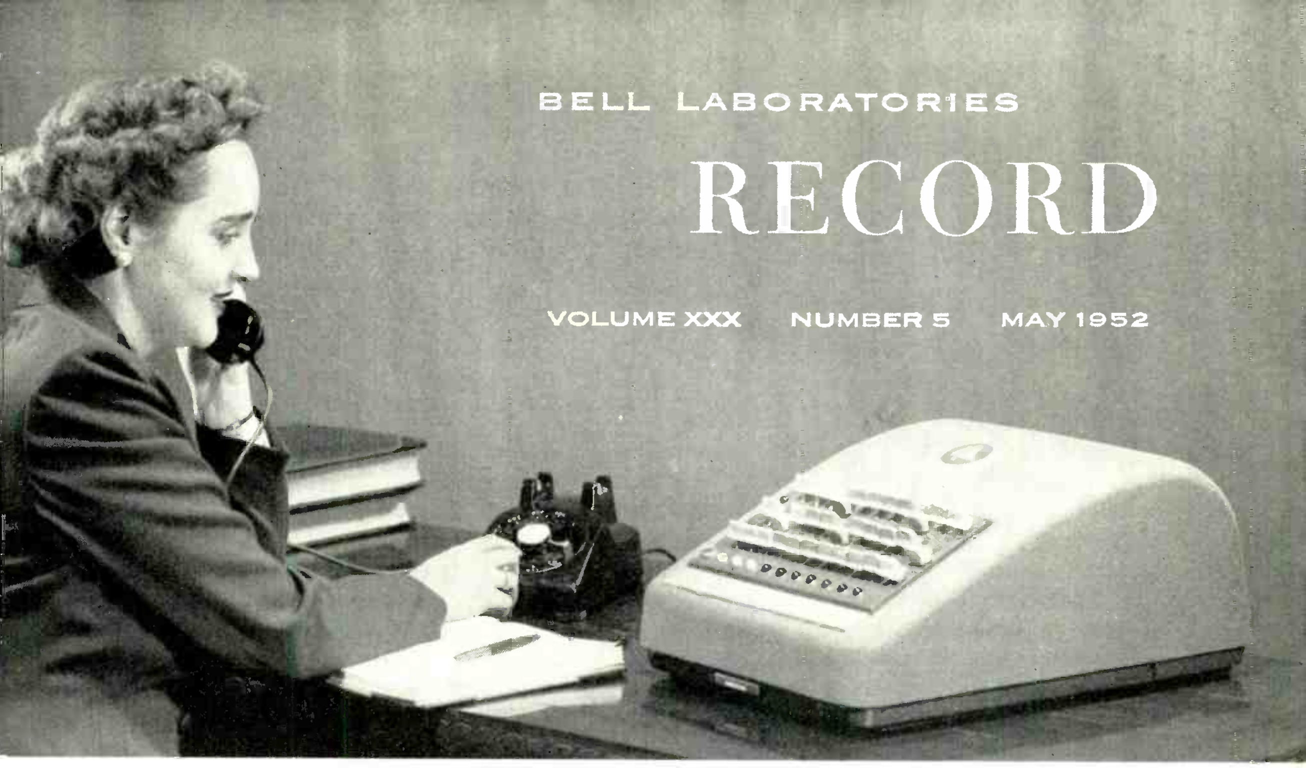


The 507A and 507B PBX

F. W. TREPTOW
Switching Engineering

The 507-type PBX is a key-operated manual switchboard intended to replace the 506* type, which has been in general use for many years. The older design has been widely used by small businesses where not more than twelve station extensions and five central office trunks were required. Following the war, the Laboratories undertook a thorough modernization of this switchboard, which is the last PBX in the Bell System using magnetic signals and drops as line and supervisory signals. The replacement of these magnetic signals and drops by lamps was of prime consideration and was made economically possible by the development of a low-current lamp.

The 507A PBX, shown in Figure 1, has a capacity for three central office trunks and seven extension lines, and the 507B PBX has a capacity of five central office trunks and twelve extensions. Both switchboards are provided with five connecting paths over which trunks are connected to extensions or which may be used for establishing extension to extension connections. Manufacture by the Western Electric Company of these switchboards was started in the second quarter of 1951.

The new PBX is a self-contained unit having modern styling and other features that make it compare favorably with present day commercial office equipment. The switchboard housing consists of lightweight die-castings finished in a beige-gray color with a fine wrinkle texture. The key handles have been especially contoured for maximum comfort and for ease of operation as well as to improve the appearance of the

* Record, *April* 1929, *page* 331.

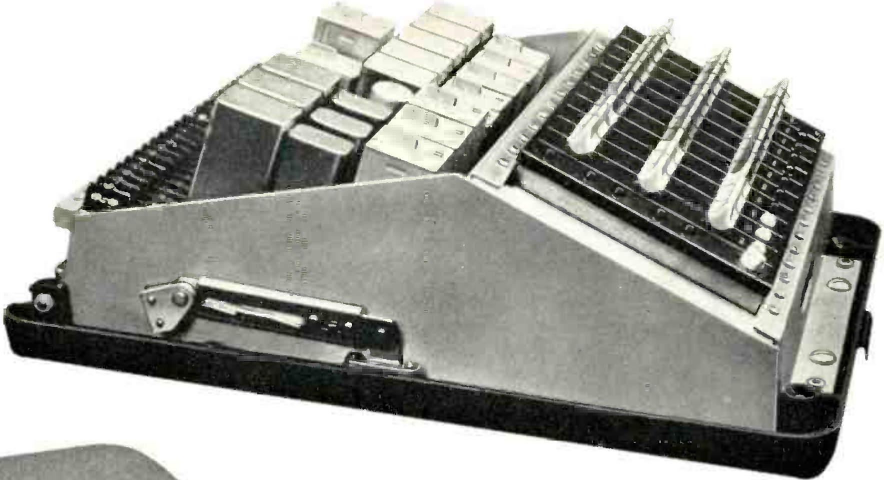


Fig. 2—Removing the cover of the PBX exposes all the apparatus mounted on a metal chassis.

Fig. 1—The 507A PBX has capacity for three central office trunks and seven extension lines.

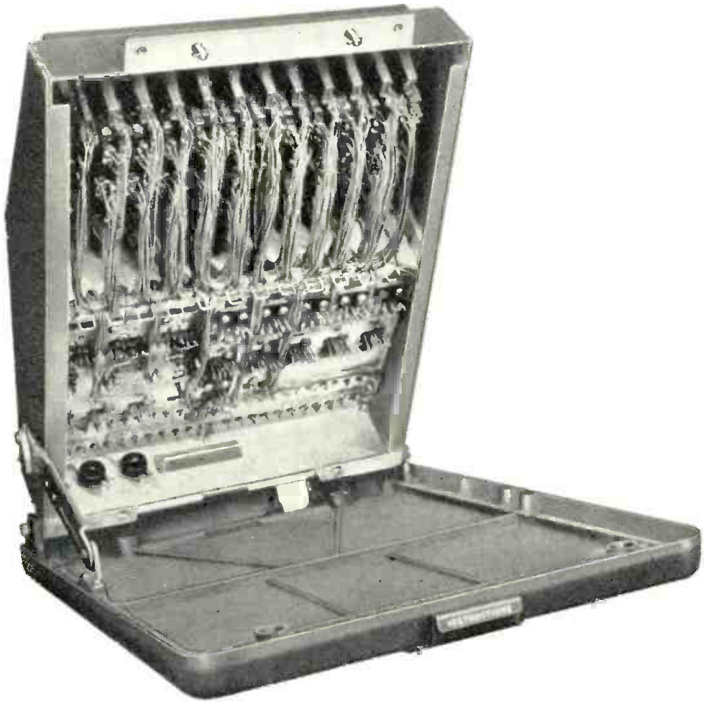


Fig. 3—The chassis is hinged, and may be lifted to expose the wiring.

board. The use of lamps in place of magnetic drops and signals contributes significantly to the improvement of the over-all appearance. To further enhance the appearance of the board, the operating instructions have been provided on a pull-out slide located near the lower front edge of the PBX so that they are normally out of sight, and the cover locks are concealed under the designation strip, which is of the lift-off style similar to that provided on subscriber's key telephone sets only they are much larger.

Removing the cover exposes the sheet metal chassis, Figure 2, which mounts all apparatus including the keys, and is hinged so that it may be raised, Figure 3, to give access to the wiring, quite like the arrangement used for key shelves on conventional switchboards. The entire unit is surface wired with the aid of an ingenious wire retaining detail secured to the chassis. This detail supports the wires and provides a method of multiplying leads between keys without sewing or tying. The resulting wire loops permit removal of keys for adjustment and maintenance. A cable entrance hole is provided in the rear of the switchboard near the base to accommodate the house cable leads and the attendant's telephone-set cord, as well as the wiring for all optional equipment items. All external lead connections are terminated on screw terminals at the top rear of the chassis. The weight of the 507 PBX is approximately two-thirds that of the previous 506 board, and its volume less than one half.

Operation of the 507 PBX is essentially the same as of the 506 PBX except for the use of lamps in place of magnetic signals and drops. There are three keys in a vertical file associated with each trunk, with each extension, and with the attendant's telephone set. Those for the trunks are at the left and have light tan handles; those for the attendant's set also have light tan handles and are at the extreme right. Between these keys with light tan handles are keys with dark tan handles for the extensions. All key levers have three positions: up, normal, and down. The contacts of the operated positions of the two upper horizontal rows of keys, and the upper position of the lower row, are multipled to form five connecting paths to which any of the trunks or extensions may be connected, as indicated in Figure 4. The down position of the keys in the lower row provides a hold position for trunks and a ringing position for the extensions. Below the keys is a horizontal row of line lamps, with white caps for the trunks and red caps for the extensions. At the left side of the cabinet is a vertical row of supervisory lamps with red caps for the five connecting paths.

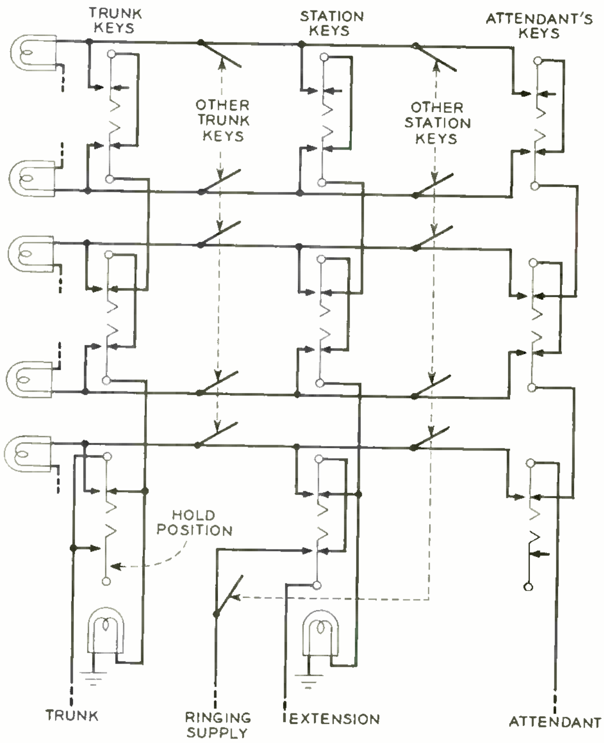


Fig. 4—Single-line diagram of the 507 type PBX indicating the arrangement of the trunks, extensions, and connecting paths.

When the line lamp of one of the trunks or extensions lights, the attendant operates one of the keys of her set to connect it to any of the five connecting paths that may be idle; and then operates the corresponding key for the calling trunk to connect it to the same path, and answers the call. If it is for an extension that is not busy, she operates the corresponding key for this extension to the selected connecting path, and then operates the lower key for this exten-

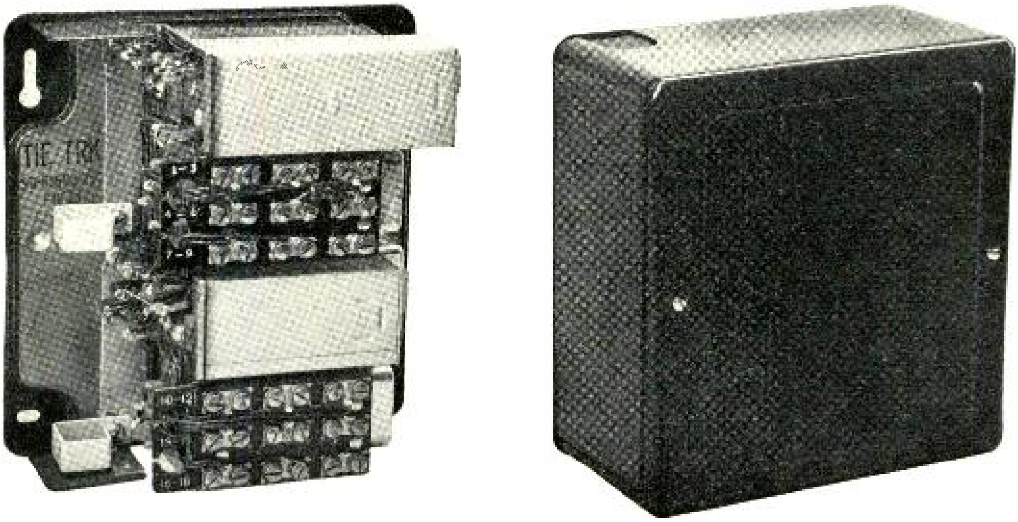


Fig. 5—The tie-trunk unit for the 507 PBX.

