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Error detecting and correcting codes

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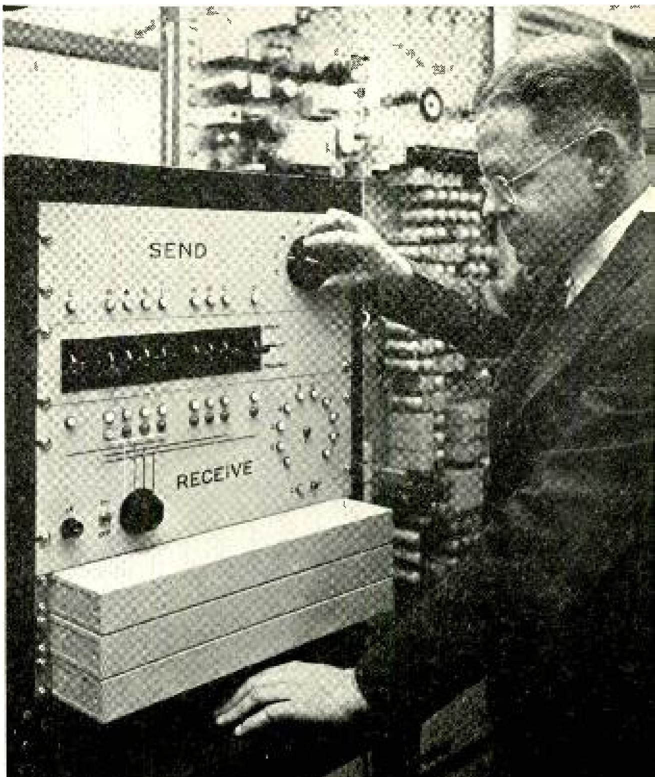
Although the telegraph was the first system to use codes for transmitting information electrically, and is still their most extensive user, other applications have assumed greater and greater importance in recent years. All common-control telephone switching systems use code for transmitting information between circuits; and electronic digital computers, which are daily coming into more extensive use, employ them exclusively, not only for transmitting information between component circuits, but in carrying out the actual computations. Moreover, some attention has always been paid to methods of detecting errors, caused perhaps by faulty contacts, by open circuits, or by disturbances induced by outside sources. The word-count at the end of a telegram is one simple method, and the two-out-of-five method employed widely in telephone switching is another and very effective way of making it impossible for the more common types of error to escape detection. The next step in these efforts to eliminate errors, is to devise methods of not only detecting but of correcting any pre-assigned number of errors that may occur.

In relay computing machines, of which a number have been designed and built by the Laboratories*, two-valued elements are generally employed. A symbol in such a code may be represented by a succession of 1's or 0's—the 1's representing the transmission of current and the 0's, no current. Such a code is particularly suited for use with relay circuits since relays may



The apparatus developed by B. D. Holbrook to demonstrate error detecting and correcting codes.

*RECORD, *October*, 1940, *page* V; *December*, 1946, *page* 457; *January*, 1947, *page* 5; *February*, 1947, *page* 49; *and May*, 1948, *page* 208.

be in either of two conditions: operated or non-operated. The former corresponds to a 1 in the code, and the latter to a 0. It is also well suited to represent electronic circuits involving flip-flops and various systems employing perforated tapes.

A convenient example of a two-valued code is the binary code. The succession of the digits 0 or 1 in a binary symbol represents a number just as the succession of the digits 0 to 9 represents a number in the decimal system in which the digits from right to left are interpreted as the coefficients of successive powers of 10, while in a binary number they are the coefficients of the successive powers of 2. The decimal number 237, for example, is interpreted as:

$$2 \times 10^2 + 3 \times 10^1 + 7 \times 10^0;$$

the binary number 1101 would be:

$$1 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0.$$

In transmitting and operating with symbols in a binary code, one may send the individual 1's and 0's one after the other *in sequence,* or all at the same time *in parallel.* The Laboratories' relay machines operate, in the main, in parallel. As far as the codes discussed here are concerned, however, there is no reason to distinguish the two types, since the methods and arguments used apply equally well to both.

With binary codes, it is very easy to detect errors by means of what is known as a parity check. Although it is not essential, the assumption that each code symbol is always made to include the same number of binary digits is not only of great convenience in exposition but represents the situation in almost all practical situations thus far contemplated. A code consisting of symbols of this type is known as a *systematic code.* If a six-digit symbol were to be employed, a symbol for the number 1 would be 000001, while the symbol for the number 53 would be 110101. To provide a parity check for such a code, the number of digits would be increased to seven; the first six digits would carry the information, and the final place would be for the parity check. Into this last place at the sending end of the circuit would be placed a 0 or a 1 to make the total number of 1's either even or odd. If the parity check digit is used to make the total number of 1's even, it is called an even parity check; for the sake of simplicity this will be the only type considered here. With an even parity check, the symbol transmitted for number 53 would be 1101010—a 0 being put in the last position since there are four, and thus an even number of 1's in the information positions.

Suppose now that due to some disturbance in the circuit, this symbol were received as 1001010—the 1 in the second position having been lost in transmission. At the receiving end, a parity check on this symbol would reveal that there should be a 1 in the last, or check, position, while a 0 is actually found there. It is evident, therefore, that the symbol has been mutilated some way in transmission. The receiving circuit would be designed to indicate the fact by giving an alarm, or ceasing to operate, or both.

Such a scheme would prevent a computer from giving most of the possible erroneous results, but if it were unattended at the time the trouble arose, it would remain idle until the operating force returned and located and corrected the trouble. If it were possible, however, for the error detecting circuit not only to detect an error but to discover its exact position, it could be corrected by replacing the digit in that position by a 1 if it were a 0 or by a 0 if it were a 1. After the correction had been made, action could be continued as though no error had occurred, and no operating time of the machine would be lost. This is what the present studies have made possible. A method has been devised of using parity checks to identify precisely the position of an error and thus allowing it to be corrected. In principle a code may be devised to correct any preassigned number of errors; in fact the correction of single errors in code symbols seems to be as far as it is economically sound to go at present. Thus only single-error correcting codes will be discussed.

There is no reason, of course, why more than one parity check cannot be used, each being applied over some of the digits of the symbol, and advantage is taken of this fact in determining the exact position of the error. The proposal is to apply a number of parity checks in a specified order at the sending end, and to put in the place reserved for each parity check a 0 when a check shows

Table I

m	n	k	R	m	n	k	R
1	3	2	3.0	7	11	4	1.57
2	5	3	2.5	8	12	4	1.50
3	6	3	2.0	9	13	4	1.44
4	7	3	1.75	10	14	4	1.40
5	9	4	1.80	11	15	4	1.36
6	10	4	1.67	12	17	5	1.42

an even number of 1's in the checked position, and a 1 when it shows an odd number. At the receiving end, the parity checks would again be applied in the same order, but over the same positions *plus* the check position, and each time these parity checks show an even number of 1's, a 0 will be recorded, while each time these checks show an odd number of 1's, a 1 will be recorded. These latter digits if written from right to left may be viewed as a binary number, which is known as the checking number. The number of checks and the positions in which the results of each check are placed are so selected that this checking number is the number of the position in the original symbol in which the error has occurred.

In order to fix ideas, let k be a number of parity checks to be used—the value of k will be determined a little later. Just as a decimal number of k digits can indicate any of 10^k values, so a binary number of k digits can indicate any of 2^k values. It is thus necessary to make k large enough so that 2^k will be great enough to indicate any of the positions of the symbol plus one value to indicate no error. Now if n is allowed to represent the total number of digits in the symbol, and k the number of positions for the parity checks, then there will remain $n - k = m$ positions for the information. Since k is to be large enough to indicate any position of the symbol plus one indication for no error, 2^k must be equal to or greater than $(n + 1)$. Since $k = n - m$, this relationship may be written as $2^{(n-m)} \geqq (n + 1)$, or, since $2^{(n-m)} = 2^n/2^m$, this readily converts to $2^n/(n + 1) \geqq 2^m$.

Whenever the number of digits in a symbol is increased to obtain parity checks, however, the efficiency of transmission is reduced, since more digits must be transmitted than are needed to convey the required information. This decrease in efficiency may be measured by the ratio, R, of the total number of digits, n, to the number, m, required to transmit the information. This ratio, $R = n/m$, is called the redundancy. In calculating the corresponding values of k, m, and n from the above expression, therefore, only the values of n and k are used that give the lowest redundancy for each value of m. The values of k, m, and n that meet this requirement are given in Table I.

Having thus determined the number of check positions that will be required for any number of information positions, it is necessary next to determine the positions over which the k parity checks should be made in order to make the checking number indicate the position in error. Assume, for example, that four parity checks are used, and that as a result of making the parity checks at the receiving end of the circuit, a four-digit checking number is available. This number will obviously be one of those listed in the left-hand column of Table II, which gives all possible four-digit binary numbers. If the four positions in the checking number are marked from right to left in the order in which they are written down as a result of the parity checks, a 1 in the first position will indicate that the first parity check has disclosed an error. Likewise a 1 in the second, third, or fourth position will indicate that the second, third, or fourth parity check has disclosed an error. The decimal numbers in the right-hand column of Table II, are the equivalents of the binary numbers opposite them, and thus represent the position of the symbol in error when the corresponding binary number was obtained as the checking number.

Table II

Binary Checking No.	*Equivalent Decimal No.*	*Binary Checking No.*	*Equivalent Decimal No.*
0000	0	1000	8
0001	1	1001	9
0010	2	1010	10
0011	3	1011	11
0100	4	1100	12
0101	5	1101	13
0110	6	1110	14
0111	7	1111	15

A comparison of the two columns of Table II will show that if the first parity check has shown an error, resulting in a 1 in the first position of the checking number, the position of the symbol in error should be odd, that is, the first, third, fifth, . . . positions. To bring this about, the first parity check must be made over these positions of the symbol. Similarly a failure of the second parity check, resulting in a 1 in the second position of the checking number, indicates an error in positions 2, 3, 6, 7, 10, 11, . . . of the symbol, and thus the second parity check must be made over these positions. In the same way it may be seen that a failure of the third parity check indicates an error in the 4th, 5th, 6th, 7th, 12th, 13th, . . . position, and a failure of the fourth parity check indicates an error in the 8th, 9th, 10th, 11th, . . . position, and thus the third and fourth parity checks should be made over these positions respectively. An equivalent analysis could be made if more than four parity checks were to be used.

Having now determined the number of parity checks required for various numbers of information positions and the positions over which the various parity checks are to be made, it remains only to decide which places of the symbol will be used for information and which for the parity checks. Since the parity digits are inserted in order at the sending end, the digit for the first parity check may be placed in any of the check positions, but that for the second should not be put in any position covered by the first parity check, and thus not in positions 1, 3, 5, 7 and so forth, since if it were, the first parity check at the receiving end could not be calculated before the second one. Similarly, that for the third should not be put in any of the positions covered by the first two parity checks, and thus should not be put in positions 1, 2, 3, 5, 6, 7 and so forth. Thus while any position may be used for the first parity check digit, only positions 2, 4, 6, 8 and so forth should be used for the second, and only 4, 8, 12 and so forth for the third. Thus when k is 3, positions 1, 2, and 4 may be used for the check digits.

It is not at all essential that this method be followed in selecting the positions to be used for the various parity checks, since the method of applying the parity check at the receiving end may be modified to accommodate other methods. The method described, however, permits the parity checks to be applied at the receiving end in exactly the same manner as at the sending end, and thus simplifies the explanation of how the system works.

All the requirements have now been established for a single-error correcting code, and an example will show how the system would work in practice. Assuming that four information positions are needed, Table I shows that three checking positions are required, giving a seven-position symbol. Assume further that the symbol 1100, the binary equivalent for the decimal number 12, is to be transmitted. Since positions 1, 2, and 4 are to be the checking positions, the information will be placed in positions 3, 5, 6, and 7. At the sending end, the first step would be to insert this binary number in the information positions of the symbol. This gives the result shown in line 2 of Table III. Performing the first parity check on the symbol as it now stands shows an even number of 1's in positions 1, 3, 5, and 7, and thus a 0 is put in position 1, the first check position, as shown in line 3 of the table. Performing the second parity check

Table III

Positions in Symbol

1	*1*	*2*	*3*	*4*	*5*	*6*	*7*	
2			1		1	0	0	
3	0		1		1	0	0	
4	0	1	1		1	0	0	
5	0	1	1	1	1	0	0	
6	0	1	1	0	1	0	0	
7	0	1	1	1	1	0	0	0
8	0	1	1	0	1	0	0	0
9	0	1	0	0	1	0	0	0

finds an odd number of 1's in positions 2, 3, 6, and 7, and thus a 1 is put into position 2, the second check position, as shown in line 4 of the table. Performing the third parity check, over positions 4, 5, 6, and 7, also finds an odd number of 1's, and thus a 1 is put into position 4, the third check position. The symbol transmitted is thus that shown in line 5.

If this symbol is received as sent, the three checks applied at the receiving end will all show no error, and thus the checking number is 000. Suppose, however, that the 1 in the fourth position were lost in transmission, and thus the number received was that shown in line 6. Performing the checks on this symbol shows no error for the first two checks and an error for the third, and thus the checking number is 100. This indicates that the fourth position is in error, and by changing the 0 in this position to a 1, the correct symbol is obtained.

It is obvious that a parity check will fail if there are two errors, since with two 1's substituted for 0's, or two 0's for 1's, or one of each type of substitution, the parity check at the receiving end would not reveal the error. The effectiveness of a parity check that will identify and correct one error thus depends on the likelihood of two or more errors in the same symbol, and this—in turn—depends on the total number of digits in the symbol. Two errors in a single symbol is ordinarily a very rare occurrence. Observations on one of the Laboratories' designed relay computers showed an average of about one relay failure per two or three million relay operations. With failures occurring so infrequently, it is obvious that the chance of two errors in the same symbol is very small, and that the chance of more than two errors is negligible. If it were possible, therefore, to devise a method that would detect and correct an error if there were only one in the symbol, and would give an alarm and stop computing if two errors occurred in the same symbol, the computer would be able to perform continuously and without attendance for long periods of time without danger of the computer's stopping because of an error.

Such a system can be provided by adding an eighth position to the symbol to be used as a parity check over the preceding seven positions. The symbol transmitted under these conditions would be that shown in line 7 of Table III. A 0 has been put in the eighth position at the sending end since the parity check over the preceding seven positions shows an even number of 1's. If this symbol is received as sent, all parity checks including the last will be satisfied, thus indicating no error.

If, as before, the 1 in the fourth position were lost in transmission, the symbol received would be that shown in line 8. Performing the four parity checks would give a checking number 1100 – the first two checks giving a 0 result and the last two a 1 result. The 1 for the fourth parity check indicates that there is an error in transmission, and the remaining three-digit checking number indicates that this has occurred in the fourth position.

Now assume that the 1's in the third and fourth positions are lost in transmission, making the received signal as shown in line 9. Performing the four parity checks on this gives 0111. The fact that the three-digit checking number shows an error while the fourth parity check does not is an indication that two errors have occurred, but no indication of their location is given.

