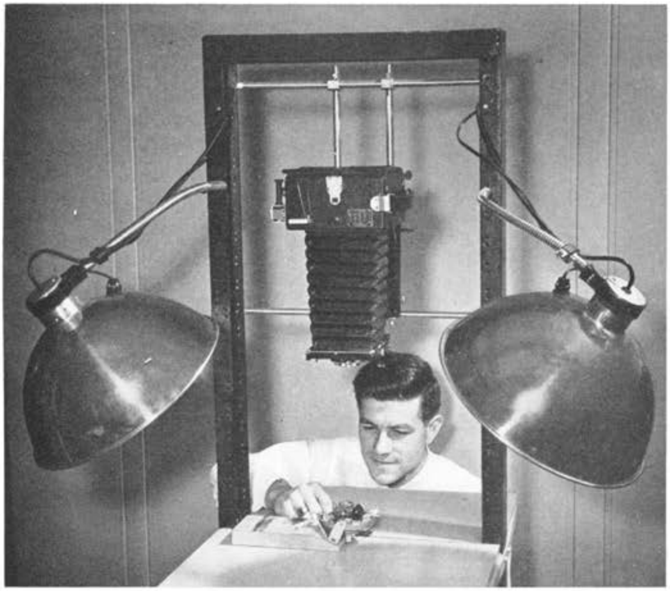

Dial for 500 Type Telephone Set

R. E. PRESCOTT
Station Apparatus Development

Using a one ten-thousandth second flash, W. Pferd photographs a dial governor in action.

The primary development objective of the new 7A-3 dial was to provide a mechanism, Figure 1, capable of dialing over the longer telephone lines permitted by the extended transmission and ringing efficiency of the 500 type telephone set. The letters and numbers were located outside the fingerwheel periphery where they receive better illumination and are more readily seen, Figure 2. The dial was designed to blend with the contours of the housing and thus contribute to the set's appearance.

The function of a telephone dial is to cause interruptions in the line current, thus originating sequences of pulses corresponding to the called party's telephone number. This is done by opening and closing a pair of contacts in series with the line to operate and release line selecting relays in the central office. Agreement between the operation of the relays and the digit dialed depends upon maintaining each pulse for a time interval and at a current level sufficient to operate these relays. The pulse must also decay rapidly enough to release the relay before the arrival of the succeeding pulse. Distortion which affects either pulse amplitude or duration limits the loop length over which pulses can be effectively transmitted.

In practice, no dialing mechanism sends out perfectly timed pulses. They may vary in either spacing in a sequence of pulses or in pulse duration. Added to this initial time distortion is the distortion of pulse shape or amplitude introduced by the electrical characteristics of the telephone line between the calling party's telephone set and the central office. Since line distortion is generally greater over the longer telephone lines allowed by the improved transmission and ringing abilities of the new set, it was necessary to compensate for this increase in possible line distortion by a reduction in the initial dial distortion. In terms of an improved dial this meant a more accurate pulsing mechanism and speed regulation that was steadier.

The pulsing mechanism of the new dial is shown in Figure 3. The pulsing contacts are actuated by a single-lobed cam mounted on a shaft geared to the fingerwheel in a ratio of 12:1. When the dial is in its "at rest" or normal position, the cam is oriented so that the contacts which form part of the talking circuit are held firmly closed.

