Dial Testing Equipment

F. WEST *Station Apparatus Development*

Many telephone users have a vague idea that somehow the operation of a telephone dial has something to do with the apparatus needed to route a call to the desired destination. Relatively few users realize, however, that the dial actually generates series of pulses that direct automatic central office equipment in completing a call. These pulses must be of the right size, shape and frequency so that the switching equipment will react properly. Recently, a new method has been developed at the Laboratories to test the performance of dials and assure that they will generate pulses accurately.

Telephone dials perform the important function of producing the pulse trains required to establish the interconnection of two telephones in a machine switched telephone system. These pulse trains are produced during the "run-down", after the finger-wheel is released, by means of a cam-driven pulsing contact which interrupts the current in the loop to the central office at a uniform rate. The number of pulses produced by these interruptions during the run-down is the same as the digit number that is being dialed.

The central office equipment that receives these dial pulses will perform correctly only if the pulses have specified characteristics. Hence, it is important that the dial be properly designed and constructed to provide such pulses. Particularly important are the make and break times of the pulsing contacts; these times must be accurately repeated pulse after pulse. The percentages of a pulse period that are devoted respectively to the open and closed states of the pulsing contact; that is, the "per cent break" and "per cent make" are determined by the cam that drives the contacts, and by the relative location of the contact springs and the cam. The total duration of a pulse is determined by the run-down speed of the dial which is controlled by a centrifugal governor. Hence, the time of break and time of make are determined by the per cent break, or make, and the dial speed. The nominal dial adjustment is for 61 per cent break and a 10 pulse per second speed, and at present, manufacturing tolerances of ±3 per cent break and ±0.5 pulse per second are set for these values.

Recently developed dials for use in the new telephone sets possess operational precision that make previously existing laboratory equipment inadequate for measuring their pulse characteristics. A study was, therefore, instituted to develop an improved measuring device. This study resulted in the machine illustrated in the headpiece of this article which displays the break and make time of every operation of the pulsing contact during dial run-

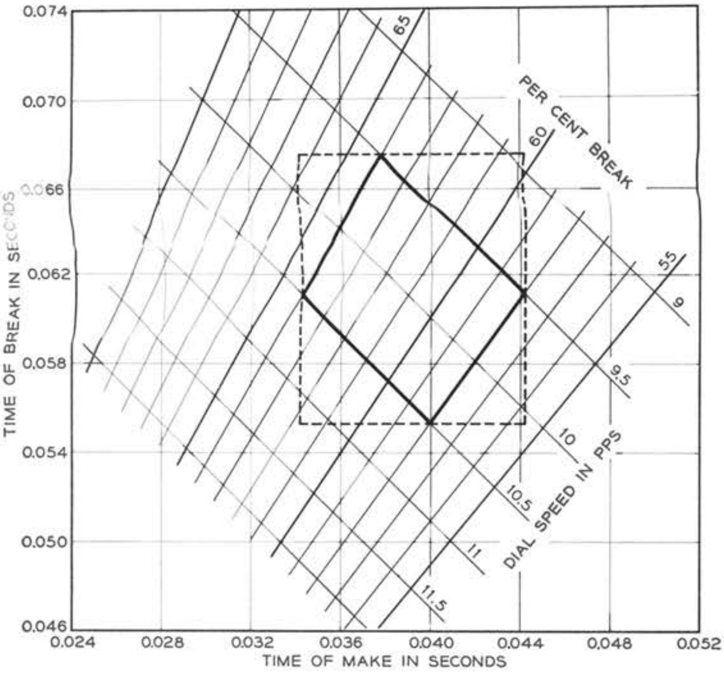

Fig. 1 — Graphic representation relating time-of-break and time-of-make to per cent break and dial speed.

down. The display appears on the face of a cathode ray tube in the form of dots plotted on the coordinate axes of Figure 1 with break time as the ordinate and make time as the abscissa. Each dot represents the break and make time of the contact operation of a single pulse.

Laboratory use of this equipment has demonstrated the expected merits of this method. Contact behavior for each pulse can be observed during the dial run-down, and the progress of the dot pattern aids in determining the cause of faulty dial operation, when present. Figure 1, which is a diagram relating time of break and time of make to per cent break and dial speed, shows that a dot progression along a line of constant per cent break on the scope would cross lines of constant speed. This would show that the dial speed was changing during run-down and throw suspicion on the governor. Similarly, a progression of dots along a line of constant speed would show variable per cent break, and point to trouble in the pulsing contact or associated mechanism. A widely scattered dot pattern would show a variable condition with some such possible cause as an eccentric or damaged gear in the dial gear train. Thus, in the same time as is required by previously used dial testing equipment, the new machine provides a considerably larger amount of more direct information about dial characteristics.

