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Performance Studies of AMA Readers and Perforators

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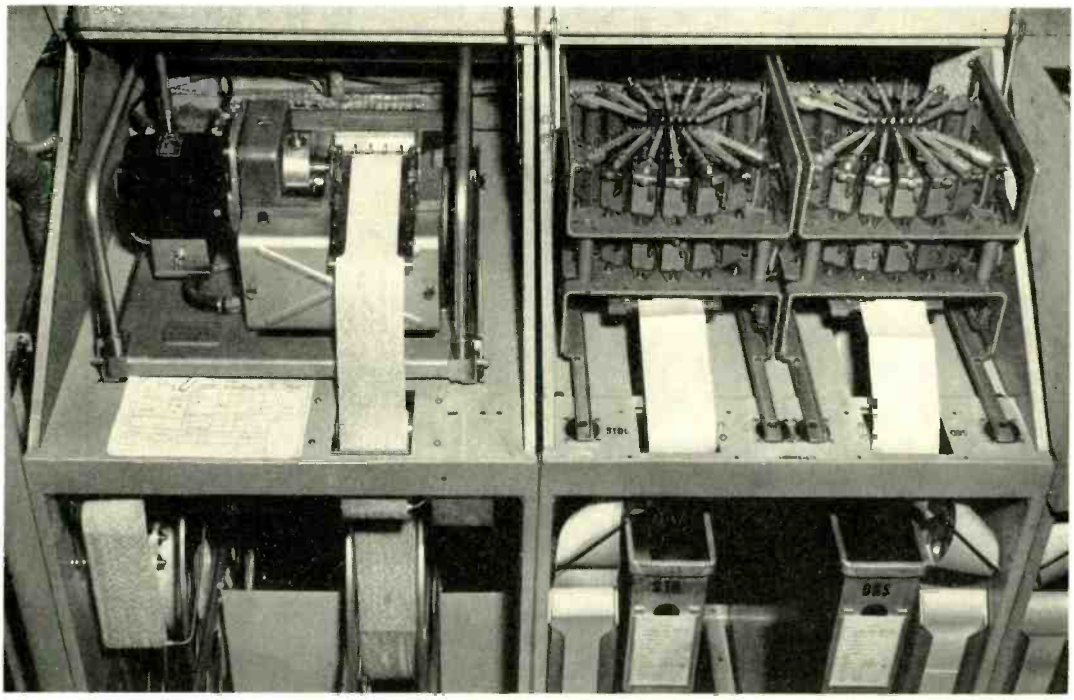
Perforators and readers, used in the accounting center of the AMA system, may be subjected to 25,000,000 and 250,000,000 operations per year, respectively, and in spite of their heavy operating schedules, they must perform reliably and require a minimum time-out-of-service for maintenance purposes. This goal has been achieved not only by rugged design of the machines but also by obtaining a thorough knowledge of the operating capabilities of the apparatus through intensive laboratory studies, thereby permitting the machines to be used at their optimum capability in the various circuit applications. These studies of readers and perforators were undertaken for three general purposes; first, to determine the operating characteristics of the reader or perforator as manufactured; second, to recommend changes in design to improve speed, assure reliability, lengthen maintenance-free service periods, and to increase circuit operating margins; and third, to establish working limits and field test requirements for the final product to insure the maximum service interval before readjustment is necessary.

The physical characteristics of the paper tape used for recording call data have considerable influence on the reliable operation of readers and perforators. The texture of the tape must be such as to permit it to be readily punched by the perforator, yet strong enough to resist penetration by repeated impact of the reading pins when the tape is stationary in the reader. Oiled perforator tape paper four thousandths of an inch thick was selected as providing the best over-all performance. This is a No. 1 grade (best quality) sulphite bond paper made without the clay loading usually used in sulphite papers to render them more opaque and to make the surface more satisfactory for writing or typing. Clay loading is considered objectionable in AMA tapes because it increases abrasiveness of the paper.

The tape, three inches wide, is supplied in approximately three-thousand foot lengths, which are fan-folded into a nineteen-inch package approximately eleven inches high. Folding in this manner permits the tape to be withdrawn from the container without excessive drag, and makes a continuous supply of tape available for the perforator, since the trailing end of one package can be readily spliced to the leading end of the next package.

The early experimental models of readers and perforators were designed and constructed under the direction of W. W. Carpenter. To establish the range of operating capabilities, the models were tested under limiting conditions, simulating extremes of actual operating conditions. To do this a special laboratory test frame was constructed which provides facilities for repetitive or start-stop operation of a group of perforator magnets at various speeds and circuit closure intervals. The circuit, shown in Fig. 1, is arranged so that pulse-machine closures operate a group of fifteen mercury-contact relays each of which, in turn, when operated, closes a ground to operate one of the perforating magnets. Jacks and keys provide facilities for operating the perforator magnets in any desired combination, as well as the paper advance magnet. The mercury contact relays provide chatter-free impulses, and adjustment of the timing potentiometer permits the operate and release times of the relays to be made equal so that no distortion of the impulses is indicated when the pulse trace is observed on an oscilloscope. The impulse which controls the paper advance mechanism may be delayed in continuously variable amounts up to nine milliseconds by the condenser-timed delay relay. Controlled variations in the speed and the ratio of make-to-break intervals of the pulse machine provide means for establishing the limiting conditions under which satisfactory operation of the perforators may be obtained.



A reader at the left and two perforators at the right as used in an AMA accounting center.

For satisfactory perforator operation, all magnets, when operated in groups of fourteen, must produce well centered, fully embossed, uniform perforations, and the advance of the tape through the perforator must be accomplished without observable irregularity. The over-all operating capability of the perforator is thus limited either by the perforating magnet having the poorest capability or by the paper advance mag-

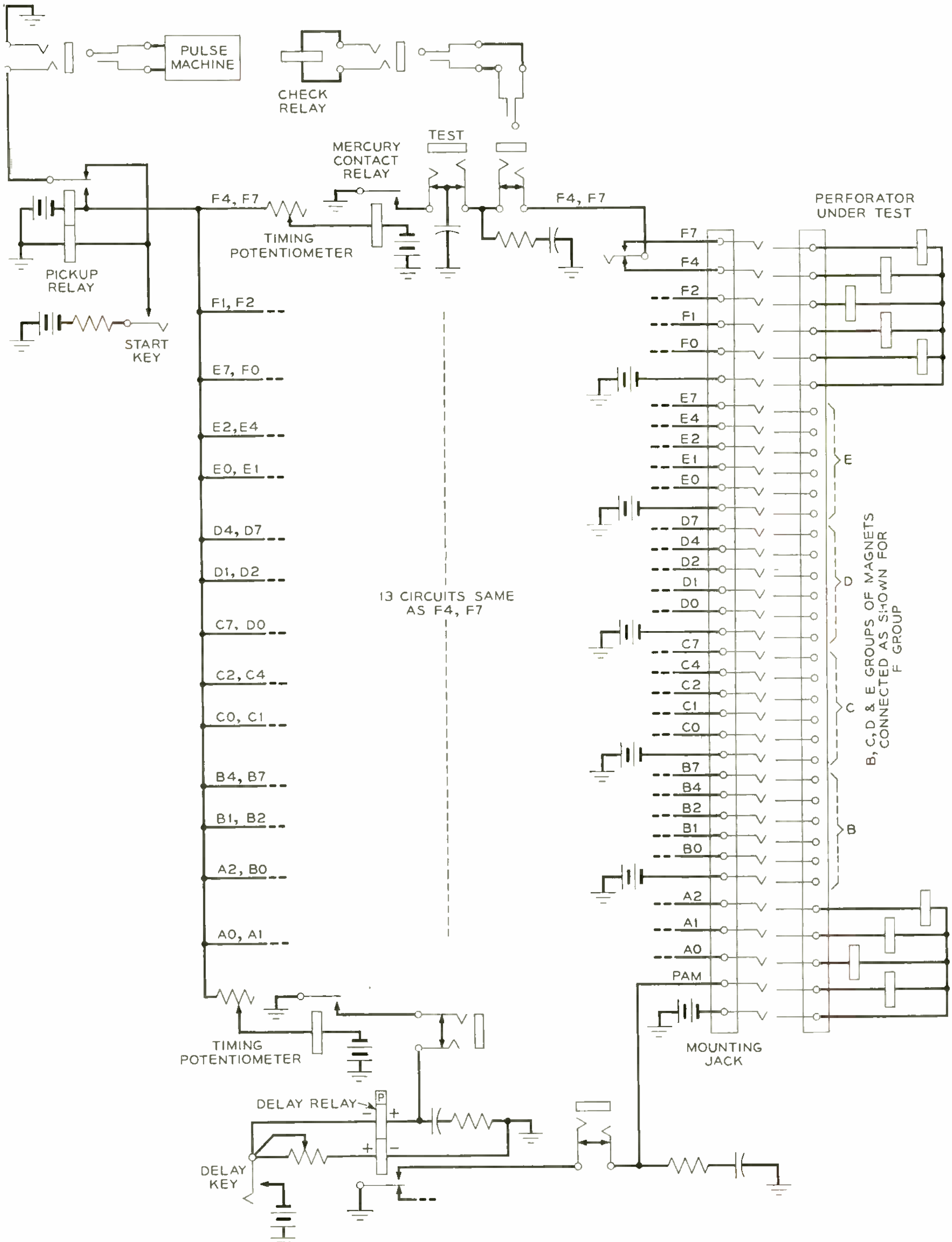


Fig. 1—Perforator testing circuit.

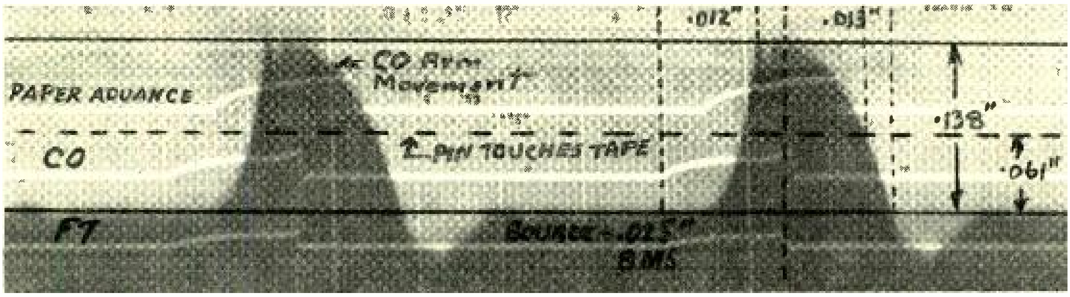


Fig. 2—Shadowgram showing movement of the CO perforating arm.

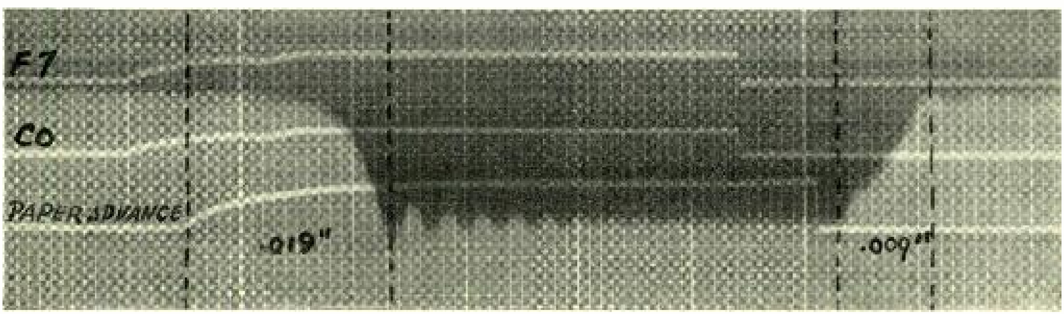
net. In making these tests, the effects on over-all capability of series check relays, of variations in mechanical adjustments of the individual perforating magnets, and of variations in lead resistance and voltage are also determined. The variations investigated include adjustments of armature travel, distance of perforating pins from tape, armature restoring spring tension, and similar factors. Proper consideration is also given to the effects of magnetic interaction and the vibration of the parts under repetitive operation at various speeds.

To determine the capability range, impulses of a selected speed were applied to the groups of perforating magnets, and the ratio of the open and closed periods of the impulses was varied in small steps until the perforator either failed to advance the tape properly or until inspection of the perforated tape disclosed light, missing, or off-center perforations. When this point had been determined, the make-break ratio of the operating impulses was adjusted until satisfactory perforations and advance of the tape were obtained and the maximum and minimum settings were recorded as the limiting capability at the selected speed. Similar data were obtained at speeds ranging between five and twenty-five impulses per second. To estimate the anticipated life of the perforators, the models were operated continuously with frequent inspections to determine the wear and adjustment changes.

The results of the tests outlined above indicated that the design was functionally satisfactory. The need for modifications of the original design to reduce wear, increase reliability of operation, and facilitate manufacture and field maintenance, however, was also indicated. Some very effective tools for determining and recording the various motions are the stroboscope, the shadowgraph, and the high-speed motion picture. A preliminary analysis of the motions of the various parts was obtained by operating the perforators at various speeds and circuit-closure times from an interrupter, and observing the motion of the parts using a stroboscope. In this manner critical motions were located and selected for more detailed study and analysis. By means of the stroboscope, the apparent motion of the various parts may be slowed or stopped and the action of the parts under operating conditions observed visually.

For more detailed study of the motion of individual parts and the relation of this

Fig. 3—Shadowgram showing motion of the armature of the paper advance magnet.



motion to the current flow through the magnets, the rapid record oscillograph equipped with a shadowgraph attachment was used for obtaining a photographic record of the time relation of the events involved. Figure 2 shows a typical shadowgram illustrating the movement of the perforating magnet arm, and Figure 3 is a similar illustration the operated position. The trace of the current operating the perforating magnet is marked CO on both oscillograms, while that for the current to the paper advance magnet is marked PAPER ADVANCE. Trace F7, which is in synchronism with CO, may be neglected. The fine vertical lines of the figures are spaced one millisecond apart, thus provid-

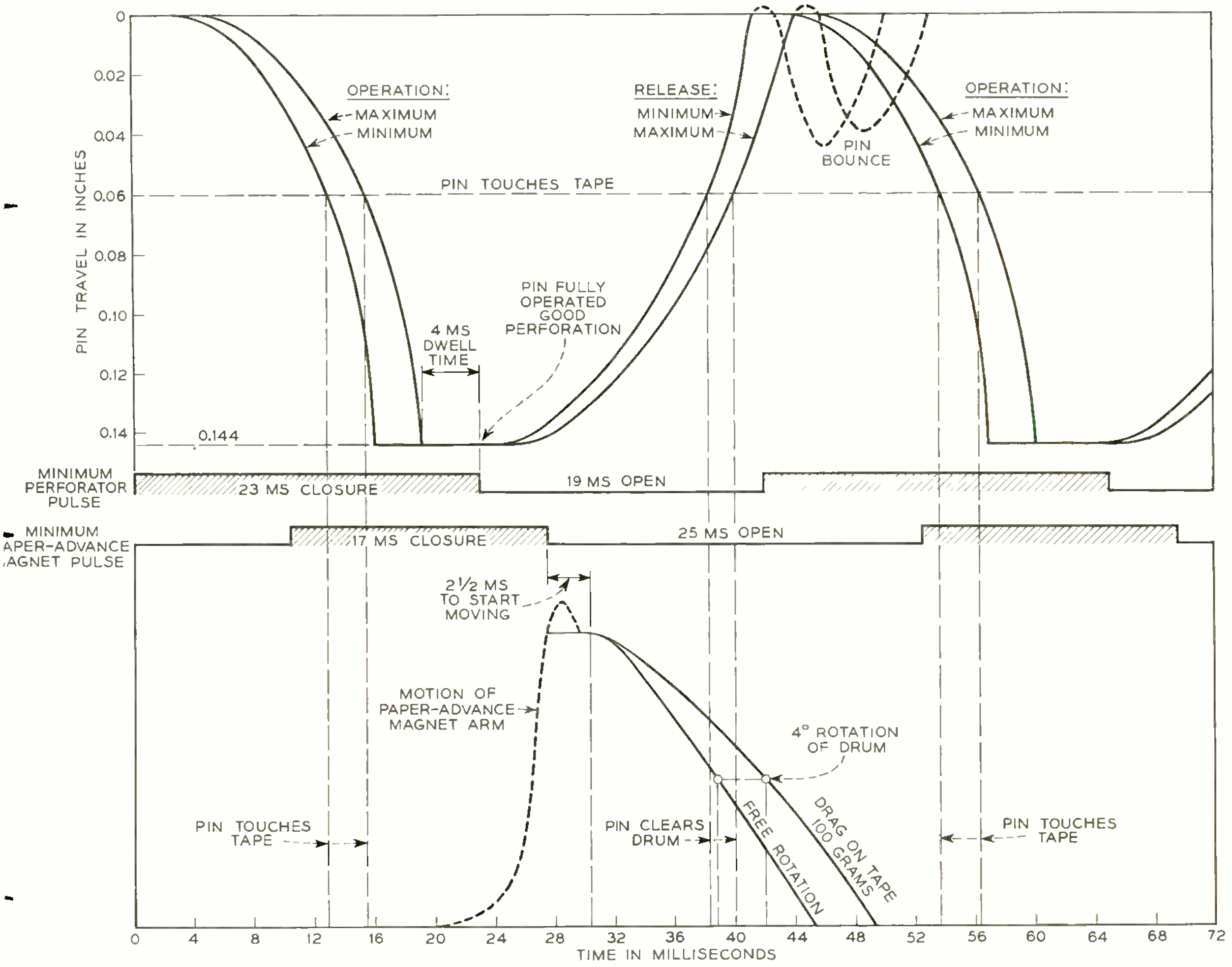


Fig. 4—Maximum operating limits of the KS-13882 perforator.

showing the motion of the arm of the paper advance magnet. The electrical circuit of the magnet is connected to the oscillograph string in such a manner that a deflection proportional to the current through the magnet is reproduced on the sensitized paper. Superimposed on this current record is the shadow showing the motion of a point on the arm as it moves from the unoperated to ing a positive measurement of the time of application of the operate current and the motion of the arm. By this means the speed of motion of critical parts was determined for establishing final requirements. High-speed motion pictures of the action of various parts under repetitive operation contributed further to the determination of the capability of the perforators, and disclosed interactions that could be eliminated by modification either in mechanical adjustment or in the associated control circuits.

