Measuring Dial Speeds

By O. F. FORSBERG

A LITTLE instrument, known as the dial, has in recent years become a valuable adjunct to the modern facilities of communication; yet many of us have placidly accepted it as a mere convenience without giving much thought to its importance or to the wonders it performs. In the realm of wired communication it opens paths of conversation for thousands of people; and, mounted on a desk-stand or other telephone, it unerringly directs the intricate machine-switching mechanisms which, without the aid of operators, make possible a myriad of speech highways.

The dial has a rotating wheel with ten finger holes to each of which a number is assigned. This wheel controls a set of interrupter contacts at the subscriber's end of the telephone line. To dial, a finger is inserted and the wheel rotated to the stop. For any telephone call the dialing operation must be performed a number of times corresponding to the number of digits and letters in the telephone designation of the called subscriber. When the dial is released it returns to the normal position under the control of a speed governor, and produces in the signalling current on the line, interruptions which correspond to the number of the hole in which the finger was inserted. The successive opening and closing of the telephone circuit results in the transmission to the central office of electrical impulses, and there these operate electro-magnetic switching apparatus which sets up the desired connections.

To insure satisfactory operation of this central-office equipment, which is controlled by the dials, the electrical impulses must, within certain limits, be regularly transmitted and of equal duration. Some accurate and convenient means of checking this impulse rate or "dial speed" must therefore be provided. Several methods have been used in the Bell System since the inception of machine switching. These range from a simple stroboscopic method, using a tuning fork to time the impulses, to that of the new instrument, in which a pendulum measures the dial speed.

With this new instrument, the repairman at the subscriber's station first dials the test-desk man, who in turn connects him to the dial tester. The repairman then dials 0, and tones

automatically put on the line by the instrument indicate whether the dial is too fast, too slow, or is operating at normal speed.

The timing element of the new tester is the pendulum, the use of which, as a means of measuring time intervals, dates back to Galileo in the sixteenth century. In the tester it measures the time taken by the nine impulses which the repairman dials. At the beginning of the first impulse the pendulum is released and allowed to swing. At the end of the ninth impulse a contact is closed which records the position of the pendulum at that instant. After the ninth, if the impulses had the proper duration, the pendulum will be in one position; but if they occurred in too long or too short a time it will either be beyond or not up to this position. Corresponding to these three positions are three separate contacts and for each a distinctive tone is transmitted to the repairman.

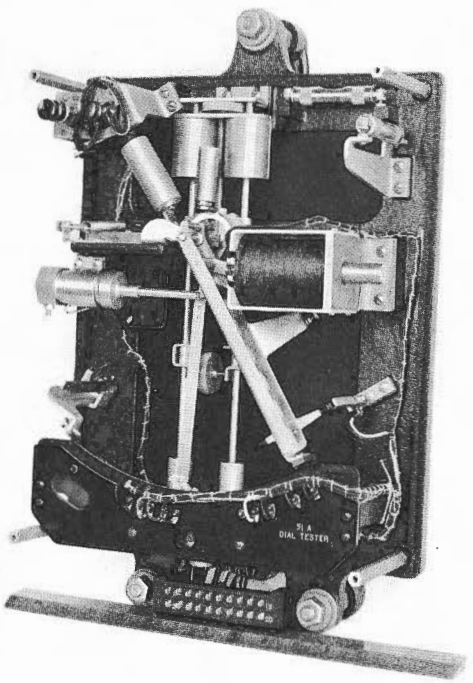

Figure One

The pendulum is mounted on knife-edge bearings, as shown in Figure 1, and can swing through an angle of approximately sixty degrees. A magnet holds it in the starting position, thirty degrees to the left of the vertical. The contacting device involves a vane attached to the pendulum. When the pendulum is started the vane is pulled toward it by a magnet. When this magnet is de-energized at the end of the ninth impulse the vane springs away and makes contact with a metal strip which is divided into nine segments separated by narrow gaps. In line with the gap between each two segments is a small projection which acts as a stop to the vane and prevents it from sliding along to the adjacent segment. These segments and stops are shown in Figure 2, in which the plate on which they are mounted has been removed from the dial tester. Contact between the vane and a segment closes a circuit which sends over the line a tone characteristic to that segment.

Associated with the pendulum are a number of other devices necessary for completely automatic operation of the tester. For example, to return the pendulum to its starting position there is an electromagnet formed by a solenoid and a plunger. The plunger is linked to a pivoted arm which engages and moves the pendulum and the vane. A dash-pot regulates the speed of the plunger, preventing injury to the fine knife edges due to the pendulum being moved too quickly. After the pendulum has been engaged

by the magnet which holds it in the starting position, the solenoid is automatically de-energized and the arm withdrawn under the action of a coiled spring. This resetting mechanism is automatically controlled by means of an associated electrical circuit.

The development of this dial tester involved a number of interesting problems. In the first place, it was necessary to demonstrate that the pendulum could be adapted for use in an instrument of this kind. The tester is required to check both subscribers' dials, which should send from eight to eleven impulses a second and also operators' dials, which should send twenty impulses a second. In order to meet these conditions, the time required for the pendulum to swing its entire arc must be slightly greater than nine-eighths of a second.