An additional value of the pictorial presentation of the dial performance can be explained by reference to Figure 1. In this diagram lines representing the established limits of maximum and minimum per cent break and speed form a diamond-shaped area which encloses all possible acceptable combinations of per cent break and speed. Horizontal lines through the upper and lower apices of the diamond, and vertical lines through the right and left apices, define the maximum and minimum break and make times which correspond to the limits established for speed and per cent break. These lines, shown dashed in Figure 1, enclose a rectangle which includes acceptable pairs of break and make times and which has an area considerably larger than that of the diamond. Although certain portions of this rectangle include dial speeds or per cent break values that are unacceptable, it is considered likely that an irregular area within the bounds of the rectangle might be established which would provide somewhat more lenient inspection requirements without impairing the quality of the product. Such an area would be indicated by a template applied to the face of the cathode ray tube. It would

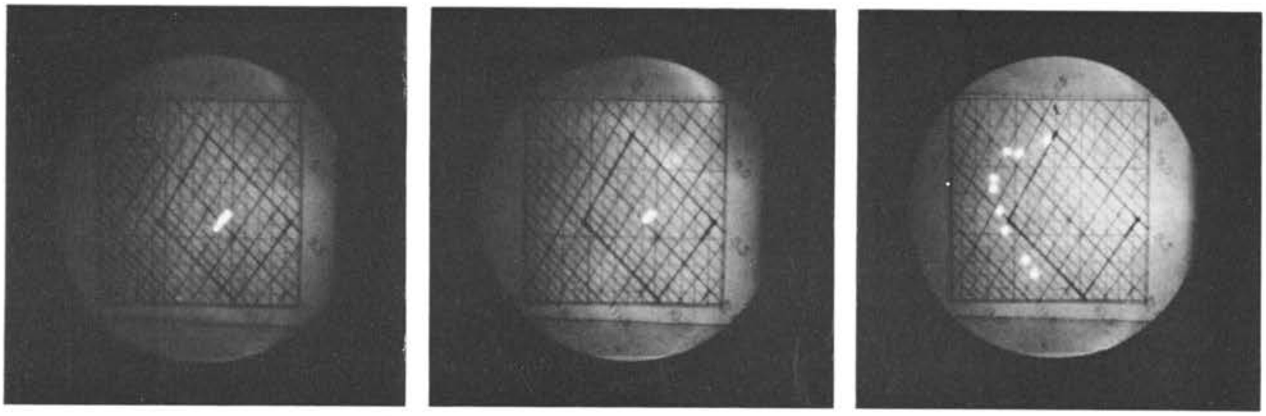

Fig. 2 — Left, dot pattern for dial that has a slight drift in run-down speed. Center, dot pattern showing excellent dial performance. Right, dot pattern for poor dial with variations in speed and per cent break.

require no complicated instructions to the operator of the equipment.

Figure 2 shows the actual dot patterns taken on this equipment when the digit "0" (ten pulses) is used. An acceptable dial having a slight drift (approximately ¼ pulse per second) in speed during run-down is shown in Figure 2, left. The close grouping produced by a very good dial is illustrated in Figure 2, center, and Figure 2, right, illustrates a dial of the older type with variation in both speed and per cent break. These are recorded patterns; actually, the dots appear successively as each break and make cycle occurs during the dial run-down. Also, since the pulsing contacts start and end closed, there are ten measurable break times for the digit "0" during run-down but only nine measurable make times, as the last make ends the run-down. This means that only nine corresponding pairs of break and make times are measurable and accounts for the appearance of only nine dots on Figure 2, right.

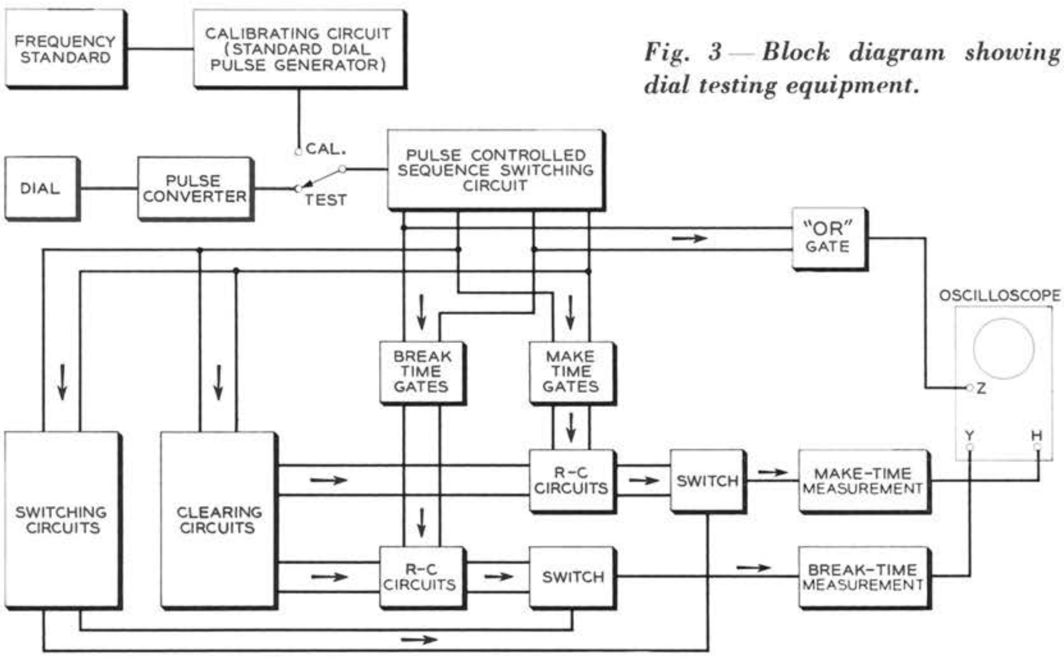

Fig. 3 — Block diagram showing dial testing equipment.