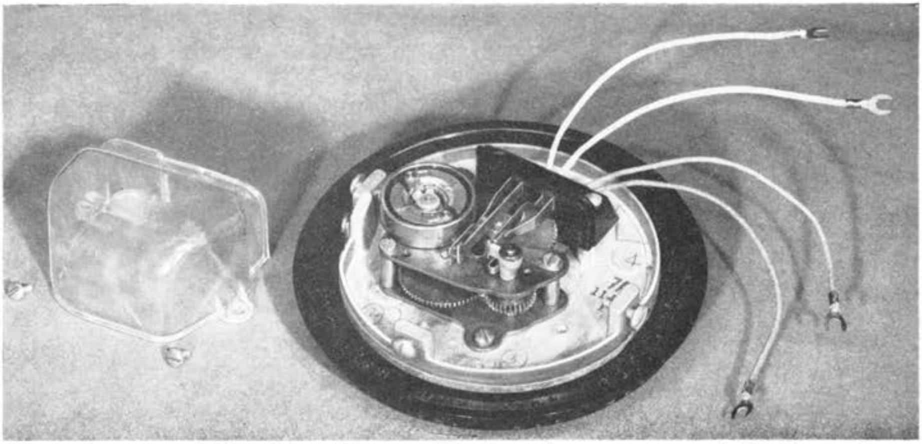

Fig. 1—Rear view of 7A-3 dial mechanism with plastic dust cover removed. (Left) speed governor, (center) off-normal contact and (right) pulsing mechanism.

When the dial is wound up, a spring controlled friction drive carries the pawl around to position 1 to rest against a stop. During this first cam shaft revolution, the cam lifts and lowers both springs A and B once for each rotation of the cam. However, since spring A is tensioned against spring B the contacts remain closed, and no pulses are formed during this revolution. The end of the windup finds the springs resting on the cam's high dwell (see broken lines). To increase the reliability of the pulsing contact operations springs A and B carry dual contacts and A is bifurcated.

When the dial is released it is returned to its normal position by the tensioned motor spring at a speed controlled by the governor. As the dial runs down, the cam first lowers then lifts the springs during its first revolution. During this interval no pulse occurs since the contacts in motion remain tensioned, one pair against the other. Also during this revolution, the pawl finger travels clockwise to position 2 where it supports spring A and prevents it from following spring B during the "break" portion of the cam cycle in the course of the second cam revolution. Thereafter, as spring B continues to follow the cam, the contacts are opened and closed once per cam revolution to produce pulses. Rundown stops with the springs resting on the cam high dwell and the contacts closed. The "per cent break" (ratio of break time to sum of make and break times) is adjusted accurately by bending the formed end of spring B to distribute the effective cam lift between the contact gap and the clearance between spring A and pawl finger.

The time between successive sequences of pulses corresponding to the digits of a dialed telephone number—termed "interdigital time"—must be long enough to enable line selecting relays to recognize the identity of separate sequences. Interdigital time is composed of "hunt," the time required by the subscriber to locate the next

Fig. 2—New dial is designed for improved visibility and ease of use.

digit to be dialed, "windup," and the controlled increment added during the first "no pulse" rotation of the cam shaft during rundown. Hunt and windup time may be short when low value digits are dialed; therefore, the controlled increment is provided to insure that line relays do not confuse, for example, a pair of ones with a single two.

The earlier 5 type dial employed a ten-lobed cam, each lobe engaging the impulse pawl to produce a pulse. By forming all pulses with the same cam lobe in the new dial, pulse variations due to spacing and other dimensional variations as well as differential wear are virtually eliminated. This results in an improvement of at least 50 per cent in control of the per cent break.

Uniform pulsing requires that the contact springs perform in a predictable and regular manner. In addition to studies to determine strength, stiffness and endurance, the vibration characteristics of the springs were theoretically analyzed to insure freedom from torsional or flexural resonances which might lead to either preliminary opens or contact chatter. Either of these parasitic motions can give rise to spurious pulses, and cause wrong numbers. Both performance data and the study of spring behavior with the aid of high speed photography have confirmed the successful elimination of this type of faulty operation.

The dial has another function allied with, but secondary to pulsing. It must be provided with switching contacts to prevent disagreeable receiver clicks resulting from pulsing and switching. The new dial is equipped with a pair of "off-normal" contacts, Figure 1, which are held open by a rubber stud on the main gear when the dial is in its normal position. When the stud is moved away during the act of dialing, these contacts close. This shorts the receiver and thus by-passes the receiver impedance so as to increase dialing range, and prevents the high voltage transients caused by breaking the inductive line circuit from reaching the receiver. On completion of dialing each digit there is a minimum interval of 0.015 seconds before the contacts open to restore the receiver—enough time to permit the decay of objectionable transients.