After analyzing motions of various parts of many typical perforators by the method described above, a composite chart of the perforator operation was prepared and used to establish limits of operation from which maintenance and manufacturing requirements were set. This type of chart is illustrated in Figure 4 for the limiting capability of the perforator. The circuit to the perforating magnet is closed at the left end of the upper diagram and remains closed for twenty-three milliseconds. About six milliseconds passes before the magnet begins to operate, and about twelve milliseconds more is required for the perforating pin to complete its travel. These figures are averages; the maximum and minimum are both indicated on the diagram. A dwell period of about four milliseconds is then allowed to insure a crisp, fully embossed perforation before the circuit to the magnet is opened and the perforating pins are retracted. A horizontal line indicates the point where the pin touches or leaves the paper tape.

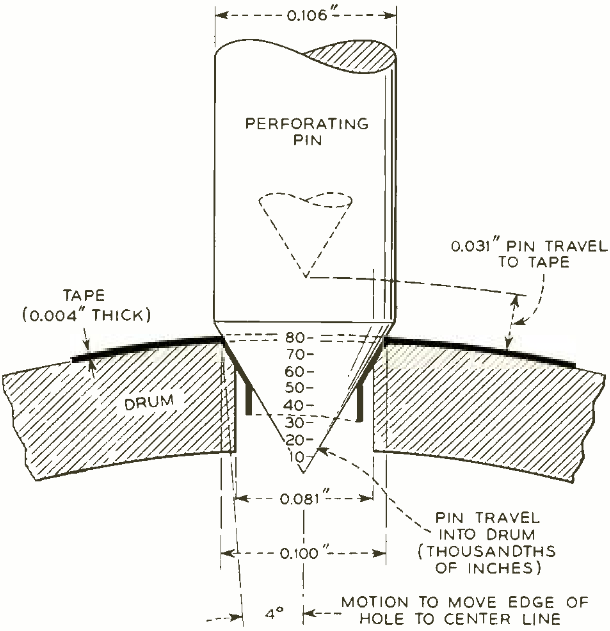


Fig. 5—Cross section of a perforator pin and part of the drum (ten times actual size).

The circuit to the paper advance magnet is closed about eight milliseconds after the circuit to the perforating magnet has been closed. Tape advance is accomplished, however, on the release of the paper advance magnet, and the circuit to the magnet is not opened until after the perforating pins have started to retract. Because of the conical ends of the perforating pins, indicated in Figure 5, rotation of the drum may be begun before the perforating pin has completely left the paper. Actually nearly half the rotation has been made by the time the tip of the perforating pin leaves the upper surface of the paper.

Figure 6 shows the test limits established for the perforators to insure proper operation in service based on a testing speed of twenty pulses per second. Service operation is at a speed of sixteen pulses per second, twelve milliseconds being added to the closed contact intervals to provide time for the operation of associated circuit control relays before the perforating pulse is applied to the magnets.

Mechanical requirements applying to the various moving parts were selected to insure maximum over-all speed of operation and fully embossed uniform perforations. Variations of such adjustments as perforating-magnet armature travel, retractile spring tension, and operated armature gaps were explored, and limits were established that would insure most effective operation of the perforators. For example, the retractile spring tension of the perforating magnet must be sufficiently high to insure proper withdrawal of the pin, but must not be high enough to require excessive current through the magnet or to increase the maximum operate time of the magnet beyond the limits imposed by the over-all operating conditions. Oscillographic records of operate and release times obtained with various retractile spring tension adjustments supplied the basic information for establishing the ultimate requirement.

To show the full satisfactory operating range of the perforators and the relationships of the various test points to this range, plots like that of Figure 6 were employed. The duration of an operating cycle, which is the reciprocal of the operating frequency, consists of a break period, b, and a make period, m, of the circuit to the operating magnet; and the break period as a percentage of the total, p, is thus 100b divided by m + b. When the break period is too short, the drum will not advance properly because the pins will not have sufficient time to withdraw. When the break period is too long, on the other hand, the make period will become too short to allow the pins to perforate the paper properly. There is thus both a lower and an upper limit for the per cent break period at any frequency, and these are indicated by the two curves of Figure 7.

equation $p = 100bf$. As may be seen from Figure 7, the lower curve is a straight line and gives a break period of about 17.6 milliseconds. Similarly if the same minimum make period was required at all frequencies, the upper curve would be a straight line with an equation $p = 100\,(1\text{-}mf)$. This curve also is seen to be straight, and gives a value of m of 16.3 milliseconds. The maximum operating frequency, which is the reciprocal of m + b, is thus 29.5 cycles. This, it will be observed, is the frequency where the curves intercept.

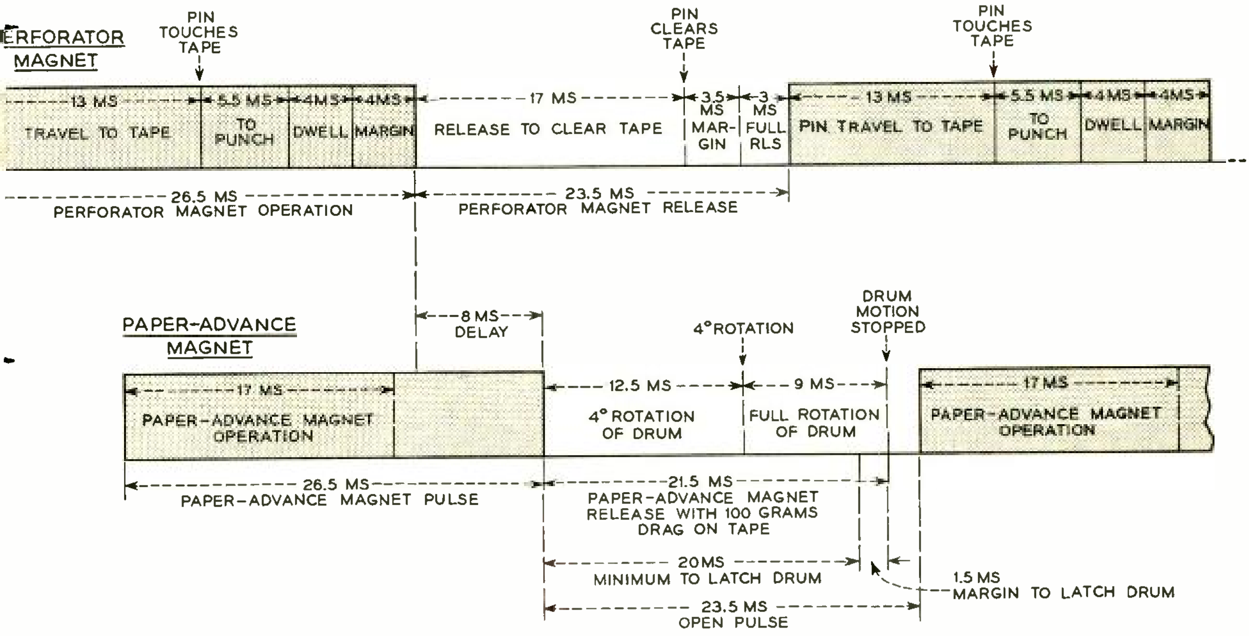


Fig. 6—Operating-time chart for perforator test at twenty cycles per second.

The per cent break is readily varied for test purposes by changing the make-to-break ratio of the interrupter supplying the operating magnets. The lower curve of Figure 7 was obtained by adjusting this ratio at various operating frequencies until the shortest break period was found at which the perforator would advance properly. Similarly the upper curve was determined by increasing the per cent break until the make period was just long enough to give satisfactory perforation. If the minimum break period were the same at all frequencies, the lower curve would be a straight line with the

Any combination of per cent break and frequency that lies in the space enclosed by these two curves is within the limiting overall capability of the perforator. The normal operating point is indicated by a circle, while the field test point is indicated by a triangle. Shop test points for minimum break period and minimum make period are also indicated.

The primary function of the accounting center reader is to translate the perforations in the tape into contact closures of proper duration to cause the associated relay circuits and perforators to function and thus

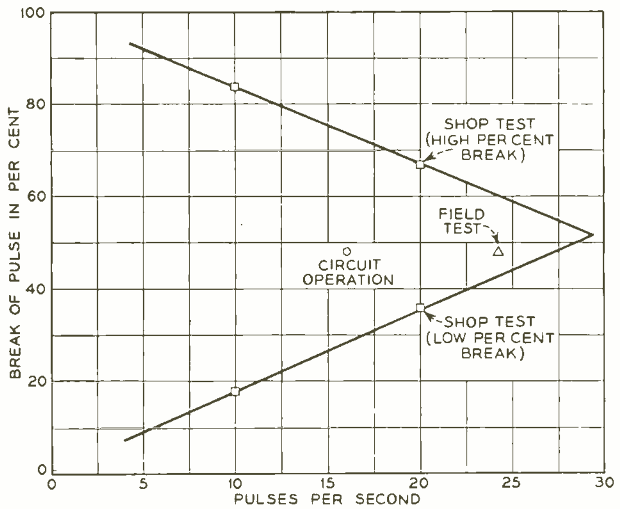


Fig. 7—Operating range of the perforator in terms of frequency and of the ratio of the break period to the length of the operating cycle, which is the reciprocal of the operating frequency.

accomplish the assembling, sorting, computing, and billing functions incident to processing the tape. Auxiliary contacts, operating either in synchronism with the reading contacts or at a predetermined interval later, provide for circuit control, paper advance, and perforator operation.

In the accounting operation, each line of information on the input tapes must be accurately read and recorded before the tape is permitted to advance to the next line. The paper advance mechanism of the reader is held locked in position under circuit control until the associated circuit indicates that the line has been accurately read and recorded. At this point the drum locking feature is released permitting the reader to advance to the next line. Critical time margins are involved in these operations, and laboratory studies established release times adequate to insure proper movement of the tape during circuit operation.

The permissible variation in phase of the reading and control contacts, the effect of instantaneous speed variation on the reader pulses, and the effect of the drag on the input tape were explored and the design of the readers and the associated control circuit coordinated to insure adequate margins for accurate reading.

Laboratory studies on the current readers were concerned chiefly with the determination of the operational characteristics of the various parts of the reader mechanism and the over-all coordination of these characteristics with the circuit conditions imposed by the associated circuits. Items considered in the laboratory studies included contact phasing and chatter, margins for preventing false closure on unperforated tape, interposer magnet operate and release characteristics, relation of drum motion to reading pin motion, and the resistance of tape to false perforation under repetitive impact of the reading pins. As in the case of the perforator, the stroboscope, the rapid record oscillograph, and high-speed motion pictures were used to obtain data for use as the basis of establishing requirements for mainte-

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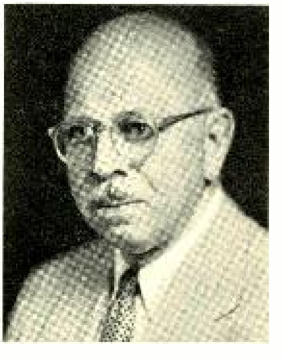

nance and for recommended improvements in reader design.

The initial commercial installation of the AMA system was put into operation in Philadelphia during 1948. Subsequent installations have been made in Newark, Chicago, Detroit, and other locations. The performance of the readers and perforators in these installations has been outstanding, and has clearly demonstrated the value of thorough analysis of the inherent capabilities of the apparatus in its application to the proposed circuit arrangements. Laboratory studies of the readers and perforators, with the resultant improvements of apparatus and circuit design, contributed materially to bring about the reliable record of operation of these machines.

Patents Issued to Members of Bell Telephone Laboratories During December

Aikens, A. J., see N. Botsford.

Alsberg, D. A., and R. P. Muhlsteff – *Indicating Apparatus* – 2,622,127.

Anderson, A. E., and R. L. Trent – *Bistable Circuit* – 2,622,212.

Botsford, N., A. P. Boysen, Jr., A. J. Aikens, E. Dietze, W. D. Goodale, Jr., and A. H. Inglis – *Telephone Substation Circuit with Automatic Compensation for Length of Line* – 2,620,402.

Boyson, A. P., Jr., see N. Botsford.

Dietze, E., see N. Botsford.

Gent, E. W. and W. W. Werring – *Machine for Beading Silver Chloride Plates* – 2,622,271.

Goodale, W. D., Jr., see N. Botsford.

Hamming, R. W., and B. D. Holbrook – *Error-Detecting and Correcting System* – Re 23,601 (Reissue of Patent No. 2,552,629).

Haring, H. E., and R. L. Taylor – *Method and Apparatus for Beading Silver Chloride Sheets* – 2,622,272.

Harris, J. R. – *Transistor Circuit for Pulse Amplifier Delay and the Like* – 2,622,213.

Hebenstreit, W. B. – *Tunable Magnetron* – 2,623,-198.

Holbrook, B. D., see R. W. Hamming.

Holden, W. H. T. – *Fault Signaling System* – 2,623,108.

Inglis, A. H., see N. Botsford.

Kircher, R. J. – *Semiconductor Signal Translating Device* – 2,623,103.

Lacy, L. Y. – *Electrical Wave Producing Circuit* – 2,621,295.

Low, F. K. – *Pulse Counting and Registering Circuits* – 2,623,114.

Malthaner, W. A. – *Telephone Switching System Employing Repetitive Impulsing* – 2,620,399.

Matte, A. L. – *Carrier Telegraph System* – 2,623,123.

Muhlsteff, R. P., see D. A. Alsberg.

Trent, R. L. – *Stabilized Transistor Trigger Circuit* – 2,622,211.

Shockley, W. – *Circuit Element Utilizing Semiconductive Materials* – 2,623,102.

Shockley, W., and M. Sparks – *Semiconductor Translating Device Having Controlled Gain* – 2,623,105.

Sparks, M., see W. Shockley.

Spencer, H. H. – *Circuit Protection Apparatus* – 2,624,036.

Taylor, R. L., see H. E. Haring.

Trent, R. L., see A. E. Anderson.

Wallace, R. L., Jr. – *Transistor Trigger Circuits* – 2,620,448.

Werring, W. W., see E. W. Gent.

Zobel, O. J. – *Microwave Filter* – 2,623,120.

New Eight-Party Service for Panel and No. 1 Crossbar

H. C. GREEN
Switching Systems Development

Heretofore in panel and No. 1 crossbar offices, multi-party service for more than four subscribers on a single line has required the use of ten-party divided code ringing, in which each subscriber hears five ringing codes including his own, and operator assistance is required to complete a connection between any two of the ten parties on the same line. To improve this situation, facilities have been developed that provide both eight-party semi-selective ringing, which reduces the number of ringing codes heard by a subscriber to two, and the reverting ringing feature, which obviates the necessity for operator assistance to connect two parties together on the same line.

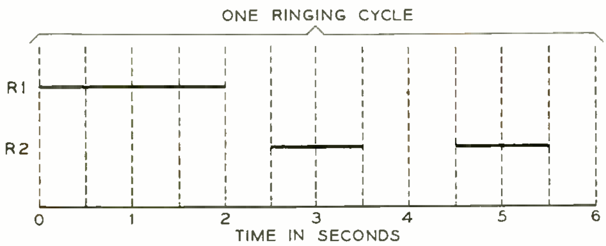

Fig. 1—Ringing codes used for eight-party semi-selective ringing lines.

With the new eight-party semi-selective ringing system, two ringing codes are provided, and each may be applied to the line in any of four ways. Standard twenty-cycle ringing superimposed on either positive or negative battery may be applied to either the tip or the ring conductor of the line. These methods of applying ringing are commonly referred to as types of ringing signal, and the two ringing codes with these four ringing signals provide distinctive indications for eight parties on a line. The two ringing codes are shown in Figure 1, while the combinations of ringing code and ringing signal used with the new eight-party semi-selective system are indicated in Figure 2.

All of these ringing combinations could have been provided by modifying the incoming trunk or selector circuits and certain control circuits. Since the number of eight-party lines in an office is not great, however, it is more economical to provide separate facilities for obtaining the additional ringing combinations. These consist of an auxiliary line circuit, which in No. 1 crossbar offices is connected between the line link frame and the subscriber line, and in panel offices between the final multiple and the subscriber line. In addition, use is made of the ringing interrupter and alarm circuit, which is normally common to an entire office of either type.

In No. 1 crossbar offices, an incoming call to one of the eight parties assigned to an auxiliary line circuit comes into the incoming trunk and utilizes a terminating

PARTY	RINGING SIGNALS				RINGING CODES	
	LINE CONDUCTOR		SUPERIMPOSED POLARITY ON RINGING CURRENT			
	TIP	RING	NEGATIVE	POSITIVE	R1	R2
P1		X	X		X	
P2	X		X		X	
P3		X		X	X	
P4	X			X	X	
P5		X	X			X
P6	X		X			X
P7		X		X		X
P8	X			X		X

Fig. 2—Ringing signals and ringing codes for eight-party semi-selective ringing.