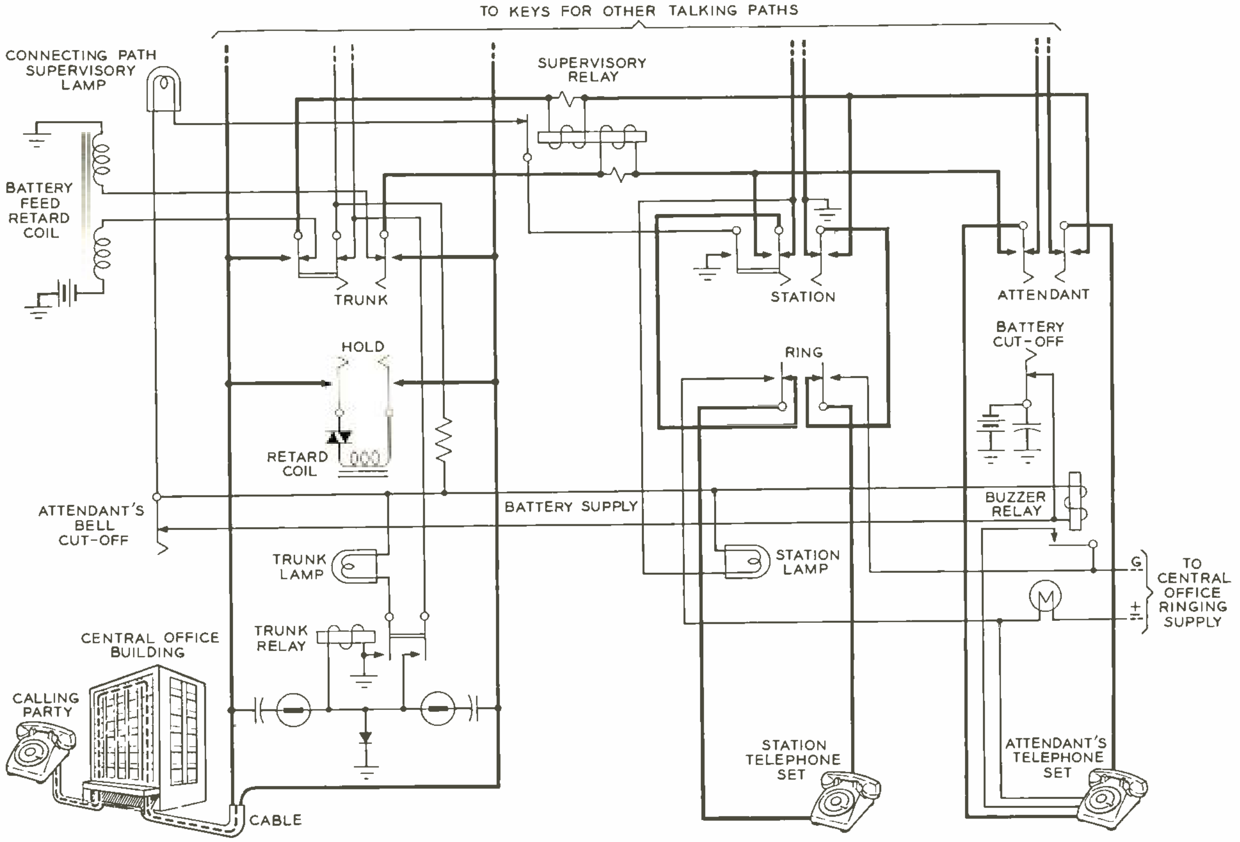


Fig. 6—Circuit schematic of the 507 type PBX showing circuit for one trunk, one extension, and the attendant's telephone set.

sion to the down position to ring. After the called station answers, the attendant restores her own key to normal. The same procedure is followed whether the call comes from a trunk or an extension. If the call is from an extension to a trunk, the procedure is similar except that ringing is not required, and the attendant may have to dial using the dial on her telephone set to establish the desired connection.

If the buzzer key at the lower left of the key panel is turned ON, the ringer in the attendant's telephone set will ring whenever a lamp lights. This enables the attendant to give attention to other duties during periods of light traffic.

The supervisory relays associated with the five connecting paths in the PBX are each provided with two identical sets of windings, indicated in Figure 6, one of which is connected in the tip and the other in the ring lead so as to minimize noise and crosstalk, particularly on connections involving long off-premise lines where balanced transmission is quite important. Also the battery feed retard coils, one of which is required for each of the connecting paths, have been designed with a resistance high enough to be self-protecting on 48-volt batteries, eliminating the need for resistance lamps in these circuits which would otherwise be required.

The trunk lamp is under control of a ring-up lock-up relay and lights on incoming calls from the central office. The relay is operated by rectified ringing current from a half-wave germanium varistor rectifier, and is held up through a locking contact connected to the d-c battery supply. The rectifying circuit is provided with two series thermistors to guard against false operation of the trunk lamp during dialing or other momentary pulses, and blocking condensers are employed to isolate the rectifier circuit from talking battery.

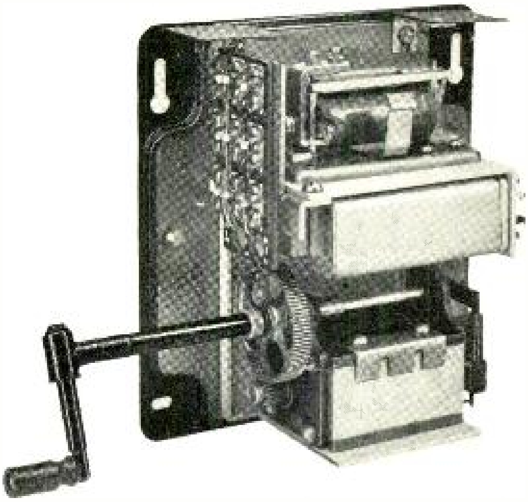
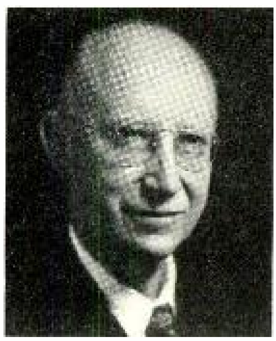


Fig. 7—Hand generator and buzzer unit for the 507 PBX, with cover removed.

The trunk holding bridge, which is applied manually by means of the trunk holding key, embodies a new arrangement of a low resistance retardation coil and a silicon-carbide varistor. This combination, because of the characteristic resistance of the silicon-carbide, provides a low resistance path during holding and a high resistance bridge

THE AUTHOR: After F. W. TREPTOW left Stevens Institute of Technology in 1918, he worked for several concerns before coming to the Bell Laboratories (then Western Electric Engineering Department) in 1920. His first assignment was that of draftsman in Apparatus Development, but shortly afterwards he transferred to Systems Drafting. In 1922 he became concerned with equipment engineering on dial systems, continuing in this work, which included No. 1 Crossbar development, until World War II. During the war, he was in charge of the mechanical design of several radar projects, including parts of the SCR 545 gun-laying radar, the AN/APQ-7 bombing radar, and the AN/APG-1 night fighter radar. Since the war, and until recently, he was in charge of the mechanical design of telegraph systems, key telephone equipments, and manual and dial PBX's. A short while ago, he was placed in charge of the large and small step-by-step central office mechanical design, and continuing his work on manual and dial PBX's.



when shunted by a connected telephone. This occurs because the resistance of the varistor increases as the voltage across it decreases. The arrangement minimizes transmission losses due to the presence of a holding bridge on a completed connection if the attendant through oversight fails to restore the holding key. The station extension key at the extreme right of the board is equipped with a line relay, which under low battery-voltage conditions will permit a longer extension loop than the other keys.

Two auxiliary units have been made available for use with the 507 PBX, and local conditions will determine the need for either or both. A ring-down tie trunk unit so compactly designed that it will mount in a 7 x 7½ x 3½-inch apparatus box, Figure 5, has been provided for installations requiring direct connections with another PBX. The wiring for the first station extension circuit of the switchboard is wired in such a manner that conversion for its use as a ring-down type trunk is accomplished simply by disconnecting some strap wires at the terminal strip and attaching the cable to the tie trunk. This is a considerable improvement over the tie trunk arrangement used in the present 506 PBX, which requires a costly wiring rearrangement in the PBX proper.

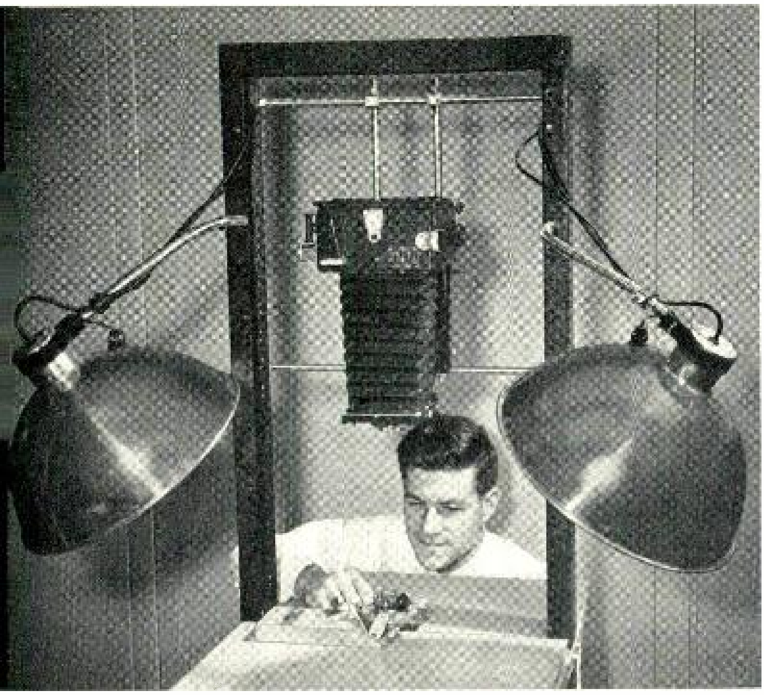
In cases where ac ringing power is not available, or where it is desired to cover failure of the regular ringing power, a hand generator is provided in a 7 x 7½ x 3½-inch apparatus box, Figure 7, which may be mounted on the end of the attendant's desk. This unit has been flexibly designed for either right- or left-hand operation as may be desired.

New Word Counter for Teletypewriter Circuits

In the large teletypewriter systems now coming into use, accurate traffic studies are important because of the economic losses that may occur if circuits are over or underloaded. To count the number of words transmitted, an instrument has been developed by W. Y. Lang of the Laboratories which will be generally available to the Associated Companies next Fall. It resembles a conventional start-stop teletypewriter mechanism to the extent that a moving element is released on each "start" pulse and stopped on each "stop" pulse. The mechanism includes a small 115-volt 60-cycle synchronous motor which drives an escapement wheel equipped with six stop points through a clutch and gearing at one-sixth the speed of a teletypewriter. When a "start" impulse is received by the magnet, the escapement is released. Any of the subsequent "mark" and "space" impulses in the five-element groups which select a letter are disregarded by the counter because the escapement wheel is in such a position as not to be intercepted by any movement of the armature. However, when the time has arrived for a "stop" pulse to be expected, a pin on the escapement wheel is in position to be blocked by the armature, and thus the pulse locks the escapement wheel until the next "start" pulse comes in. Each pair of "start" and "stop" pulses allows the escapement wheel to advance one-sixth turn, and a complete revolution is recorded as one "word" on an associated counter.

The counters are enclosed in metal boxes about six inches each way with the counter element mounted on the front.

They will be available for use on 60-speed and 75-speed circuits and may be wired permanently into a circuit or inserted by means of a cord and plug.



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.

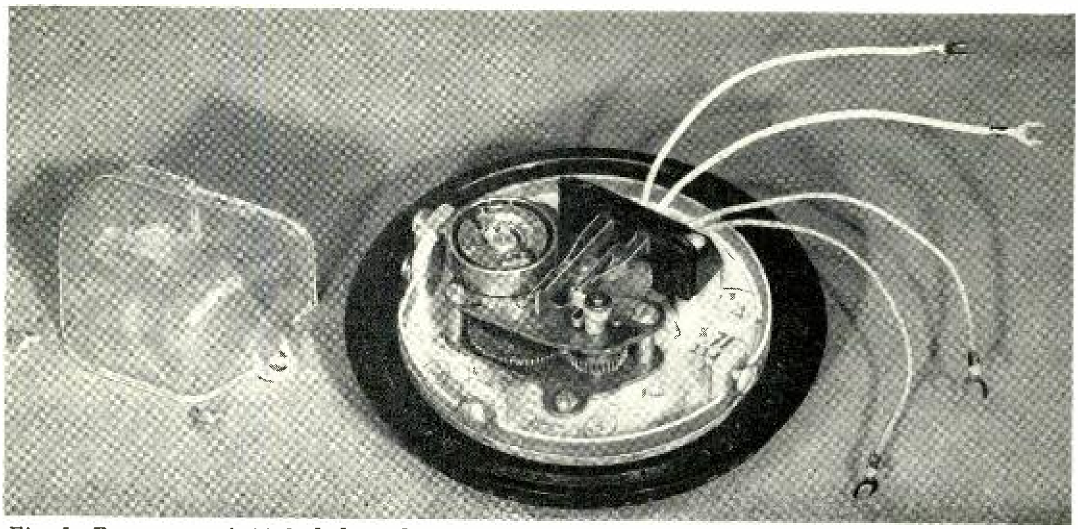


Fig. 1—Rear view of 7A-3 dial mechanism with plastic dust cover removed. (Left) speed governor, (center) off-normal contact and (right) pulsing mechanism.

