme-centimetres is obtained, which is from 80 to 200 times the torque of the ordinary measuring instrument in which the indications of a pointer on a scale are observed, and from 3 to 15 times the torque of the usual integrating, or curve-drawing instruments.

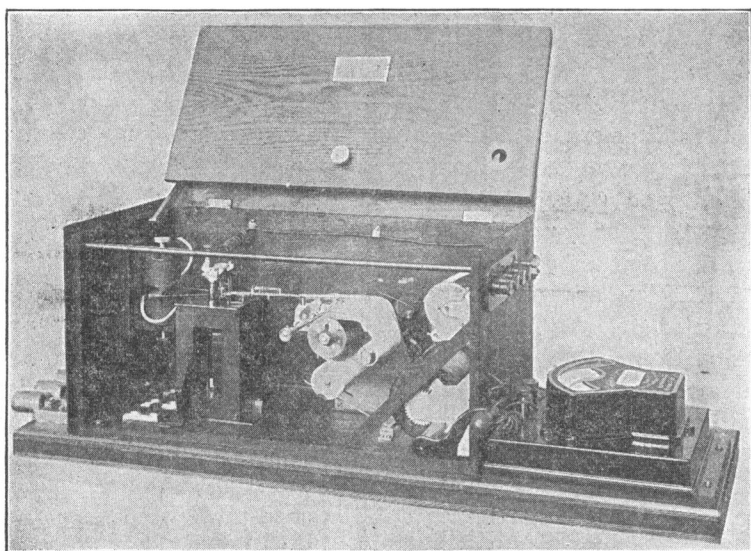


FIG. 1.

The pen used is a capillary tube supplied by a syphon which is filled from an ink reservoir placed at some distance from the recording point in the direction of the axis of the instrument. This arrangement secures a continual supply of ink and a fine line, and prevents blotting when the pen and paper are at rest. It also decreases the inertia of the moving system.

The different conditions under which the instrument is used require a variable pressure of the pen on the paper; if the instrument be used on a stationary platform, the pen should barely touch the paper if on a car moving at high speed, the entire weight of the pen should rest on the paper. This adjustment

is made by means of a joint in the pointer and a small adjustable spring capable of supporting the entire weight of the movable part of the pointer.

The record is made on paper punched and ruled by a special machine and passed through the instrument by means of a toothed wheel driven by a spring motor, similar to that used for driving a phonograph. The speed of the paper can be adjusted to from four to eight inches per minute, but is ordinarily six inches per minute. The paper is about $3\frac{1}{2}$ inches wide and is used in rolls 65 feet long. The machine that has been designed for ruling the paper can give any ruling, and special paper can be

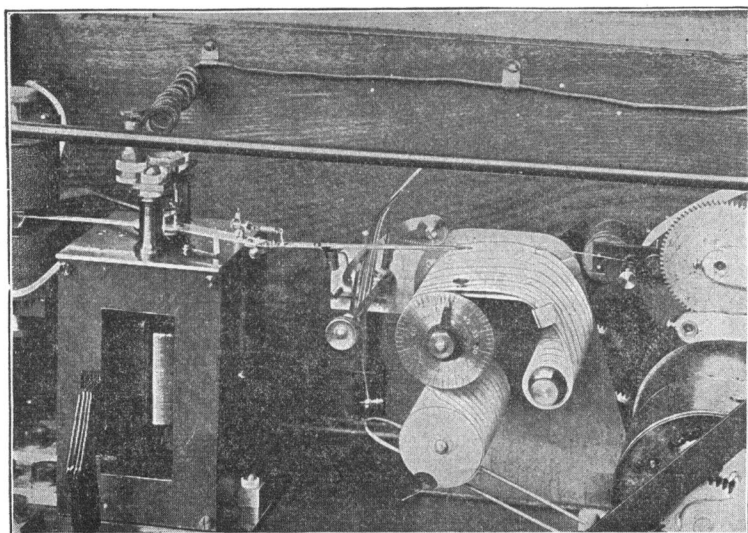


FIG. 2.

made for each instrument; ordinarily, however, instruments of the same capacity are nearly enough alike to permit paper of uniform spacing to be used.

There is a second small pen employed to mark time accurately on the paper. This pen is actuated by a time-marker clock, through a small electromagnet, controlled by the clock. By this means, intervals of five seconds are marked on the paper. With this addition, it is possible to obtain simultaneous readings on a number of instruments placed upon different cars of a train. This marking device also serves to calibrate the speed at which

the paper is moving, thus making it unnecessary to calibrate the paper by means of a watch.