Since the torque input supplied by the motor spring to the dial mechanism increases as the fingerwheel is wound up by as much as two-thirds above the initial

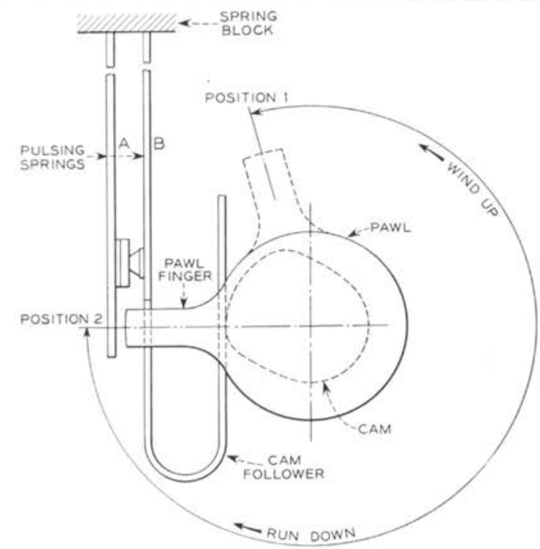

Fig. 3—Pulsing mechanism.

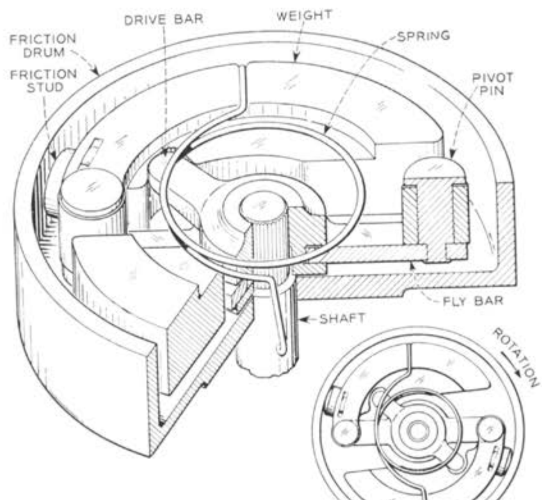

Fig. 4—Speed governor.

Fig. 5—J. H. Ham determines variations in finger-wheel torque by means of an electromechanical transducer and a recorder.

spring torque, the pulsing speed of the dial during rundown would vary over a wide range if not controlled by a governor. To insure complete rundown the motor spring supplies more energy than is required to return the dial to its normal or stopped position. This excess energy, which would normally accelerate the dial to a high speed, is absorbed by the governor which acts as a friction brake. As the governor shaft rotates during dial rundown, two weights, Figure 4, are caused by centrifugal force to overcome a counterbalancing spring tension until friction studs located near the weight pivots bear against the inner surface of the drum. At the critical velocity for which the spring has been adjusted, braking begins and increases as the speed increases; similarly, if the speed drops, braking decreases.

In developing the new governor to improve speed regulation, analysis of earlier theory indicated that increased governor speed together with reversed direction of rotation would accomplish this requirement. Extension of the theory suggested the drive bar as an additional improvement which, when coupled with a simplified mechanical design, produced the governor in its present form. In earlier governors (as represented by the 5 type dial governor) the weights were pivoted on ends of a bar driven by the shaft in a direction of rotation opposite to that shown in Figure 4. When rotated, the weights swung outwards on their pivots, due to centrifugal force, pressing friction studs against the drum to produce a friction force opposing the driving torque; but this force also opposed the centrifugal force thus reducing braking effectiveness. In the new design, the weights are pivoted as before, but the fly bar is free to rotate with respect to the shaft. Driving of the weights is accomplished by the drive bar which acts against them causing a component of the driving torque to aid centrifugal force in pressing the friction studs against the drum. When contact be-