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

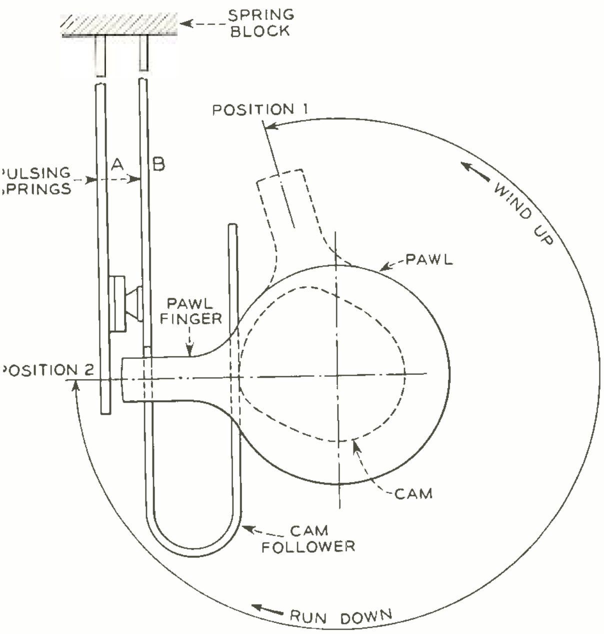


Fig. 3—Pulsing mechanism.

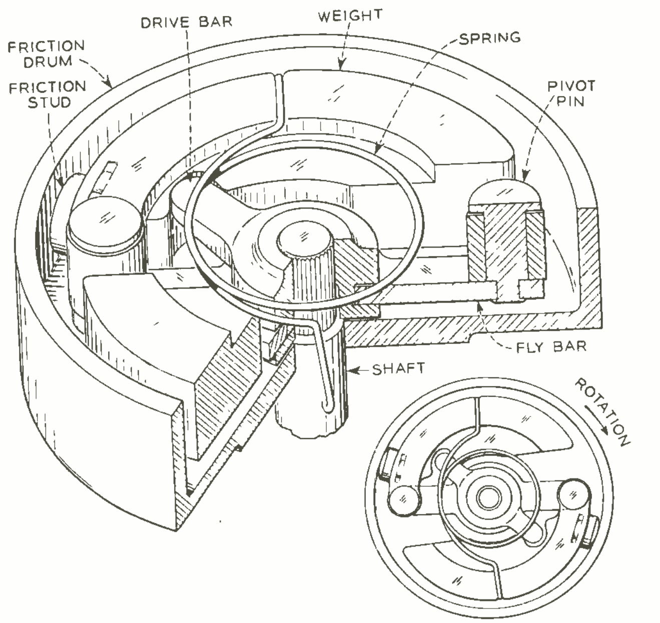


Fig. 4—Speed governor.

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-

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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 design-

ing 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 wind-up 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.

The RECORD *Expands its Technical Coverage*

When the first issue of the RECORD appeared in September, 1925, there were some fourteen hundred members on the Technical Staff of Bell Telephone Laboratories. The RECORD undertook the task of acquainting these scientists and engineers, working in a large number of different fields and departments, with the general nature of the work and accomplishments of their confreres. Along with this record of technical accomplishments, it was planned also to include information regarding the many incidental activities of the Laboratories' personnel. As a result of this double assignment, the RECORD has been partly a technical magazine and partly a news magazine.

In 1925, however, both Bell Telephone Laboratories and the Bell System it serves were considerably smaller than they are now. While at that time there were less than twelve million Bell System telephones in the United States, there are over thirty-seven million at the present time. Even this very considerable increase does not truly measure the growth of the Bell System, however, since it omits such things as nationwide radio and television networks, teletypewriter circuits and switching facilities, and radio links with some thirty million foreign telephones. It also omits all the radar and other devices, systems, and equipment provided for the armed forces during the last war and the very large amount of research and development now being carried on for our rearmament program. As a result of this growth in Bell System services, the staff of Bell Telephone Laboratories has naturally increased until at the present time it includes over seven thousand people, of which some twenty-five hundred are on the Technical Staff. Included in this figure is the staff of the Department of Development and Research of the American Telephone and Telegraph Company, which was consolidated with the Bell Telephone Laboratories in 1934.

Such a growth in the work of the Laboratories has quite naturally changed the outlook of the RECORD. There is still another situation, however, that calls for some reconsideration of the form the RECORD should take. Along with the growth of the Laboratories there has been an increasing interest in its work on the part of people outside the Bell System. This was recognized by putting the RECORD on a subscription basis as long ago as 1934. Although it was recognized also that much of the material carried in the news section would be of only minor interest to those outside the Bell System, the situation did not seem of enough importance at that time to require immediate action. There was still space within the covers of a single, moderate size magazine to cover both phases of the Laboratories' activities, and the need for two magazines—one for the technical material and one for the news—did not seem great.

With the large increase in both work and personnel that the RECORD must now cover, and with the scope of the work broadened, and further with the natural widening of the interests and collateral activities of the greatly increased personnel, the provision of two magazines seems clearly indicated. Beginning with this issue, therefore, BELL LABORATORIES RECORD will be devoted exclusively to the technical and scientific phases of the Laboratories work. As before, it will carry articles by members of the technical staffs describing their work, and it will also carry news of a strictly technical nature. It will no longer carry news of social activities, however, nor other material primarily of interest within the Laboratories itself. All such material, increased in amount and more effectively presented, will appear in a new magazine.

The new RECORD is starting as a thirty-two page magazine. It is planned, however, that as material becomes available, to increase the number of pages as may be required to cover all phases of the work of the Laboratories.

The Key West-Havana Cable:

Regulated DC Power Supply

G. W. MESZAROS
Power Development

Success of the new Key West-Havana submarine cable system depends to a great extent upon the life of the electron tubes that form an integral part of the built-in repeaters. To obtain the maximum life from these tubes, a current regulating system is provided in the power supply to hold the cathode heater current constant to better than one per cent. This article discusses the special features of the regulating system of the power supply that has been described in a previous article*.

There are three main components in the regulating system, as shown in Figure 1 and in the schematic, Figure 2: (1) the ac control unit to regulate the input; (2) the rectifier unit to convert to dc; and (3) the current regulator to control the dc input to the cable. In the ac control unit, an autotransformer furnishes the power to the rectifier unit, the voltage being variable from 0 to 270 volts under control of a two-phase motor. This motor is operated by the current regulator acting as a servo, or feedback control system. The servo system makes use of a bridge circuit, including a saturable reactor, that supplies continuously variable signals to provide exceptionally close control of the input to the two-phase motor. Moreover, the saturable reactor and associated circuits are so designed that when two rectifiers simultaneously supply current to the cables, substantially equal division of the load is maintained between them.

The rectifier, consisting of a step-up transformer and four stacks of selenium discs, has a nominal output of 500 volts. By connecting two rectifiers in series, sufficient voltage is developed to energize one of the cables. The output of these rectifiers passes through a two-stage inductor-capacitor fil-

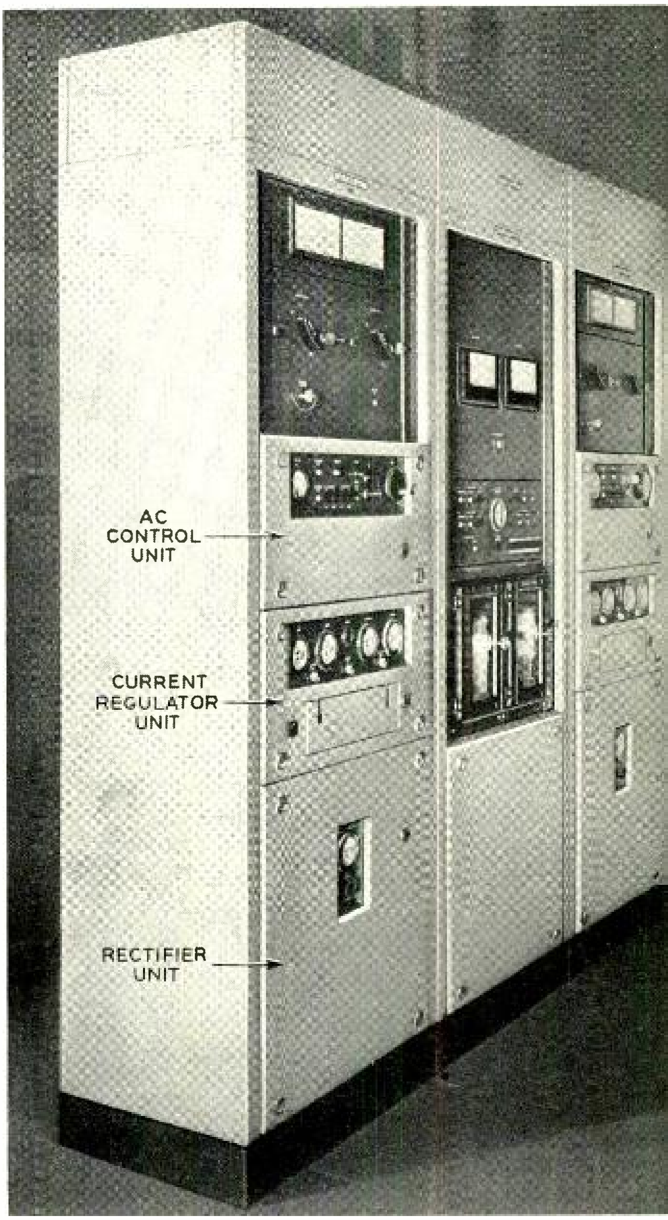


Fig. 1—The components of the regulating systems are housed in the end cabinets of the dc supply.

*RECORD, *April,* 1952, *page* 166.

ter, and then into the current regulator, where the path is through a parallel circuit of two 715B electron tubes (see Figure 2). From the current regulator, the current passes through a cable current control resistor, 50-henry inductor, power separation filter, to the cable.

In the current regulator, input to the dc amplifier is supplied by the voltage drop across the cable current control resistor. The output of the amplifier is connected to the control grids of the 715B electron tubes, so that a change in the cable current results in a change in the voltage applied to these grids. This in turn changes the tube impedance so as to return the cable current to its nominal value. Either tube is capable of regulating the total cable load, but for additional protection against service interruption, two tubes in parallel are used.

Use of the feedback control system previously mentioned improves the cable current regulation and increases the life of the 715B series tubes. The voltage drop across the tubes varies with the input ac changes, earth potential changes between Key West and Havana, line and load changes during periods of testing, and would change if an accidental fault occurred in the cable. Under these conditions, without the feedback control system, a higher 715B plate voltage would be required to keep the cable current at the regulated value and more tubes would be required to confine the power dissipation per tube within its capabilities. With the control system used, one tube is sufficient since the plate voltage is always returned to the same low value.