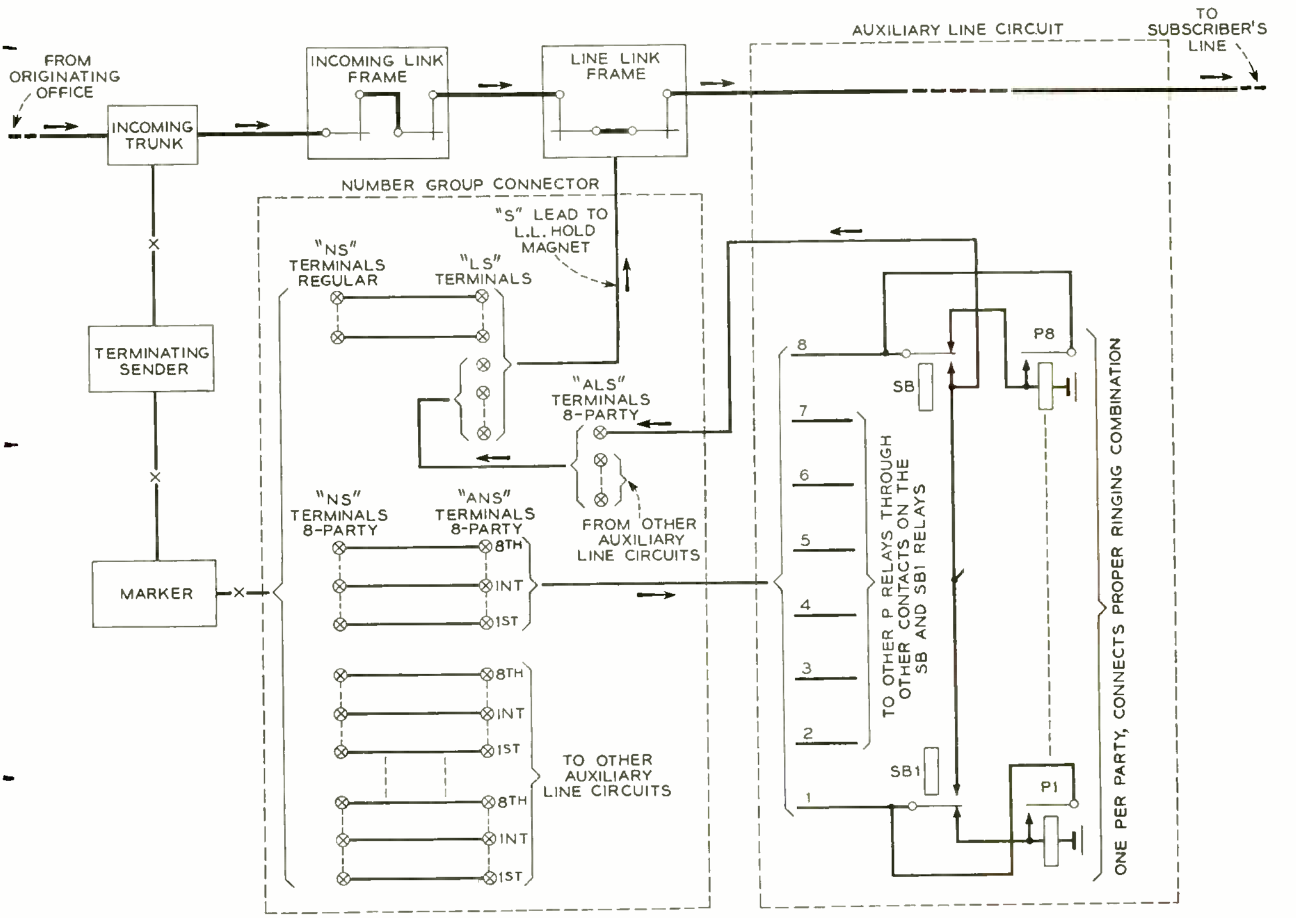

Fig. 3—Block diagram showing circuits involved on an incoming call to an eight-party auxiliary line circuit.

sender, a terminating marker, and a number group connector in the conventional fashion, as indicated in Figure 3. The marker selects an NS terminal in the number group connector corresponding to the called party's directory number. Each of these NS terminals is normally cross-connected to an LS terminal connected to the hold magnet of the called subscriber's line link. With eight-party semi-selective ringing, however, a separate NS terminal is provided for each party, and instead of being cross-connected directly to an LS terminal, the NS terminals of each eight-party line are cross-connected to a group of ANS terminals of which there is also one for each party on the line. Each group of ANS terminals is brought into a separate auxiliary line circuit, one of which is shown in Figure 3. Here they are extended through back contacts of the SB and SB-1 relays to the windings of the eight P relays. The operation of one of these P relays controls the connection of the proper ringing combination corresponding to the subscriber to be rung. The simplified sketch in Figure 3 shows only two P relays: P1 and P8. After a P relay has been operated, the SB and SB1 relays operate to transfer the ANS leads from the P relays to a common lead running to an ALS terminal in the number group connector. This ALS terminal is cross-connected to an LS terminal as required for operation of the primary hold magnet of the subscriber line link.

Meanwhile the marker has set up the connection between the incoming trunk and the auxiliary line circuit through the incoming link and line link. When this con-

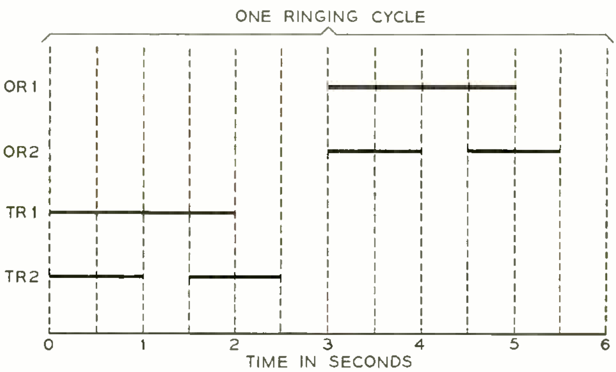

Fig. 4—Ringing codes used by reverting call trunk circuits.

nection has been completed, as indicated by the reception of ringing current from the incoming trunk, the auxiliary line circuit trips the ringing. It then connects the proper ringing combination to the multiparty line. Answering by the called subscriber trips the ringing supplied by the auxiliary line circuit and cuts the circuit through for conversation.

To provide the necessary ringing codes for use by the auxiliary line circuit, a ringing interrupter circuit is provided. This circuit converts pulses available from the office interrupter into pulses that duplicate the R1 and R2 ringing codes. Continuous superimposed positive and superimposed negative ringing current are also supplied to the auxiliary line circuit. With the ringing codes and continuous positive and negative superimposed ringing thus available in the auxiliary line circuit, the operated P relay causes the proper ringing signal and ringing code to be connected to the subscriber line.

The ringing interrupter circuit supplies pulses only on demand from the auxiliary line circuits and reverting call trunks (later described) so as to eliminate unnecessary wear of the equipment during idle periods. In line with conventional practices in semiselective ringing, this circuit is arranged with a "pick-up" feature that insures connection of ringing current only at the beginning of the cycle, since otherwise partial codes might result. The ringing interrupter circuit provides alarms to indicate falsely grounded and open leads to its connecting circuits, and a spare unit is provided which can be switched in by means of keys.

In panel offices, the eight-party semiselective ringing feature operates for the most part as described above for No. 1 crossbar offices. There are some differences, however, and these are fundamental to the two systems. In a panel office each party has a separate appearance on the final multiple, and selection of the proper terminal by the final selector operates the corresponding P relay. In No. 1 crossbar offices, outgoing calls from subscribers on an eight-party line pass through the auxiliary line circuit with all relays normal. In panel offices, on the other hand, the auxiliary line circuit is not used on outgoing calls, there being a separate path provided for this purpose.

Reverting ringing is provided by use of reverting call trunk circuits in conjunction with the ringing interrupter and alarm circuit. Reverting call trunks appear at the office or district selector multiple in a panel office or at the office link frame in a crossbar office, and the number provided depends on the traffic. For each station on an eight-party line special numbers must be assigned to enable dialing for connection to other parties on the same line. These numbers are not listed in the directory but are given to the subscribers by the local telephone company. The calling subscriber must dial a full complement of six or seven digits into the sender. The first two or three digits, equivalent to an office code, will serve to direct the call to the group of reverting call trunks. The last four digits, the numericals. will be pulsed out from the sender to the reverting call trunk. The thousands and hundreds digits are discarded by the trunk, but the tens and units digits register in the trunk the numbers of the calling and called stations. For example, CH 8 (or 248), if unused, could be assigned for directing the call to a group of reverting call trunks; "1" digits could be assigned for the thousands and hundreds digits of the numericals, and if Party 8 is calling Party 3, an 8 and a 3 would be used for the tens and units digits respectively.

For the assumed condition, CH 8-1183

would be dialed. The identifying numbers of the parties of a multi-party line duplicate those shown in Figure 2 in the left-hand column. The requirement for dialing a full complement of digits arises from the necessity of supplying the same type of information to the sender as is required for regular outgoing calls, since otherwise an expensive sender rearrangement would be required. After registration of the dialed number, a "line busy" signal is given to the calling subscriber by the reverting call trunk to indicate to him that he should restore his receiver on the switchhook. Ringing then takes place—the reverting call trunk operating in conjunction with the ringing interrupter circuit. Ringing for the calling and called parties is applied alternately to the line, and when the called party answers, ringing for both parties is stopped. This cessation of ringing is an indication to the calling party that the called party has answered, and he at once removes his own handset from the cradle and conversation begins.

As shown in Figure 1, each ringing code – either one long ring or two short rings – is applied once in each six second ringing cycle. With reverting ringing, however, ringing is applied alternately for the calling and called parties, and if the ringing cycle of Figure 1 were used, each party would hear his code only once in 12 seconds. To provide the same length of the ringing cycle for reverting ringing as is used on direct ringing, the ringing interrupter circuit is arranged to provide a ringing cycle that applies the code for both the calling and called party in a single six-second period. This arrangement is shown in Figure 4, where OR1 and OR2 are the codes for the calling party, and TR1 and TR2, those for the called party. It will be noticed that the ringing periods for both codes are of the same duration in Figure 4 as in Figure 1; the only difference is that there is a one-half second longer pause between the two ringing pulses of R2 in Figure 1 than in Figure 4. This is not enough of a difference to be very noticeable to the subscriber, however. The main difference between Figure 1 and Figure 4 is that in the latter a ringing code for both calling and called subscriber is provided within the same six-second cycle.

An exception to alternately ringing the calling and called party codes occurs when the called party has the same ringing signal as the calling party. If ringing were applied for both parties under these conditions both parties would hear both Code 1 and Code 2 in each six-second period, which might be confusing. When both parties have the same ringing signal, therefore, only the ringing code of the called party is applied to the line. The calling party hears

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From 1946-49 Mr. Green was assigned to the toll group, where he designed trunk circuits and later made laboratory tests of certain transmission and switching features. In 1949 he became a member of a group engaged in the development of AMA central office circuits and he has been responsible for a number of design improvements in these circuits.

Following his graduation from Clemson A & M College in 1938 with a B.E.E. degree, Mr. Green spent four and a half years in various headquarters organizations of the U. S. Ordnance Department, including a year overseas when he helped introduce the M9 director to the military forces.

it, and when it ceases, he knows the party has answered, and he picks up his handset.

In the event of a "don't answer," the calling party is required to momentarily remove his handset from the cradle to trip ringing. On answered connections, disconnect takes place on restoral of the handset by both parties. For an abandoned call, restoral of the calling party's handset causes the reverting call trunks and associated circuits to release automatically unless the call has progressed to the "busy tone" condition. If the "busy tone" condition has been reached, the calling party must proceed as outlined above for a "don't answer."

Although the reverting call trunk circuit was designed primarily for use with eight-party semi-selective-ringing lines, the circuit can also be used with two-party flat rate, four-party full-selective, and four-party semi-selective lines.

Since the operating companies are responsible for instructing customers regarding the revertive ringing feature, some differences exist in the methods of providing the operating instructions and the special numbers used. In some areas post cards are sent to the customers when the service is initiated, and when changes occur. In other areas oral instructions are adequate. Telephone directories indicate what operator to call to obtain this information.

Since each subscriber must listen to all ringing codes, the superiority of the eight-party system, in which each subscriber hears only two codes, to the ten-party system, in which each subscriber hears five, is very apparent. To provide a ten-party system in which each subscriber would hear only two codes would require an additional ringing signal and this was found to be prohibitive in cost.

Frank B. Jewett Post-Doctoral Fellowships

Five outstanding young scientists have been named by Bell Laboratories to receive the Frank B. Jewett post-doctoral fellowships for 1953-54. The winners are: Marshall Fixman of Massachusetts Institute of Technology and Clayton, Mo.; Dr. Henry Helson, of Yale University and New Haven, Conn.; Roger Gerhard Newton, of Harvard University and Cambridge, Mass.; Dr. Richard Scott Pierce of Yale University and Mar Vista, Calif.; and Daniel Burrill Ray of Cornell University and Brooklyn, N. Y.

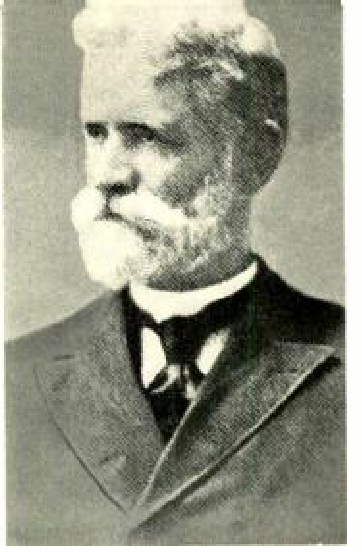
Three of the recipients are mathematicians, one is a physicist and the fifth is a physical chemist. Dr. Helson was among the winners last year.

Grants for the fellowships were established in 1944 by the American Telephone and Telegraph Company, upon the retirement of the late Dr. Jewett as Vice President in charge of Development and Research. The awards are designed to stimulate and assist research in the fundamental physical sciences. Since they were established, forty-six fellowships have been awarded. The awards grant $4,000 to the recipient of each fellowship and $1,500 to the particular institution.

Jewett fellows have conducted creative research at the nation's leading centers of higher education, each recipient being free to select the institution at which he will do his research. Fellowships are awarded on recommendation of a committee of scientists from the technical staff of Bell Laboratories. Primary criteria are the research ability of the applicant, the importance of his proposed problem and the likelihood of his growth as a scientist. The awards are limited to those who have recently received doctors' degrees or who are about to receive them.

The Early Years of the Strowger System

R. B. HILL
General Staff



Almon B. Strowger in his later years, from "Telephony" for October 15, 1949.

Some of the early attempts to devise automatic telephone systems were described briefly in a previous article*, and it was stated that, while some of the early inventions embodied ideas that were later developed into important features of the modern automatic art, none of the systems themselves went into commercial use. It remained for Almon B. Strowger, an undertaker of Kansas City, Mo., to devise the first automatic telephone system to be used commercially. The important feature of this invention was that of imparting to the switch arm first a vertical movement, and then a rotary motion in a horizontal plane. Strowger is said to have constructed the first crude model of his switch from a cardboard collar box and a paper of pins. He stuck the pins from the outside of the box toward the center until he had ten horizontal rows of ten pins each, one row above the other, to represent the line terminals. The vertical shaft for carrying the switch arm was represented by a lead pencil through the center of the box.

Strowger filed his patent application on March 12, 1889, and it was issued on March 10, 1891 as patent No. 447,918. The mechanism of Strowger's patent is shown in Figure 1. While this particular arrangement was never used commercially, it illustrates the inventor's original ideas. As may be seen, an individual switch was required at the central office for each subscriber line. The switch consisted essentially of a hollow cylinder with a shaft capable of both vertical and rotary motion. This shaft carried a wiper arm capable of wiping over all the horizontal rows of contacts on the inside of the cylinder. All of the subscriber lines were multipled to the rows of terminals around the cylinder of every switch, while one of the subscriber lines was connected to the wiper of each switch. Strowger did not specify in his patent the maximum number of lines which could be terminated in his switch, but in a circular issued in April, 1891, he claimed that it would "connect telephones in a system from two to ten thousand." In describing its method of operation, however, most writers have assumed ten horizontal rows of 100 contacts each. (Even this number would have required a switch prohibitive in size and cost.) The vertical and rotary motions of the shaft were controlled by electromagnets actuated by impulses sent from the subscriber station. Four push buttons on the subscriber telephone box each controlled a wire to the central office, while the fifth wire was for talking.

To call the number 315, Strowger states in his patent, the subscriber pressed his "hundreds" button (G′) three times, thus lifting the shaft of his switch three notches and bringing the wiper opposite the third row of terminals. He then pressed his "tens"

* Record, *January*, 1953, *page* 22.

button (H′) once, which gave a single rotation to a 10-toothed ratchet wheel (E′) attached to the shaft and moved the wiper arm to 310. Pressing the "units" button (I′) five times operated a 100-toothed ratchet wheel (E) attached to the shaft and moved the wiper arm five more points to 315.

Ringing was done with a magneto or battery. When through talking, the calling subscriber pressed the (P′) button, which energized the release magnets and brought the shaft and wiper arm back to their normal positions. The use of five wires and ground was, of course, an impractical feature, but Strowger planned to later reduce the number of wires. A heavy battery was to be employed at each sub-station for operating the central office switch. There was no provision against the calling subscriber being connected to a busy line.

The first company was incorporated on October 30, 1891, under the name of the Strowger Automatic Telephone Exchange. Early in 1892, A. E. Keith, who had previously been employed by the Brush Electric Company, of Baltimore, entered the service of the Strowger company and was for many years thereafter one of its leading technicians and inventors.

On November 3, 1892, the first Strowger exchange was opened for public service at La Porte, Ind., with about seventy-five subscribers. This was the first automatic telephone exchange to be installed anywhere, and a considerable amount of ceremony was attached to the affair, with a special train run from Chicago and a brass band on hand to greet the guests. Since this system was designed for less than 100 lines, there was no need for a switch with a two-way movement, and a flat rubber disc type of switch was employed, with but one (rotary) movement for the wiper arm and one circular row of contacts. There were still five line wires, as in Strowger's patent, and each telephone was equipped with four push buttons, although the hundreds button was not used. The battery for operating the switches was now located at the central office. There was still no provision against a subscriber being connected to a busy line. The system worked with reasonable accuracy when the subscribers operated their push buttons correctly and remembered to press the release button after a conversation was finished.

In 1893, a small Strowger equipment was exhibited at the Chicago World's Fair.

About the beginning of the year 1894, Frank A. Lundquist and the Erickson brothers, John and Charles J., entered the service of the Strowger company, and, with A. E. Keith, started work on an improved system employing the so-called "piano wire" terminal banks with a flat-faced multiple and a switch arm capable of both a rotary and a longitudinal movement. Switches of this type, which were covered by patent No. 540,168, were installed at La Porte, Ind., in the fall of 1894 to replace the original equipment, and at Michigan City, Ind., in the same year. These new installations employed a simple form of busy signal. When the calling subscriber rang, both bells responded if the called line was free. If it was busy, the calling subscriber bell remained silent. They also utilized the first automatic release arrangement, invented by A. E. Keith in 1893 and covered by patent No. 573,884, embodying a mercury switch connected with the subscriber switchhook, which restored the central office switch to its normal position upon the hanging up of the receiver.

The "piano wire" form of switch did not prove successful, and in 1895 a return was made to the principle of Strowger's original patent. Patent No. 638,249, issued to A. E. Keith and the Erickson brothers, covered a switch which more nearly resembled the modern step-by-step switch. Two views of it in the patent are shown in Figure 2. It employed semi-circular banks and the familiar "up-and-around" motion of the selector rod and wipers. One-hundred-line switches of this type replaced the "piano wire" switches at La Porte in June, 1895. In August, 1895, a similar system, with 200-line switches, was installed at Michigan City.

At this time, the Strowger system employed, between a subscriber's premises and the central office, two hard drawn copper line wires, and a soft copper battery wire which branched into all the stations to supply signaling current. This arrangement continued in use until about the year 1900.