THE AUTHOR: When R. E. Prescott received his B.S. in M.E. from the University of Wisconsin in 1934, he spent the following four years designing industrial furnaces and automotive type Diesel engines. Coming to the Illinois Bell Telephone Company in Chicago in 1939, he spent two years on outside installations and central office work. Transferring to the Engineering Department, he became responsible for the installation of emergency Diesel engine-driven generator sets. Coming to the Bell Laboratories in 1942, he worked on the mechanical aspects of sound power telephones, subsequently becoming engaged in the mechanical design of transducers for underwater sound use. Later, his work included loudspeakers and special sound power instruments for soldiers' helmets. Following the war, he was concerned with phonographic reproducers and recorders, and the artificial larynx. Since 1948 he has been assigned to the Station Apparatus Development Department where his work has been on the dials for telephone sets.

tween the studs and drum occurs, and friction braking begins, this friction force is also in the direction to aid centrifugal force. The result is a more powerful braking action with at least a 50 per cent reduction in the range of speed variation as compared with the 5 type dial.

During windup a band-spring type of clutch decouples the governor so that neither its inertia nor braking opposes a rapid windup desirable from the standpoint of obtaining minimum register holding time.

An individual's accuracy and speed in operating a dial, apart from his ability to remember the telephone number, depend upon proper co-ordination between his eye in picking the right letter or digit, and his finger in finding the corresponding hole in the fingerwheel. To dial in the least possible time, he must locate the next digit while the fingerwheel is in motion, and have his finger poised ready to wind up the dial as soon as the wheel comes to rest.

To facilitate dialing the numbers and letters were located outside the fingerwheel periphery, Figure 2, where they are no longer partially obscured by solid portions of the fingerwheel. They are clearly visible while the fingerwheel is in motion and under a wider range of lighting conditions. Aided by a slightly concave number plate surface, the new location of characters also increases the range of viewing angles.

Since the eye is drawn to the focal point of convergent lines, letters and numbers as well as the word "operator" are arranged in groups roughly simulating arrows pointing to the associated holes in the fingerwheel. At the center of each hole is a white dot which provides a target for both eye and finger. In addition the dots cause a flicker which abruptly ceases when the fingerwheel comes to rest with a sharp click. Thus the subscriber is informed by both eye and ear that the time has come to dial the next digit.

The new design also features broad changes in concepts relating to manufacture. A precision gear train, accurately assembled as a unit and so, ready to be placed on the dial frame in mesh with the main gear, reduces adjustment time. A frame die cast in one piece provides all the necessary mounting points and replaces the frame formerly fabricated from several punched and formed parts. The contact spring block assembly is composed of springs molded into a phenolic block. Manufacture of the specially shaped weights and drivebar of the governor to close dimensional tolerances is simplified through the use of sintered metal techniques. Molded nylon is used for the cam and pawl to insure long life and stability. The plastic number plate is produced by a unique method of injection molding which permits the use of one color for characters, and another for the background to produce excellent contrast and legibility. A plastic cover protects the entire mechanism from dust.

First Southern Radio-Relay Link

Telephone and television service by microwave radio relay reached Atlanta recently when the new six-station route between that city and Charlotte was first put to use. The link, 295 miles long, is part of a $6,000,000 project which will connect Atlanta with Washington.

Augmenting other cable and wire facilities at present furnishing telephone service to this section, the completed Charlotte-Atlanta leg provides fifty telephone circuits initially and additional circuits as needed to handle the greatly increased telephone traffic through the South. It also furnishes a direct interconnection between the Atlantic Coast and southern transcontinental coaxial cable routes, thus adding to the flexibility of routing long distance telephone messages. Addition of this TV link to the Long Lines network will enable Atlanta to receive live network programs via Birmingham, Alabama, Jacksonville and Charlotte, making available three separate routes to serve the three stations in this city.