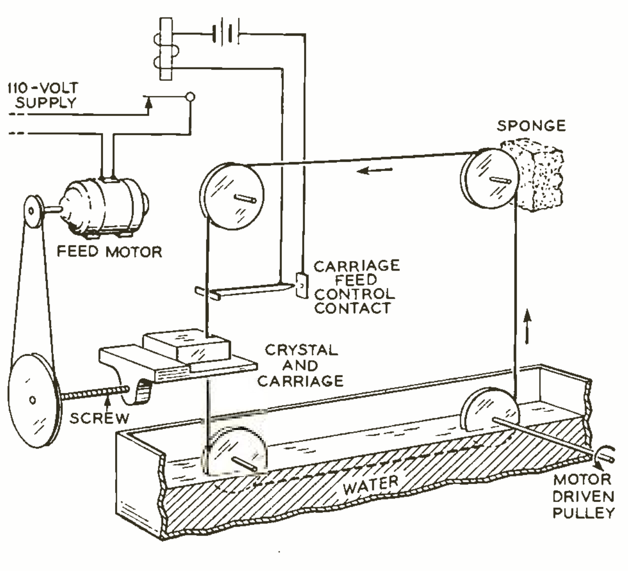
To what extent these error correcting codes will be used is primarily a matter of economics. They require an appreciable amount of additional equipment, and the efficiency of operation is lowered because of the increased redundancy arising from the increase in the number of digits used

THE AUTHOR: R. W. HAMMING received a B.S. from the University of Chicago in 1937, an M.A. from the University of Nebraska in 1939, and a Ph.D. from the University of Illinois in 1942. He became interested in the use of large scale computing machines for scientific research while at the Los Alamos Laboratories and has continued working in this field since joining the Laboratories in 1946.

for each symbol. To show how error correcting codes work, circuits for inserting the check digits at the sending end and for performing the checks and correction at the receiving end have been built by B. D. Holbrook of the Switching Research Department and have been thoroughly tested. A demonstration model has been built using circuits designed by Mr. Holbrook. In this model open wires and grounds may be put in by means of switches. A selector switch selects the type of code to be used. A number is then chosen and set up at the sending end. The parity checks are automatically calculated and inserted. At the receiving end, having gone through grounds and open wires, the number is converted back, if possible, to the correct value. A general discussion of the theory and a proof that systems as outlined above are, in a certain sense, the best possible was given in the *Bell System Technical Journal* for April, 1950. Actual field installations, however, are still in the future.

Automatic Feed for String Saws

Water soluble crystals, such as the EDT type for broadband carrier system filters, are cut with a "string saw" in which a wet string is drawn continuously across the crystal. As illustrated herewith, a tightly stretched, endless string passes over four pulleys, one of which is driven by a motor. The string's speed is about 100 feet per minute. The lower part of the string passes through water, most of which is removed by the sponge. Pressed against the string by a motor driven feed, the crystal is accurately dissolved along its line of contact with the string.



To speed cutting, the crystal is fed against the string as fast as practicable. But if the crystal is fed too fast, the string may be appreciably bent, and then tend to move sideways and make an uneven cut. The optimum rate of feed depends on the kind of crystal and its thickness. To obtain maximum cutting speed and eliminate human error, the saw was made self-adjusting through a method suggested by W. L. Bond.

As shown at left of figure, the string moves past a lever which operates an electrical contact. When the string is bent excessively, it moves the lever, closing the contact; battery current then flows through a relay causing it to open the feed drive motor circuit. Where the two pulleys nearest the crystal are a foot apart, the contact lever is usually set to operate for a maximum string deflection of 1/32 of an inch. The feed drive motor operates intermittently so that this deflection is not exceeded. When the manufacture of EDT crystals was undertaken, this principle was applied to a "gang-string" saw in which a number of parallel strings slice the crystal into several wafers at once. A single bar contact placed back of the strings insures that excessive deflection in a single string stops the feed motor until this string has caught up with the others.

T. V. CURLEY
Switching Development

Operator connections in No. 5 crossbar

Calls from subscribers in a No. 5 crossbar office to other subscribers in the same office, and for the most part other subscribers in other offices in the immediate area, are completed mechanically under control of the subscriber's dial. Although these mechanically completed calls constitute most of the traffic originating in the office, there are many occasions when a dial subscriber requires the assistance of an operator to complete a call, and a considerable number of trunk equipments are needed to serve these operator-assistance calls.

Operator's assistance is sometimes required to complete calls to manual offices, and also, at the present time, to complete long distance calls. Even though all offices were of the dial type, however, and even should subscriber dialing for toll calls become universal, there still would be occasions when an operator's assistance was needed. Such conditions as the provision of telephones for the blind often make it necessary to furnish manual service even in dial offices. Certain types of emergency calls also require access to an operator.

For all such outgoing operator calls in crossbar or panel areas, either a recording-completing or a special-service trunk will be used when the subscriber dials 211 or 0.* With previous types of offices, two different types of trunks were generally used, but for the No. 5 office a single circuit has been designed that is used as either a recording-completing or a special-service trunk—the former terminating in a toll position and the latter in a DSA position. It is common practice to combine the DSA and toll boards, and thus dialing either 0 or 211 may reach the same switchboard, but in considering the handling of the calls this fact may be ignored.

For originating calls of any type in a No. 5 crossbar office, a marker is connected to the line by the lifting of the handset, and in turn connects an originating register to receive the number to be dialed. The marker then releases. After recording the digits, the register calls in a marker to establish a connection between the subscriber's line and a suitable trunk, as determined from the code dialed. So far, the operation is the same for all types of dial calls; the difference is in the type of trunk the marker connects to the line. If the code dialed were 211 or 0, either a recording-completing or a special-service trunk will be connected. On calls from manual lines, where the subscriber does not dial, the steps taken are essentially the same except that the marker, when called in by the lifting of the handset, recognizes that a manual line is calling and indicates this fact to the register it selects. The register, in turn, after seizing a marker to complete the connection to the trunk, will indicate to the marker that a DSA operator is required.

Besides making provisions to enable a subscriber in a No. 5 crossbar office to reach an operator, there must be provisions for operators at DSA or toll boards to reach a subscriber in a No. 5 office. Incoming operator-assistance trunks will thus be required as well as the outgoing trunks.

Both outgoing and incoming trunks between a No. 5 crossbar office and toll and DSA operator positions are of several types, as indicated diagrammatically in Figure 1. Outgoing trunks may be for use with coin or non-coin lines, and in either of these forms they may or may not be arranged to give a class-of-service signal to the operator. This class-of-service signal is used to identify a particular class of subscriber when an out-

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*In areas predominantly step-by-step, codes of the type 11X are commonly used.

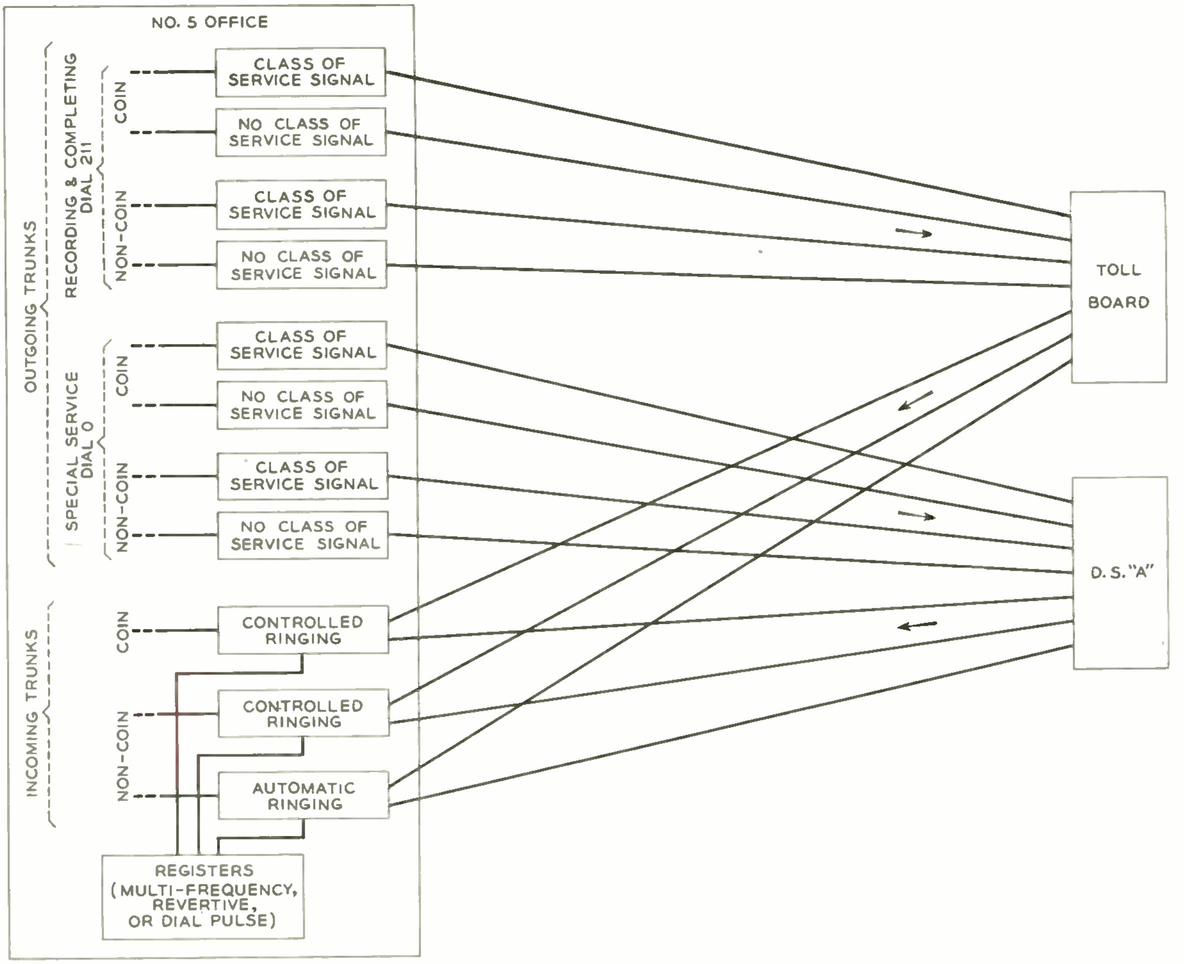


Fig. 1—In each of the three major classes of operator-assistance trunks—recording-completing, special-service, and incoming—there are subgroups for coin and noncoin lines which are further subdivided depending on the type of ringing provided and on whether or not a class-of-service signal is used.

going group of trunks serves two or more classes of subscriber service. With non-coin trunks, the class-of-service signal is used to indicate that the call is from a manual line, such as is provided for an incapacitated subscriber, while with coin trunks it may indicate that the call is from a manual coin-box line.

All of the outgoing trunks of the above type include provisions for ring-back. They differ in this respect from outgoing trunks to dial offices since the operator may need to recall the subscriber before the call is terminated. With coin trunks, continuous ringing voltage may be applied across the line under control of the operator whether or not the subscriber has hung up. With non-coin lines, two types of ringing are provided. One, used principally for PBX trunks, rings under off-hook conditions, since even though the subscriber has hung up, the trunk will be in the off-hook condition as long as the PBX operator is plugged into it. The other type, used primarily in emergencies, applies all ringing voltages to the line successively regardless of whether the line is in the on-hook or off-hook condition. This latter type of ringing and its purpose have already been described in the RECORD.*

There are also several types of incoming trunks used for operator-assistance calls. They differ in their ringing provisions and also in being arranged for coin or non-coin

*RECORD, *March*, 1941, *page* 206.

traffic. Coin incoming trunks are not arranged for automatic ringing, but only for controlled ringing. After the trunk is seized and a marker has subsequently established a connection to the called line, the marker sets up the proper ringing conditions.† Ringing will not be applied, however, until the ringing key at the switchboard is operated. This permits the operator to seize and hold the line at once, but not to ring until she is ready to bring the subscriber into the connection.

Non-coin incoming trunks may be arranged for either controlled or automatic ringing. With the latter type of ringing, the subscriber line is rung as soon as it is seized, and after the subscriber answers, the ringing switch is disconnected and is not available for further use. With controlled ringing, for both coin and non-coin trunks, the ringing switch remains connected with the trunk until final disconnection, and may be reused under control of the operator. All of these incoming trunks may be connected to any of the three types of registers: multifrequency, revertive, or dial pulse.

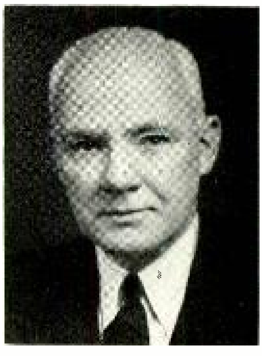
In the trunk diagram of Figure 1, only certain of the features that differentiate the various types of trunks are indicated. In addition to these features, all of the coin trunks—either outgoing or incoming—have provision for collecting and returning coins. For outgoing trunks this is obviously necessary, but it is also needed sometimes with incoming trunks, such, for example, as when the charge is to revert to the called subscriber. The return of the original coin used to reach the operator is under control of the originating register, and the coin is returned automatically on calls dialing 0 or 211. Subsequent return or collection of the coin, however, is done by the trunk under control of the operator.

In addition to the differences mentioned above, operator-assistance trunks are available in two forms commonly referred to as two-wire and three-wire trunks. The latter form is used when the switchboard is in the same building as the No. 5 office, and the former when it is in a distant building. With the switchboard in the same building, three wires—tip, ring, and sleeve—are carried from the trunk circuit to the switchboard, and the third or sleeve lead provides an extra path for supervisory signals and for holding switches and relays operated. Circuits to distant offices, however, have only two wires—tip and ring conductors—and thus the trunk circuits used at both ends of the circuit must have additional relays and other elements to substitute for the third conductor. Two-wire trunks are thus somewhat larger and more expensive than three-wire trunks.

Operator-assistance trunks are used in considerable quantity; a 10,000 line office will usually have more than 100 of them. The quantity varies over a wide range, depending upon the percentage of the traffic that is not handled on a full-mechanical basis.

†Record, *April*, 1941, *page* 170.

THE AUTHOR: T. V. Curley has, during the past thirty years, been chiefly engaged in the development and design of recording-completing and toll switching facilities between toll and "A" switchboards, and manual, step-by-step, panel and crossbar local systems. His work also included the development of coin control, number checking, and toll diversion arrangements between the toll switchboards and the various local systems. He has just completed the development of these same facilities between the No. 3C and No. 3CF toll switchboards and the No. 5 crossbar system, and is at present engaged in the modernization of the local test desk facilities. During the war he was associated with the development of power rectifiers and voltage regulators for the Signal Corps, and prepared the training and maintenance manual on the power equipment of the M9 director. Mr. Curley is a graduate of New York University with the degree of Bachelor of Science in Electrical Engineering.