The circuitry selected for use in the new dial testing equipment was chosen after considering relative ease of trouble detection, over-all simplicity, accuracy of reading, and simplicity of fundamental calibration. These circuit functions are shown by the block diagram of Figure 3. Break and make times are stored, for simultaneous measurement, as charges proportional to these times on capacitors in R-C circuits. Two pairs of R-C circuits are used alternately to provide time for clearing one time measurement while the succeeding one is being made. An electronic sequence switching circuit, controlled by suitably converted dial pulses, is the control center of the device and performs the following functions: It turns on the appropriate timing gates for the duration of the break and make times of the pulsing contact; directs the operation of the clearing circuit to de-energize the proper R-C circuits after each time measurement; switches the time measuring circuits to the proper capacitors in the R-C circuits, and brightens the oscilloscope spot through an "OR" gate connection to the "Z-axis" (brightness control) of the oscilloscope. The R-C circuits are series arranged resistance and capacitor combinations which are connected to a dc source when the timing gates are turned on by the sequence switching circuit. Thus, the capacitor of the R-C circuit is charged to a voltage proportional to the break or make time during which it has been charged. This voltage is retained until displayed on the oscilloscope. The time measurement circuits measure the voltages on the capacitors of the two R-C circuits to which they are connected by the switching circuit. They are designed to have substantially no effect on the capacitor voltage, and to supply a proportional voltage at low impedance to the oscilloscope for display. The break time voltage is applied to the vertical, Y-axis, and the make time voltage to the horizontal, X-axis, dc deflection amplifiers of the oscilloscope. Spot brightening, referred to above, occurs after the break and make times of a given pulsing contact operation have been completed and stored as voltages on the R-C capacitors. Therefore, the capacitor voltages are fixed and the brightened spot is stationary on the screen.

The calibrating circuit, indicated in Figure 3, produces synthetic, accurately timed dial pulses from a standard frequency supply. Two pulse characteristics are provided having differing "break" and "make" times to provide two spot locations on the oscilloscope. Since these "make" and "break" times are known, it is possible to align the spots with the horizontal and vertical time scales selected for the display. Controls are provided in the circuit for scale alignment.

The advantages of this new measuring method suggested that it might be of value for inspection of dials during manufacture. Present production inspection of the pulsing contact adjustment for conformance with the tolerances previously described is made by averaging the per cent break time over ten pulses and measuring the average dial speed in pulses per second. This method of test has several disadvantages such as the fact that the break and make times of individual dial pulses cannot be determined. Two additional disadvantages are that the precision of measurement is not compatible with the improved dials, and maintenance of the dial testing equipment, particularly the pulse averaging feature, is difficult.

Consequently, at the Indianapolis plant of the Western Electric Company, dial testing equipment based on the Laboratories design has been constructed and steps are being taken to place it in service on the assembly lines. Use of this equipment will make more accurate dial adjustment possible while providing, without loss of time, a more complete analysis of the adjustment required to bring the dial within performance requirements. The establishment of modified testing requirements for telephone dials, as has been discussed in this article, is also under consideration.

THE AUTHOR

FRED WEST graduated from Johns Hopkins University in 1928 with a B.E. degree in electrical engineering, and joined the Laboratories Station Apparatus Development Department in that same year. He was concerned with the development of methods for measuring characteristics of station apparatus, as well as the development of test equipment for manufacturing control of station apparatus until 1953. At that time he was assigned to exploratory development in the Station Development Department. During World War II he participated in the development of devices for military use.

First DEW Building Accepted by U. S. Air Force

The first buildings constructed to accommodate the electronic equipment at a number of sites of the Distant Early Warning (DEW) Line have been completed and turned over to the U. S. Air Force by Western Electric Company. W. H. C. Higgins, Director of Military Electronics Development, represented the Laboratories at the ceremonies.

The present schedule of construction calls for 95 per cent completion this winter of all road networks, air-strip work, buildings and general utility works. Tests of the equipment for this radar network are already under way at several of the sites.

The design of the DEW Line and its equipment was undertaken for the government in 1952 by the Laboratories and the Western Electric Company with advice and assistance from the Lincoln Laboratory of the Massachusetts Institute of Technology. The radome at Whippany was erected to facilitate tests of equipment now in use in the Arctic defense system. The Laboratories participation in the project will continue for a substantial period during the first year of operation.

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