In the summer of 1896, an important forward step was made with the introduction of the finger-wheel dial to replace the push buttons. It was covered by patent No. 597,-

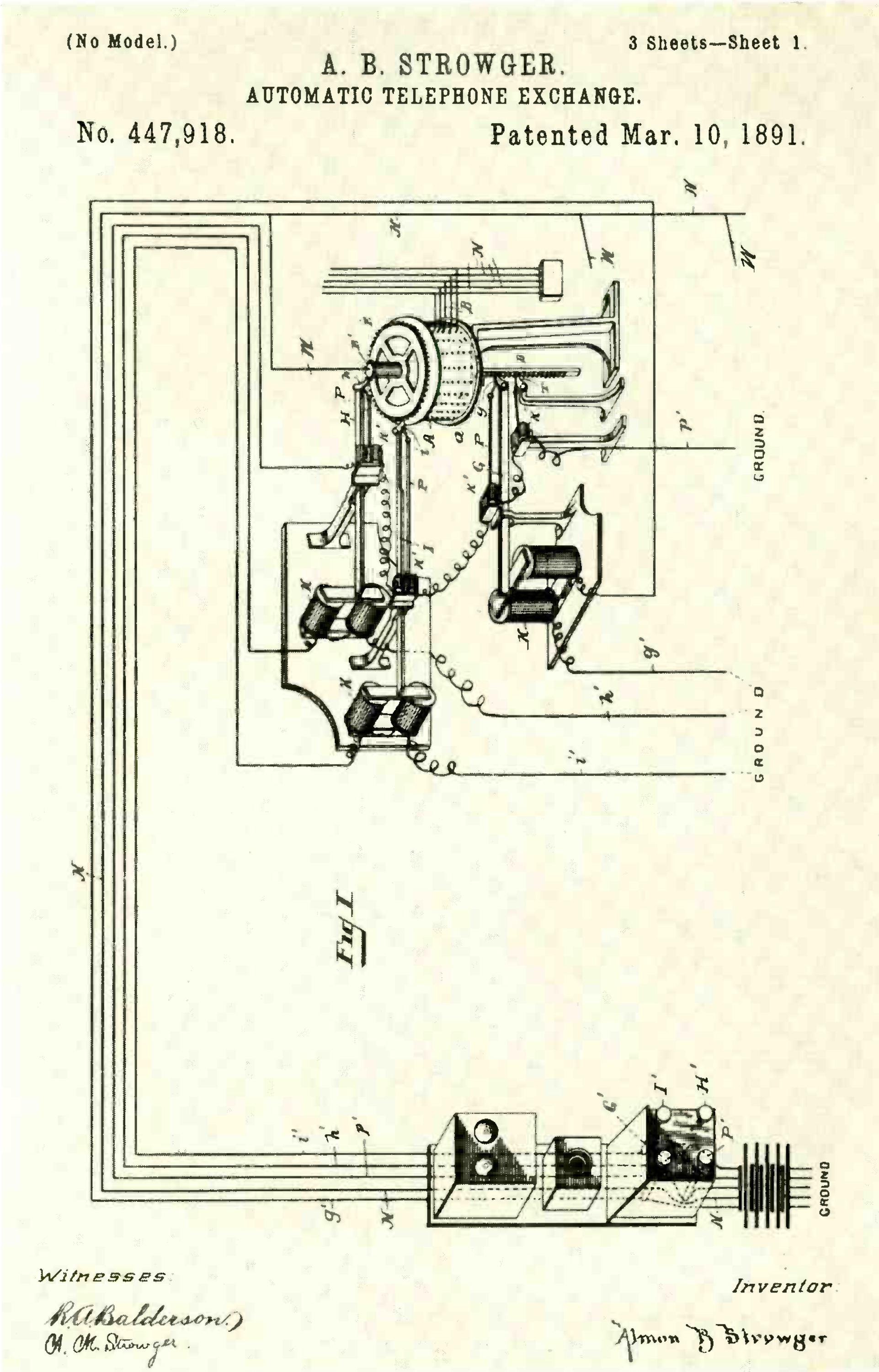


Fig. 1—Strowger's first automatic telephone system, as disclosed in his patent No. 447,918.

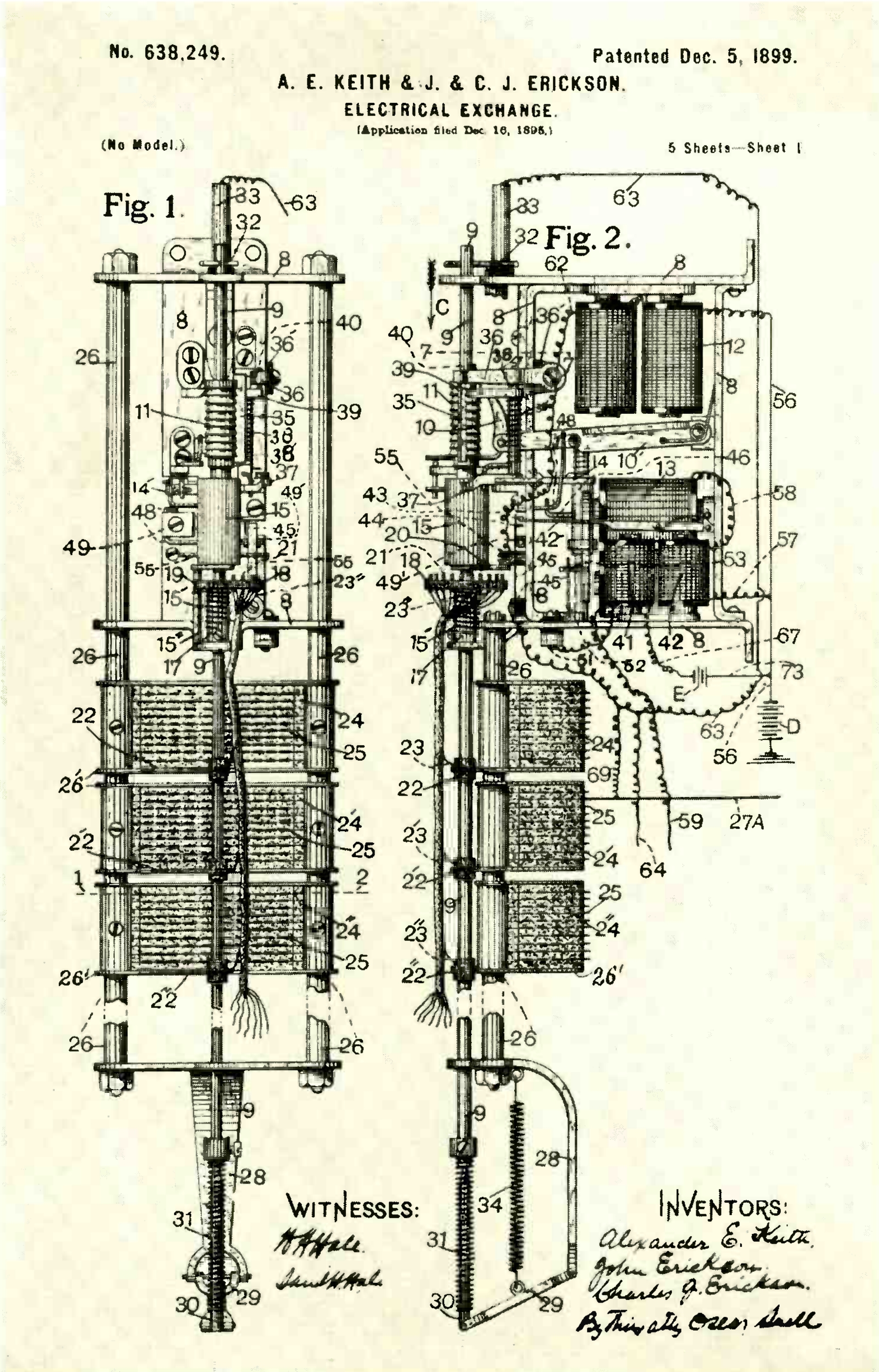


Fig. 2—Front and side views of the first Strowger switch to bear a general resemblance to the modern step-by-step switch.

062, issued to A. E. Keith and the Erickson brothers. As will be seen from Figure 3, this first form employed numbered finger holds mounted on the periphery of a rotatable circular plate. Dialing a number wound up a spring whose tension, when the finger was withdrawn, caused the dial to return to its normal position. The return rotation was limited to a moderate speed by an escapement mechanism, and, during the return, the required number of circuit interruptions took place to control the movement of the central office apparatus.

In the fall of 1896, A. B. Strowger left the Strowger Company and went to Florida for his health. He took no part thereafter in the development of the system which bore his name, and he died in St. Petersburg, Florida, in May, 1902.

It was also during the year 1896 that A. E. Keith and the Erickson brothers started work on a 1,000-line system employing the trunking or transfer principle in order to remove the limitation on the size of an automatic exchange imposed by the necessity of multipling all of the subscriber lines to each switch. The idea was not new*, of course, but none of the previous workers had produced an arrangement suitable for commercial use. Under such a plan the switches which make connection to called lines would each be limited to reaching 100 lines, and enough groups of such connector switches would be provided to serve the various hundreds of lines. They would be preceded by a stage of selector switches. The selector would respond to the initial or hundreds digit of the number and extend the call to a connector in the proper group; the latter would respond to the tens and units digits and connect to the desired line. Two switches would be used on each call, but they might be made smaller and cheaper than a single large switch.

The Keith-Erickson 1,000-line trunking system, covered by patent No. 672,942 was of this character. It was employed in the Strowger exchange installed at Augusta, Ga., in March, 1897, to serve some 400 lines. In this installation the selector had only one set of terminals at each of the ten positions to which it could be dialed, and thus each group of selectors had only one trunk to each group of connectors. Because of the inefficiency of these one-trunk groups, the system although operable was not commercially practicable.

In the summer of 1897, however, the Strowger engineers started work on the problem of a 1000-line trunking system employing automatic trunk selection. Under this plan the selector would have several sets of contacts in each row, leading to the several connectors serving a group of 100 lines, and would be arranged to connect with the first idle trunk it found in rotating over these contacts. In the first arrangement designed for this purpose, the pulses for rotating the selector were provided by the calling subscriber, through the device of inserting a dummy "O" in the directory number following the hundreds digit. The selector was designed to rotate in response to the pulses of the dummy digit until an idle trunk was encountered, after which the remaining pulses were disregarded. This plan was soon superseded by one in which the pulses were furnished by a continuously operating interrupter in the central office. The plan could be extended to exchanges of 10,000 lines by inserting another stage of selectors in the train.

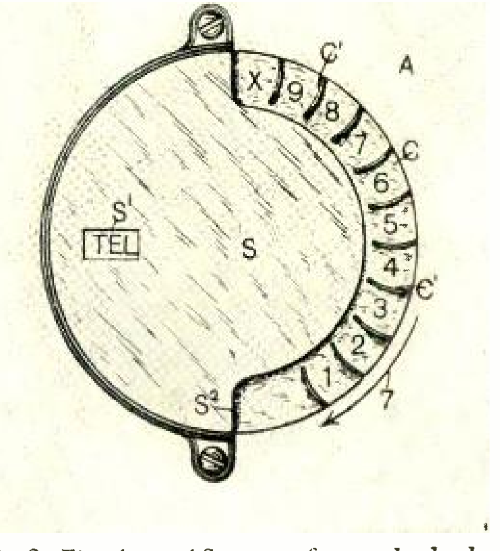


Fig. 3—First form of Strowger finger-wheel substation dial, which replaced the push buttons previously used.

* RECORD, *January*, 1953, *page* 22.

Incidentally, after protracted Patent Office interference proceedings, the patent (No. 776,524) covering the automatic selection of an idle trunk was awarded to Frank A. Lundquist, who had left the Strowger Company in 1896.

The Strowger exchange at New Bedford, Mass. – the first automatic exchange to employ a practicable form of trunking system – was opened for service in November, 1900. It employed first and second selectors, and was equipped for some 3,600 lines.

Other improvements were also made in this installation. The common battery supply wire was discarded, only the two line wires being carried back to the central office. However, the telephone had a third wire connected to ground, which served as a common return, the call being made by grounding one line or the other the required number of times. For this reason, this arrangement, which was standard until 1907, was usually referred to as a three-wire system. Local batteries still furnished the talking current, and the subscriber rang by operating a push button which connected a central office ringing generator into the circuit.

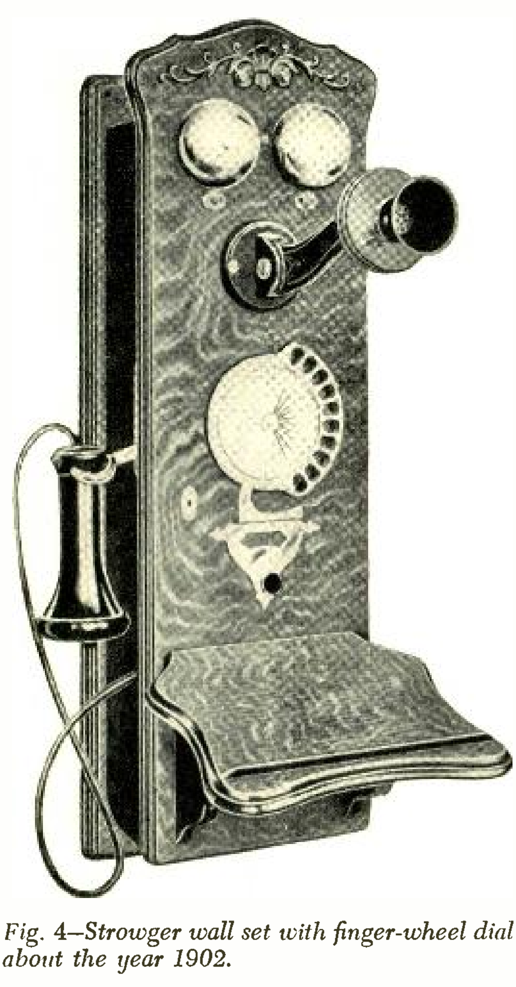


Fig. 4–Strowger wall set with finger-wheel dial about the year 1902.

In September, 1901, a Strowger exchange very similar to the New Bedford installation was opened for service at Fall River, Mass., with about 400 subscribers.

During the year 1901, the Automatic Electric Company was organized and acquired the United States rights to manufacture and sell Strowger equipment. The Strowger Automatic Exchange remained only a patent holding company until 1908, when its stock was acquired by Automatic Electric.

The New Bedford and Fall River installations may be said to mark the beginning of the work which eventually led to the development of a Strowger system suitable for use in large single-office cities. There were still many improvements to be made, the most important of which were: bridging the switch-controlling relays across the line, instead of placing them in series with the line; common battery talking; automatic ringing; the provision of practical forms of measured rate and selective party-line service; means for eliminating the need of an expensive first selector for each subscriber line; and the replacement of the three-wire (two-wire and ground) system with a straight two-wire system. Until these improvements were introduced, there was no prospect of the Strowger system competing on anything like even terms with the manual common battery system.

What some of the apparatus of the Automatic Electric Company looked like at this period (about the year 1902) is shown in accompanying illustrations. Figure 4 shows a wall set equipped with a finger-wheel dial. Figure 5 shows front and side views of the selector switch, of which there was one for each subscriber line. In the upper half were the electromagnets and their associated equipment. The lower half consisted of three banks of terminals, with a wiper for each bank. The upper, or "busy," bank was used to show whether a trunk was busy, and the two lower, or "line," banks provided the

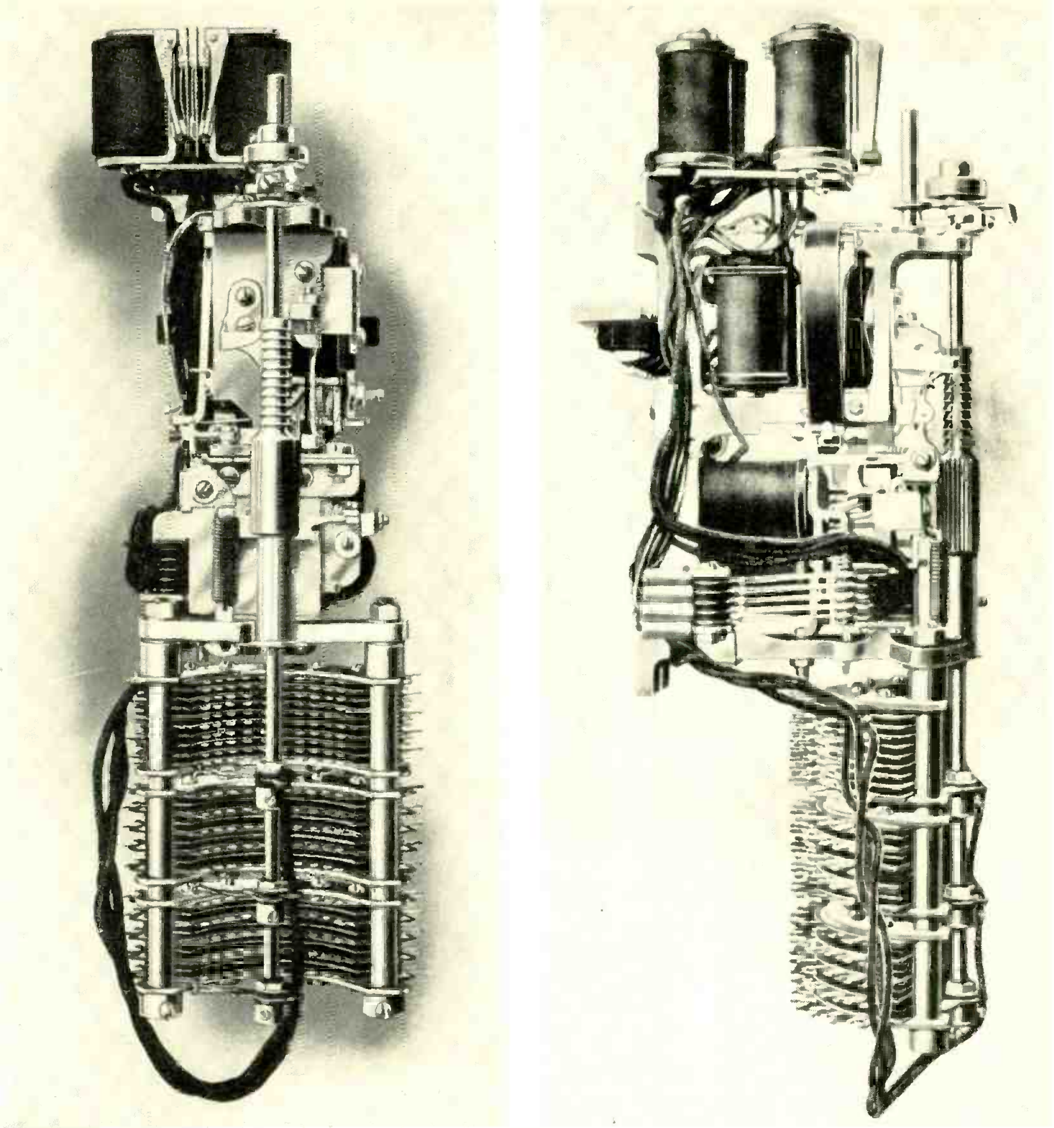


Fig. 5—Front and side views of Strowger selector switch about the year 1902.

talking connections. Three-digit systems employed first selectors and connectors, while four-digit systems employed first selectors, second selectors and connectors. The latter were very similar in appearance to the selectors. Later, mechanical improvements made it possible to incorporate the 200 line terminals into a single line bank, and resulted in a shorter two-bank switch.