This construction is, of course, applicable to a voltmeter or wattmeter, as well as to an ammeter. By the use of these



FIG. 3.—Current-curve taken by graphic recording-ammeter on a car equipped with multiple-unit control with automatic accelerating device.

instruments it is possible to obtain current and voltage readings with accuracy; the instrument does away with the labor of several men formerly required by the old method of two-second readings, and gives much more accurate results. It has become a simple matter to make all-day tests upon a railway motor, taking a sufficient number of readings to obtain a fair average, and thus determine the copper losses quickly and accurately. Knowing the voltage and current, it is possible to compute the core-loss of a motor from stand-tests and in this manner obtain the total energy-loss in heating the motor for any given service. The use of this instrument makes it comparatively simple in this way to determine the thermal capacity of a motor, and this with

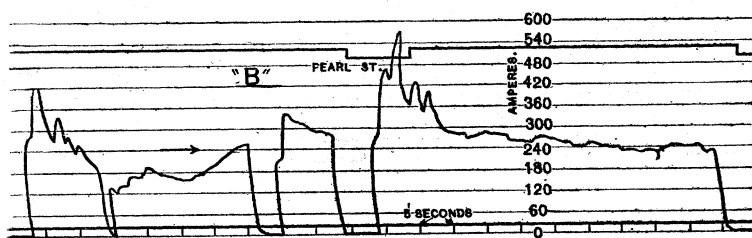


FIG. 4.—Current-curve taken by graphic recording-ammeter on one of the Schenectady-Albany cars equipped with four GE-73 motors. This car was climbing a heavy grade and the motors were in series.

such accuracy that consistent results are assured in comparing motors of different sizes and designs.

Figs. 1 and 2 give general views of the instrument, and Figs. 3, 4, 5, 6 and 7 copies of records taken under different conditions.

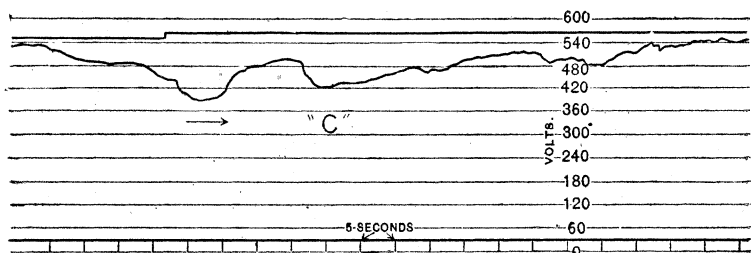


FIG. 5.—Voltage-curve taken by graphic recording-voltmeter on one of the Schenectady-Albany cars,

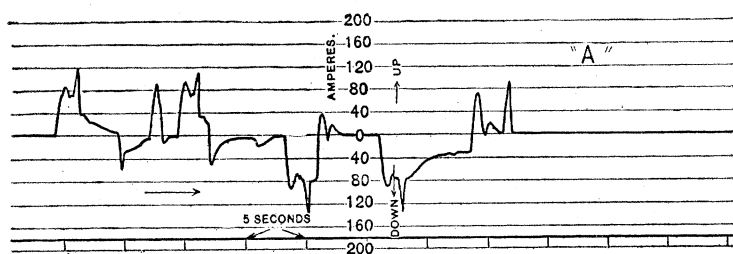


FIG. 6.—Current-curve taken by graphic recording-ammeter on an Otis elevator motor.

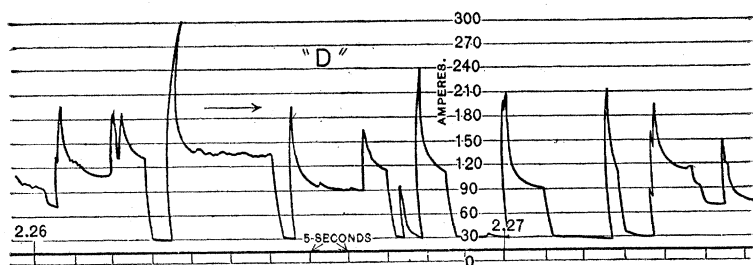


FIG. 7.—Current-curve taken by graphic recording-ammeter on a compound-wound generator.

The general data of the instrument shown in Figs. 1 and 2 is as follows.

Length, $32\frac{1}{2}$ "

Width, $13\frac{1}{2}$ "

Height, $11\frac{1}{4}$ "

Approximate weight, 100 lbs.

Torque of ammeter, 210 gm.-cm. (Full scale 24 degrees.)

" " voltmeter, 200 "

Period, 0.33 seconds for complete cycle.

Ampere-turns in fixed coil of ammeter,	2400
“ “ “ “ “ voltmeter,	950
“ “ moving “ “ ammeter,	80
“ “ “ “ “ voltmeter,	189
Watts consumed in moving coil of ammeter,	1
“ “ “ “ “ voltmeter,.	3.3
“ “ “ fixed “ “ ammeter	130
“ “ “ “ “ voltmeter,	33