A change in the plate voltage will vary the direct current in the voltage regulator winding of the saturable reactor connected in shunt with the 715B tubes. This changes the magnetic flux in the cores of the reactor, thereby changing the impedance of its ac winding. Now, this winding is one leg of a bridge whose other three legs are the fixed impedance of the ac control unit and two identical impedances made up of equal numbers of turns on the autotransformer winding. The control winding of the two-phase motor is connected across the normally balanced corners of this bridge. With the bridge balance disturbed, the motor drives the tap on the autotransformer in the

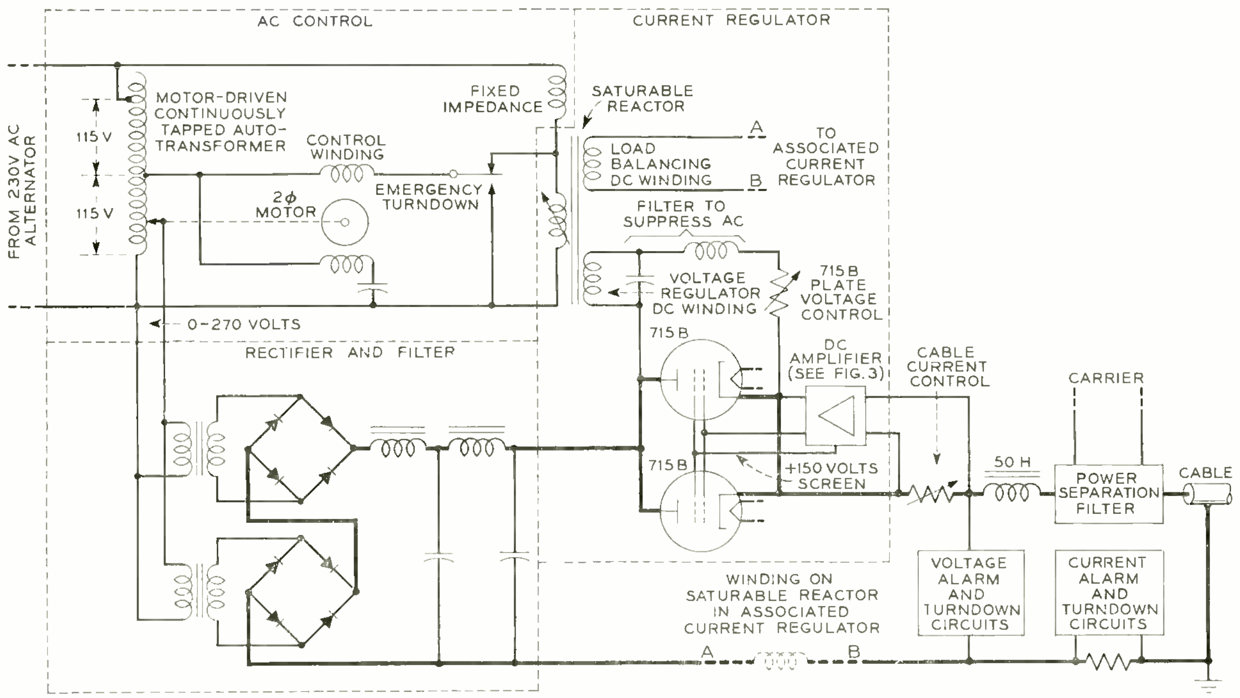


Fig. 2—Simplified circuit of the regulating system.

direction to change the rectifier input and restore the plate voltage on the 715B tubes to the nominal value.

The speed of response of this system depends upon the magnitude of the change in plate voltage. A small change causes the motor to creep until the quiescent condition is restored; however, a large change, such as that due to a trouble condition, will drive the motor at a very rapid rate until the nominal steady state is reached. In an emergency, a "turndown" feature, operated from several remote points, either manually or automatically, will reduce the autotransformer output to zero in less than two seconds. For simplicity, only the manual turndown feature is shown in Figure 2. It operates simply by switching one end of the motor control winding from one corner of the bridge to the other, thus applying half of the input voltage to the control winding. The turndown operates automatically whenever the cable voltage or cable current reaches abnormally high values, preventing injury to the cable and repeater tubes.

Manual operation of the auto-transformer tap is provided to raise the cable current slowly, either initially or after a turndown. The hand wheel, visible in Figure 1 near the right hand side of the regulator bay, provides this control. When manual operation is desired, a switch turned to the manual position opens the feedback control path, permitting the tap to be stopped at any position on the auto-transformer. A dynamic brake, consisting of a short circuit on the motor control winding, prevents the motor from creeping or coasting when the operator releases the hand wheel since the fixed phase of the two-phase motor is always energized. The turndown feature takes precedence over the short circuit of the motor control winding, so as to be able to energize the motor in the event of abnormally high cable current or voltage.

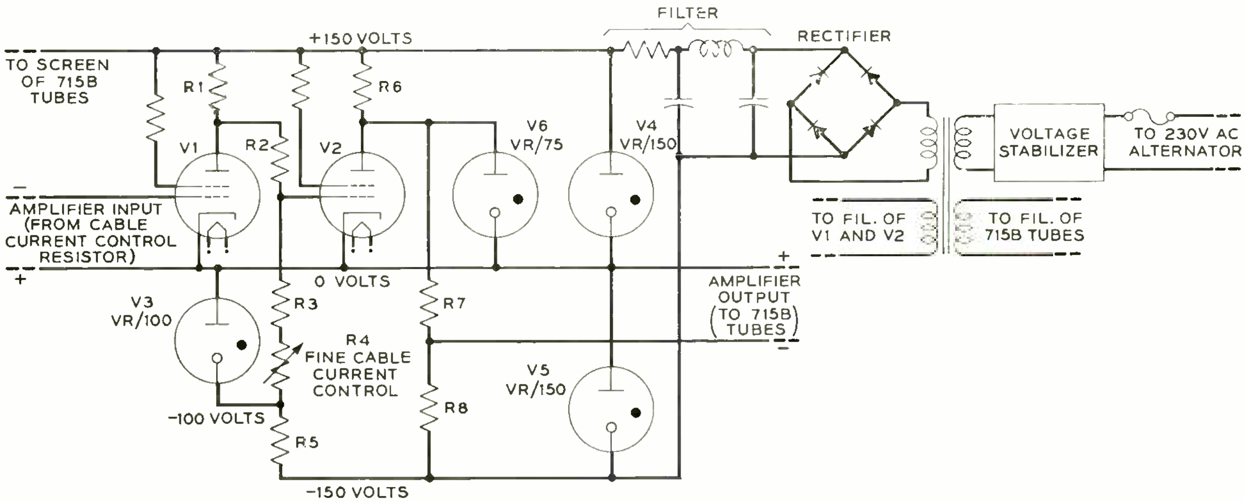


Fig. 3—Schematic of the two-stage dc amplifier.

When two regulating bays are connected in parallel there is a tendency for one bay to take more than its share of the cable load. To split the load equally between the bays, a second dc winding on the saturable reactor is used. This is the load balancing winding A-B of Figure 2 and is connected in series with the rectifier output of the associated bay. Its effect is to upset the bridge balance of the ac regulator whenever the direct current in the two bays are unequal. The control winding of each regulator bay receives a signal, one motor driving the auto-transformer tap in a direction to deliver more voltage to its rectifier and in the other one to deliver less, which restores the balance of loads between the two bays.

The circuit of the dc amplifier of Figure 2 is shown in Figure 3. The amplifier input is the voltage across the series cable current control resistance, Figure 2, with the negative side connected to the control grid of tube V1. Any change in the cable current is amplified in the two stages, V1 and V2; for example, if the cable current increases, then the grid potential of V1 becomes more negative with respect to its cathode, reducing the plate current in R1 and making the grid of V2 less negative. The plate current of V2 then increases, producing a greater voltage drop in R6. Resistors R6, R7, and R8 form a potentiometer across the +150-volt and −150-volt supplies, with a tap between R7 and R8. This tap is one side of the output of the amplifier and is connected to the control grids of the 715B series regulator tubes as shown in Figure 2. The other amplifier output connection goes to the cathodes of the 715B tubes.

An increased current in resistor R6 will produce a greater voltage drop in that resistor, making the control grids of the 715B tubes more negative with respect to their cathodes, thus increasing the impedance of these tubes to compensate very nearly for the assumed potential change in the load. Since the rectifier unit now "sees" the same impedance before and after the cable current change, this current will be restored to its normal value.

If a change in the load should occur that would cause the voltage across the 715B tubes to rise by 10 volts or more, the current through the voltage regulator winding of the saturable reactor would increase sufficiently to start the servo system. This will alter the rectifier input to restore the drop across the 715B tubes to its former value. Without the servo system, a decrease of 100 volts in the voltage across the 715B tubes will cause an increase in cable current of 1 milliampere in 250; with the servo system, a similar load voltage change in the system will change the cable current less than 0.1 milliampere.

To maintain the dc supplies constant for the several plates, screen grids, and cathode heaters of the regulating system, a number of devices are used. Voltage regulator tubes because of their constant voltage drop characteristics, are provided to hold the reference potentials constant and at the same time help to smooth out remanent ripple from the filter. A magnetic voltage stabilizer, which consists of a phase shifting network of inductors and a capacitor, maintains a fairly constant input voltage to the rectifier and cathode heater transformer. This aids the amplifier regulation in two ways; first, by limiting the required operating voltage of the VR tubes to a relatively narrow range, and second, by keeping the tube cathodes at nearly constant temperature. Instantaneous dips in alternator voltage to the amplifier, which may occur during switching of driving motors in cases of trouble, are minimized by the voltage stabilizer. Without the stabilizer, these dips might allow the VR tubes to drop out of their regulating range and at times to be extinguished momentarily. If this should happen, the amplifier would lose control of the cable current and possibly result in a false turn down of the cable.

Fig. 4—R. R. Gay is placing the amplifier tube in its special mounting on the current regulator panel.

An additional stabilizing feature in the amplifier is the use of two VR tubes, V5 and V3 in cascade, to control the negative reference potential for tube V1. Tube V3 is a tube recently designed by the Laboratories and has extremely good regulation and stability —the regulation is of the order of a few tenths of a volt as compared to several volts for the other VR tubes—and its stability for 1,000 hours is 0.3 volt.

Tube V4 in the +150-volt supply does not need to have such good regulation and stability characteristics, since variations in this voltage do not affect the regulated current significantly. The +150-volt supply is common to the screen and plate of each stage, so that a change in the screen potential causes a plate current change that compensates approximately for the plate potential change. Then too, the second stage being 180 degrees out of phase with the first, partially compensates for spurious changes in amplifier output due to the first stage.

Voltage regulator tube V6 is a protective tube that fires only when either V2 or V3 fails. The loss of either V2 of V3 drops the current in resistor R6 until the potential of V6 reaches its firing point. Tube V6 will then raise the current through R6 and thus increase the negative bias on the 715B tubes sufficiently to prevent the cable current from exceeding 300 milliamperes. The loss of any other tube in the amplifier circuit will automatically lower the cable current due to the inherent phasing of the amplifier circuit.

If the fuse ahead of the voltage stabilizer should blow, and thus remove all controlling bias on the series 715B tubes, Figure 2, the screen grid potential of the 715B tubes is also removed and the cable current is reduced to a minimum. In this event, the second or parallel regulating bay will furnish current to the cable.

Should a short circuit occur in the submarine cable, the 715B tubes would instantly absorb the change in load and hold the cable current to its regulated value, thus preventing injury to the repeaters still connected to the power end of the cable. If the cable were suddenly parted, the high voltage developed at the power supply would cause an immediate turndown of the power.

Amplifier tubes V1 and V2 are the same types as used in the submarine cable repeaters. They were selected for this circuit because of their reliability, as they are expected to have a minimum life of twenty years. In Figure 4 one can observe the relative size and construction of the tube; it comes provided with pigtail leads so that it may be wired permanently in place, thus eliminating a socket and its hazards of loose or poor connections. The tube is mounted on special details that contain rubber cushions to reduce mechanical stresses and microphonics.

THE AUTHOR: George W. Meszaros started his Bell System career in the Systems Drafting Department directly after his graduation from high school in 1926. In 1939, just prior to his receiving his B. E.E. degree from the College of the City of New York, evening division, he joined the trial installation group. Here he helped in the engineering and installation of the first radio telephone system for emergency vehicles for Long Lines. Shortly thereafter, he worked in the current development group analyzing special problems in connection with Western Electric carrier telephone installations. In 1941 he transferred to the toll equipment group, and later that year to the power development group. For the past ten years he has specialized on electronic controlled power equipment; he is currently designing power circuits for a number of military projects.

Diplex Radio Telegraph for Caribbean Area

The first diplex radio telegraph circuit in the Caribbean area was inaugurated on February 1 between the United States and Nassau, capital of the Bahamas, by the Tropical Radio Telegraph Company and the Telecommunications Administration of the Bahamas.

The diplex operation of two parallel circuits, radiotelegraphic in each direction and using one frequency in each direction, is between Tropical's station at Fort Lauderdale and the Bahamas Administration's station at Nassau. Volume of traffic between Nassau and the United States has increased more and more each year as Nassau has become one of the outstanding tourists' resorts of the Western Hemisphere.

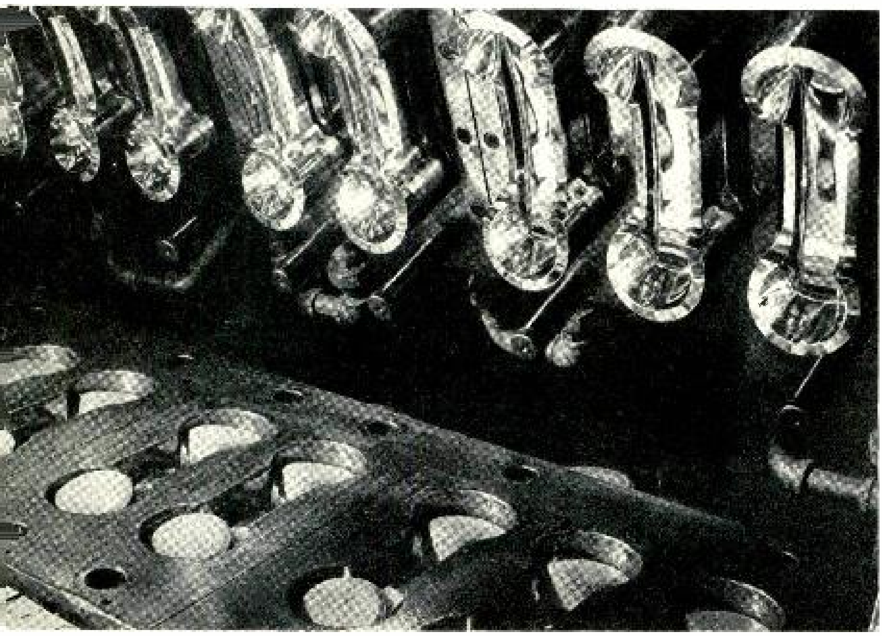
This diplex system was invented by Bell Laboratories engineers prior to World War II, and further developed in cooperation with Teletype Corporation engineers during World War II for use, particularly, on radio telegraph circuits so as to provide two instead of one communication channel on each circuit. This is done by providing a two-channel time division on the sending distributor, so arranging the distributor segments that the signals from two different transmitters alternate. At the receiving end, standard start-stop teletypewriters are used, with the selector of the first channel receiver adjusted to pick up the leading set of signals and that of the second channel receiver to pick up the second channel signal.