A new duct-type bay for toll transmission equipment

P. T. HAURY
Transmission Systems Development

Until the advent of the K carrier system, the segregation and shielding of high and low level leads, while at times necessary, had not assumed such a high degree of importance. The framework of a bay of transmission equipment served merely to support the apparatus and wiring much as the human skeleton supports the organs of the body and their connecting arteries and veins. This simile may be extended by letting the heart represent the amplifier, the veins represent the wires carrying input, or low level, currents in need of rejuvenation, and the arteries represent the output, or high level, currents that have been rejuvenated. With these earlier frameworks, the veins and arteries were usually more or less interlaced and run on the outside of the framework, so that segregation of the two was difficult. Suppose now that with this type of structure, some change brought about a condition akin to osmosis, that would permit part of the blood to pass directly from the arteries to the veins without circulating through the body. Complications would arise that would vitiate the normal functioning of the body. Such were the complications foreseen for K carrier amplifier equipments where, because of the higher frequencies and larger differences between input and output levels, the currents in the output leads would induce their counterpart in the input leads.

The author lowering a panel on a double-sided frame to obtain access to the wiring.

It was to meet this situation that the duct type bay* was developed. With this type of bay, the wires are placed within the supporting structure itself. The bay uprights are in the form of ducts, and the low level leads are carried in the duct at one side of the bay, and the high level leads in the duct on the other side. The bay uprights are so designed that when two duct type bays are placed adjacent and joined by appropriate details, a duct is formed at the junction that has two sections electrically shielded from each other. A cross section of this original duct type bay is shown in Figure 1.

Since the close of the war, the telephone companies have been called on for a very rapid expansion of the telephone plant and of telephone service. Coincident with this demand came the still prevalent high cost of building to provide floor space for additional equipment. Means had to be found for conserving existing available floor space by installing more equipment in a given area. Two schemes, adaptable to different types of equipment, were standardized to do this. The first of these was to locate the bays back-to-back in the lineups, leaving only the wiring side of the bays open for maintenance. Such an arrangement is used for equipment that requires access to the apparatus side only for replacement purposes, routine maintenance predominating on the wiring side. This back-to-back arrangement was planned for in the original design of much of the carrier equipment, but its application was withheld pending collection

*Record, *January*, 1950, *page* 22.

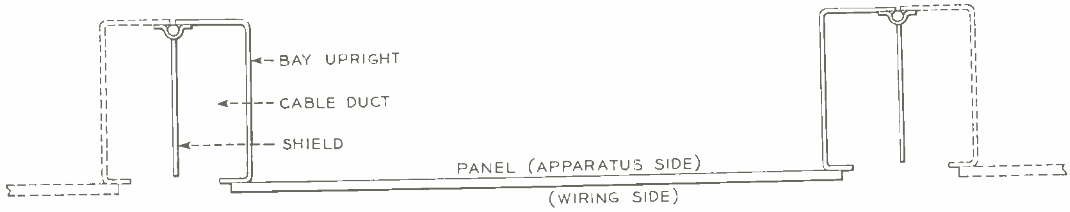


Fig. 1—Cross section of the original duct type bay.

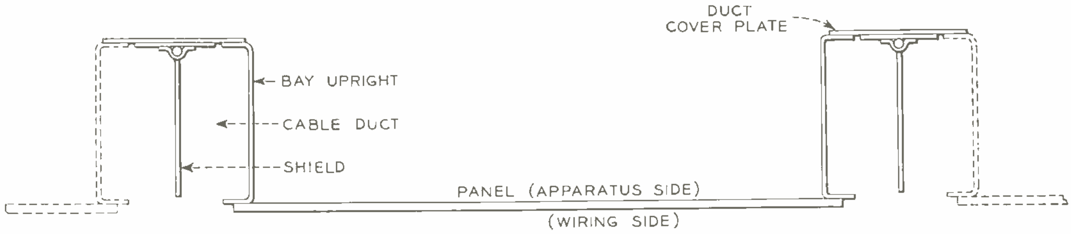


Fig. 2—Cross section of the new duct type bay arranged for single-sided mounting.

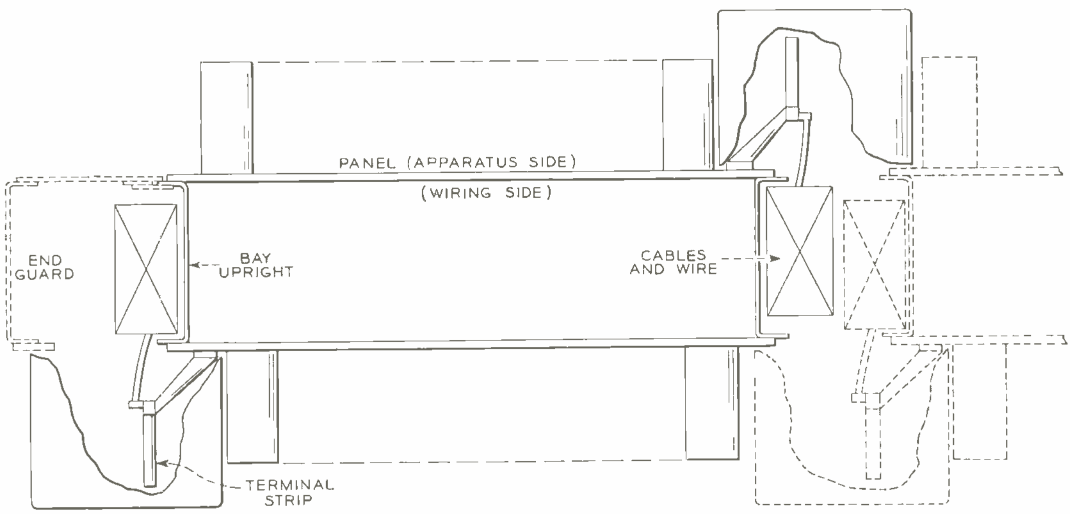


Fig. 3—Cross section of the new duct type bay arranged for double-sided mounting.

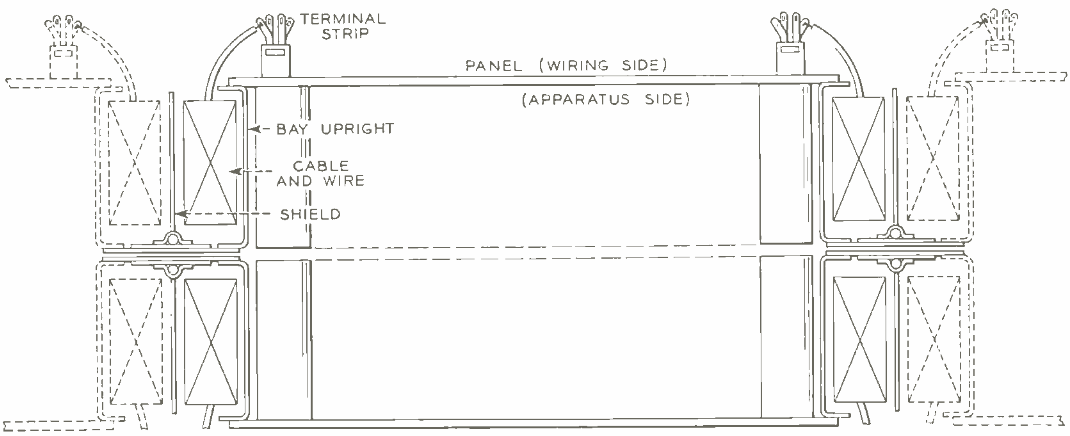


Fig. 4—Cross section of the new duct type bay arranged for back-to-back mounting.

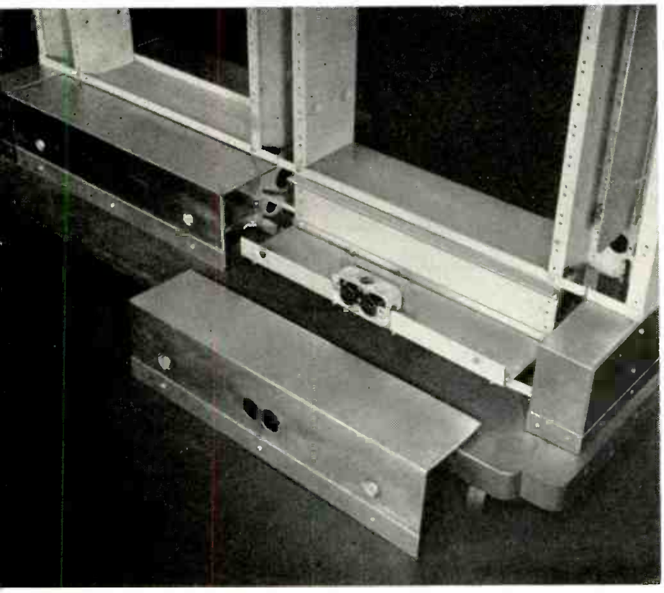


Fig. 5—Details at the base of one of the new duct type bays.

of trouble incidence data for the apparatus located on the blind side of equipment. Experience has shown this trouble rate is of the order of 0.20 trouble per bay per year, and thus the slight inconvenience in maintaining equipment on the blind side of bays located back-to-back could be easily justified.

The second scheme for conserving floor space was to mount the equipment on both sides of the frames with the apparatus side exposed for maintenance. This double-sided mounting is intended for relay equipment or other panels on which routine maintenance work is predominantly on the apparatus, and need for access to wiring arises only for wiring repairs. Actually it is expected that the trouble rate on the wiring of panels mounted on a double-sided basis will be reduced by virtue of the protection afforded the wiring side of the panels.

The original duct type bay, although it could be used back-to-back, did not lend itself to double-sided mounting because the uprights, as may be seen in Figure 1, had one wide and one narrow flange, and the wide flange blocked access to the cable duct from its side of the bay. A differently designed frame would thus be necessary for double-sided mounting. To avoid having two types of frames, one for single-sided or back-to-back mounting and one for double-sided mounting, a new framework was designed that can be used for any of the three mounting arrangements. This new design has bay uprights with equal narrow flanges, and has removable guard rails that may be attached to either or both sides as desired. Cover plates are provided for closing one side of the ducts on bays used for either single-side or back-to-back mounting. It is thus possible to discontinue manufacture of the original duct type bay and produce only the newer and more flexible design. A cross section of this new frame is shown for single-sided mounting in Figure 2 and for double-sided mounting in Figure 3. The back-to-back arrangement of the new bay is shown in Figure 4.

A number of niceties have been incorporated in the new design. Briefly these comprise utilization of space under the guard

Fig. 6—Method of gaining access to apparatus when back-to-back mounting is employed.

rails as a wiring trough, fabrication of the guard rails from stainless steel to reduce maintenance expense of touch-up painting, and provision of drop plates with each guard rail section that can be adjusted to meet the floor and keep out dust. Figure 5 shows the details of the base construction of the new design. The bay to the left has guard rails attached to both sides as required for the double-sided arrangement while the bay to the right has a guard rail on the near side only as required for single-side or back-to-back mounting.

When the back-to-back or double-sided arrangements are used, either the apparatus or wiring is normally inaccessible. The obvious way to gain access to the hidden panel surfaces is to dismount the panels from the bay framework. Such a procedure, however, is time consuming and may be hazardous for personnel; in some cases it may endanger the operation of circuits in nearby panels. Therefore, despite the low trouble rate, the design of tools for maintenance of these panels was undertaken. Two designs were provided; one for panels on bays located back-to-back, the use of which is illustrated in Figure 6, and another for panels mounted on a double-sided basis illustrated in Figure 7. In both cases, the brackets are attached to the bay only when a panel is to be serviced, the brackets being stored when not in use. In using either set of brackets the panel can be slid away from the bay on supporting rods inserted through regular panel mounting holes so that there is no danger of dropping the panel. The importance of this factor is pointed up when it is considered that the maintenance man may be working from a ladder and servicing a panel about eleven feet above the floor. Cabling to the panels must be arranged so that there is sufficient slack to permit sliding the panels to the limit without disconnecting the wiring.

Besides retaining all the advantages of a duct type bay in separating the high-level from the low-level leads, this new design offers a number of other advantages. One basic bay can be used for single-sided, double-sided, or back-to-back mounting of equipment. Guard rails of different depths can be attached depending on the application for which the bay is used. Where the equipment can be adapted for back-to-back or double-sided mounting, the new design permits a considerable saving in floor space. This saving is of the order of 30 per cent for equipment mounted back-to-back and 40 per cent for equipment mounted double-sided. Maintenance brackets are available which permit servicing panels mounted back-to-back or double-sided without hazard to personnel or to other operating circuits.

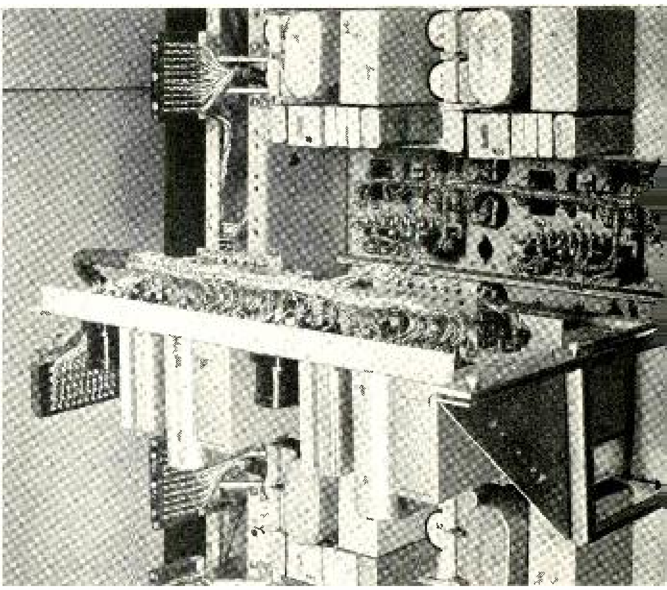
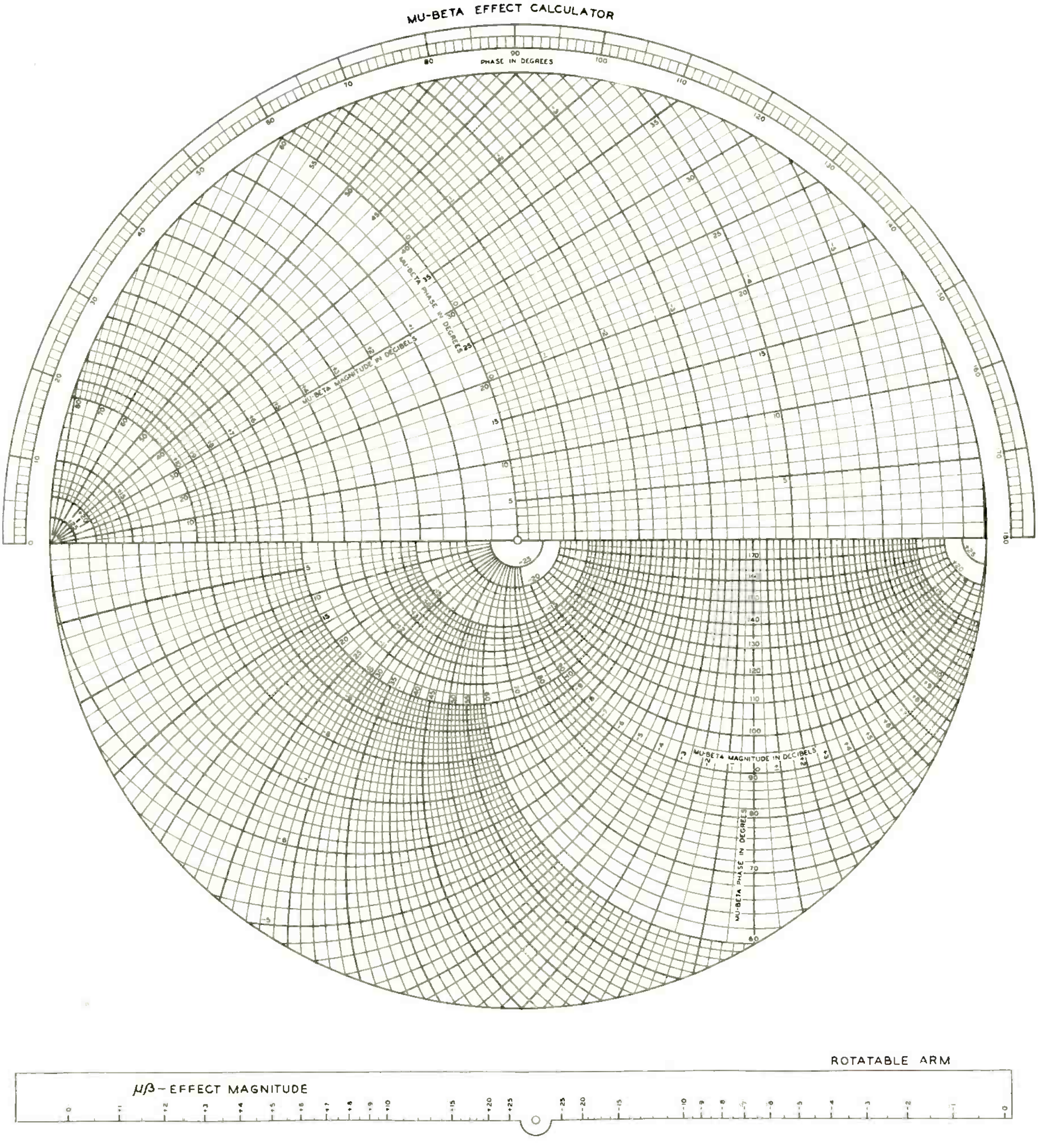


Fig. 7—Method of gaining access to wiring of double-sided frames.