After the Fall River exchange, Strowger exchanges were installed in the "Loop" district of Chicago in February, 1903, with about 1,500 subscribers; at Dayton, Ohio, in July 1903, with 1,300 subscribers; and at Grand Rapids, Mich., in January 1904, with 5,300 subscribers, replacing a manual board. The Chicago installation was the first Strowger exchange to furnish any type of message rate service, the first selectors being equipped with a commercial form of meter (Veeder meters). These did not register a busy call, but did register all completed calls, whether answered or not. The Dayton exchange was the first in which the controlling magnets were bridged across the line, instead of being in series with it, thus effecting a considerable improvement in transmission characteristics.

The first of several Strowger branch offices, designed to connect with and supplement the Main (independent) manual exchange at Los Angeles, was completed in July, 1904. Several years later, the Main exchange was cut over to dial operation.

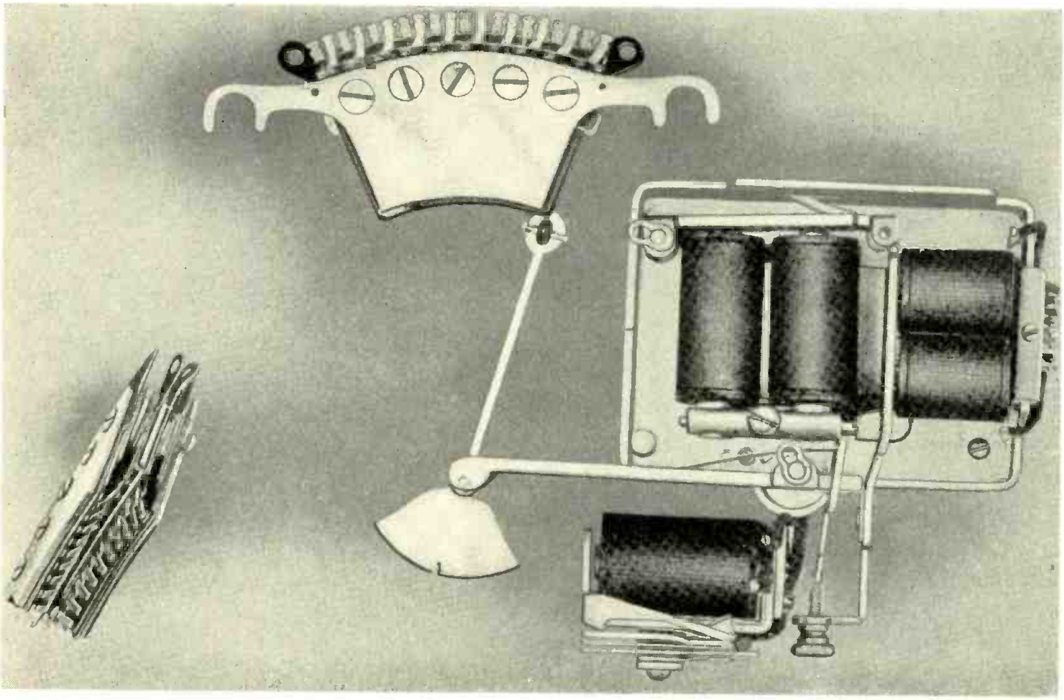


Fig. 6—Early form of Keith line switch.

The first Strowger exchange with common battery talking was installed at South Bend, Ind., in May, 1905, to operate jointly with a manual common battery board in the same building. It served about 700 subscribers. With the advent of common battery operation, it became possible to employ automatic (machine) ringing, whereby the called subscriber bell was rung automatically as soon as the connection was made to his line. Common battery operation and machine ringing were, of course, old in manual switchboard practice at this time. The Hayes repeating coil system of common battery supply had been developed by the Bell System in the 1890's and was widely used in their exchanges, while the Hibbard machine ringing system had been standard in Bell exchanges for many years. The early Strowger common battery exchanges used a bridged impedance type of circuit.

An arrangement aimed at convenience and economy in the grouping of the apparatus was covered by A. E. Keith's patent No. 831,876, filed on March 9, 1905. It called for ten rows of ten frames each, every frame containing the switches for serving 100 subscribers, and consisting of 100 first selectors, 10 second selectors and 10 connectors. This arrangement provided for 10,000 lines, each row serving a particular 1,000 lines. This patent also covered the important feature known as "bank slip," wherein the trunk multiples are wired or "slipped" in such a way that if ten selectors start at the same time to test the same trunk group, they will all at their first step test a different trunk. This arrangement shortened the time necessary for a selector to find an idle trunk, reduced the possibility of two selectors seizing the same trunk, and equalized the wear on the switches.

About the year 1905, the Automatic Electric Company developed a four-party selective signaling system for use with their common battery equipment. This feature, of course, was also old in Bell System manual exchanges, the Hibbard system, employing oppositely biased polarized bells, having been in use for many years. The Strowger exchanges used harmonic ringing.

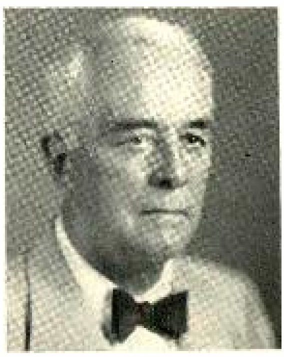
The earliest Strowger exchanges had all been equipped with a first selector for each subscriber line, and this practice had continued when the larger exchanges, employing trunking, had come into use. It involved a great waste of equipment, since only about ten per cent of the first selectors would be in use at any one time. This very serious limitation on the economy of the Strowger system was removed by A. E. Keith's patent No. 1,304,324, covering a line switch of the plunger type, filed on April 29, 1905, but not issued until many years later. With this arrangement, which went into general use around the year 1907, and eliminated about 90 per cent of the first selector switches, each subscriber line terminated in a line switch, much smaller and cheaper than a first selector, whose function was to connect his line automatically to an idle first selector as soon as he removed his receiver from the hook. The first selector then received the initial dialing impulses in the usual manner. This line switch, shown in Figure 6, consisted essentially of a magnet and a lever carrying on its end a plunger. The latter, when actuated through the lever by the magnet, pressed together certain springs that connected the subscriber line to one of ten trunks leading to first selectors. One hundred line switches were controlled mechanically by a common "master switch," which kept the plungers of the idle line switches directed toward idle trunks.

Early in 1908, the first Strowger straight two-wire system, in which the ground was eliminated, was installed at Pontiac, Ill. This was accomplished by the use of a sluggish, or slow-release, relay which, when energized by a current, held its contacts closed for a short period after the circuit through its winding had been broken. In the two-wire system, the pulses were sent by opening the line a certain number of times, instead of grounding one side of it. The vertical and rotary relays of the previous three-wire system were replaced, respectively, by a quick-acting relay and a sluggish relay. When a series of pulses (one dialing operation) had been received, the pause before a second series could be sent in allowed the sluggish relay, which was held up during the dialing, to fall off, giving the signal for the switch arm to rotate and choose an idle trunk. The two-wire system simplified the central office wiring, eliminated, during dialing, the disturbing influences due to differences in earth potential, and permitted a considerable simplification of the substation dial itself.

With the two-wire common battery system, provision was made for measured service by employing a differential or polarized service meter associated with the line switch and operated by the reversal of the current through the line of the calling subscriber at the time the called subscriber answered his telephone.

The advent of the two-wire system, with its basic simplification of the method of signaling from the station to the central office, marks the beginning of the modern phase of the Strowger (or "step-by-step") system. The engineers of the Automatic Electric Company continued to make improvements in the step-by-step system, while the Bell engineers developed the panel type of machine switching system. These parallel developments and the far-reaching effects of World War I led to the adoption by the Bell System after the war of step-by-step equipment for small and medium size cities and panel in the largest ones.

THE AUTHOR: ROGER B. HILL received a B.S. degree from Harvard University in 1911 and entered the Engineering Department of the American Telephone and Telegraph Company in August of that year. For several years thereafter he was engaged principally in appraisal and depreciation studies. When the Department of Development and Research was formed in 1919, he transferred to it, and since then, until his retirement in 1951, had been largely concerned with studies of the economic phases of development and operation. He had been a member of the staff of Bell Telephone Laboratories since 1934, first in the Outside Plant Development Department and later in the Staff Department.



Improved Contact Flanges for Waveguides

A. F. POMEROY
Transmission Systems Development

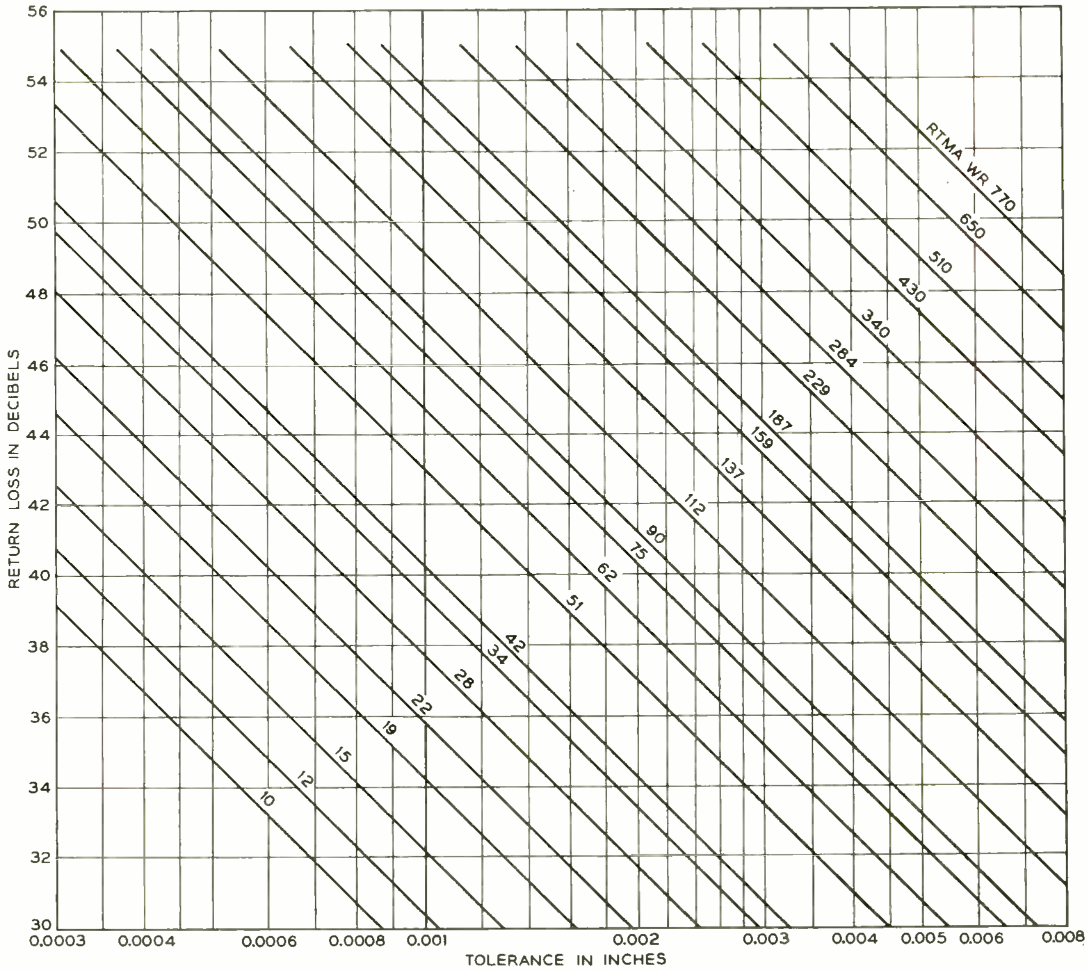
With the development of the TD-2 radio relay system* one of the important difficulties to be overcome was to secure a satisfactory economical coupling for waveguide sections. In the TD-2 system the antennas are at the top of a tall building or tower while the radio transmitters and receivers will, in general, be at a considerable distance below them. As a result there are fairly long runs of waveguide. Moreover, the guides transmit not a single frequency or a narrow band of frequencies, as have most previous systems in extensive use, but a very wide band – some 500 million cycles per second. A coupling method that might be satisfactory for waveguides carrying narrow bands of frequencies over short runs would not serve. In addition, the mid-band frequency of the TD-2 system – about 4,000 megacycles per second – required a size of guide that had been used little if at all before, and there was thus no previous art to serve as a guide. A thorough and fundamental study was undertaken of coupling requirements, and from it has sprung a design for a coupling that can be produced at moderate cost and that meets all the difficult requirements.

When two sections of rectangular waveguide of the same nominal size are coupled together, a mismatch may occur because of any or all of four conditions. The center lines of the two sections may not line up; the two sections, although of the same nominal size, may not be of the same actual size; one section may be rotated slightly with respect to the other; or the abutting edges of the guides may not be in continuous contact because of unevenesses in the surfaces of the coupling flanges. The mismatch in impedance resulting from any of these causes will result in impairment of television quality or crosstalk between telephone channels. These effects are especially serious when many repeaters are connected in tandem.

Of these four possible sources of mismatch, three could be eliminated by an ideal coupling, but one could not. With such an ideal coupling, the center lines of the adjoining sections would be perfectly lined up, there would be no rotation of one section relative to the other, and the abutting surfaces would be in perfect contact. Even under such ideal conditions, however, a mismatch would be possible because of the slight differences in inside dimensions of the two sections of guide. The standards for rectangular waveguides, TR/108, established by the Radio-Television Manufacturer's Association give nominal dimensions and also the permissible tolerances, which range from ±0.0005 to ±0.005 inches for the 23 sizes of waveguides listed – from 0.100 by 0.050 to 7.700 by 3.850 inches inside dimensions. Since differences in inside dimensions up to the limits of these tolerances may always be expected, this source of mismatch cannot be eliminated even with a perfect coupling.

As part of the development of a satisfactory coupling, therefore, it seemed desirable to calculate the maximum mismatch that could occur because of this possible difference in internal dimensions. Such mis-

* Record, *October*, 1950, *page* 442.



INTERNAL DIMENSIONS IN INCHES					
WAVEGUIDE WR NO.	WIDE	NARROW	WAVEGUIDE WR NO.	WIDE	NARROW
10	0.100	0.050	112	1.122	0.497
12	0.122	0.061	137	1.372	0.622
15	0.148	0.074	159	1.590	0.795
19	0.188	0.094	187	1.872	0.872
22	0.224	0.112	229	2.290	1.145
28	0.280	0.140	284	2.840	1.340
34	0.340	0.170	340	3.400	1.700
42	0.420	0.170	430	4.300	2.150
51	0.510	0.255	510	5.100	2.550
62	0.622	0.311	650	6.500	3.250
75	0.750	0.375	770	7.700	3.850
90	0.900	0.400			

Fig. 1—Curves showing the return loss in decibels resulting from mismatches in waveguide sizes due to allowable tolerances. Dimensions of the guides of various sizes are given in the table below the graph.

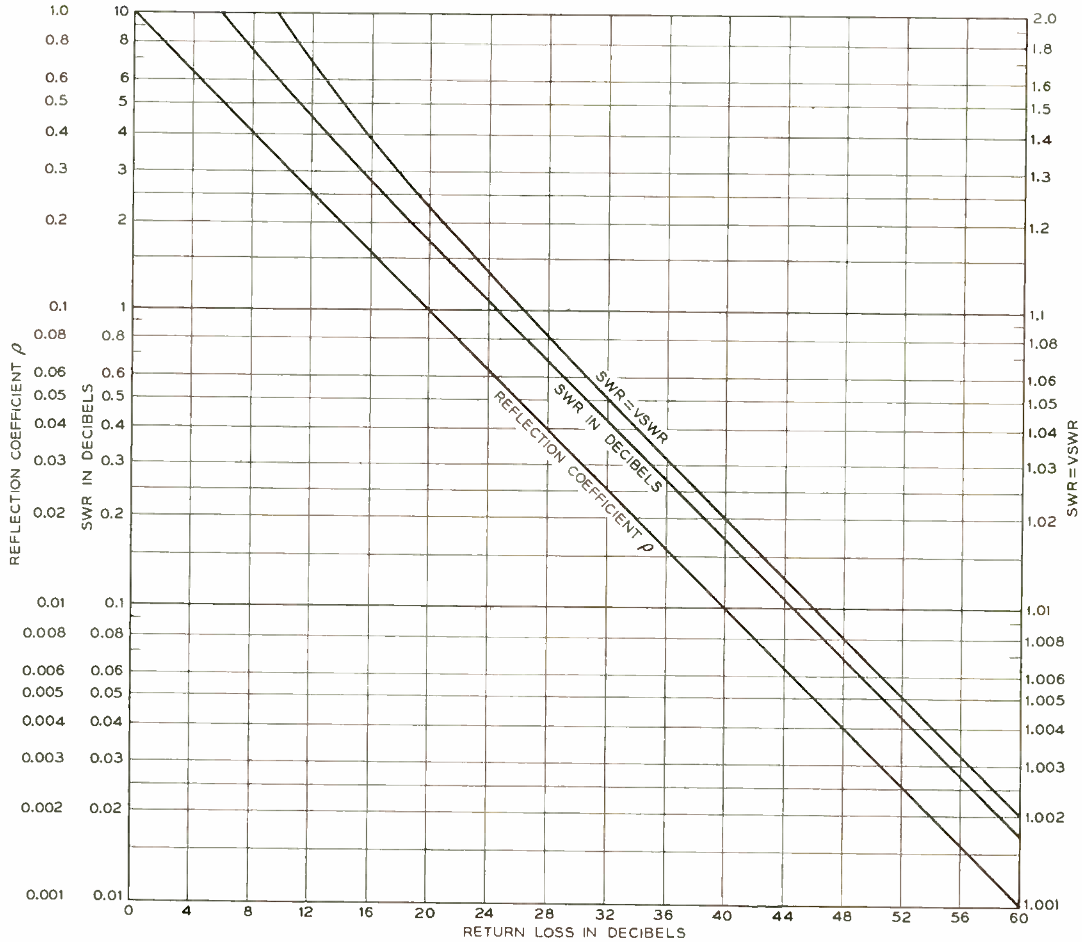


Fig. 2—Curves for translating return loss into reflection coefficient and standing wave ratio.