Golden Anniversary Meeting of the Electrochemical Society

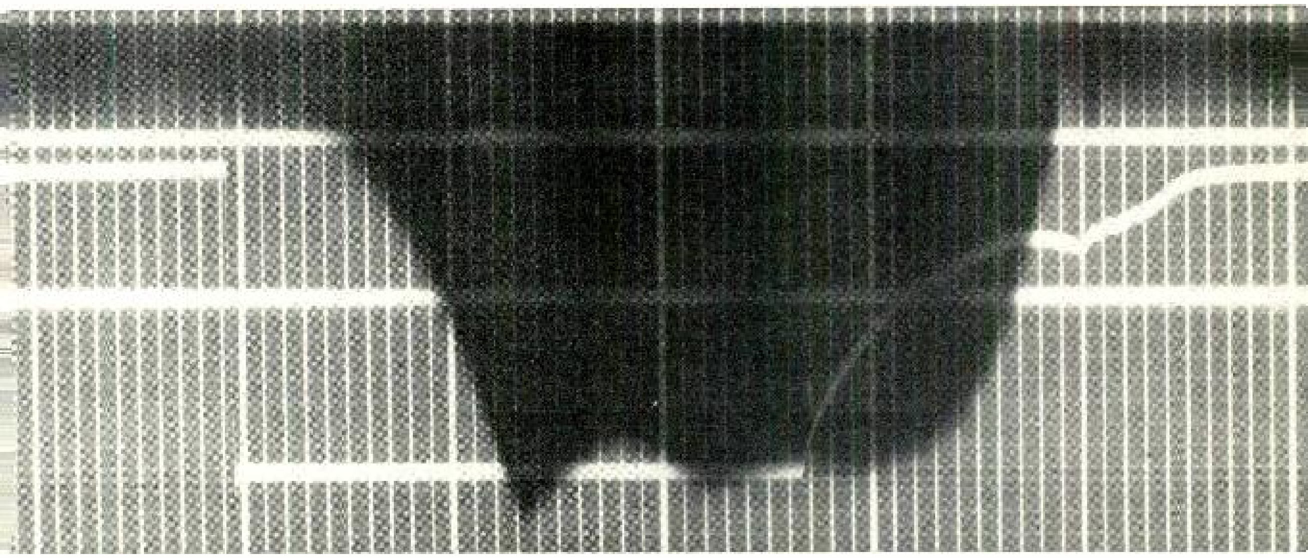
The Electrochemical Society, founded April 3, 1902, in Philadelphia, will return to that city for its Golden Anniversary meeting from May 4 to 8. The Laboratories will be represented by R. M. Burns at the ceremonies honoring the ten living charter members. Mr. Burns has held the offices of president, treasurer, and secretary of the society and is now chairman of the Editorial Staff of the Journal of the Society.

Several members of the Laboratories have been active in the society. K. G. Compton has headed the New York Section and was general chairman for the New York meeting in 1948. U. B. Thomas is News Editor of the Journal and Secretary-Treasurer of the Battery Division. H. E. Haring served on the Board of Managers.

Included in the program at the Philadelphia meeting are more than a hundred technical papers.



In Western Electric's new Indianapolis plant where the 500 type combined set is being made, eight handle dies are mounted in a massive molding press capable of exerting a pressure of 350 tons. The phenolic molding material is preformed electronically into a cake resembling a hockey puck, and two of these are inserted in each cavity just prior to closing the dies.



An improved shadowgraph

P. HUSTA
Switching Systems Development

Analyzing the dynamic characteristics of high-speed switching apparatus is greatly facilitated by the use of the rapid record oscillograph*. This device can be made to record motion of a moving part by equipping the oscillograph with a simple optical projection system commonly called a shadowgraph, that projects a shadow of the moving part on the sensitive surface of the moving photographic paper. At the same time, the galvanometer strings and time lines of the oscillograph are used in the normal manner for time reference and to record electrical characteristics, associated with the moving part, either superimposed on, or displaced above or below the string traces. Figure 1 illustrates the method of obtaining shadowgraph views of relay springs in vibration.

When the apparatus under study is too large to mount directly on the oscillograph, the alignment procedure becomes particularly involved if the single objective lens is employed. To bring the shadow of the moving part into sharp focus, and to provide the desired deflection of the moving shadow on the photographic paper, involve positioning the oscillograph, focusing the lens, and positioning of the subject. Then too, small deflections of the subject require relatively large magnifications, while moderate deflections require only small magnification to produce the shadow movement of the desired size.

A method of projecting the image of a subject onto the photographic paper, using a single projection lens, that has been used in the Laboratories for many years, is shown in Figure 2. The purpose of the dove prism is to enable the operator to rotate the shadow deflection so that, regardless of whether the subject deflection is in a horizontal or perpendicular plane, the image deflection will always be in the horizontal plane. The magnitude of the shadow motion, or magnification, is a function of the focal length of the projection lens, the distance from subject to lens, and distance from the lens

*Record, *September,* 1937, *page* 26.

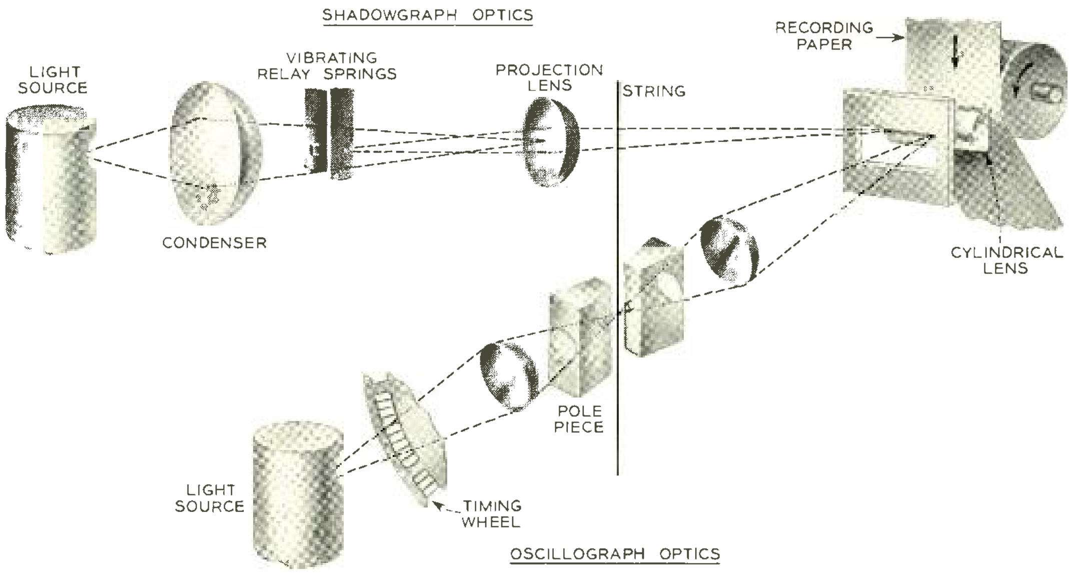


Fig. 1—Shadow-oscillograms are made by condensing light from a brilliant source onto the moving parts being studied and projecting the image on the photographic recording paper.

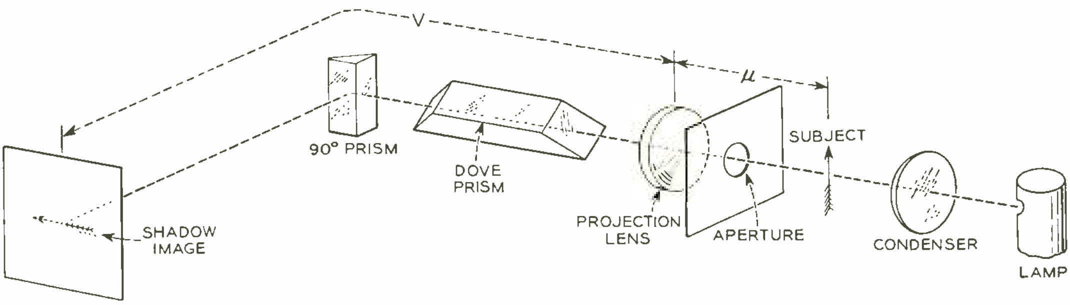


Fig. 2—The shadow of the subject under study is projected onto the recording paper in the oscillograph through a single objective lens, a dove prism to rotate the image, and a 90° prism for locating the image on the recording paper.

to the image on the photographic paper. From the relations* between these distances, it can be seen that, to cover the wide range of deflections and necessary magnifications encountered in the study of various types of apparatus, a number of lenses of different focal length are required to obtain the desired magnification with a minimum amount of positioning of the subject, image and lens. An example of this is given in Figure 3, where the curves show the subject to image distance that takes place with changes in desired image magnification, using a single lens.

By using a two-lens projection system, as shown in Figure 4, it is possible to produce an equivalent focal length for the lens system that can be varied to suit the deflection requirements, merely by adjusting the posi-

* If f = focal length of the lens, m = magnification, v = lens to image distance, u = lens to subject distance, h = subject deflection, and h′ = shadow deflection, then

$$m = \frac{h'}{h} = \frac{v}{u} = \frac{v-f}{f} = \frac{f}{u-f}$$

$$v = mu = (m+1)f$$

$$u = \frac{v}{m} = (\frac{1}{m} + 1)f$$

or subject to image distance

$$u + v = \frac{(m+1)^2}{m} \cdot f$$

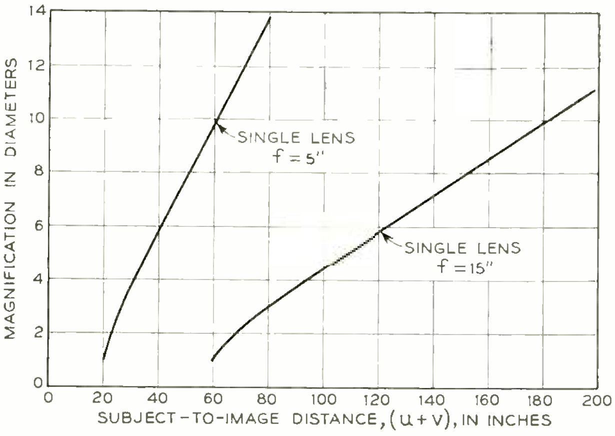


Fig. 3—Relation of subject to image distance, to change in magnification.

tion of the two lenses along the optical axis. This system employs a positive achromatic lens in combination with a plano-concave lens*, and is similar in operating principle to the "Zoom" type lens used on television cameras for rapidly changing from long distance to close-up views, or vice versa. The required magnification is obtained by sliding the lens carriages on the ways of an optical bench to the proper relative positions, where the carriages are then locked in place.

Large apparatus, in particular, can best be studied with the two-lens system. The apparatus may be mounted on a work bench adjacent to the oscillograph, or, with the element under study in its normal operating position and as it performs its function in combination with other parts of the machine, its shadow can be projected across to the oscillograph from the machine itself.

*Similar results could be obtained if both lenses were positive and of the proper focal length.

The flexibility of this combination makes it possible to maintain a constant subject to image distance over a wide range of magnifications. If

f_1 = focal length of one lens
f_2 = focal length of the other lens

Then the effective focal length of the combination of lenses becomes

$$f = \frac{f_1 f_2}{f_1 + f_2 - D}$$

where D is the distance between the two lenses*.

This flexibility is illustrated by the following example. With a pair of lenses having focal lengths of +7 inches and −8 inches, and the distance between the subject and image held constant at 85 inches, magnifications of from 3 to 15 diameters can be obtained merely by changing the separation of the lenses from 2.5 inches to 10.25 inches as they are moved to the proper relative positions on the optical bench.

As shown in Figure 5, the apparatus being analyzed, in this case, a perforator† for the automatic message accounting system, is mounted on a bench so that the vertical moving part under study is in the light beam of the lamp A. The light beam then passes through the convex lens B, into the tube C, which contains the plano-concave lens and the dove prism, used to rotate the

* "Mirrors, Prisms and Lenses," J. P. C. Southall, MacMillan, N. Y. 1933, page 367.

†RECORD, *November*, 1951, *page* 504.