THE AUTHOR: P. T. Haury graduated summa cum laude with B.E. degree in Electrical Engineering from Vanderbilt University in 1941, and after one year on fellowship at Rutgers University, he joined the Laboratories in June of 1942. His first work, with the trial engineering group, was the preparation of models of wartime radar designs. From early 1943 to early 1946, he engaged in equipment design of radar units. He then undertook equipment development work on the K and L carrier telephone systems. Recently he has transferred to development work on carrier systems for open-wire lines.

Mu-beta effect chart for feedback



The mathematical basis of feedback is well understood; yet when the engineer is confronted with making a series of calculations to check a design, he sometimes proceeds with sureness of theory but uncertainty of arithmetic. The accompanying chart was constructed by J. H. Felker to be used as the face of a calculator that would eliminate arithmetic from feedback calculations. The complex algebra of feedback is built into the chart in such a way that the user can set in Mu-Beta and read out the

Mu-Beta effect with about the same ease that he reads a simple product from a conventional slide rule.

It will be noticed that the top and bottom halves of the chart contain different families of curves. If the curves in the top half had been extended to cover all the regions of interest, the chart would have grown to about ten feet in diameter. By performing a simple mathematical transformation, it was possible to take all the points that would appear outside the top semicircle and transform them into the small semicircle at the bottom of the chart. This mathematical dodge confines all points from zero to infinity to a sheet of paper of convenient size.

This chart is described in detail in the *Proceedings of the Institute of Radio Engineers* for October, 1949, and is available from the library as monograph No. 1706—*Calculator and Chart for Feedback Problems.* A vinylite calculator based on the chart can be purchased from Graphimatics, Kirkwood, Missouri.

EXTENSION FLASHLIGHT

Now available to the Bell System is an extension flashlight, here shown in use by W. J. Brennan, telephone repairman at West Street. The extension light may be clamped to the user's clothing, or to any convenient structure. Its 3½ foot cord ends in a plug, which is inserted in a socket in the top of the main flashlight.

The extension light gives a flood beam, while the accompanying flashlight furnishes a spotlight. A flashlight without the extension feature may be had with either a spotlight for illumination of work some distance from the light source, or with a flood beam for close work.

Early development of the extension, as a modification of an outside supplier's standard flashlight, was carried on by W. T. Pritchard, and after his retirement by H. C. Rubly, both of Outside Plant Development.

The extension flashlight, above right, draws its power from the two-cell battery of a standard flashlight equipped with a suitable socket.

George Brennan, below right, New York Telephone repairman at West Street, shows how the new extension flashlight can be used.

A tuned plate multivibrator

A. E. JOHANSON
Transmission Research

The exponential decay of the voltage on a condenser discharging through a resistance has long been used as a stop-watch to measure time intervals beginning at the start of the discharge. Many types of multivibrators* employ such "interval timers" in their operation. At very high frequencies, however, precise timing becomes difficult with a simple R-C discharge circuit, and in recent years inductances have been associated with the circuit to enhance the timing accuracy. The radar range unit† and the PCM decoder‡ are examples of this use of inductance with R-C circuits. Pulse durations as small as 0.4 μs were required for the latter system.

In recent experimental studies of time division multiplex systems employing pulse modulation, however, frequencies were required of over 18 mc and pulse durations as short as 0.02 μs—an interval so short that light—which would circle the earth more than seven times in a second—travels less than 20 feet. At these frequencies and pulse durations, inherent limitations of the frequency range of a typical multivibrator circuit restrict its use. It has been generally necessary, therefore, to employ a new type of multivibrator that has a capacitance, an inductance, and a rectifier of the varistor type in its plate circuit.

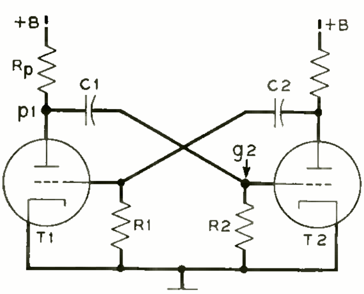


Fig. 1 — Typical arrangement of a multivibrator circuit.

Why the ordinary multivibrator circuit becomes unsatisfactory at such high frequencies will become apparent on a brief analysis of the action of the circuit shown in Figure 1. In this circuit the frequency of oscillation is inversely proportional to the sum of the time constants R1C2 and R2C1, and is also dependent on the tube characteristics, the electrode voltages, and other remaining circuit constants. At higher frequencies, where very small time constants are required, difficulty is encountered in obtaining sufficient amplification to enable the drop in voltage transferred from the plate of one tube to the grid of the other to drive the grid below cutoff.

Suppose, for example, that in order to make R1C2 and R2C1 small enough to produce the desired oscillation frequency, C1 and C2 are each equal to the effective grid-to-cathode capacitance of the tube used. Then only half the voltage developed at the plate of one tube is transmitted to the opposite grid, and twice as much amplification is necessary for multivibrator action at the proper frequency. Unfortunately at oscillation frequencies where the coupling capacitance is necessarily as small as the tube capacitance, a high voltage drop at the plate is difficult to achieve. This difficulty has now been overcome by replacing the plate resistance load of the multivibrator tubes of Figure 1 by a parallel combination of an inductance, a capacitance, and a varistor rectifier as shown in Figure 2. The resulting circuit, although bearing a superficial resemblance to Figure 1 is quite different in performance. Here the frequency of oscillation is determined primarily by the resonance of inductance and capacitance in the plate circuits of the two tubes, hence the name tuned plate multivibrator.

When the grid voltage of a tube having a

*Record, *September*, 1943, *page* 19.
†Record, *June*, 1947, *page* 234.
‡Record, *November*, 1948, *page* 455.

capacitance and inductance in parallel in its plate circuit becomes high enough to cause current to flow, the circuit will start to oscillate at its resonant frequency—current in the external circuit starting from zero along the negative lobe of the resonant cycle. At resonance frequency, the impedance of a parallel circuit of inductance and capacitance is high, and thus the amplitude of the voltage wave is large. Since the coupling and grid leak resistances of Figure 2 play no part in determining the frequency of oscillation,

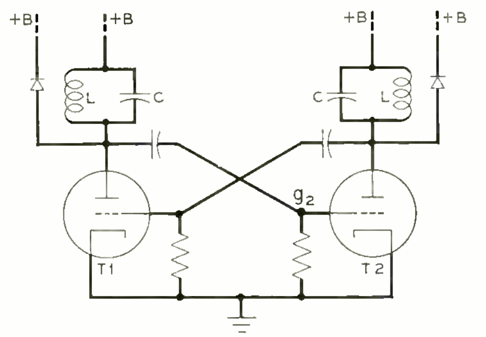


Fig. 2—Typical arrangement of a tuned plate multivibrator.

they may both be large, thus permitting the large negative voltage developed at the plate to be transferred to the opposite grid with negligible change in either amplitude or shape. Moreover, the timing becomes much more precise.

Assume, for example, that T2 of Figure 1 is conducting and that T1 is not because its grid is below the cutoff voltage. Capacitor C1 will thus be fully charged to voltage B. If the grid voltage of T1 is now raised above cutoff—by means that need not be considered for the moment—T1 will suddenly start to conduct. The resulting current through R_p will instantly drop the voltage at p_1 to some small voltage v_0 equal to the drop across the tube. The terminal of capacitor C1 that had been at potential B will suddenly be lowered by the amount $B—v_0$, and since the voltage across the capacitor cannot change until the charge changes, which requires time, the potential at the other terminal of C1, which had been zero, will drop to $-(B—v_0)$. Since this is well below the cutoff voltage, T2 will at once cease to conduct. At the same instant, C1 will start to discharge, and as it does so the voltage at g_2 will rise toward zero following the exponential curve at the left of Figure 3. When it reaches the cutoff voltage, T2 will start to conduct. This cuts off T1 just as the starting of T1 had cut off T2.

The half period for such a circuit would be from the point t_1 of Figure 3, where tube T2 starts to conduct, to the following corresponding point where tube T1 again starts to conduct. It will be noticed, however, that at these instants, the voltage on the grid is rising slowly, and thus any slight variations in the voltage will make a relatively large change in time. The precision to which the frequency can be held is limited by this fact.

With the circuit of Figure 2, on the other hand, the voltage at g_2 after T1 has started to conduct is as shown at the right of Figure 3. Instead of dropping suddenly and then rising exponentially as in the left-hand diagram, the voltage follows the negative lobe of a steep sine wave. Thus, T2, will be cut off almost instantly and will remain cut off until the voltage again reaches the cutoff value on the rising side of the wave. At this point, however, the curve is very steep, and thus a comparatively large change in the amplitude of the wave will have a comparatively small effect on the time at which cutoff occurs. The timing is thus relatively free from changes caused by variations in tube characteristics or electrode voltages. This is in contrast to the circuit of Figure 1 where transfer is effected at a time which depends greatly on such factors as tube characteristics and electrode voltages.

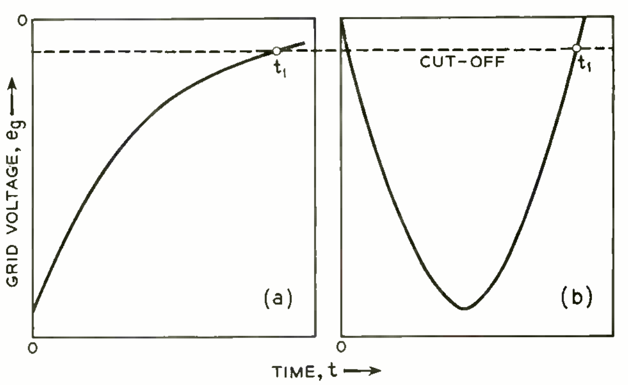


Fig. 3—Plot of voltage at g_2 against time: at the left for the circuit of Fig. 1, and at the right for that of Fig. 2.

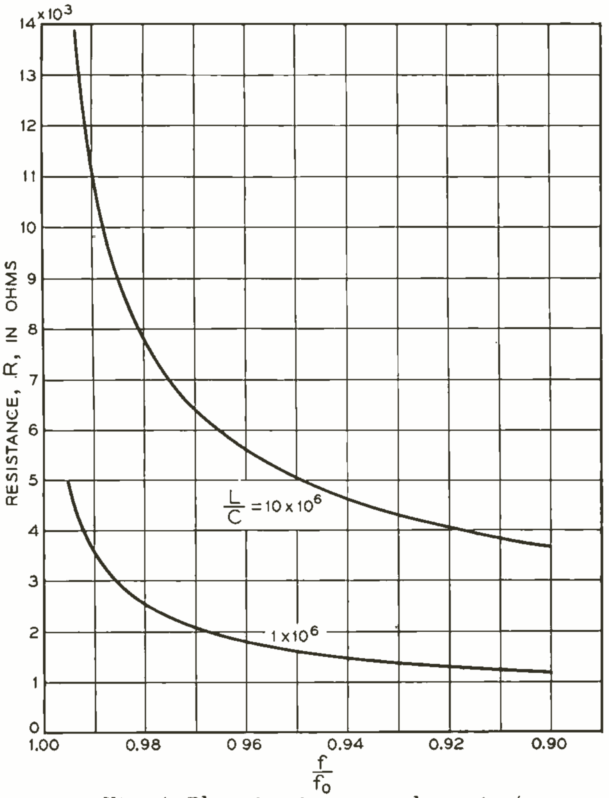


Fig. 4—Plot of R *for two values of* L/C.

ure 4. It is apparent here that if R is sufficiently high, the oscillation frequency is relatively independent of R, and is very nearly the resonant frequency of the tuned circuit.

Since R includes the resistance of the varistor, it is not constant. It will be very small when the cathode of the varistor is at a lower potential than its anode and very large when it is at a higher potential. The necessary condition for oscillation is satisfied when both the tube plate resistance and the varistor resistance are high. This occurs each time the tube starts to conduct. At the end of the half cycle oscillation, however, when the voltage of the plate starts to rise above +B, the varistor impedance becomes low, making R less than $\sqrt{L/4C}$, thus placing the circuit in the nonoscillatory condition. Oscillation thus takes place only over the negative half cycle.

This change from the oscillatory to the nonoscillatory state occurs at the time the current in the inductance, and hence its stored energy, is at a maximum value. Before another oscillation can start, a large portion of this stored energy must be dissipated.