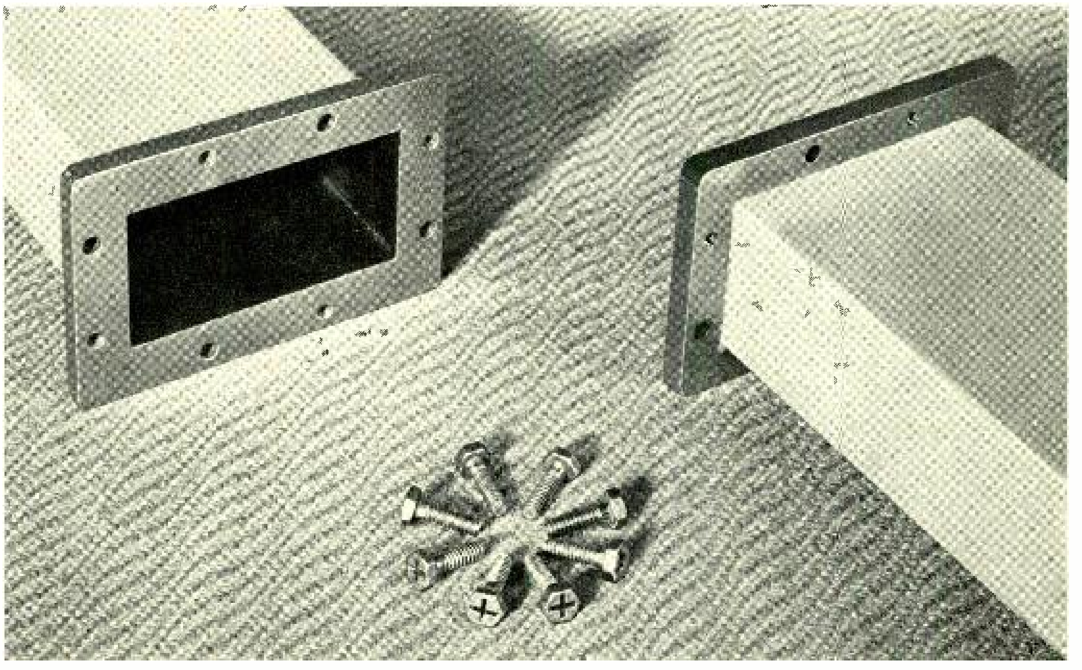


Fig. 3—The contact type waveguide coupling for indoor use.

matches would represent the limiting values to which a mismatch could be reduced by suitably designed couplings.

An impedance mismatch has, in general, a resistive and a reactive component. It may be deduced*, however, that the reactive component due to the different internal dimensions of the adjoining sections is negligible for contact type flanges. As a result, only the resistive component of the mismatch was used in calculating the characteristics shown in Figure 1. There is one line for each of the 23 standard sizes of rectangular waveguide, and the mismatch per coupling is given for any dimensional tolerance from 0.0003 to 0.0080 inches. The mismatch is expressed as return loss, which is the ratio in db between the incident power and the reflected power at a mismatch. The return losses shown in Figure 1 are those for maximum deviation within the allowable tolerances. At any one coupling, however, the return loss due to differences in internal dimensions alone is usually less than that shown but never more.

Within the Bell System, and quite extensively elsewhere, return loss is used to compare the values of mismatches of this type. However, reflection coefficient, ρ, or the standing wave ratio (SWR), synonymous with voltage standing wave ratio, is often used, too. The latter is sometimes employed in another form, SWR in db. For the convenience of those more familiar with these other forms of indicating mismatch, Figure 2 has been prepared. This shows the values of the other three quantities for return losses from 0 to 60 db.

Preliminary studies with contact flanges on the WR229 (2.290 x 1.145 inches) waveguide, which had been selected for the TD-2 system, showed that displacement of the two sections parallel to their axes but without twist would have relatively small effect on the mismatch if the displacement were not more than a few thousandths of an inch. A displacement of 0.005 inch, for example, changed the return loss from 60 to about 45 db. It was also found that 3 degrees of rotation of one flange with respect to the other changed the mismatch by about the same amount. Either of these effects would be made worse, however, if the guides were not in contact along their inner edges.

With such information as a guide, two contact type couplings have been designed;

* I.R.E., Proc., 32, *pp.* 91-115, *Feb.*, 1944.

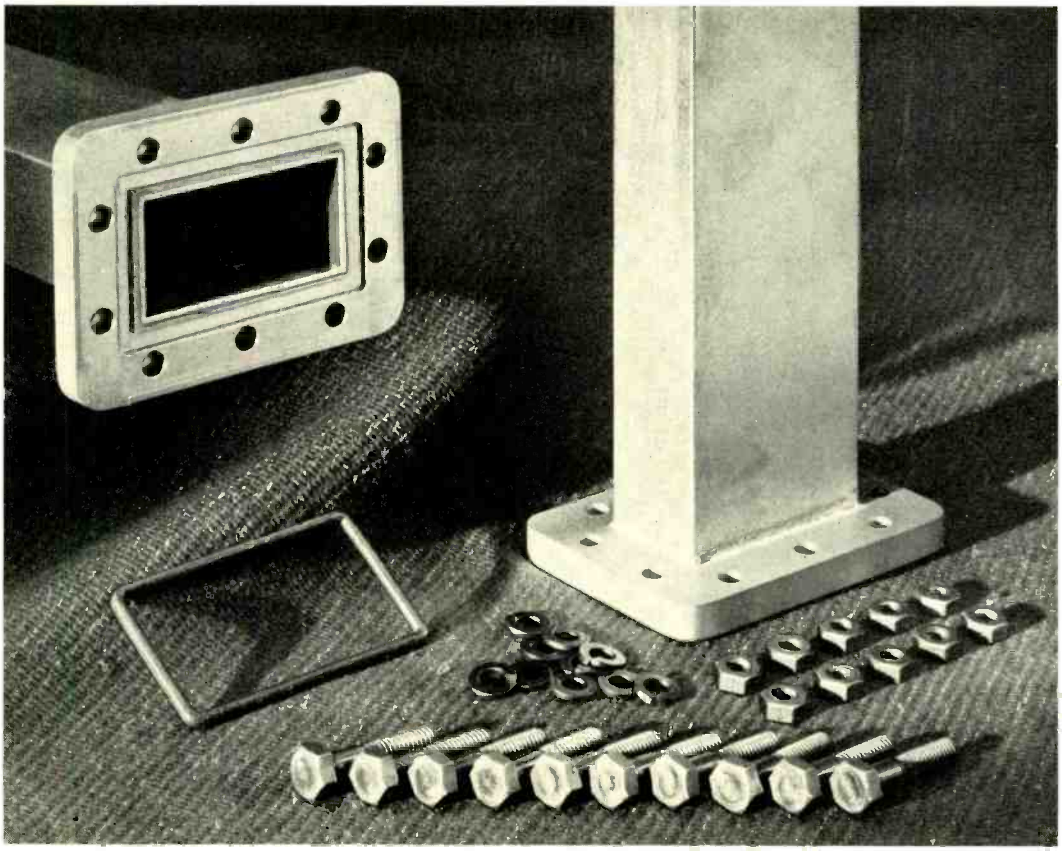
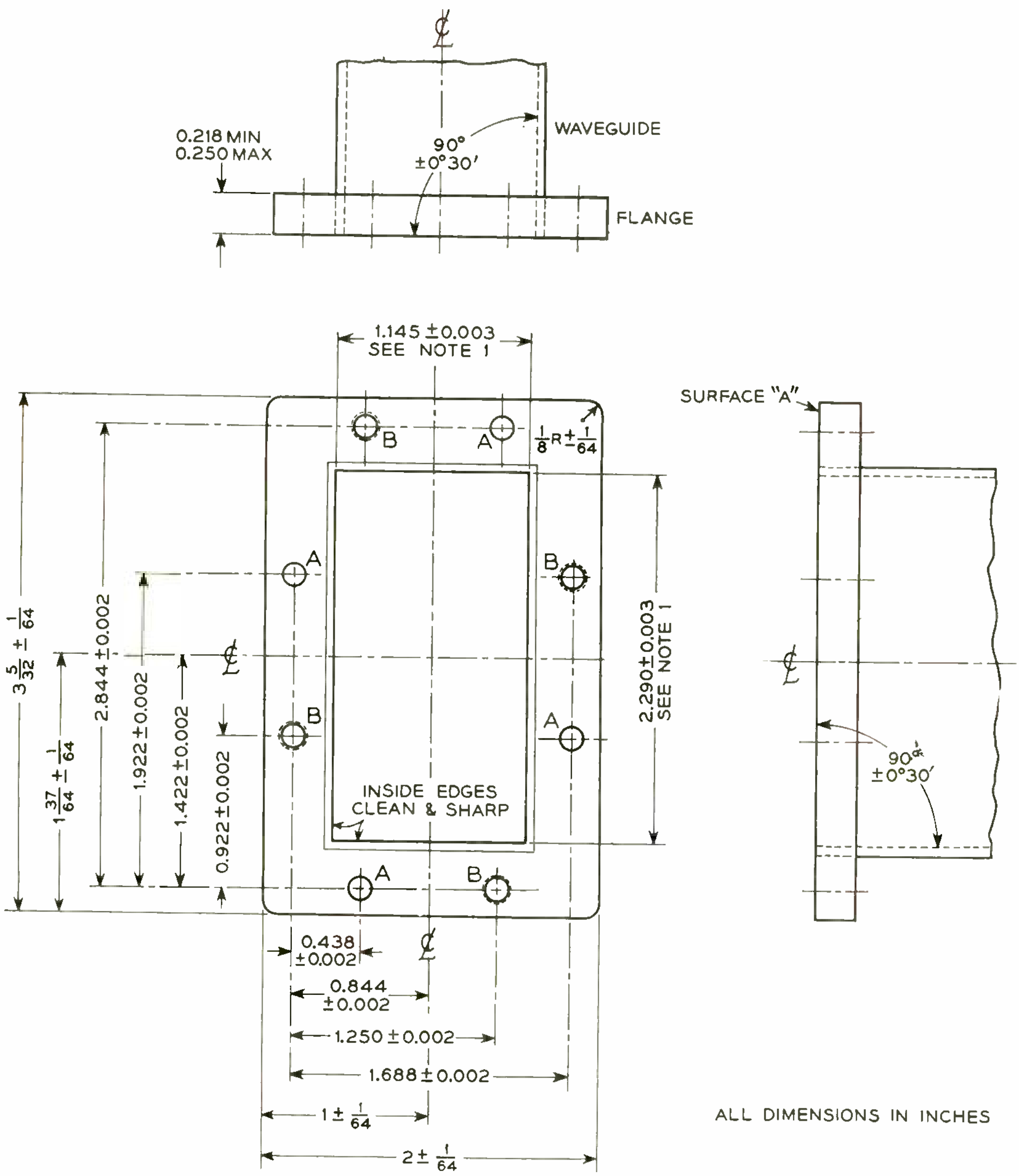


Fig. 4–The contact type waveguide for outdoor use.

one for indoor and the other for outdoor use. The former is shown in Figure 3 and the latter in Figure 4. The two are similar in general construction and tolerances, but the outdoor coupling uses a gasket, which provides a weather and pressure type seal. Detailed drawings giving all dimensions and tolerances for a size WR229 flange are presented in Figures 5 and 6. A flange of this size of either type must show a return loss of not less than 42 db, in the factory, when mated to a "perfect" flange, which is

THE AUTHOR: ALLEN F. POMEROY is engaged in the development of equipment for measuring attenuations and reflection co-efficients for broadband microwave radio systems. He joined the Laboratories in 1929 after graduating from Brown University with a B.S. degree. Until 1935 he was engaged in the development of acoustical delay circuits for making talker reaction studies of telephone circuits with extremely long delay time. From then until the outbreak of World War II, when he assisted in the development of waveguide test equipment, Mr. Pomeroy was concerned with measuring various features, such as attenuations, phase shifts, and envelope delays, of coaxial cable systems designed for television transmission. After the war he assumed his present responsibilities.



LEGEND	
HOLE	SIZE
A	0.147 +0.004 −0.003
B	0.138–32 NC–2 TAP

NOTES:

1. AFTER SOLDERING AND BEFORE MACHINING, IF DISTORTION HAS OCCURRED DURING SOLDERING, INSIDE DIMENSIONS OF TUBING AT THE FLANGE SHALL BE RESTORED BY SWAGING TO DIMENSIONS AND TOLERANCES SHOWN, SWAGING PLUG TO HAVE POLISHED SURFACES.
2. SURFACE "A" SHALL NOT EXCEED 63 RMS MICROINCHES PER ASA B46 SURFACE ROUGHNESS STANDARD.

Fig. 5—Detailed drawing for the indoor type flange. The NC-2 fit specified for tapped hole B is described in the American Standard B-1.1, which includes a unified thread series.

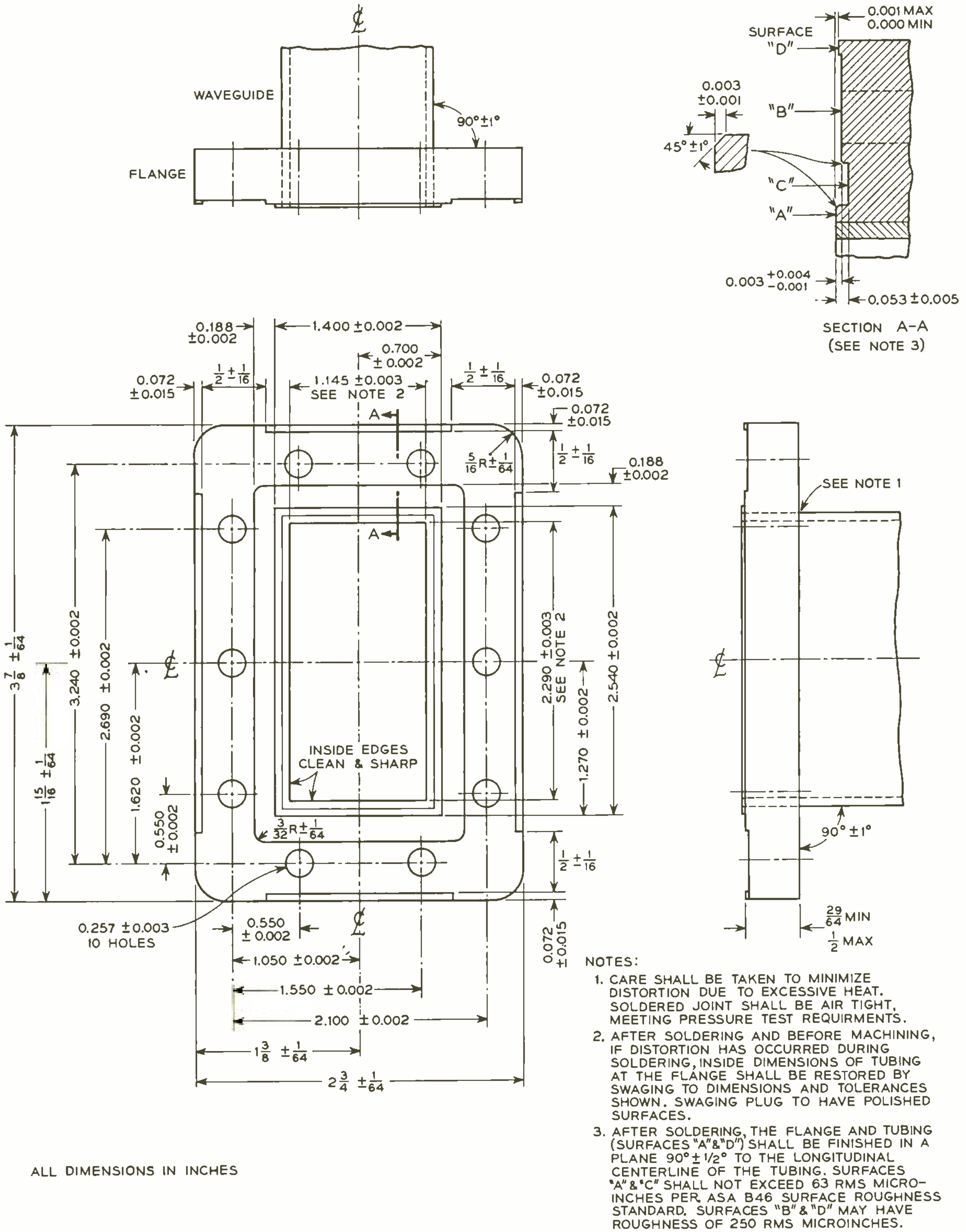


Fig. 6—Detailed drawing for the outdoor type flange.

a flange not deviating more than ±0.001 inch from the standard dimensions.

These satisfactory results were achieved by designing the coupling so that the bolts are as close to the guide as the dimensions of the bolthead will permit; by using a flange that is thick relative to the width of the contact surface; by specifying close fits of the bolts in the holes; by using as narrow a flange as possible so that the pressure will be applied over a small area; and by specifying the allowable roughness of the abutting surfaces. The bolt holes are not drilled until after the flanges have been fastened to the waveguide.

A study of the possible misalignment with the tolerances allowed showed that with all bolts in place, the rotation of one flange with respect to the other was less than half a degree. With such precision the use of alignment pins is unnecessary.

By keeping the bolts as close to the guide as the dimensions of the bolthead will permit, and by using a flange that is thick relative to the width of its contact surface, good contact is secured along the inner edges of the guide. The roughness of these mating surfaces is held to 63 rms microinches – determined according to American Standard B-46 for surface roughness.

Many members of the Laboratories have contributed to the design of these flanges. Among them are P. V. Koos, A. H. Lince, W. L. Tierney, and the author. The computations for Figure 1 were carried out by Mrs. E. C. Keifer.

Papers Published by Members of the Laboratories

Following is a list of the authors, titles, and place of publication of recent papers published by members of the Laboratories:

Babcock, W. C., Intermodulation Interference in Radio Systems. Bell System Tech. J., 32, pp. 63-73, Jan., 1953.

Balashek, S., see K. H. Davis.

Bardeen, John, see W. H. Brattain.

Biddulph, R., see K. H. Davis.

Brattain, W. H., and John Bardeen, Surface Properties of Germanium. Bell System Tech. J., 32, pp. 1-41, Jan., 1953.