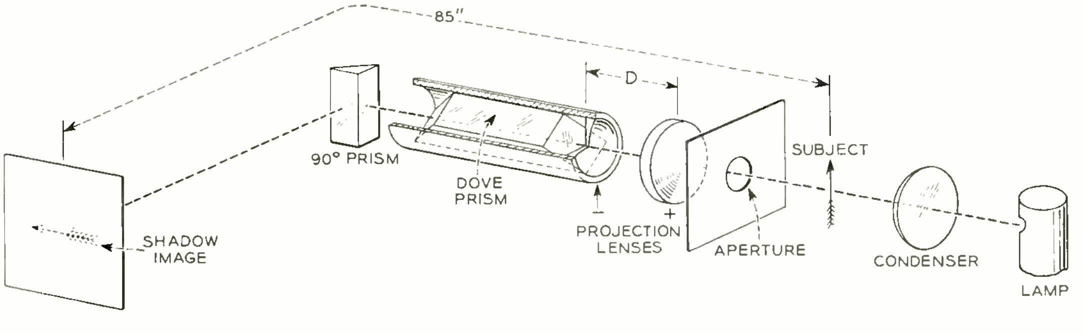


Fig. 4—Schematic of the two-lens objective system. The focal length of the system can be varied simply by adjusting the position of the two lenses along the optical axis.

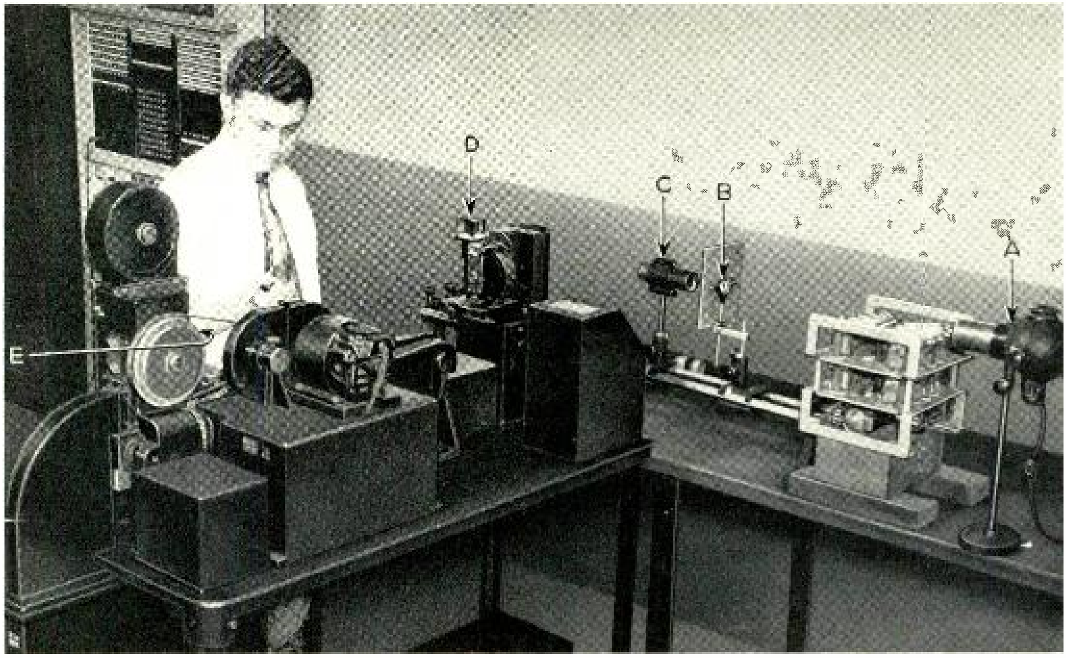


Fig. 5—E. M. Drobny operating the rapid record oscillograph equipped with a two-lens projection system for making shadowgrams.

projected image into the horizontal plane on the photographic paper. The projected light beam is then aligned with the aperture in front of the photographic paper by means of a 90-degree prism, D, mounted on the optical bench. The shadow image at the required magnification is then brought to a sharp focus, simply by sliding the two lens holders, shown at B and C, as required.

This method of studying the motion of elements of large switching apparatus has given excellent service in the Switching Systems Development laboratory for several years. The process is simple, flexible, and can be adapted to many types of apparatus regardless of size or direction of motion.

THE AUTHOR: P. HUSTA's career at the Laboratories began with piezoelectric crystal studies in 1918 after two years at C.C.N.Y. Shortly afterwards he enlisted in New York University's Student Army Training Corps, returning to the Laboratories in 1919 after World War I. While working on ac signaling problems in Switching Systems Development, he was in the first group to take and complete the Student Assistant's Training Course.

In 1928 he was placed in charge of a group for fundamental pulsing studies and laboratory tests of various types of switching circuits and apparatus. During World War II he supervised a group that developed the maintenance test sets for the M9 gun director and prepared the associated manuals. Following the war he was in charge of a group responsible for performance studies and systems evaluation of new apparatus including the trouble recorder, crossbar switches, AMA apparatus, and transistor applications to toll crossbar. Recently, he was transferred to Switching Apparatus Development where he is correlating the work of Switching Systems Development and Switching Apparatus Development, on matters involving requirements and performance evaluation of switching apparatus.

The AMA Assembler

GLEN G. DREW
Switching Systems Development

In central offices employing automatic message accounting, a recorder perforates a tape for all AMA calls handled by a group of 100 transmission circuits—trunks in the No. 5 crossbar, and district junctors in the No. 1 crossbar system. Such tapes are sent periodically to a common accounting center* so that bills may be prepared from the information perforated on them. The information pertaining to any one completed call is contained in three entries—a disconnect time entry, an answer time entry, and an initial entry. Typical initial and timing entries are shown in Figure 2. The entries for any one call are usually interspersed with similar entries of other calls and the first step in the accounting center is to bring the entries pertaining to each call together. This is done by the assembler, which consists of a reader, a relay circuit, and ten perforators, as shown in Figure 1. Only one of the ten perforators is used at a time, but the control circuit of the assembler, guided by information it reads on the input tape, can choose which perforator to use for recording each entry found on the input

* RECORD, *February*, 1952, *page* 70.

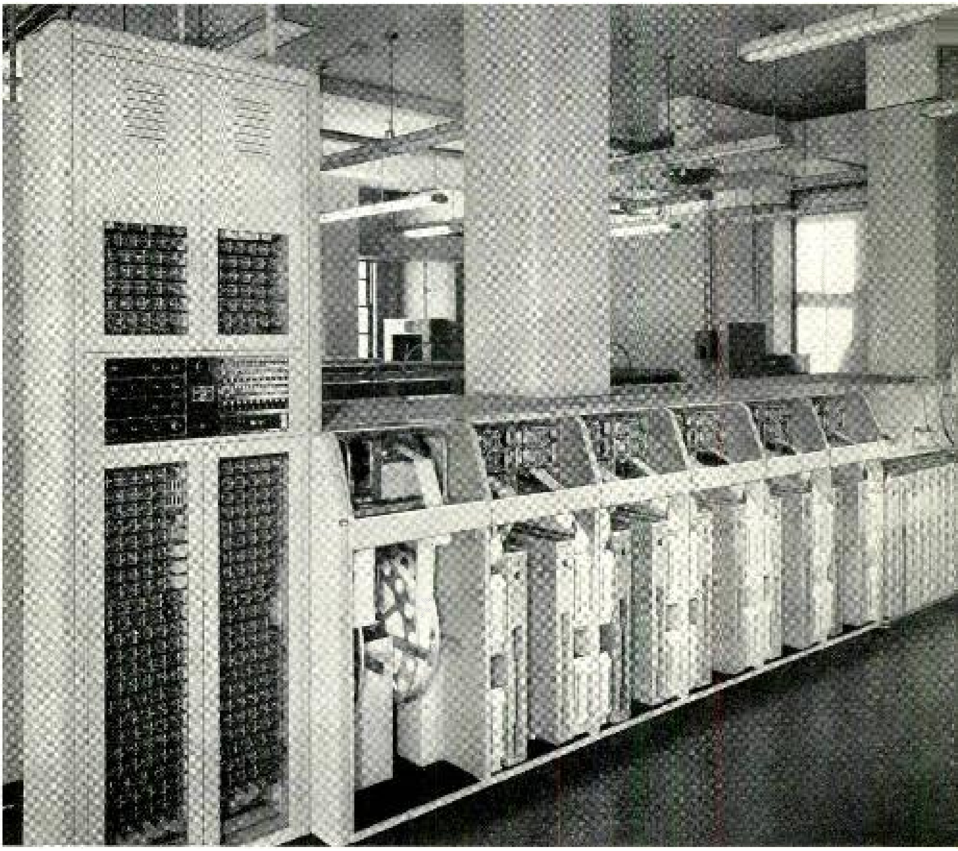


Fig. 1—An AMA assembler consists of a reader, a relay circuit and ten perforators.

tape. The result of this assembling process is an arrangement of call records and time indications that is the same as would result if a separate perforator had been provided at the central office for each transmission circuit and then the resulting tapes had been joined together in numerical order.

Each of the entries pertaining to a call on the central office tape carries a call identity index (CII), which is a two-digit number identifying the trunk or junctor that is being used for the call. Although each of these transmission circuits may be used for many different calls recorded on the same carrying the same CII, and since these entries are perforated in the same time sequence in which they appear on the central office tape, the entries for each call will always be grouped together. Such an assembling is brought about by a double sorting process, using first the units digit of the CII and then the tens digit. For the first stage sort, the units digit of the CII, which is the F digit on the tape, is used to select one of the ten perforators for recording the entry. The perforators are designated from 0 to 9, inclusive, and all entries with an F digit zero are recorded on the number zero

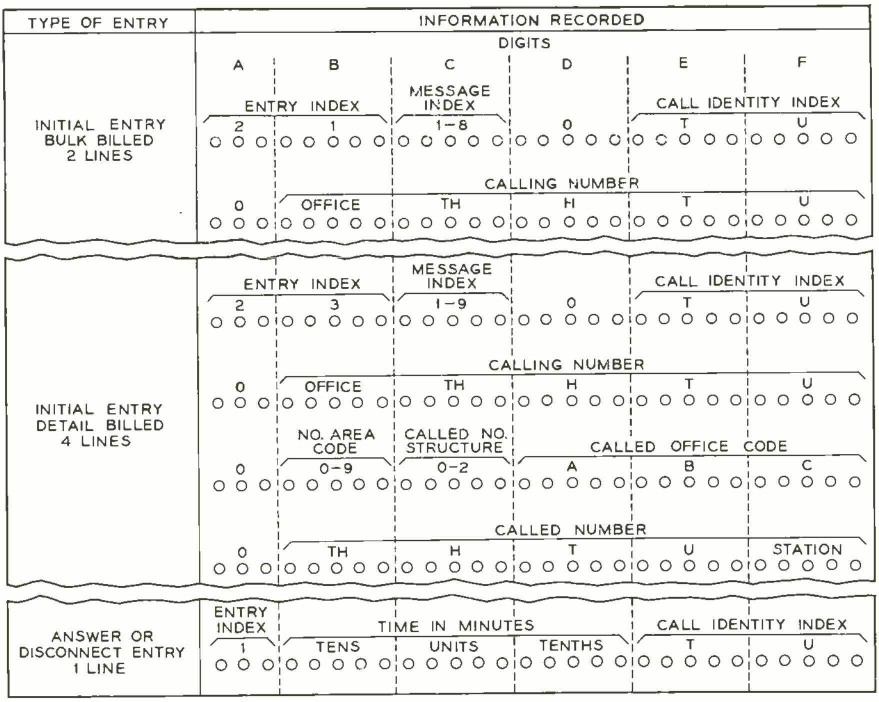


Fig. 2—Three entries are associated with each completed call: an original entry, an answer time entry, and a disconnect time entry. The answer and disconnect time entries are identical in type and differ only in the time recorded. Two types of initial entries are employed: one for bulk-billed calls and one for detailed billed calls.

tape, it will of course serve only one at a time. In an accounting center, the tapes are read in reverse time order, and thus if a call was completed, the first entry for it encountered by the reader will be the disconnect entry. The other two entries for this particular call would be the next two encountered that carry the same CII as the disconnect entry. It is this fact that the assembler takes advantage of to bring the entries for each call to adjacent positions on the output tape.

In general the process consists in bringing together on the output tapes all entries perforator, all with an F digit 1 on the number 1 perforator, and so on. After the proper perforator has been selected, the entry is recorded on it exactly as it appears on the central office tape.

After the input tape has been completely sorted in this manner, the ten new output tapes are spliced together in numerical order and then used as the input tape for the second stage sort. Exactly the same process is again carried out except at this time it is the tens digit of the CII, the E digit of the entry, that is used to select the perforator used for recording the entry. A chart indicating how the two stages of sorting distribute the entries is given in Figure 3 for a simplified section of a central office tape. It shows the information recorded on the central office tape and on the various output tapes of the assembler. The information is indicated by a letter to give the type of entry—I, initial; A, answer; and D, disconnect—followed by two digits representing the call identity index. At the left of the tape is an identifying number. On the input tape these run in sequence from 1 to 27, but they will be rearranged on the various output tapes. The ten output tapes from the second sorting stage are spliced together and serve as the input tape for the computer, which takes the next step in the accounting center procedure.