The oscillating frequency of the plate circuit of Figure 2 is given by the expression:

$$f = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{1}{4C^2R^2}} \qquad (1)$$

where R is the parallel combination of the tube plate resistance and the resistance of the rectifier. Included in C are the tube and wiring capacitances, while the resistance of coil L is neglected. Oscillation will occur only when R is greater than $\sqrt{L/4C}$. If equation (1) is divided by the resonant frequency of the tuned circuit f_0, where

$$f_0 = \frac{1}{2\pi\sqrt{LC}},$$

the resulting equation becomes:

$$f/f_0 = \sqrt{1 - \frac{L}{C} \cdot \frac{1}{4R^2}} \qquad (2).$$

Plotting R versus f/f_0 for different values of L/C yields curves similar to those of Fig-

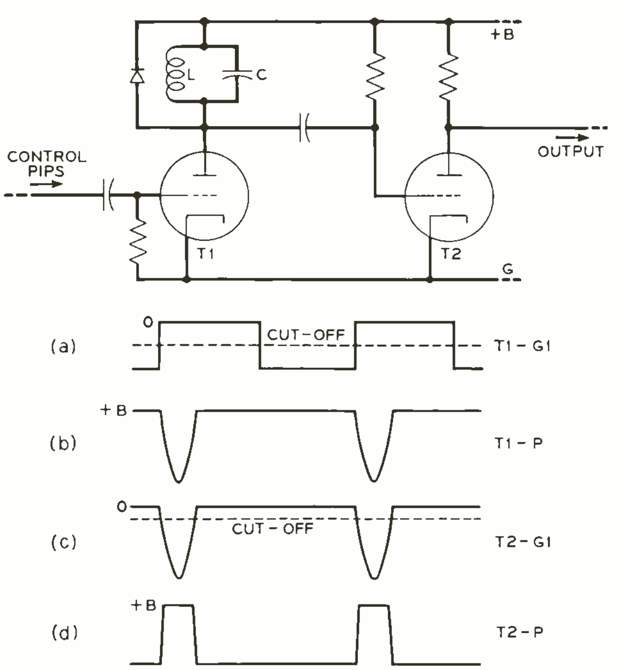


Fig. 5—A basic tuned plate multivibrator circuit, above, and operating voltage graphs, below.

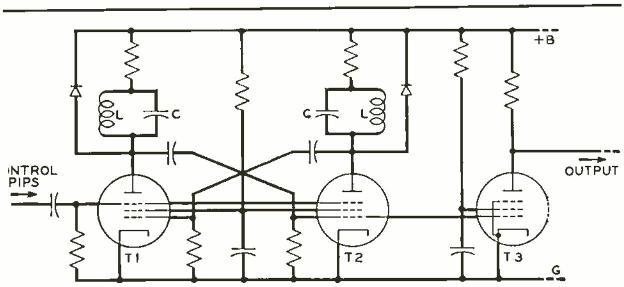


Fig. 6—A tuned plate multivibrator circuit as used to secure frequency division at high frequencies.

Since dissipation takes place in the resistance R over a period of time proportional to L/R, it may be necessary at high repetition rates to accelerate the dissipation of energy by the addition of resistance to the discharge path.

The basic circuit of the multivibrator of Figure 2 consists of a single tube with a tuned plate load. It produces a negative pulse each time the tube is driven from non-conduction to full conduction by a steep wave front. It may thus be used for providing a sequence of short flat-topped pulses by the addition of a tube that inverts the polarity of the pulse and clips off its rounded top. The operation of the circuit, shown in the upper part of Figure 5, is as indicated in the lower part of the diagram. The input to the grid of T1 is a square wave—shown on line (a)—of sufficient amplitude to swing T1 from below cutoff to zero grid. The steep rise in this wave starts the oscillation which lasts for just a half cycle of the sine wave as shown in line (b). This voltage is transferred to the grid of T2 as shown in line (c), thus stopping conduction of T2 for the duration of the pulse and resulting in an output from T2 as shown in line (d). The length of the "on" time of the input square wave is not critical, and may be of longer duration than the output pulse. This is different from the usual single-trip multivibrator where the duration of the tripping pulse is short compared to that of the output. Pulses of very short duration as well as longer ones may be generated in this manner. Using 6AK5 tubes for T1 and T2, an inductance of about 5μH for L, and using tube and wiring capacitances for C, a pulse estimated at 0.02 μs in duration was produced at either 8 or 576 kc.

The spectral analysis of the sequence of pulses of line (b), when the resonant frequency of the tuned plate is high compared to the repetition frequency and is a multiple thereof, shows a fairly even distribution of harmonics of the lower frequency over a wide range. Thus the basic circuit in itself is a very useful harmonic generator which requires no special tuning or shaping of the input wave.

A further modification of the basic circuit results in a multivibrator type circuit very useful in frequency division at high frequencies. This is shown in Figure 6 with explanatory wave form diagrams on Figure 7. It consists of two of the basic circuits cross-connected in typical multivibrator fashion. Pentodes are shown here, instead of triodes, with negative control pips applied to both suppressor grids. A small resistance is added in series with the tuned circuit to provide a load impedance for the control pips and to accelerate the dissipation of energy stored in the inductance. Since the frequency of operation is not determined by the R-C time constant, both the coupling condensers and grid leak resistors may be as large as practical, limited by other considerations such as stray capacity to ground, grid leak bias,

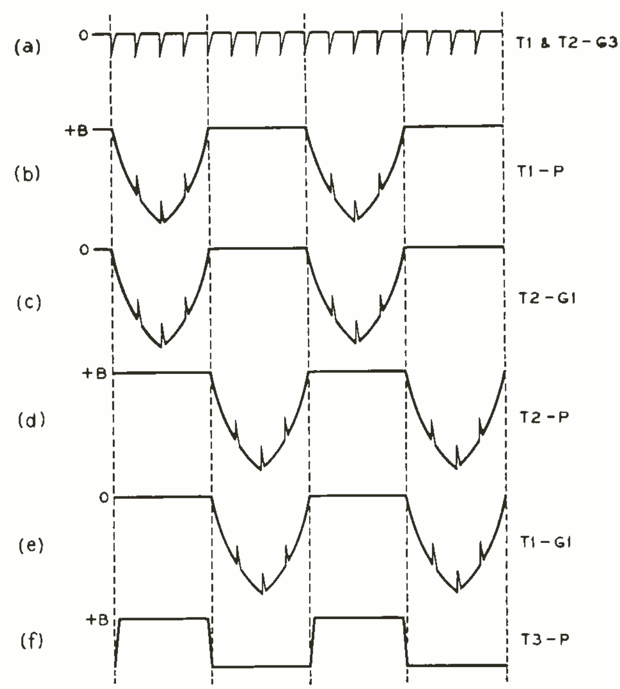


Fig. 7—Operating voltage graphs for circuit of Fig. 6.

THE AUTHOR: A. E. JOHANSON joined the Laboratories after graduating from high school in 1929. Beginning as a messenger, he progressed to Technical Assistant and finally to Member of the Technical Staff. He received the degree of B.E.E. from New York University in 1944. As a member of the Transmission Research Department, his work is primarily on multiplex pulse modulation systems. During the war he was concerned with the development of non-linear coils for radar applications.

and the like. The output may be taken from either plate or grid, but is shown as being taken from one grid through T3.

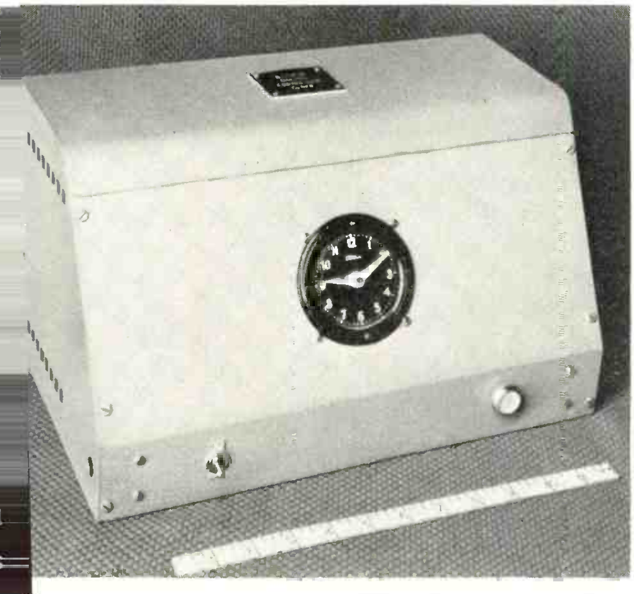
Wave forms are shown for an 8 to 1 stepdown. Line (a), Figure 7, shows sharp negative control pips applied to both suppressor grids. Assume at the beginning of operations T1 is cut off and T2 is conducting. In this condition negative pips on the suppressor grid of T1 have no effect, but the first negative pip on the suppressor of T2 will cut off T2 causing its plate voltage to rise suddenly. This rise is transferred to the grid of T1 causing it to conduct. Then as was previously shown, the voltage at the plate of T1 line b) will begin to describe a sine wave of frequency determined approximately by LC. This voltage is transferred to the grid of T2 holding it in the cutoff condition. Each time a negative pip appears on the suppressor grid of T1 a positive pip is produced across the small resistor in series with the tuned circuit in the plate of T1, and hence is added to the sine wave being transferred to the grid of T2. These pips are ineffective until the sum of the sine wave voltage and pip voltage on the grid of T2, enters the conducting region of T2. The fifth pip then causes T2 to switch on, and by multivibrator action T1 goes off. The plate voltage of T1 trying to go above +B is restrained by the varistor and held at +B. The process thus repeats with T1 and T2 changing roles at every fourth pip on the suppressor, thus giving an 8 to 1 stepdown. This method was used in the laboratory in stepping down from 18.432 mc to 8 kc in the following steps: 8 to 1 from 18.432 mc to 2.304 mc, 4 to 1 from 2.304 mc to 576 kc, 6 to 1 from 576 kc to 96 kc, and 12 to 1 from 96 kc to 8 kc.

This Month's Cover

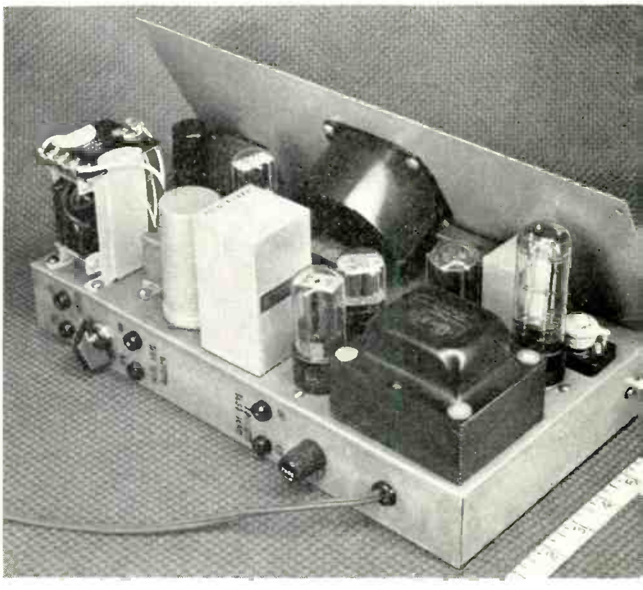
With the equipment shown on the front cover, Bell Telephone Laboratories engineers can determine, in less than one working day, what happens to a telephone handset during an average four years of customer usage. Simulating the user's "hanging up" action, the machine drops the handsets once each second until 22,000 drops have been made. Main object of the test is to study the effects of usage on the tiny carbon granules contained in the transmitter. It has also been applied to determine durability of finishes.

Crystal-controlled clock

Accurate time at sea is necessary in the calculation of a ship's position by nautical astronomy, and since their invention in the eighteenth century, compensated mechanical clocks of high accuracy, called chronometers, have been an important and carefully guarded part of the navigating equipment. On all larger ships, it has been common practice in the past to carry at least three chronometers so that variations in one could be detected by comparison with the others. In recent years, the need for chronometers has diminished because of radio broadcasting of time signals, but an accurate timekeeper is nevertheless a valuable adjunct to the navigator's equipment.



With the adaptation of quartz crystals to timekeeping,* a crystal-controlled clock for navigational purposes became a possible future achievement. Shortages of chronometers during the war led to the Laboratories being requested to undertake the development, under the direction of M. D. Brill, of the experimental crystal-controlled clock shown in the accompanying photographs. The circuit includes an oscillator, with an 1800 cps duplex crystal, a buffer amplifier, two multivibrators that divide the frequency by factors of 6 and 5, respectively, and a power amplifier to drive the 60-cycle clock. Without temperature control, correct time was maintained to within 0.22 second per day over an eight-day period, and data indicated that with only a small amount of



temperature control, the accuracy would be better than 0.09 second per day, which is more than adequate for use aboard ship.

In view of its war production schedule at that time, the Western Electric Company could not undertake the manufacture of such equipment, and the widespread use of other position-locating systems such as Loran made the need for chronometers less urgent. The design of this crystal clock, however, remains available for use wherever a portable, highly accurate standard of time is needed, as in isolated laboratories, and on scientific expeditions.

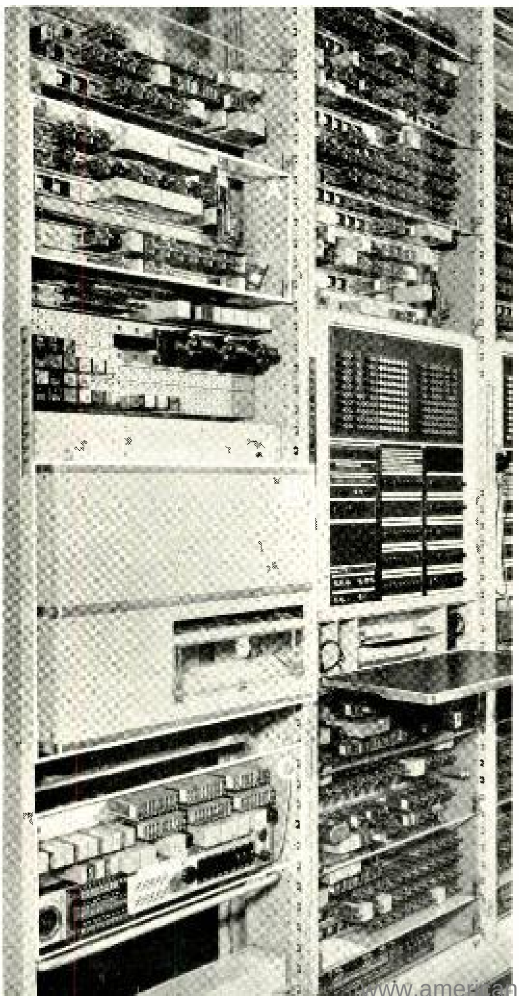
*Record, *March*, 1944, *page* 335.