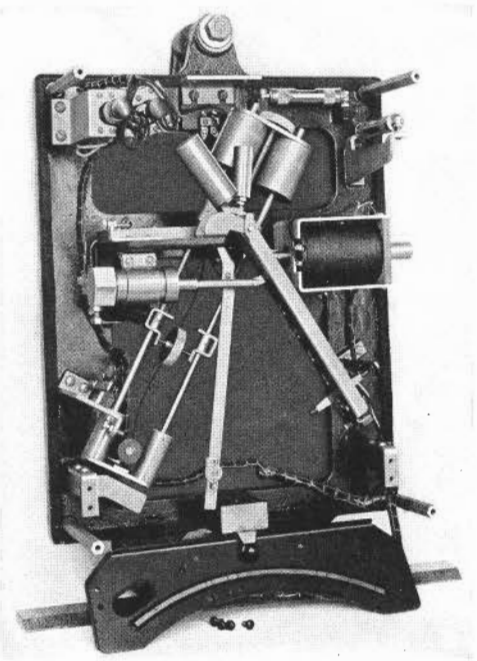

Figure Two

A theoretical study, therefore, was made of the pendulum motion and a time-displacement curve plotted showing the time for the pendulum to swing from its start position to various points in its arc. The curve shown in Figure 3 was computed from the fundamental pendulum equation which had to be completely solved with the aid of elliptic integrals.

A laboratory set-up was then made and oscillograph measurements were taken of the time required for the pendulum to swing through measured arcs. A stiff wire projecting from the lower part of the pendulum was arranged to make contact, as the pendulum swung, with another wire which could be fixed in position corresponding to any desired angle of pendulum swing. A magnet released the pendulum from its position thirty degrees from the vertical, and oscillograms were taken of the times between the release and the contact with the "protractor wire" as set at various angles. The results of this investigation indicated that consistent performance might be expected and that further development was warranted.

Another problem was adjusting the pendulum to the proper period. To vary the period it is necessary to change the position of a pair of cylindrical weights which may be moved up or down on the pendulum bars. The stop watch was selected as the most practicable means for timing the period. Tests were made to determine the relation between the time of fifty swings and the time of the first swing which is used for checking dial speeds. The results of this study, showing a definite and consistent rela-

tion between these two factors, permitted the time adjustment to be made with the watch.

The next step in the development of the complete design was the layout of the segments of the commutator which should indicate whether or not dial speeds were within the limits specified for proper functioning. Computations were made on the basis of the theoretical curve to determine the arcs through which the pendulum would swing during the time intervals represented by nine dial impulses at the various standard rates. In determining the location of the projecting edges or stops of the commutator segments, it was necessary to modify somewhat the theoretical time-displacement values to allow for factors introduced by the associated apparatus for starting and stopping the pendulum.

Based on data collected through these studies and on preliminary experiments, complete models were then built. These were calibrated under conditions closely simulating field conditions. This calibration and tests on the models bore out the forecast of the preliminary studies that the apparatus was entirely satisfactory as a timing element. The pendulum dial-tester, therefore, is now a part of the equipment of several metropolitan telephone exchanges.

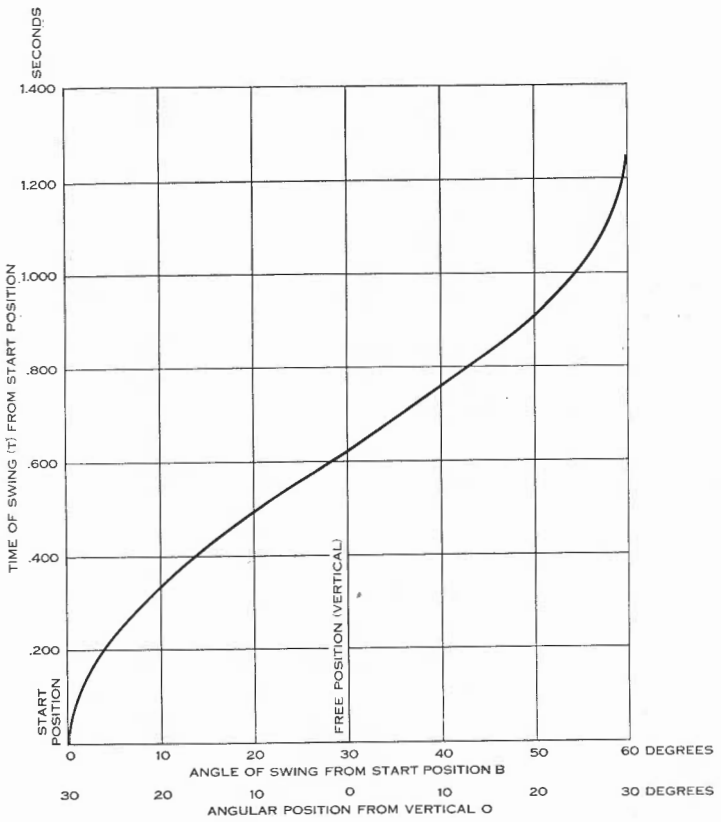

Figure Three