Besides the entries for each call, the input tape includes certain other entries to identify the particular group of calls it includes and to indicate the hour of the day. The perforators at the central office place a tape identification entry at each side of a splice, and these entries will thus appear at the beginning and end of each tape. In addition, at the beginning of each hour they perforate an hour entry on the tape. All of the information in the central office tape identification entry is not needed on the output tapes of the assembler, but certain additional information is needed. The assembler, using some of the data read on the central office tape identification entry and supplying the other information itself prepares a new tape identification entry of seven lines. These two tape identification entries and the hour entry are shown in Figure 4. The hour entry and the new tape identification entry must be perforated on all ten output tapes of the assembler. This process is called "spreading" the entry. When an entry to be spread is encountered, the advance of the reader is stopped, and a sequence circuit causes the entry to be perforated on one output tape after another until all have been perforated. The reader is then allowed to advance.

A block schematic for the assembler is given in Figure 5. Although assembling the entries for each call is its chief function, there are other operations that it must carry out to insure accuracy, which is essential throughout the accounting process. For this purpose the assembler is provided with circuits that check the accuracy of both the input and output of the machine. As indicated by the diagram, input checking features connect to the reading relays and parts of the control circuit, and check that the proper number of holes is detected in each line of the input tape, that the reader drum

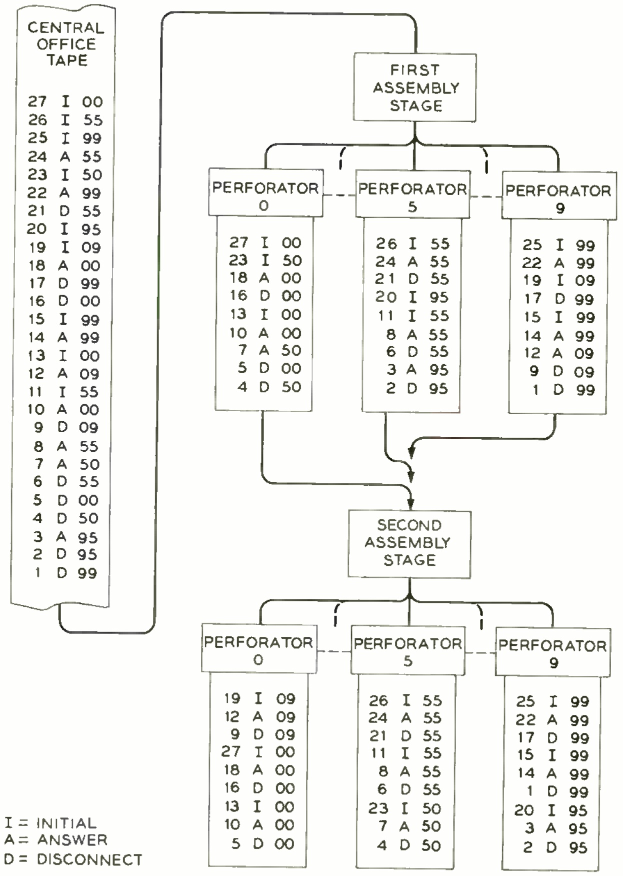


Fig. 3—Simplified chart indicating how the entries are distributed on the ten output tapes by the two sorting stages.

advances one line each time it is instructed to, that no line of an entry is either omitted or repeated, and that the proper tapes are fed into the assembler in the correct order. Output checking features insure that the proper number of holes is perforated in each line, that the perforation takes place on only one perforator at a time, and that the perforator tape advances after each

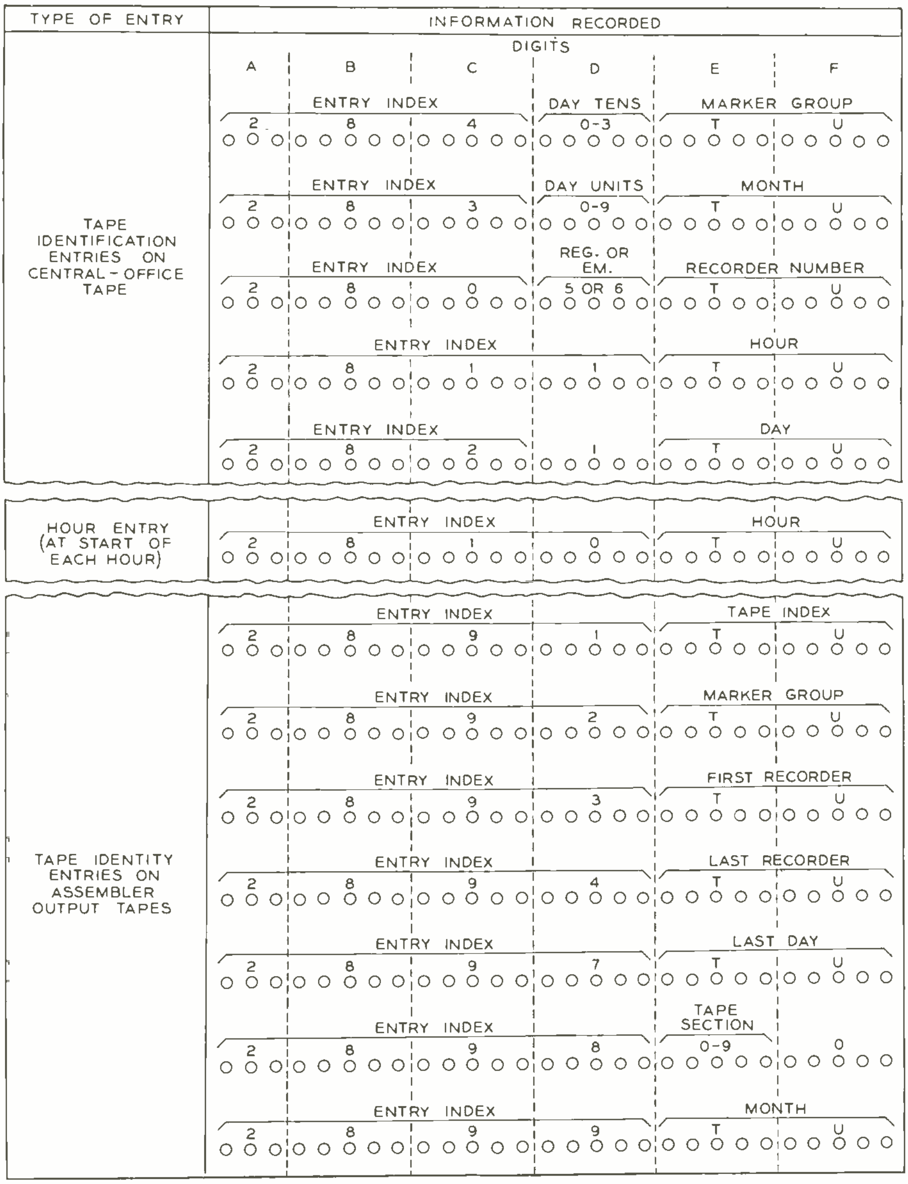


Fig. 4—A central-office tape identification entry, above; an hour entry, center; and below, the tape identification entry put on by the assembler.

perforation. Failure of any of the above checks will cause the operation of the machine to stop with an alarm lamp indicating the type of trouble.

These checks are provided for by wiring, through various relay contacts, circuits that will not be closed unless the proper conditions exist. Through the contacts of the reading relays for the various digits, for example, circuits are wired that are closed when two and only two of the reading relays for digits from B to F, inclusive, are operated. To make sure that only the proper tapes are being processed at any one time, somewhat similar circuits are wired through contacts of the reading relays and also through contacts of some of the dial switches on the control panel. On this control panel, there is one dial switch to indicate the assembly stage, either the first or the second, two to indicate the marker group in tens and units, a tens and units dial for both the first and last recorder of the group for which the tapes are being processed, a tens and units dial for the month, and a tens and units dial for the last day of the period for which the tapes are being processed. Before the assembler is started, these dial switches are all set in accordance with the particular tapes to be processed. If the assembler, in reading the tapes, finds that the various tape identification entries do not correspond with the settings of these switches, the reader stops and an alarm given.

To accomplish these tests, a group of series circuits are established through the contacts of the various reading relays and through the contacts of the various dial switches on the control panels in such a way that a closed circuit is established only when the information indicated by the operated reading relays corresponds to the information set on the dials. Figure 6 indicates the conditions for a closed circuit for one particular line of identification information. The A, B, and C digits of each such line indicate the type of information carried by the remaining digits of the line. If the A, B, and C digits are 284, for example, the D digit will carry the day tens digit, and the E and F digits will carry the marker group tens and units digits.

When the A, B, and C reading relays indicate 284, therefore, a path is established to the contacts of the D reading relays. There are five relays for each digit except A, and since the information is recorded in a "2 out of 5" code, two of the relays will be operated. Circuits through the contacts of the five relays of the D digit are used to translate from "2 out of 5" to decimal code in such a way that ground on the single input lead will be extended to one of four output leads depending on the digit indicated. These four output leads run to the last-day tens dial switch on the control panel, and the ground on one of the leads will pass through the switch only if the dial is set to that particular digit. From this switch, a lead runs to the contacts of the E reading relays. Here again the circuit translates from "2 out of 5" to decimal code, and the ten output leads run to the tens dial switch for the marker group. The single lead from the arm of the marker group tens dial switch runs to the contacts of the F reading relays. These similarly translate the "2 out of 5" code on the F relays to decimal code, and the 10 decimal leads leaving the F relays run to the ten points on the marker-group units dial switch. From the arm of this switch, the lead runs to the reader step control relay, which will operate and allow the reader to advance only if a closed circuit has been established through the entire chain. For other codes conveyed by the A, B, and C digits, similar circuits are established through the D, E, and F reading relays and other dial switches on the control panels.

In addition to these various checking features, it is necessary also to dispose of certain erroneous or mutilated entries on the input tape. Recorder circuits in the central office have checking features that enable them to detect irregularities in the perforation on any line of the tape, and to detect other conditions that would cause false charging. When any such condition is found, an entry is perforated by the central office recorder to indicate that an irregularity has occurred, and as far as possible to give the nature of the trouble. If it has been determined that more or less than two holes had been perforated for

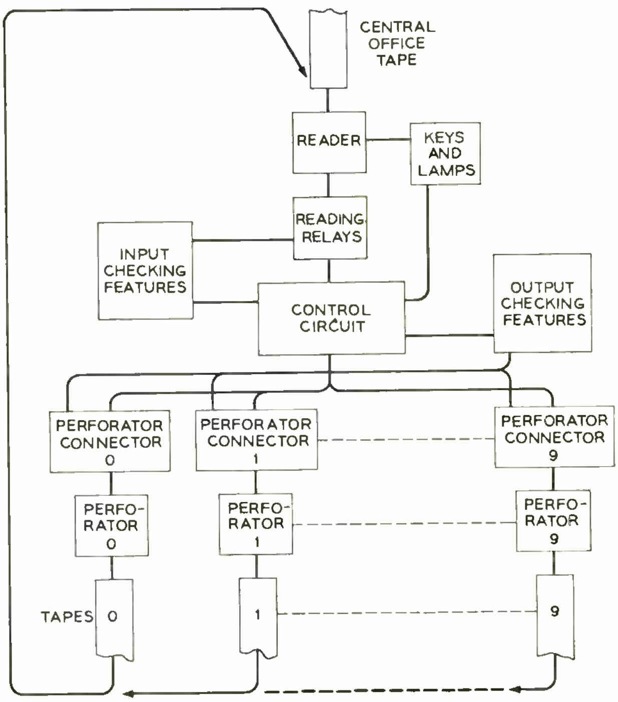


Fig. 5—Block schematic of the assembler.

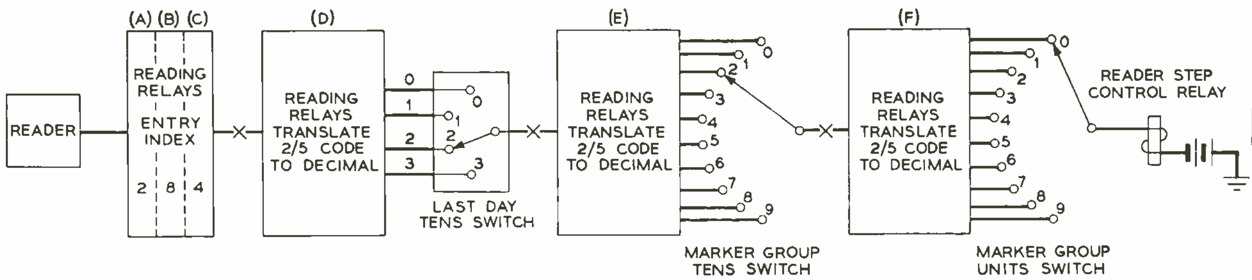


Fig. 6—Block diagram of part of the circuit used in checking the input tapes against information set on the control dials.

any digit on any line of an initial entry, a cancel entry is perforated as the next line. The assembler upon reading the cancel entry (reading the central office tape backward) will skip over the line which was found in difficulty, and any other lines of the initial entry already perforated. The faulty entry is thus thrown out at the first assembly stage.

Provision is also made in the assembler to care for mutilated entries for which no cancel entries have been perforated at the central office. Such mutilations may occur due to weak spots in the tape through which the reading pins project. The circuit is arranged to stop with an alarm at these conditions, and the machine will not start until the attendant takes appropriate action.