Trouble recording for the No. 5 crossbar system

A. C. MEHRING
Switching Systems Development

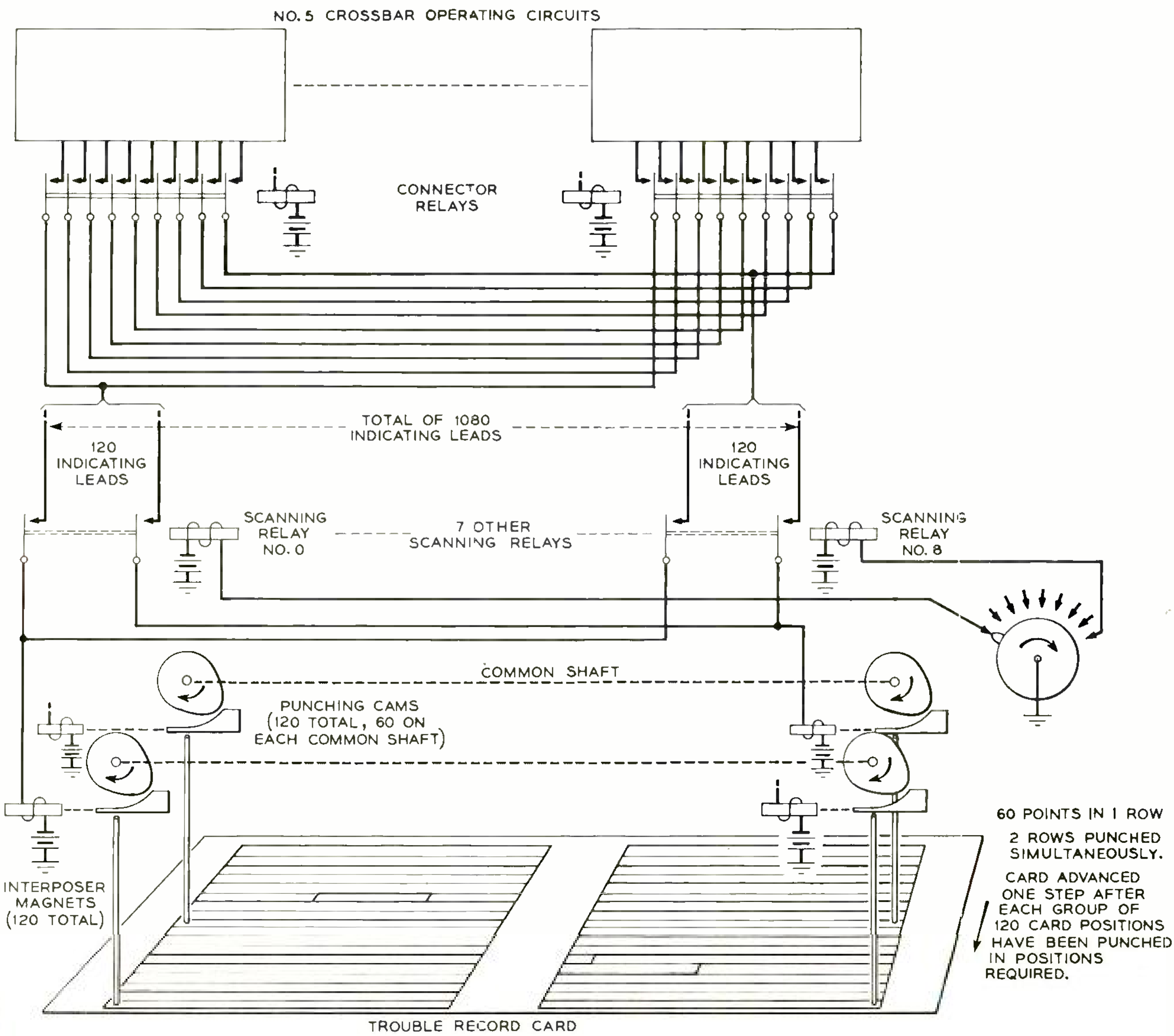
In the No. 1 crossbar system, trouble indicators are employed to give information that will assist the maintenance force in locating troubles as they arise. When such a condition occurs, lamps in various groups light up, and a maintenance man records the information they display. With continually recurring trouble conditions, this recording alone requires considerable time. When trouble conditions recur in rapid sequence, moreover, it is impossible to record all of them; under some conditions only a small percentage may be recorded. Since these records are used as a guide in clearing the trouble conditions, it has been desirable to provide a much faster recording method so that a higher percentage of the troubles would be recorded, and so that records could be made when the office was unattended. To make this possible, a trouble recorder perforator and associated circuits, shown in the accompanying illustration, have been provided as a part of the maintenance center in the No. 5 crossbar office.

At the maintenance center in Media, the trouble recorder occupies part of the left hand bay. The trouble recorder circuit is at A, the trouble recorder unit at B, and the perforator test circuit at C.



For each trouble it handles, this recorder punches a trouble record card, one of which is shown on pages 216 and 217. There are 1080 positions on this card arranged in eighteen lines of sixty positions each. Those points in the central office from which an indication is required when locating troubles are given designations and assigned positions on this card. As a trouble record is being taken, all of the points associated with the circuit that indicated a trouble are tested; where a positive signal is received, the trouble recorder perforates a hole in the corresponding position on the trouble record card referred to above.

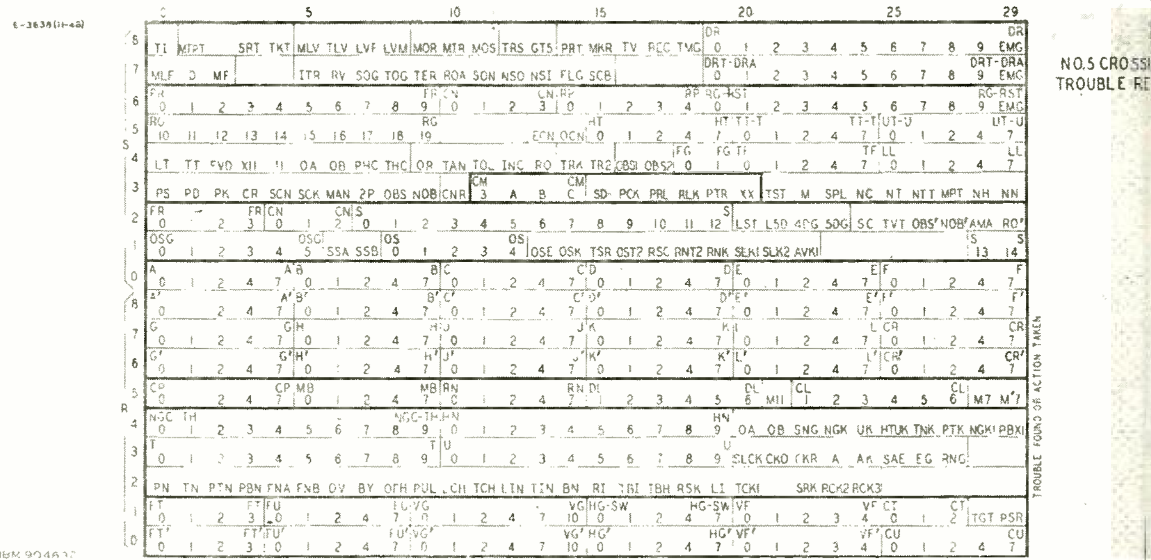
In the recorder there is a bank of 120 punches mounted in such a way that they can punch any or all of the sixty positions in each of two lines on the card. The first and the tenth lines from the bottom of the card are punched first, and then the card is shifted to permit the second and the eleventh to be punched, and so on. The complete



Simplified diagram indicating the arrangement of the trouble recorder and its associated circuit.

punching operation is thus made in nine steps to cover the eighteen lines on the card. The entire punching operation requires about one second. Which holes are punched in each operation is controlled by an interposer magnet for each of the 120 punches. These magnets act to interpose a link between the punches and the operating cams, and holes are punched simultaneously by all the punches for which the interposer magnet is operated. There is thus only a single punching operation for each two lines of the card.

The information punched on a record card consists of six major groups: (1) the equipment included in establishing the connection; (2) the type of connection being established; (3) how far the various circuit operations had progressed before the trouble occurred; (4) information as to the specific test that has indicated trouble; (5) information which is helpful or necessary in determining the source of the trouble, such as the identification of the calling line, the called line, the trunk, and the channel through which the connection is established; and in



Card used for recording trouble.

some offices (6) the time the trouble occurred.

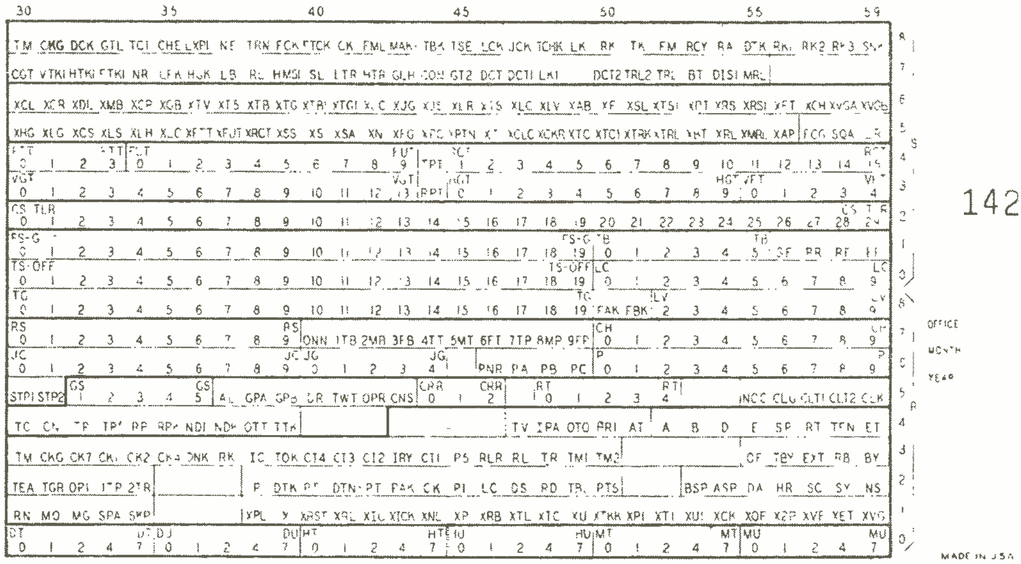
This information is derived from a number of sources but chiefly from the marker and the automatic message accounting equipment when the office includes it. In the No. 5 crossbar system the greater portion of the control of a connection is associated with a marker. Each marker circuit is provided with a system of checking features so that it can detect the presence of a trouble condition within itself or within the circuits with which it is associated. Should trouble be detected by a marker, the marker will stop its circuit operations, and request the trouble recorder to make a detailed record of the information the marker contains and also of certain information of the circuits associated with the marker. A similar process is carried out by the transverter, the recorder and the master timing circuits of the AMA equipment, and by the automatic monitor register and sender test circuit.

Connections between these operating circuits and the trouble recorder are made chiefly by multicontact relays under the control of the master test frame connector circuit. Each multicontact relay will connect sixty leads, but since a circuit such as a marker will require many more than sixty leads to record the required information, there will, in general, be several multicontact relays comprising a connector to a marker or other circuit. There will be one connector for each circuit that may make a trouble record: one for each marker, one for each AMA transverter, one for each AMA recorder, and so forth. From one side of the connectors, leads run to the operating circuits that originate the trouble record, while from the other side the leads are multiplied to a set of 1080 wires—one for each specific piece of information that may be recorded. This arrangement is indicated in the diagram on page 215.

Between this set of 1080 leads and the interposer magnets of the recorder are nine scanning relays each connecting 120 of the group of 1080 leads to the 120 interposer magnets. When the recorder is seized, the proper connector is operated to connect the recorder to the circuit that has indicated a trouble condition exists. This puts the trouble information on the set of 1080 leads. The scanning relays then operate one after another in rapid sequence to extend these leads so that the perforator may punch the information on the card. After this, the connector is released and the recorder is ready to punch another card.

In general, the troubles are recorded in the order in which they occur, but a preference circuit is provided so that in the case of two simultaneous troubles, the master test frame

SYSTEM
DER CARD



connector circuit will give preference to one of the requesting circuits and will exclude the others. When some unusual condition causes a number of troubles to appear in rapid sequence, all of them will not be recorded, but since a complete recording operation, including the punching of the card and recycling the perforator to the normal position, requires only a little over a second, it has been found that most of the troubles will leave a record.

In addition to providing means of recording information when a trouble condition occurs, the trouble recorder perforator and circuits are arranged to record as well the results of certain tests initiated at the master test frame.

Besides providing information to guide the maintenance force in clearing trouble that has arisen, these trouble record cards also provide permanent records of the various trouble conditions that have existed in the No. 5 office. It will be possible by examining these trouble records and noting those troubles which continually recur to work toward their elimination.

THE AUTHOR: A. C. Mehring received a B.S. degree in Electrical Engineering from the University of Maryland in 1941 and then joined the Westinghouse Electric Corporation as design engineer of power protective devices. In 1945, he joined the Technical Staff of the Laboratories, and after completing the course of study of the Laboratories Switching Training School, became a member of the Switching Systems Development Department. He has since been principally engaged in the development and analyzation of switching circuits for the No. 5 crossbar system.

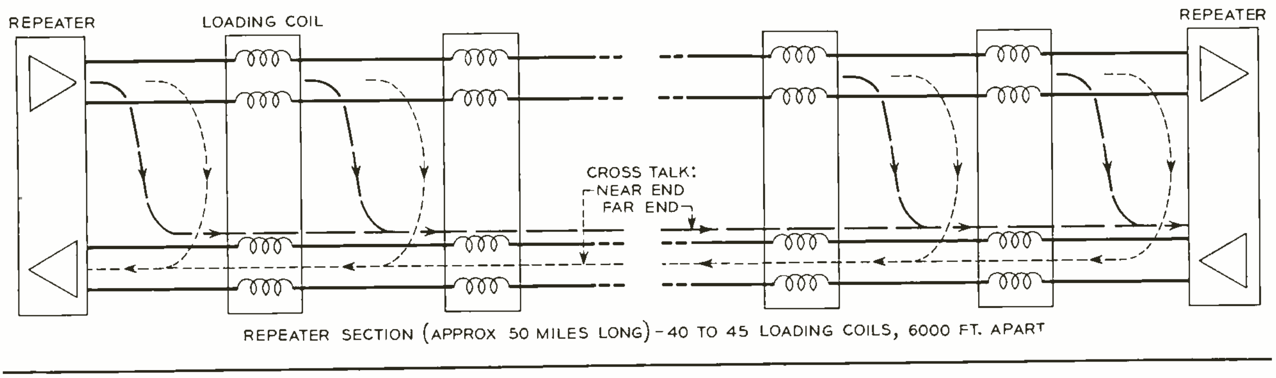
Historic firsts:
Far-end crosstalk balancing

On January 1, 1949, nearly seven million miles of K carrier* circuit were in use by the Bell System. Developed during the early 1930's, the K carrier system was of inestimable value in providing the enormous increase in channels required during the war; at the present time it comprises almost one-third of the System's total toll circuit mileage. It provides a group of twelve telephone channels over two cable pairs—one for each direction of transmission—and was the first broadband carrier system to be developed, and the first carrier system to be applied to cables. Long distance telephone transmission over cables had always been difficult because of the close spacing of the conductors, and the use of high carrier frequencies on cables had seemed highly impractical. This situation was changed primarily because of two inventions of Bell Laboratories: the feed-back amplifier† and far-end crosstalk balancing.

One of the obstacles that has plagued telephone transmission from the earliest days is crosstalk. The many ways by which it may enter a circuit, and the many ways that have been devised for reducing it cannot be discussed here. In general, there are two types of crosstalk: near-end and far-end. The former is that returning to the same end of the line as the talker, and the latter, that traveling on to the subscribers at the other end. Before the advent of four-wire circuits, near-end crosstalk had been the more formidable, and in cable circuits it had become necessary to "test splice" or to connect balancing condensers in each loading section between the three circuits of a loaded phantom group to reduce the crosstalk to tolerable proportions.