Bullington, Kenneth, Frequency Economy in Mobile Radio Bands. 32, pp. 42-62, Jan., 1953.

Colley, R. H., The Evaluation of Wood Preservatives. 32, pp. 120-169, Jan., 1953.

Darrow, K. K., Magnetic Resonance: Part I – Nuclear Magnetic Resonance. 32, pp. 74-99, Jan., 1953.

Davis, K. H., R. Biddulph, and S. Balashek, Automatic Recognition of Spoken Digits. Acoust. Soc. Am., Jl., 24, pp. 637-642, Nov., 1952.

Felker, J. H., Typical Block Diagrams for a Transistor Digital Computer. Elec. Engg. 71, pp. 1103-1108, Dec., 1952.

Heidenreich, R. D., Methods in Electron Microscopy of Solids. Rev. Sci. Instr., 23, pp. 583-594, Nov., 1952.

Keller, A. C., Economics of High-speed Photography. S. M. P. T. E., Jl., 59, pp. 365-368, Nov., 1952.

Kock, W E., Problem of Selective Voice Control. Acoust. Soc. Am., Jl., 24, pp. 625-628, Nov., 1952.

Kock, W. E., and R. L. Miller, Dynamic Spectrograms of Speech. Letter to the Editor. Acoust. Soc. Am., Jl., 24, pp. 783-784, Nov., 1952.

Miller, R. L., see W. E. Kock.

Peck, D. S., Ten-stage Cold-cathode Stepping Tube. Elec. Engg., 71, pp. 1136-1139, Dec., 1952.

Peterson, G. E., Information-bearing Elements of Speech. Acoust. Soc. Am., Jl., 24, pp. 629-637, Nov., 1952.

Pierce, J. R., New Method of Calculating Microwave Noise in Electron Streams. I. R. E., Proc., 40, pp. 1675-1680, Dec., 1952.

Riordan, John, Delay Curves for Calls Served at Random. Bell System Tech. J., 32, pp. 110-119, Jan., 1953.

Wannier, G. H., Motion of Gaseous Ions in Strong Electric Fields. Bell System Tech. J., 32, pp. 170-254, Jan., 1953.

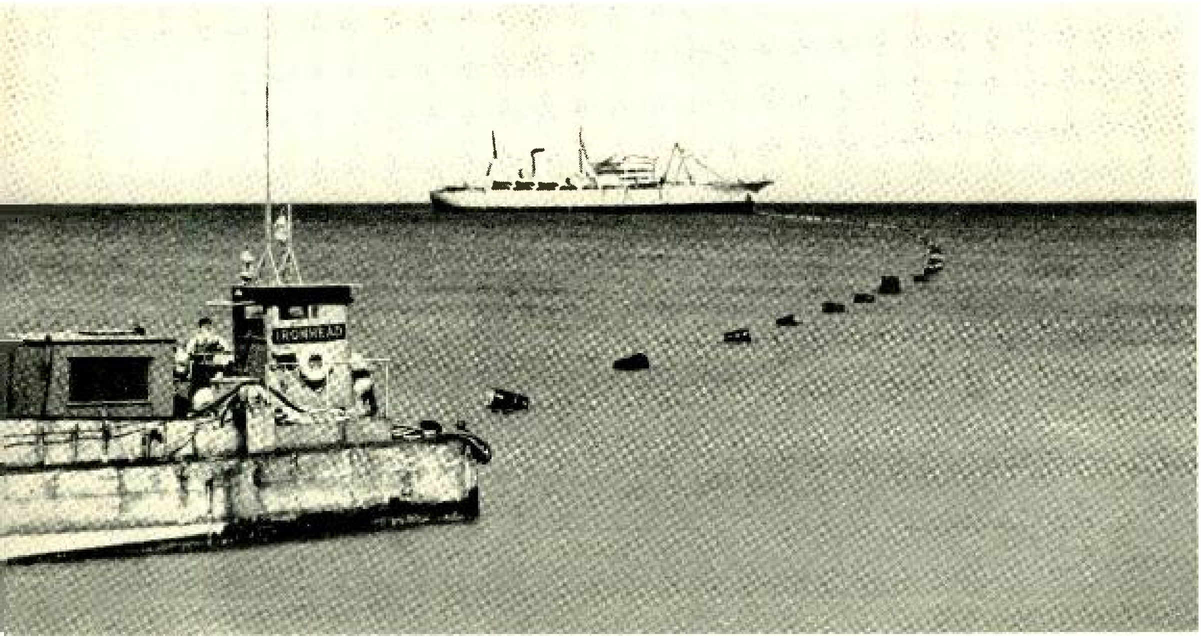
Submarine Telephone Cable for Air Force

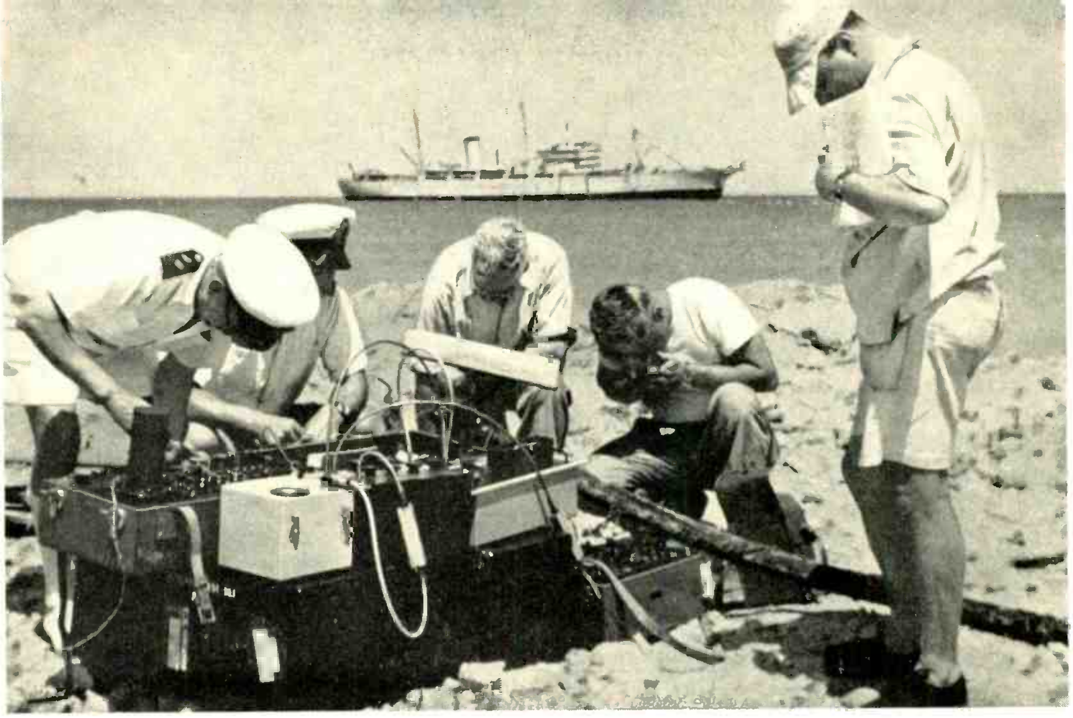
The first link, 234 nautical miles long, of a submarine telephone cable has recently been laid. Bell Telephone Laboratories designed the cable, supervised its manufacture, and chartered the new British cable ship HMTS *Monarch* to lay the deep sea portion. The shallow water portion was laid by Long Lines personnel, who had charge of all shore work for the entire cable installation. The complete cable will connect Air Force stations on the coast of Florida with those on the western tip of Puerto Rico and with points on the islands in between.

In each of the four approximately sixty-nautical-mile sections of cable, the greatest allowable variation in length was one-third nautical mile. At most landing sites the change from deep to shallow water is very abrupt, slopes of forty-five degrees are very common. The sea is three miles deep at some points, but at others it is very shallow. In fact, the ship could not even sail over one spot, so the cable was laid from a barge. To prevent the cable from hanging unsupported between high spots, to ensure against its settling in a wasteful zig-zag pattern, and to make certain that it was laid along the specified course, the cable had to be paid out with considerable exactitude. Obviously the *Monarch's* course and distance that it covered had to be very precisely determined.

However, in the Bahamas, where the cable was laid, geophysical anomalies make accurate position-fixing by ordinary nautical methods almost impossible. For example, a plumb line does not fall vertically there, because the very sharp changes in contour of the sea bottom permit the stronger attractive force of rock masses to draw the plumb line out of vertical over

HMTS Monarch *floats the cable in to the beach.*





J. J. Gilbert (center) and R. J. Tillman (right), with ship's officers, test insulation resistance, conductor resistance, capacitance, and attenuation.

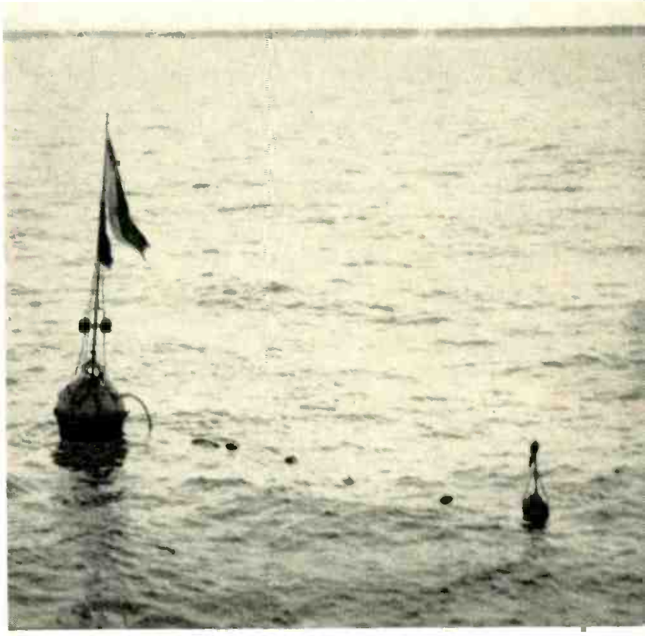
and under deep water to an angle pointing at the much shallower rock nearby. To make possible the accurate navigation necessary to this operation, the Seismograph Service Corporation supplied "Lorac", Long Range Accuracy, a radio position-fixing system accurate within three feet for both range and distance. Before the cable was laid, dry runs were made over the four cable courses to check the operation of the Lorac equipment, to confirm the profiles that had been obtained in the Hydrographic Office survey, and to obtain information regarding ocean currents. When the cable was laid, not a length exceeded the tolerance of ⅓ nautical mile:

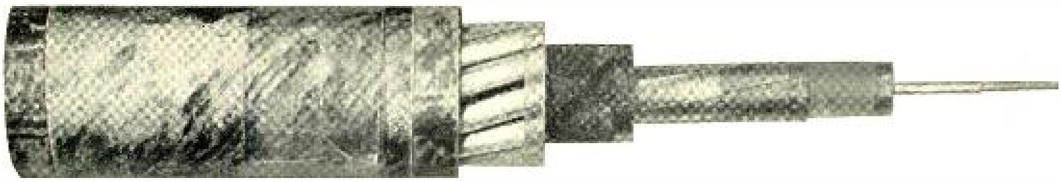
Cable Section	*Specified Length n.m.*	*Actual Length n.m.*
12	50.516	50.463
13	57.600	57.381
14	63.406	63.722
11	62.353	62.091
Totals	233.875	233.657

Due to this care in holding course, the ship laid the cable along a line very close to that originally specified.

During the laying operations, the conventional tests of insulation resistance, conductor resistance, and capacitance were made at frequent intervals with the cable in the tanks, partly laid, and on the bottom, to check that no breaks had occurred.

A cable buoy marks the point at which is the shore end of the cable. Here a joint will be made to the deep-sea section.





A piece of one type of cable used on this project.

However, to test the continuity of the return conductor, another technique was employed. The copper sheath around the insulated conductor shown herewith, is virtually open to sea water, being covered only with jute and cable armor, so direct current put into it would simply leak out into the ocean. Consequently, attenuation at a constant alternating current frequency of 64 kc per second was measured. Similar measurements were made on shore on each complete section after the final splice was on the ocean bottom.

Particular attention was paid to the technique of joining conductors and insulation. The copper conductors were brazed and the polyethylene insulation was joined in a pressure molding machine. The method was to place the joint into the machine, subject it to very high pressure at very high temperature, and hold it there until the splice was completed. Both the technique and the apparatus were developed by Bell Laboratories and the Simplex Wire and Cable Company.

J. J. Gilbert was cable engineer for the operation, N. C. Youngstrom guided the locating of the cable, R. J. Tillman directed tests of the cable, and H. Peters supervised the jointing operations.

I.R.E. National Convention

The 1953 National Convention of the I.R.E., to be held March 23-26 at the Waldorf-Astoria Hotel and Grand Central Palace in New York, will include a number of technical papers by members of the Laboratories.

At the Electronic Computers I Session, J. J. Scanlon will present his paper *Life and Reliability Experience with Transistors in a High Speed Digital Computer*. The session Antennas II—Microwave, will include H. W. Evan's paper *Crosstalk in Radio Relay Systems Caused by Foreground Reflections*. On the subject of transistors, R. L. Wallace will give his paper *Transistor Amplifiers*, at a symposium on circuits having the subject Panel Discussion on Wideband Amplifiers; at the symposium on transistor measurements of the session Instrumentation II, D. A. Alsberg will give a paper on *Transistor Metrology* and H. G. Follingstad, *A Transistor Alpha Sweeper*. The Electron Devices I—Transistors Session includes *Reliability of Transistors* by W. R. Sittner and R. M. Ryder, and *Characteristics of the M-1768 Transistor* by L. B. Valdes. F. R. Stansel will present *The Grounded-Collector Transistor Amplifier at Carrier Frequencies* at the session, Circuits IV—Active Networks—Transistors. The Instrumentation III—Electronics Session will have the paper by O. Kummer, *Wide-Band Wave Analyzer*. P. Mertz and K. W. Pfleger will present a paper *Effects of Hits in Telephotography* at the Communications Systems Session. At the Session on Engineering Management, M. J. Kelly will speak on *Research and Development Problems of Engineering Management in the Electronics Industry*.

A T & T Has High Management Rating

The A T & T was recently listed by the American Institute of Management as one of the ten best managed companies in this country. The list included Hotels Statler Company, Inc.; E. I. du Pont de Nemours and Company; B. F. Goodrich; Grand Union; Minnesota Mining and Manufacturing; National Cash Register; National City Bank of New York; Procter and Gamble; and Time, Inc.

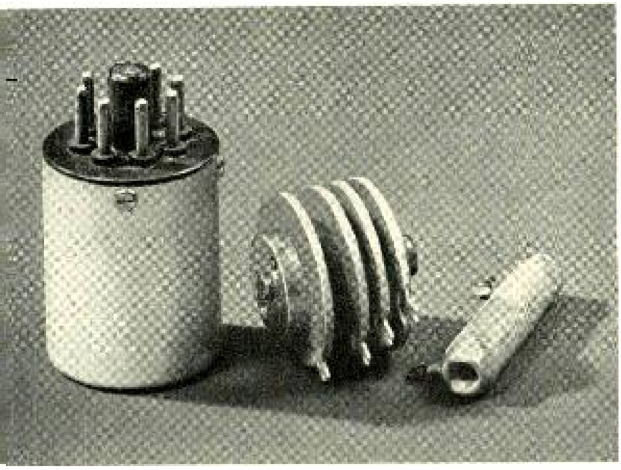


Fig. 1—KS-14521 oven (left) with 39A thermistor (center) and series resistor (right).

Oven Control with Thermistors

L. F. KOERNER
Transmission Apparatus Development

With the demand for frequency stability of increasing precision, crystals and associated elements must more often be maintained within very narrow temperature limits by housing the elements in temperature-controlled ovens. The conventional method of control is by means of thermostats, which when new are capable of the accuracy needed. However, in many instances, they cannot be relied upon to maintain this accuracy over long periods without maintenance, which would be a serious drawback in several recent Bell System applications and particularly in military installations. It has been found that temperature control of the required reliability can be obtained satisfactorily by means of thermistor networks.

In a thermostatically controlled oven the heating current is controlled by a thermally-sensitive element that is housed within the oven and responds to changes in the oven's internal temperature. With thermistor control, the thermally-sensitive element is located outside the oven and responds to changes in the ambient temperature. A simple form of thermistor-controlled oven is shown in Figure 1; the control circuit appears in Figure 2. The circuit consists of a power source, a series resistor and a heater which is shunted by a thermistor. When, for example, the ambient temperature rises, less heating current is needed to maintain the oven temperature. The thermistor responds to the rise in ambient temperature with a decrease in its resistance from a value considerably higher to a value considerably lower than the heater resistance, thereby reducing the heater current as required.

Ovens are maintained at about 70°C against ambient temperatures which, in pole-mounted telephone equipment and military installations, may vary from –40°C to +65°C. The amount of power required is small; for the oven in Figure 1 the total consumption is between 6 and 8 watts over the ambient temperature range –40 to +60°C. With the dissipation constant of the oven known, the power which must be supplied to the heater to maintain a specified temperature is simple to calculate because it is proportional to the excess of

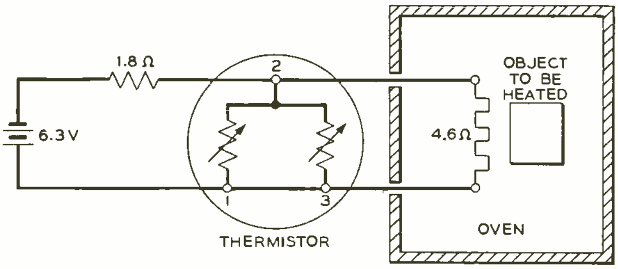


Fig. 2—Schematic of thermistor network for oven-temperature control.

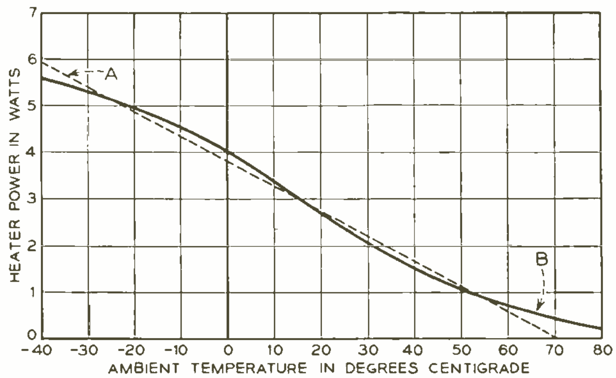


Fig. 3—Oven heater power versus ambient temperature. A — Power required to maintain oven at 70°C. B — Power supplied to oven heater by thermistor network. Total power 6-8 watts.