At sixteen lines per second about one-half mile of central office tape can be processed through the first assembly stage in an eight-hour day. This represents from 50,000 to 90,000 calls, depending on the type of traffic in the office.

THE AUTHOR: GLEN G. DREW graduated from Rutgers University in 1936 with a B.S. degree in electrical engineering. He worked for Westinghouse and the Naval Ordnance Laboratory before coming to the Laboratories in 1946. After attending the Laboratories' switching school he was assigned to the group developing AMA accounting center circuits. He has been continuously engaged in this activity except for a period of one year during which he worked on crossbar tandem circuits.

50th Anniversary A.S.T.M. Meeting

The American Society for Testing Materials celebrates its half-century of existence during the week of June 23 at the Hotels Statler and New Yorker in New York City. J. R. Townsend is Chairman of the General Arrangements Committee, and the Technical Program Committee is directed by G. R. Gohn. Some eighteen symposia and technical sessions are scheduled on a variety of subjects including *Light Microscopy, The Electron Microscope, Fatigue, Properties of Metals at Elevated Temperatures,* and many others. The entire program will be directed toward the part the Society has played in the fields of testing and development of acceptable industry-wide standards on materials and test methods. Emphasis will be on the forward-looking activities of the Society. Also participating in the program will be Foreign and American Engineering Societies.

Symposium On Progress In Quality Electronic Components

A symposium on Progress in Quality Electronic Components will be held in Washington from May 5 to 7. This conference, sponsored by the A.I.E.E., I.R.E., and R.T.M.A., is a sequel to the 1950 symposium on Improved Quality Electronic Components, which was held in Washington. In addition to the sponsoring societies, there will be active participation by several agencies of the United States Department of Defense and National Bureau of Standards.

Laboratories engineers will present several papers during this symposium. P. S. Darnell will speak on *Miniaturized Components for Transistor Application* at a session on Advances in Miniaturization. On May 6 at a session on Miscellaneous Components, J. R. Fry will give a paper, *Design Factors Influencing the Reliability of Relays.* At a session on Design and Production Methods, a paper, *Packaging Principles Employing Plastics and Printed Wiring to Improve Reliability,* will be given by W. J. Clarke and N. J. Eich. At an afternoon session the same day, on Transistors, W. R. Sittner will describe *The Transistor Development Status at Bell Telephone Laboratories,* including a demonstration.

American Society for Quality Control Holds Meeting

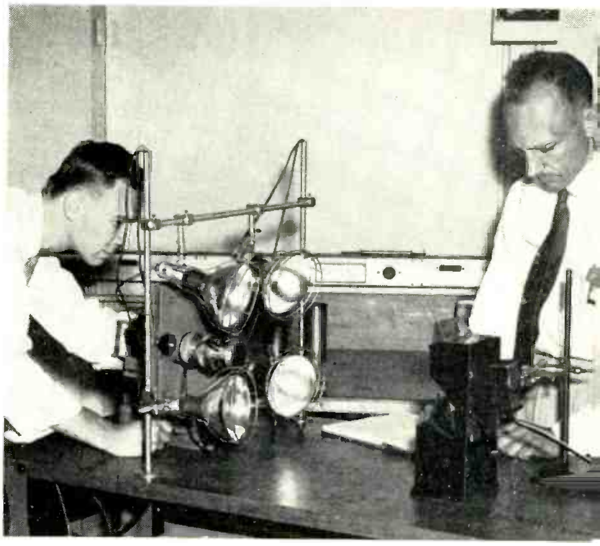
The American Society for Quality Control held a Middle Atlantic Regional Conference on quality control at the Hotel Statler, New York City, March 28-29, sponsored by several sections of the society, including the Metropolitan (New York) Section. Several Laboratories engineers took part in the conference. W. A. Shewhart presided at the Friday afternoon session, Panel F: Statistical Techniques in Research and Development. On Saturday morning, H. F. Dodge presided at Panel H: Quality Control in the Electronics Industry, and P. S. Olmstead at Panel I: New and Useful Techniques. At the latter session, E. B. Ferrell spoke on the subject, *Control Charts Using Mid-ranges and Medians.*

Mary Torrey was Conference Committee Chairman in charge of the women's program. On her committee were Alice Loe, who had charge of the luncheon, and Margaret Packer, who was hostess at the lounge. In addition to these activities, Miriam Harold was in charge of a book display.

Deal-Holmdel Colloquium

W. H. Doherty addressed the March 14 meeting held at Holmdel. His talk was on *Topics in Television Research.* Among the recent contributions to the television art by the Television Research Department is a new film scanner which automatically compensates for the difference in frame rates between standard motion picture film and the television scanning rate. The result is a high quality video signal which heretofore has not been obtained from film. Another topic was the problem of removing redundancy in television signals. Mr. Doherty concluded his talk with a discussion of the laminated cables proposed by A. M. Clogston for low loss wide band transmission.

A Multiple Exposure Camera



How coins behave in the chutes of coin collectors is a perennial subject of study, since each change in material or in the method of operation may modify the action of the coin or affect the path it follows. In connection with some recent changes in chute design, a multiple exposure camera was developed by A. P. Boysen and W. D. Goodale, Jr., to record the track of the coin in its passage through the chute. The camera records, on a single frame of 35-mm film, the successive positions of the coin at intervals as short as 1.6 milliseconds. Enlarged prints of such a frame showing the travel of a coin in two types of chutes are shown on page 235. The chute, left, had a V shaped bottom, and the coin dropped on it and rolled down without bouncing. That at the right, on the other hand, had a flat bottom, and the coin bounced considerably after striking it. For such studies, a multiple exposure camera has the advantage

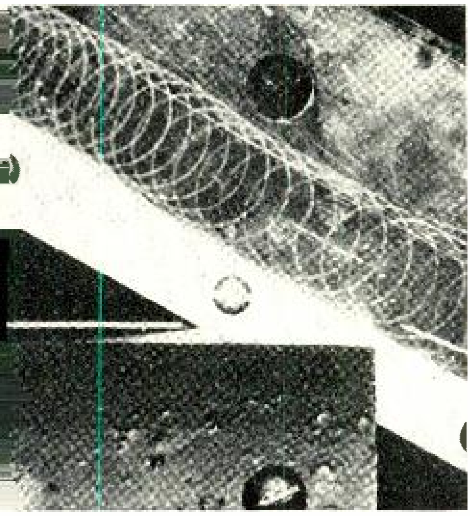
Above, the multiple exposure camera set up for coin box studies: A. P. Boysen at left; W. D. Goodale, Jr. at right. Two RFL2A photoflood lamps and two RSP2A photo spots are normally used, and a three-position control switch permits two lamps to be connected in series for focusing, and all four in parallel for the exposure period.

Left, two views of the partially disassembled camera.

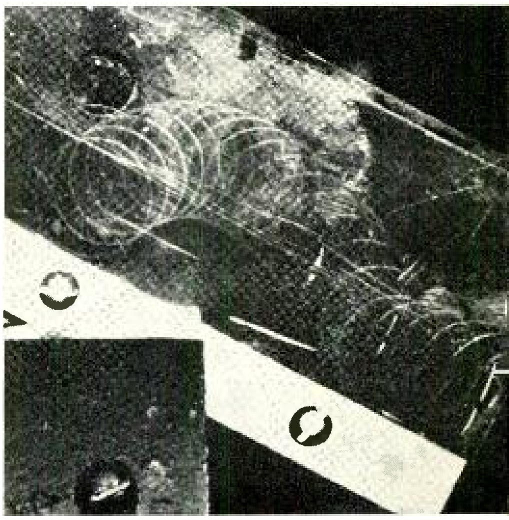
over a high-speed motion-picture camera, not only in being simpler and more economical to operate, but in recording the results on a single frame from which an enlarged print allows the behavior of the coin to be carefully studied and accurately measured.

Two views of the partially disassembled camera are shown on page 234. An opaque metal disc with 1, 2 or 4 radial slots is mounted so that it may be motor driven in a light tight enclosure between two metal plates. The film holding portion of a Kodak 35 camera is mounted on one plate and a lens system on the other such that an exposure is made each time a slit passes between them. The lens is a 127 millimeter, f 4.7 Kodak Ektar with a Supermatic shutter. Several interchangeable sliding tubes are available to give a range of focus from seven inches to 350 feet. The entire structure is mounted on gimbals on a supporting rod which permit the height and direction of the camera to be adjusted over a wide range. The complete apparatus is shown as set up for test. Besides the camera, there is a bank of lamps and a control circuit. The latter is used chiefly to permit the coin to control the shutter, and is arranged on a panel beneath the top of the table.

Although designed primarily for coin collector studies, the camera has many other applications. It is an effective tool for recording displacement data from which velocity and acceleration can be determined.



Two sets of exposures reveal the track of a coin: a V bottom chute at the left and a flat bottom chute at the right. To avoid overexposure of unessential elements, the background and the face of the coin are blackened. The rim of the coin is polished, and thus only circles appear in the photograph.



Out-Of-Hour Lecture On Radar Bombing

The sixth in the series of informative lectures was given at West Street March 17, Whippany March 18, and at Murray Hill March 20, by E. H. Sharkey. His subject was *How Radar Bombing is Done.* Mr. Sharkey described the basic considerations and requirements for target bombing, first for optical systems, and then for radar systems. The two major problems of bombing are (1) the computation required to hit a chosen aim point, and (2) determining that the chosen aim point is the one desired. In his lecture, Mr. Sharkey discussed the advantages and disadvantages of radar and optical sighting methods.

Technical Papers in May B.S.T.J.

The May issue of *The Bell System Technical Journal* will contain the following papers:

Present Status of Transistor Development, J. A. Morton.

An Experimental Electronically Controlled Automatic Switching System, W. A. Malthaner and H. Earle Vaughan.

New Techniques for Measuring Forces and Wear in Telephone Switching Apparatus, Warren P. Mason and Samuel D. White.

A Comparison of Signaling Alphabets, E. N. Gilbert.

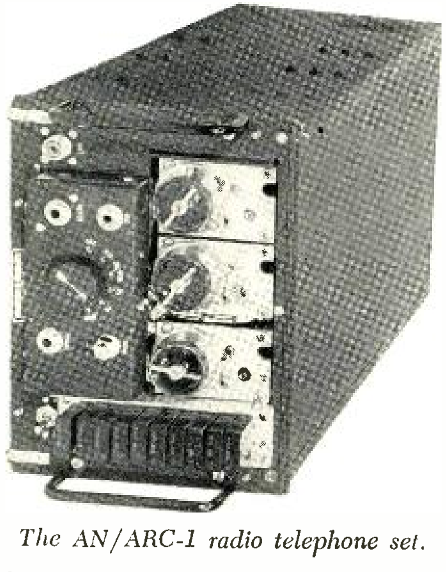
Principal Strains in Cable Sheaths and Other Buckled Surfaces, I. L. Hopkins.

A New Recording Medium for Transcribed Message Services, James Z. Menard.

Introduction to Formal Realizability Theory—Part II, Brockway McMillan.

Navy Praises Labs Radio Set

In a recent issue of the naval aviation electronics magazine, *Naval Electronics Digest,* recognition is given to the Laboratories' developed radio set AN/ARC-1. Discussing the development of a typical airborne electronic equipment, the magazine includes the statement "on the record of its performance, the AN/ARC-1 was judged to be the best all-around airborne equipment for VHF voice communication designed during the war. Its production was maintained at top speed to V-J day."



The AN/ARC-1 radio telephone set.

The Laboratories group which developed the AN/ARC-1 was headed by H. B. Fischer, with the receiver team headed by W. F. Reichle and R. F. Lane. The mechanical design was under R. H. Ricker.

K. K. DARROW delivered the fifth lecture in the Phi Beta Kappa Series at Allegheny College March 26. The subject of his lecture was *The Atom From Lucretius to the Present.* Dr. Darrow's talk is one of six lectures sponsored by Phi Beta Kappa and Allegheny College in commemoration of the half-century 1900-1950. The series was inaugurated on the theme of developments in the major fields of learning during the first fifty years of this century, and was begun in the fall of 1950 with a lecture on world literature by the late Philo M. Buck, professor of comparative literature at the University of Wisconsin.

J. R. TOWNSEND was Chairman of the March 13 meeting of the Technical Societies Council of New York. In this capacity, he introduced Dr. William Yanell Elliott who spoke on *Domestic and World-Wide Materials Outlook for Defense Mobilization and Civilian Economy.* The Technical Societies Council is an organization composed of representatives of a number of technical and scientific groups in the Metropolitan area. The Council was established for cooperation between the societies so that they may consider and act jointly on matters of common interest to the engineering and allied technical and scientific professions.

H. W. EVANS spoke on the transcontinental radio-relay system March 12 in the Mellon Institute Auditorium at Pittsburgh, before a joint meeting of the Pittsburgh Section A.I.E.E., Communications Division, and the local I.R.E. Section. In his talk, illustrated by slides, Mr. Evans described the problems of building the system. Six broadband channels in each direction can be provided in the 4000 mc. range. Since as many as 120 repeater stations may operate in tandem, stringent transmission requirements were imposed.