When vacuum tube repeaters and long cable circuits began to come into extensive use, the numerous echoes in a two-wire multi-repeater circuit proved very objectionable. Also the large difference in level of the speech in opposite directions at a repeater station greatly increased the near-end crosstalk. As a result, four-wire circuits became necessary to meet the requirements for echo and crosstalk on long lines. This pretty well took care of near-end crosstalk because the wires carrying speech in opposite directions were placed in segregated cable groups, but far-end crosstalk at once began to assume more serious proportions. To keep it within satisfactory bounds, it seemed necessary still to use test-splicing or balancing condensers in each loading section as had been done to reduce near-end crosstalk.

On June 2, 1922, A. G. Chapman and M. A. Weaver were in Worcester making tests



*Record, *April,* 1938, *page* 260.
†Record, *December,* 1943, *page* 173.

looking toward reducing far-end crosstalk between phantom circuits and their side circuits on the 50-mile cable repeater section to Boston. These tests were not completed until 3 A.M. the next morning. Some time during these midnight hours, Chapman pointed out that to balance far-end crosstalk between side circuits having the same speed of propagation, it should not be necessary to apply the correction in each loading section as had been necessary for near-end crosstalk. The near-end crosstalk arising in each loading section is out of phase with that arising in the sections preceding and following it because of the difference in the number of loading sections passed through. Crosstalk in the first section, for example, passes only through two coils; that in the second section, through four coils, and so on. With far-end crosstalk, on the other hand, since the crosstalk current does not reverse its direction of flow, it passes through all the loading sections of the line regardless of the section in which it arises, as indicated in the accompanying diagram. A single balancing network at one end of the repeater section should thus take the place of balancing in each loading section for circuits having the same speed of propagation. The soundness of this theory was soon established by a few tests.

The importance of balancing at the end of a repeater section rather than in each loading section was that the cost of balancing would be drastically reduced. Instead of having to install balancing units or test splices a few thousand feet apart, sets of condensers some 50 miles apart would give just as much improvement at a small fraction of the cost.

Although this new method was applied to some extent in the immediately following years, conditions at that time did not require its extensive use, since there were not many long four-wire cable circuits for which crosstalk balancing would be required.

This situation was changed by the development of the feedback amplifier, which in eliminating one of the most serious obstacles to carrier on cable, permitted the development of the K system to be accelerated. It soon became apparent, however, that the proper reduction of far-end crosstalk between all pairs in a cable would be very costly, if not impracticable, if the reduction required were obtained by the then available methods. The new method of balancing at once assumed major importance. A patent application disclosing both capacitive and inductive balancing was filed by Chapman in December, 1930, and patent No. 1,863,651 was issued to him on June 21, 1932. Since then, many improvements have been made in the apparatus and techniques, and M. A. Weaver, O. H. Coolidge, L. Hochgraf, and P. S. Darnell all hold important patents on one or another phase of the work. All K carrier systems have employed this new method of crosstalk balancing in one form* or another since the first installation between Toledo and South Bend. Had this new method of crosstalk balancing not been available in 1930, the cost of reducing crosstalk in K carrier systems by other methods then available would have been prohibitive.

*Record, *February*, 1939, *page* 185.

The Phototransistor

An entirely new type of "electric eye"—much smaller and sturdier than present photo-electric cells and possibly cheaper—has been invented at the Laboratories. During the past quarter-century, electric eyes have found widespread use in electronics because of their ability to control electric currents by the action of light. To the layman, one type is perhaps best known for automatically opening and closing doors, but such devices have many other important uses—in television, sound motion pictures, wirephotos, and still many more in industry.

One of the major advantages of the new electric eye is that it delivers very high power for a photo-electric device—in some cases enough to operate a switch directly without the preliminary amplification usually required.

Appropriately, the new device has been named the Phototransistor. The whole apparatus is housed in a tiny cylinder about as big as a 22 calibre rifle cartridge. Like the Transistor, it has no vacuum, no glass envelope, no grid, plate or hot cathode. It was invented by Dr. John N. Shive in the course of development work on Transistor-like devices.

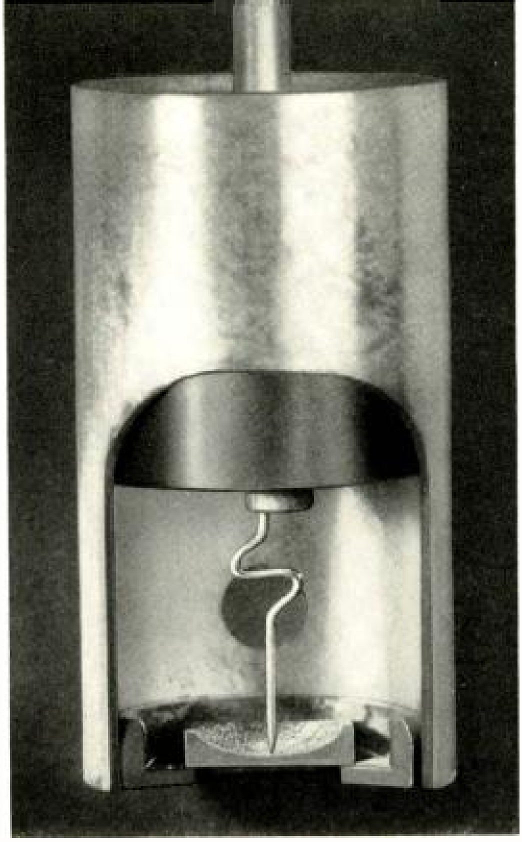
Although the Phototransistor is still in the experimental stage, Laboratories scientists and engineers expect that, after the necessary development, it may have far-reaching significance in electronics and electrical communication.

Just as the Transistor is not expected to supplant vacuum tubes, but rather to supplement them, so the Phototransistor is not expected to displace existing photo-electric cells. Because of their small size and expected long life, however, together with economies that might reasonably result from mass-production, Phototransistors should find many applications where it is not now practical to use present-day photo-electric devices.

Consideration is already being given, for example, to using them in a machine under development for toll dialing, a plan whereby a telephone operator directly dials a telephone in a distant city.

The heart of the parent device, the amplifying Transistor, is a tiny chip of germanium, a semi-conductor material, against one side of which the points of two hair-thin wires are pressed, hardly two-thousands of an inch apart. The flow of very small electrical currents in one of these wires (the emitter) controls the flow of currents in the other wire (the collector) in such a way as to give signal amplification.

The Phototransistor is similar in operation to the amplifying Transistor, but it is controlled by light rather than by the electric current of the emitter. It also uses a piece of germanium but only a single collector wire. The tip of this wire rests in a small dimple ground into one side of the germanium disk. At this point the germanium disk is only three thousandths of an inch thick.



The new photo-electric device, shown here about nine times actual size.

Light focussed on the opposite, undimpled side of the disk can control the flow of current in the wire, thus making a control device similar in function to a photo-electric cell.

The Phototransistor has a high power output for a photo-electric device and gives good response to a rapidly fluctuating light source. It is particularly sensitive to the wavelengths of light given off by ordinary incandescent light bulbs, and is well suited to operate with these easily available sources with good fidelity. Another virtue is the device's low impedance.

New President for Southwestern Bell Company

Entirely in the Bell System tradition that Bell System presidents start at the bottom is the career of James L. Crump, recently elected to that post in Southwestern Bell. Starting as a groundman at the age of 19, Mr. Crump rose through successive grades of wire chief, field engineer, and plant superintendent to become general plant manager in 1936 and first vice president in 1946.

Alexander McLean Nicolson 1880-1950

By R. A. Heising

In November, 1912, about the time interest was developing in the thermionic vacuum tube, Alexander McLean Nicolson entered our Research Department. In 1913 he began active work in vacuum tube research in association with Dr. H. D. Arnold and Dr. H. J. van der Bijl. His first important contribution was the development of the coated filament manufacturing process that was used in all telephone and radio tubes prior to 1917 and that formed the basis of the early coating methods. For a number of years, he and an assistant manufactured all the coated filaments used in Western Electric tubes. Another important invention in the line of tube design was the heater cathode tube on which Patent 1,459,412 was issued in 1923.

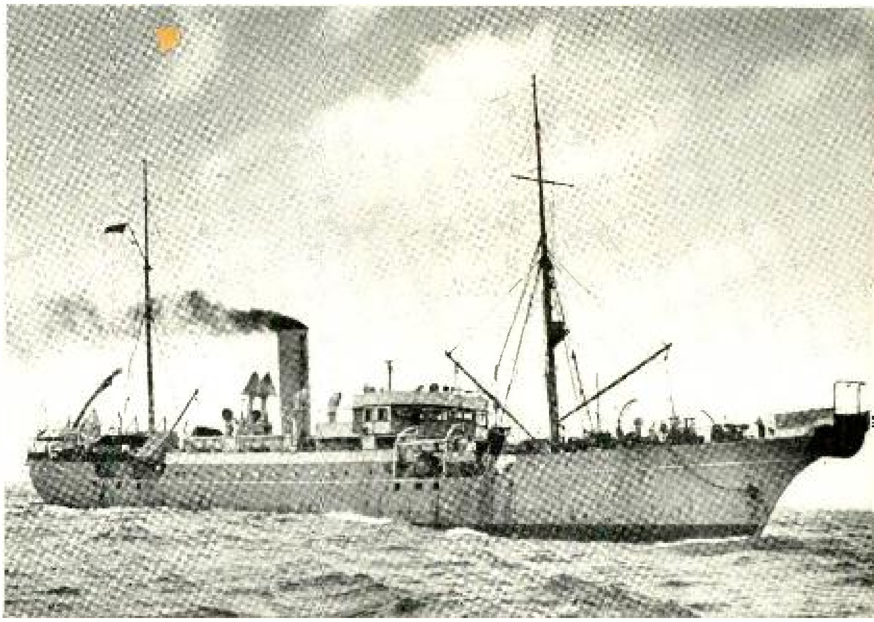
In 1917 Mr. Nicolson took up the study of piezoelectricity. He was the first to discover that the mechanical vibrations of a crystal could be coupled to an electrical circuit by means of suitable electrodes, and that the resulting electro-mechanical vibratory system performed exactly like an electrically tuned circuit, introducing positive or negative reactance into the circuit, depending upon the frequency. This discovery was published in the *Transactions of the A.I.E.E.*, October, 1919.

In the same paper, Mr. Nicolson described crystal-driven loud speakers and crystal phonograph pickups, the latter being the forerunners of those widely used today.

Probably the most valuable contribution of Nicolson, also stemming from his discovery of the coupling between the mechanical and electrical properties of piezoelectric crystals, was the crystal-controlled oscillator. His patent application on that device was filed in April, 1918, and after numerous interferences, the patent was issued in August, 1940, No. 2,212,845. He antedates all others in this field and his patent stands as a monument to him in respect to the millions of crystals manufactured by the Western Electric Company in the late war for oscillator frequency control in the Military Services.

Mr. Nicolson had a fertile imagination, and besides the above discoveries and inventions, there were many other inventions represented by over one hundred fifty United States patents. Among these might be mentioned one, No. 1,470,696 issued in 1923 on television which is fundamental to all television systems now in use. Besides embodying new circuit and system features, it embodied the cathode-ray tube at the receiver with amplitude control of the electron beam intensity as now used.

Mr. Nicolson severed his connection with the Bell System in January, 1925, and was associated with a number of organizations thereafter, among which were Wired Radio, Incorporated, and International Business Machines Corporation. He was associated with the latter at the time of his death.



Out at sea on the cable ship "Lord Kelvin" were J. J. Gilbert, E. M. Boardman, D. E. Thomas, N. C. Youngstrom and C. H. M. Quintana of Transmission Systems. Leaving Halifax on April 11, their first port of call was Key West; from there an experimental type of submarine telephone cable was laid to Havana. In charge of terminal apparatus at Havana were O. B. Jacobs and D. M. Osterholz; at Key West were L. M. Ilgenfritz, Q. E. Greenwood and W. M. Bishop.

Margarita G. O'Brien's Golden Anniversary

The years have been kind to Margarita O'Brien, supervisor of the Record Files. The spring of her step, her keen memory, and peppery personality make it hard to believe she has completed fifty years of Bell System service. Miss O'Brien is the first Laboratories woman to span a fifty-year working period unbroken by any leave of absence or long sickness period.

She started to work at 195 Broadway on May 4, 1900 as an office messenger with Western Union, which later briefly became part of the Bell System. In those days the hours were 8:30 to 5:00 with half-hour relief periods morning and afternoon. During relief, the girls studied Morse code and practiced on a key set in the messengers' office. Within a year, Miss O'Brien had become proficient in the use of the telegraph key and was promoted to operator. For nine years she worked downtown. She remembers best the colorful years of that period which she spent handling messages concerning the Panama Canal which was then being built.

In May, 1910, while Western Union was a part of the Bell System, Miss O'Brien transferred to Western Electric at West Street as a private telegraph operator. She continued to tap out messages by Morse code on Western Electric's private wire until 1917 when it was discontinued.

At that time the Record Files were being established and Miss O'Brien transferred to them. She has seen the files grow from the original few rows of records, in a vault in section 3D, to its present size, three and a half miles of shelving in 7000 square feet of space in section 3K. The files include accounting, plant, medical, purchasing, and shop records, and laboratory notebooks. She seldom has to refer to her card index. So prodigious is her memory that when an item is requested, she can almost always go straight to the shelf and find it. Miss O'Brien is assisted by two young men, the present generation of her "boys."

Earlier members of her "family" have remained close to her. Many have advanced far in the Laboratories. They see her often and visit her home with their families. One young man, formerly of the Laboratories, who used to drop in to her files on his lunch hour to learn telegraphy, has become famous. He is George Patterson, today the largest supplier of orchids east of the Mississippi. Miss O'Brien taught him Morse code and in time he left to become a radio operator in the maritime trade. On one of his trips to South America, he brought back orchid seeds and began to grow the flower commercially. Miss O'Brien, who keeps in touch with

Bachrach

him and his family, never misses his exhibits at horticulture and flower shows in the greater New York area.

She herself is well travelled. She has made several trips to the west, to Canada, and to the south and southwest, but her greatest pleasure is in cruises. By "sleeping next to the fishes," she says, she has been able to visit Jamaica, Bermuda, the Virgin Islands, Panama and Nassau, and has touched at ports in South America. She has been to Cuba more than a dozen times and has a collection of Cuban music as a result of her love of that island.

Music has played a great part in her life. In addition to her Cuban records, she also has a collection of classical music which includes many famous operas and arias which she herself has sung on the concert stage. A soprano, Miss O'Brien studied music and sang with the Catholic Oratorio Society and with the New York Oratorio Society in such places as the Juilliard School of Music, Carnegie Hall and the Metropolitan Opera House. She has been a devotee of the opera most of her life. While she does not get to the opera so often nowadays, she enjoys her recordings on her radio-phonograph. She also enjoys the theater and attends frequently.

Her fingers, nimble from years of practice at a telegraph key, are also deft in knitting and crocheting. Miss O'Brien's knit dresses and gloves look like the work of a professional.

A native Greenwich Villager, Miss O'Brien is the oldest of seven daughters born to the former Elizabeth Irene Howard and James Edward O'Brien. She attended local schools and was graduated from the Trinity School of Business. She had always lived in the Village until a few years ago when she moved to one of the housing developments where her two sisters, one a member of the Bell System, make their home with her.