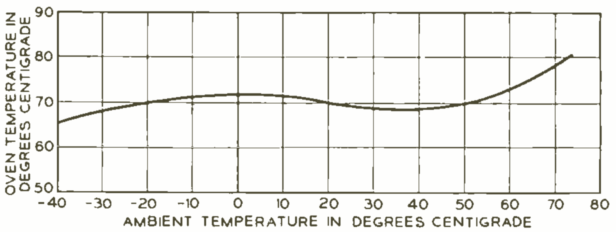


Fig. 4—Oven temperature versus ambient for oven of Figure 1.

the specified temperature over the ambient.

Design of a control network to produce the power needed to keep the oven up to temperature involves the thermistor's resistance-temperature characteristic which is expressed by an exponential equation, hence ordinary algebraic calculation is impracticable. However, the desired circuit constants may be determined with sufficient accuracy by graphical means. With the circuit constant known the performance of the network as well as that of the oven may then be calculated.

The circuit constants obtained by graphical solution for the oven in Figure 1 are indicated in Figure 2. The thermistor, consisting of two elements, has a room-temperature resistance of 10 ohms. The degree of match obtained between the power supplied by this thermistor network and the power requirements of the oven when operated at 70°C is illustrated in Figure 3, where Curve A indicates the power required to obtain a constant 70°C and Curve B, the power actually supplied by the control circuit. The resulting operating temperature of the oven appears in Figure 4.

Because a thermistor oven has its con-

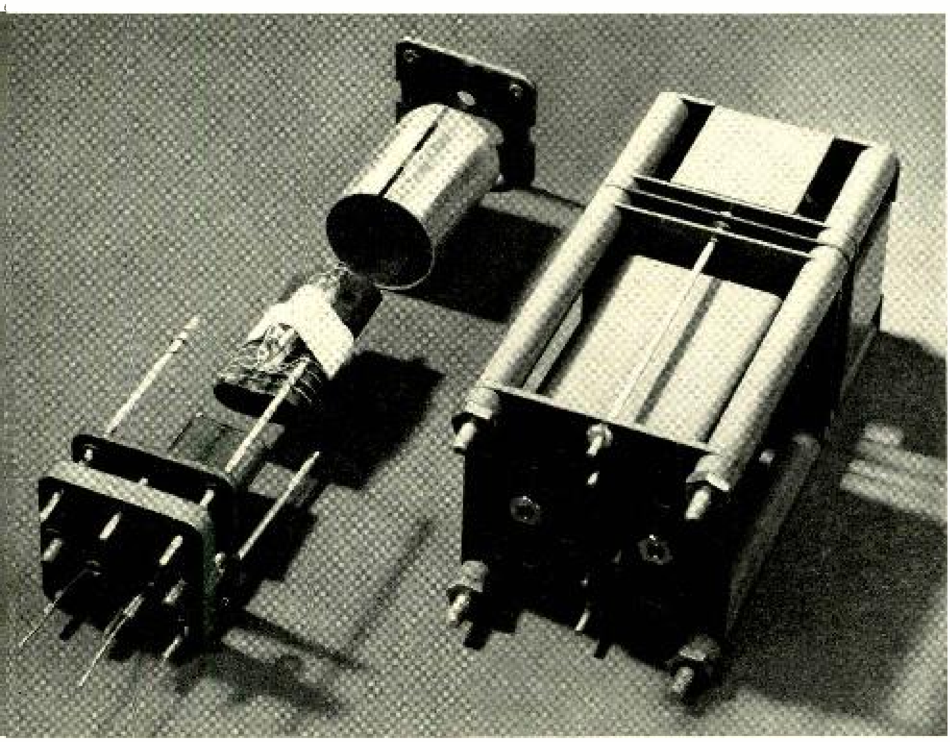


Fig. 5—Right — Oven and temperature control unit designed for the precise control of crystal-temperature in L3 coaxial system. Left — Exploded view of oven and contents. Oven operates on approximately 1.25A.

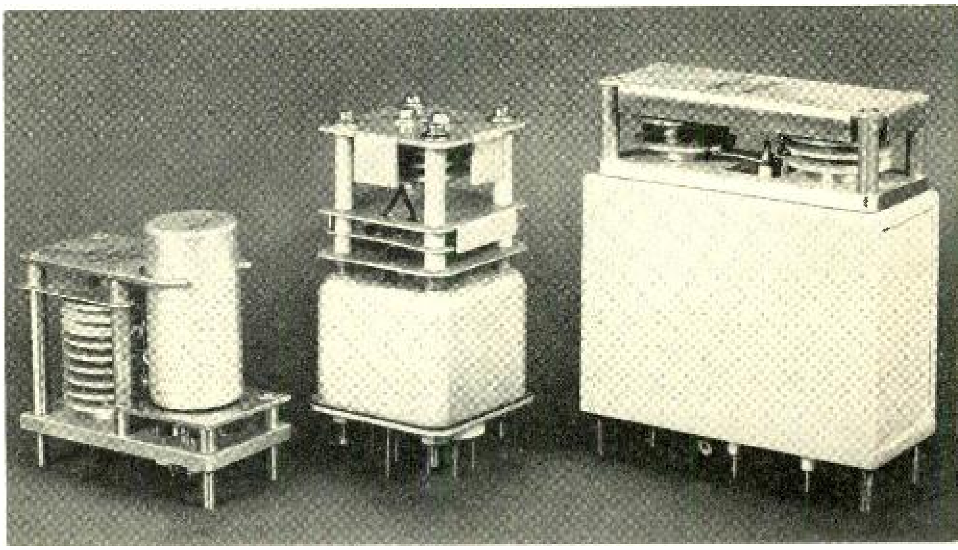


Fig. 6—Three varieties of thermistor-controlled ovens of rugged design for military uses. Operating on approximately 1.5 amperes, they maintain required temperature in ambients from −40 to +65°C.

trol outside, it can be made smaller than a thermostat oven which must be large enough to house the thermostat as well as the object to be heated. At low ambient temperatures extra power is consumed by a thermostat oven to heat the thermostat and the additional oven mass. However, at ambient temperatures approaching the temperature of the oven, the power consumed by a thermostat oven decreases toward zero. In contrast, a thermistor oven needs less power at low temperatures but consumes power at a relatively steady rate throughout the range.

A big advantage of thermistor control is that it has no moving parts or contacts to wear out and so require maintenance. There are no on-off current interruptions which may cause objectionable voltage variations in other apparatus fed by the power supply, and there can be no transients caused by the make and break of contacts. On the debit side thermistor networks call for a steadier power supply than thermostats to insure accurate temperature regulation, but usually this is unimportant because in most of the circuits in which thermistor control is utilized, closely regulated power supplies are necessary for other reasons.

An oven which has been developed for crystal units of the L3 coaxial system is shown in Figure 5. Its control circuit is the same as that in Figure 2 except an additional series resistor and shunt thermistor are needed to meet higher accuracy requirements. The complete unit appears at the right of Figure 5. The can directly above the terminal plate houses an oven containing elements for the frequency control of an oscillator. Above the can there are three plates. The controlling thermistor is mounted above the top plate and the series resistor is mounted on the middle plate which is non-metallic. The top and bottom plates are of metal and serve as radiation shields. The purpose of the bottom plate is to shield the oven from the relatively steady radiation from the series resistor. The top plate reduces radiation from the series resistor to the thermistor which ideally should be affected only by changes in the oven's ambient temperature. The oven is displayed at the left of Figure 5, together with the oscillator-control elements which consist of a crystal unit, a capacitor, a resistor and an additional thermistor which is required to stabilize the crystal current of the oscillator. This oven is ex-

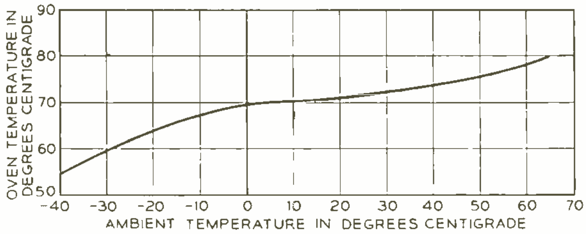


Fig. 7—Typical oven temperature versus ambient characteristic for ovens in Figure 6.

pected to maintain a temperature of ± 2°C, resulting in an oscillator frequency stability of better than ± 0.0002 per cent, over an ambient temperature range from 0°C to 60°C.

Three ovens developed to withstand the rugged conditions of military service are shown in Figure 6. In the left- and right-hand units, the components are riveted together after calibration and testing. For easy servicing they are removable and replaceable as complete assemblies. In the left-hand unit, a crystal unit and its heater are housed in the cylindrical can with the temperature controlling network at its left. In the center unit an oven contains elements for controlling the frequency of a multivibrator; the temperature controlling network is mounted above. In the right-hand assembly, the box hermetically encloses an oven containing the elements of a crystal filter; the temperature controlling network appears above. Typical performance for these ovens is shown in Figure 7.

THE AUTHOR: LAWRENCE F. KOERNER, a member of the Transmission Apparatus Development Department, has assisted in the development of crystal units and test equipment for crystal units during most of his twenty-eight years with the Laboratories. He received a B.S. degree in 1923 from Colorado College and an M.S. degree the following year from Harvard University. He joined the Laboratories in 1924, spending his first few years in the development of vacuum tube oscillators, detectors and frequency measuring equipment. In 1928 he went into crystal development, and during World War II spent several years as a consultant at Hawthorne, where crystal units were manufactured for military use. Since then he has developed crystal oscillator circuits for transmitters and receivers, and in 1947 turned his attention to the development of apparatus ovens.

E. C. Molina Honored by Eta Kappa Nu

E. C. Molina who retired as Switching Theory Engineer on January 1, 1943, became an Eminent Member of the Eta Kappa Nu Association at a ceremony preceding the banquet held during the A.I.E.E. Winter General Meeting, January 19 to 23. The highest recognition of this society of electrical engineers, eminent membership is conferred on those electrical engineers who have made outstanding contributions in their fields. Dr. Molina has attained world-wide recognition in the field of mathematical probability and is a pioneer in the application of this branch of science to the design of machine switching central offices and trunking facilities in communication systems. He is a recognized world authority on the works of LaPlace and Poisson in classical probability, and is the maker of the comprehensive and widely used Poisson Tables.

In June 1952 he was awarded the honorary degree of Doctor of Science by the Newark College of Engineering (RECORD, July, 1952, Page 308) and received the Elliott Cresson Medal of the Franklin Institute in September 1952 (RECORD, October 1952, Page 409).

Talks by Members of the Laboratories

During the month of January, a number of Laboratories people gave talks before professional and educational groups. Following is a list of the speakers, titles, and place of presentation.

Baker, W. O., Entrapped Free Radicals, Brooklyn Polytechnic Institute, Brooklyn, N. Y.

Becker, J. A., The Field Emission Microscope and Its Use in the Study of Chemisorption, American Chemical Society, Wilmington, Del.

Black, H. S., Vast Areas Opened up by Application of Negative Feedback Principles, Research Corporation, New York, N. Y.

Brown, W. L., and W. Shockley, *n*-type Conduction on *p*-type Germanium Surfaces, American Physical Society, Cambridge, Mass.

Budenbom, H. T., Complexity of Military Electronic Equipment, A. I. E. E. Winter Meeting, New York, N. Y.

Cooper, D. I., Proton-Proton Scattering, American Physical Society, Cambridge, Mass.

Crabtree, J., Stress-cracking of Rubber by Free Radicals, American Chemical Society, Newark, N. J.

Curtis, H. E., and J. B. Maggio, Frequency Considerations in the Transcontinental Radio Relay System, A. I. E. E. and I. R. E. Conference, Washington, D. C.

Darnell, P. S., Miniaturized Components and Their Applications in Transistor Electronics, Instrument Society of America, Pittsburgh, Pa., and I. R. E., Buffalo, N. Y.

Duguid, J. M., Telephone Power Plants, A. I. E. E. Winter Meeting, Toronto Section, Toronto, Canada.

Edelson, D., The Electrical Decomposition of Sulfur Hexafluoride, A. I. E. E. Winter Meeting, New York, N. Y.

Elmendorf, C. H., L3 Coaxial System – System Design, A. I. E. E. Winter Meeting, New York, N. Y.

Fox, A. G., Microwave Propagation on Dielectric Rods and in Ferromagnetic Media, A. I. E. E. – I. R. E. – N. B. S. Conference, Washington, D. C.

Groth, W. B., Principles of Tape to Card Conversion in the AMA System, A. I. E. E. Winter Meeting, New York, N. Y.

Heidenreich, R. D., Electron Metallography, Columbia University, New York, N. Y., American Society for Metals, Midland, Mich.

Hogan, C. L., The Ferromagnetic Faraday Effect at Microwave Frequencies and its Applications, A. I. E. E. Winter Meeting, New York, N. Y.

Hopkins, I. L., Ferry Reduction and the Activation Energy for Viscous Flow, American Chemical Society, North N. J. Section, N. J.

Hornbeck, J. A., Traps in Germanium and Silicon, and Secondary Photoconductivity in *p*-type Silicon, American Physical Society, Cambridge, Mass.

Keister, W., An Automatic Telephone Switching System of the Common Control Type, A. I. E. E. Winter Meeting, New York, N. Y.

Ketchledge, R. W., L3 Coaxial System Equalization and Regulation, A. I. E. E. Winter Meeting, New York, N. Y.

Lange, R. W., 40 to 4,000 Microwatt Power Meter, A. I. E. E. – I. R. E. – N. B. S. Conference, Washington, D. C.

Maggio, J. B., see H. E. Curtis.

Mason, W. P., Use of Barium Titanate in Measuring Forces and Wear in Telephone Apparatus, Essex County Chapter of Torch Club, N. J.

McRae, J. W., Electronics and Telephony, Society for the Security Analysis, Chicago, Ill.

Merrill, F. G., Air-Borne Magnetometer for Geophysical Surveying, Society of Professional Engineers, Raritan Valley, N. J.

Merz, W. J., Double Hysteresis Loop of $BaTiO_3$ at the Curie Point, American Physical Society, Cambridge, Mass.

Morin, F. J., and J. P. Maita, Comparison of Copper-Doped Germanium with Heat Treated Germanium, American Physical Society, Cambridge, Mass.

Morris, L. H., L3 Coaxial System Amplifier, A. I. E. E. Winter Meeting, New York, N. Y.

Morton, J. A., Recent Developments in Transistors, A. I. E. E., Cleveland, Ohio, I. R. E., Toledo, Ohio.

Mumford, W. W., A Note on the Stability of Microwave Noise Generators, A. I. E. E. – I. R. E. – N. B. S. Conference, Washington, D. C.

E. A. Nesbitt, see H. J. Williams.

Newhouse, R. C., A Systems Approach to Some Military Weapons Problems, I. R. E., Albuquerque.

Pearson, G. L., A High Impedance Field Effect Silicon Transistor, American Physical Society, Cambridge, Mass.

Peterson, G. E., The Development of Experimental Phonetics, Hunter College, New York, N. Y.

Reiss, H., Chemical Equilibria Involving Electrons as Independent Chemical Entities in Impurity Semiconductors, American Physical Society, Cambridge, Mass.

Rieke, J. W., L3 Coaxial System – Television Terminals, A. I. E. E. Winter Meeting, New York, N. Y.

Ring, D. H., A Microwave Double Detection System with Single Oscillator, A. I. E. E. – I. R. E. – N. B. S., Washington, D. C.

Schawlow, A. L., Nuclear Quadrupole Resonances in Some Bromine and Iodine Compounds, American Physical Society, Cambridge, Mass.

Sharp, W. O., Submarine Cable Tube, Methodist Church, Plainfield, N. J.

Shive, J. N., Germanium Phototransistors, A. I. E. E. Winter Meeting, New York, N. Y.

Shockley, W., see W. L. Brown.

Struthers, J. D., Peacetime Applications of Atomic Energy, Men's Club, Millington, N. J.

Valdes, L. B., Transistors, A. I. E. E. – I. R. E., New York, N. Y.

Van Uitert, L. G., The Solution Stability of Chelate Compounds, Massachusetts Institute of Technology, Cambridge, Mass.

Walker, A. C., Growing of Crystals, American Chemical Society, Newark, N. J.

Wallace, R. L., A New Transistor for High Frequency Use, A. I. E. E. – I. R. E. – N. B. S. Conference, Washington, D. C.

Wells, H. A., Mechanical Aspects of Communication Apparatus Development, University of Iowa, Iowa City, Iowa, Iowa State College, Iowa.

Williams, H. J., and E. A. Nesbitt, Magnetic Domains and Magnetic Structure of Alnico 5, University of Pennsylvania, Philadelphia, Pa.

Young, W. R., Jr., Comparison of Mobile Radio Transmission at 150, 450, 900 and 3,700 Megacycles, I. R. E., Washington, D. C.

American Physical Society Meeting

The 1953 annual meeting of the American Physical Society was held at Harvard University from January 22 to 24. A number of Laboratories scientists took part in the meeting. J. A. Hornbeck presented an invited paper entitled *Trapping of Injected Carriers in Semiconductors*, at the Semiconductors Session. At the same session, Howard Reiss gave his paper *Chemical Equilibria Involving Electrons as Independent Chemical Entities in Impurity Semiconductors;* G. L. Pearson, *A High Impedance Field-Effect Silicon Transistor;* W. L. Brown and W. Shockley, n-*type Conduction on* p-*type Germanium Surfaces;* and F. J. Morin and J. P. Maita, *Comparison of Copper-Doped Germanium with Heat-Treated Germanium.* At the Session on Nuclear Quadrupole Resonance, A. L. Shawlow presented his paper *Nuclear Quadrupole Resonances in Some Bromine and Iodine Compounds.* R. M. Bozorth presided at the Session on Ferromagnetics and Ferroelectrics at which time W. J. Merz gave his paper *Double Hysteresis Loop of* $BaTiO_3$ *at the Curie Point.*

Committee on Aeronautics

W. E. Campbell has been appointed to serve for the Calendar Year 1953 as a member of the Subcommittee on Lubrication and Wear of The Committee on Powerplants of the National Advisory Committee for Aeronautics.

Deal-Holmdel Colloquium

The fifth meeting of the Deal-Holmdel Colloquium was held at Holmdel, February 6. The speaker was Arthur C. Link, Project Manager, Radio Division of the Western Electric Company, who discussed guided missiles. Mr. Link gave a general description of guided missile systems, with particular stress on production problems, pointing out the things designers should keep in mind that would facilitate the manufacturing process.