Miss O'Brien will be honored by a departmental luncheon on May 2 and by an executive luncheon on May 4.

Renovated Gripsholm Has Radiotelephone Service

Continuous telephone contact with the United States is now available to passengers aboard the newly-remodeled Swedish-American liner *Gripsholm*. Long Lines announced the opening of a radiotelephone circuit with the ship at the time of her arrival in New York in March, after extensive rebuilding calculated to put her in the forefront of the Atlantic luxury trade.

Included among many major "face-lifting" operations on the *Gripsholm* was the installation of several convenient booths from which transatlantic travelers can take advantage of the Bell System's high seas service.

Suspension of Shares Elected Under Stock Plan

Under the terms of the third offering of American Telephone and Telegraph Company stock, employees were given the opportunity to purchase shares on an installment basis to the extent of one share for each full $500 of their annual basic rate of pay on December 31, 1949, subject to the fifty-share limit under all offers. However, under the terms of offering as set forth in the Prospectus which was mailed to each eligible employee, it was stated that if the number of shares elected to be purchased under this offer exceeded the approximately 600,000 shares remaining available for sale under the Employees' Stock Plan, it would be necessary to reduce the number of shares which employees may purchase through payments beginning in April, 1950.

In order to accomplish this reduction, the American Company has now increased the $500 figure of basic rate of pay to $1,000. Employees' previous elections to purchase under this offer will therefore be suspended as regards deductions beginning in April, 1950, for any shares elected which are in excess of the number determined under the revised basis of allotment. Notices of approval of elections to purchase have been mailed by the American Company; they specify the number of shares, if any, subject to such suspension.

As also noted in the Prospectus, an employee may later become entitled to purchase a part or all of the shares as to which his election has been suspended if shares become available as a result of cancellation of elections to purchase under this and earlier offers.

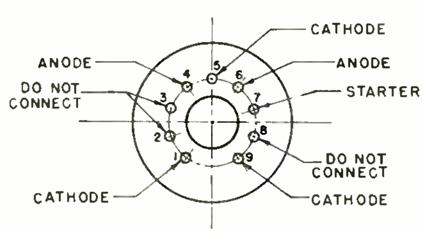
The 427A Electron Tube

A new three electrode inert-gas-filled miniature cold cathode tube, designated as the 427A, is now being manufactured by the Western Electric Company. This tube is designed for use as a voltage regulator, its initial use being to regulate the heater voltage of the 408A tube in the Type-N carrier system.

Use of a pure metal cathode instead of the common coated cathode provides a low drift of anode voltage drop throughout tube life. The function of the third element is that of a starting electrode when the supply voltage is insufficient to cause breakdown between the cathode and anode. Average characteristics of the 427A are as follows:

Anode Breakdown Voltage	165 volts
Anode Voltage Drop at 40 Milliamperes	100 volts
Starter Breakdown Voltage	125 volts
Starter Voltage Drop at 5 Milliamperes	110 volts
Stability*	0.1 volt

*The drift of anode voltage drop over a period of 1000 hours, with the tube operating at one value of current and temperature within its ratings, will not exceed 0.1 volt.



The new Western Electric 427A tube with base connections shown above.

Something Can Be Done About High Blood Pressure

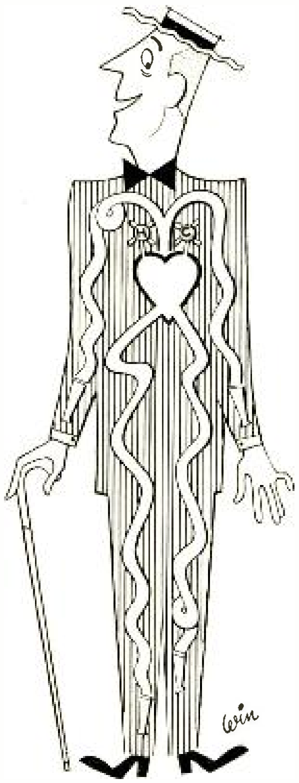
By Dr. M. H. Manson
Medical Director, A. T. & T. Company

When you read in the newspaper that "so-and-so died today of a heart condition," you may actually be reading a warning—"Stop working that pump of yours overtime," or "Get that blood pressure down before it's too late."

It is true that many persons with high blood pressure continue to work and live to ripe old ages without any too obvious restrictions. It is a safe assumption that they are following the advice of their doctor who is helping them to live with a minimum of friction and anxiety and to balance their activity in accordance with their physical capacity to "take it." This same knowledge can be used to advantage to help prevent high blood pressure, for rarely does this condition occur except as a gradual development, often as the result of accumulative stress and strain.

Blood pressure is a normal requirement for living. It is the pressure under which the blood in the arteries is made to flow. Arteries are elastic tubes, leading from the heart which acts as a pump to move the blood throughout the body. Each artery is like a garden hose carrying water from a main faucet. Anything which acts to make the heart pump blood against increased resistance serves to send blood pressure up just as a clamp on the garden hose would require greater pressure at the faucet end to keep the water flowing.

When your doctor wraps his cloth-and-rubber gadget around your arm he actually measures two blood pressures to get a true picture of how hard your heart is pumping. One is the pressure of your blood when your heart is contracted, pushing blood through your body, the other is the pressure between contractions. Most bridge-table discussions of blood pressure quote the first, called the systolic pressure which tells only part of the story, in some cases the least important part. Furthermore, the old rule-of-thumb, that blood pressure should be age plus 100 is only an approximate guide and not necessarily accurate in many instances. Actually, there are wide variations in blood pressure which must be considered in terms of a person's whole make-up before a "normal" may be determined. A physician is the person best equipped to interpret these variations and to decide also whether or not they are significant.



"Each artery is like a garden hose carrying water from a main faucet."

High blood pressure or hypertension, may occur in the course of certain kidney diseases or in conditions where some of the normal chemical processes in the body are disturbed. Likewise the improper use of certain drugs and excessive use of tobacco may contribute to high pressures. Formerly it was thought that hardening of the arteries themselves always caused blood pressure to rise but the bulk of the evidence now indicates that one condition can exist without the other.

Overweight in itself does not cause high blood pressure but the excess fat which the overweight individual carries materially adds to the work of the heart, and pressure may be increased. Consider the fact that when the body stores away an extra pound of fat, it also forms new blood vessels in order to nourish and keep this fat tissue healthy—approximately three extra miles of blood vessels for each five pounds of excess weight. Accordingly, an increased strain is placed on the heart, which must pump the blood around in these additional blood channels.

With the possible exception of meal plans built around a low-salt in-take, there is no special diet for hypertension. For example, the exclusion of red meat from the diet is now considered unnecessary. The important thing is to eat a well-balanced choice of foods, to eat moderately and, if necessary, to reduce body weight to a level preferably a little below one's ideal for height, build, and age.

More important, however, is to guard against emotional upsets. Inner friction, worry, peaks or valleys of excitement or depression and other immoderate nervous experiences are to be avoided. If these are repeated over a period of time, the pressure-raising mechanism of the body which is set in motion, keeps on going and becomes more powerful as it progresses. The heart starts working overtime and the result is high blood pressure. To avoid or remove the causes of mental and emotional strain is obviously the best way to avoid their bad results but this is often easier said than done.

One can, however, make an effort to find ways to relieve daily tension. A brief rest period during the day; recreational activity suitable to age and general physical condition; having interests which help to lessen tensions and frustration; learning to take things in one's stride, to live more slowly and calmly in every way; moderation in all things—these are some of the means by which the nervous, high-strung person may help to change himself into a more relaxed individual with a better chance of keeping out of the clutches of high blood pressure.

Pioneers Plan Picnic

Frank B. Jewett Chapter No. 54 of the Telephone Pioneers of America will hold a picnic on June 10 at Farcher's Grove, Union, N. J. Final details are being formulated, but general plans are for a real old-style picnic with games and sports. H. J. Delchamps and J. J. Kuhn are directing the organization of the picnic.

W. L. Black is handling Murray Hill publicity and J. Cameron and A. R. Thompson, New York. The Entertainment Committee consists of I. W. Whiteside and A. R. Brooks for Murray Hill and Harold Schmitt and Joyce Thompson for New York. The various committees working with them are:

Food & Signs—A. J. Akehurst, Chairman at Murray Hill with H. Anderson, D. P. Barry, R. C. Carrigan, Miss I. Cummings and O. H. Danielson; H. A. Milmoe, Chairman for New York with C. T. Boyles.

Ticket Committee—H. G. Geetlein, Chairman at Murray Hill with F. J. Boyle, D. R. Brobst, Mrs. Filmer, Miss McAlevey, W. J. Means, W. Stumpf, B. O. Templeton, E. Van Horn, J. W. West and J. G. Whytock; L. T. Cox, Chairman for New York with Miss M. L. Ressler and C. T. Boyles.

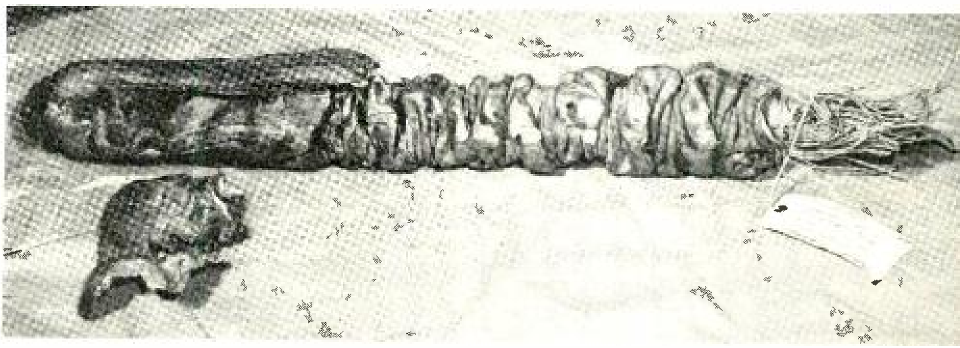
Games and Hospitality Committee — O. B. Cook, Chairman at Murray Hill with T. J. Crowe, G. B. Hamm, C. F. Benner, L. B. Cooke, F. L. Crutchfield, R. A. Devereux, R. G. Dolbear, Miss H. Giles, R. J. Guenther, L. S. Hulin, H. E. Mendenhall, Mrs. H. S. Reoch and Miss D. Storm; H. D. Peckham, Chairman for New York with N. H. Thorn, A. J. Kuczma, F. T. Meyer and W. A. MacNair.

THE TELEPHONE HOUR WINS "MICHAEL" AWARD

The Telephone Hour, for ten years one of radio's most honored music programs, won a new award in March—the "Michael" for the best musical program on the air, awarded by the Academy of Radio and Television Best Arts and Sciences.

A Cable Oddity

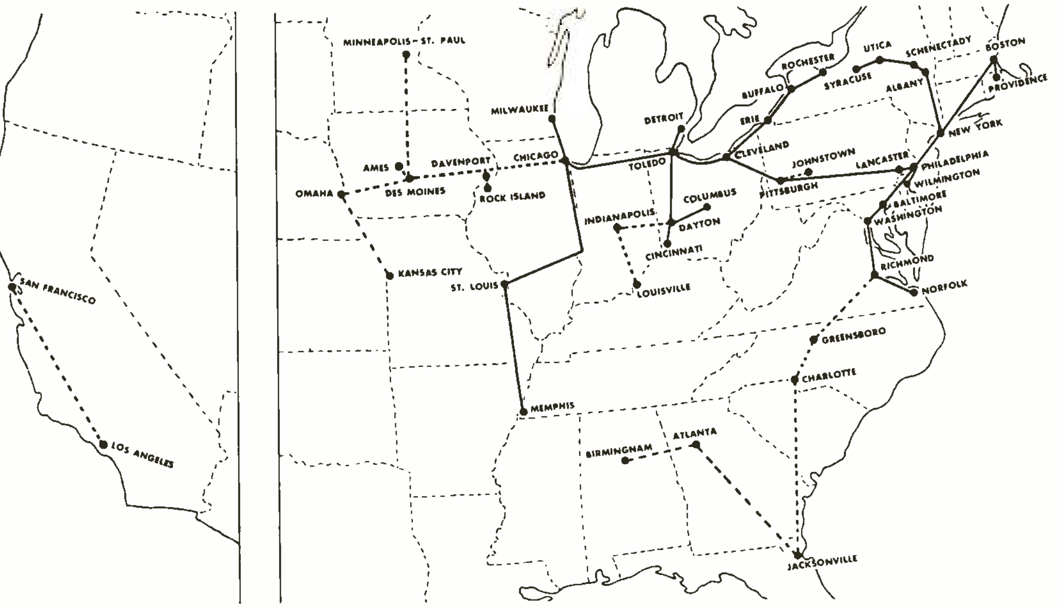
Placed on a bridge between East Boston and Chelsea, Mass, thirty-two years ago, the cable below was removed in connection with a channel dredging job. Astonished cablemen found that a couple of feet of lead sheath had piled up against a splice which had been forced solidly against the end of a wooden duct. Most likely the explanation is that traffic vibrations through three decades had made the cable creep along the ducts. But not a single case of trouble had developed on the 303 pairs enclosed by the badly-crumpled sheath!



This section of a 303-pair, 19-gauge lead sheath cable recently removed from beneath a bridge was still in good operating condition.

BELL SYSTEM TELEVISION NETWORK ROUTES

——— IN SERVICE . . . . PLANNED FOR 1950



This map shows the Bell System TV network routes now in service and those planned for service later on in the year. By the end of 1950, over 15,000 miles of our intercity channels are expected to be available for video programs.

At present there are 27 cities connected to the network (not including Albany which has no station at the present time). This number is expected to be raised to more than 40 by the end of this year.

New Radio Link to Israel

Inauguration of a radiotelephone circuit extending more than 5,700 miles between New York and Tel Aviv was announced by Long Lines on March 10. The new link makes possible direct telephone service between the United States and Israel, replacing an arrangement whereby calls were carried by radio from New York to Tangier, amplified at that point, and sent on by radio to Tel Aviv.

The Murray Hill Chorus

The Murray Hill Chorus gave a noon hour program on March 30 in the Arnold Auditorium under the direction of Leo W. Collins, with Capitola Dickerson the accompanist. The Chorus sang *Onward Ye Peoples* by Sibelius; excerpts from *Cantata 131* by J. S. Bach, with George Bachman, bass soloist; and *Alleluia, Amen* by Handel. John Karlin on the violin was accompanied by U. A. Matson at the piano in a selection of *Gypsy Airs* by Pablo de Sarasate.

Instrumental accompaniment for the program was supplied by R. H. Nichols, Jr., violin; J. V. Domaleski and P. E. Mills, violas; R. N. Larson, cello; Marilyn Miller, oboe; and B. P. Bogert, bassoon.

The Murray Hill Chorus has been invited to join the Guild Choir of Riverside Church in New York on Sunday, May 14 to sing Bach's *Cantata No. 131 (Aus Der Tiefe)*.

The date for the fifth annual Spring Concert of the Chorus at the Summit High School has been set tentatively for Friday evening, May 26.

Out-of-Hour Lectures Given by Ingram and Baker

Recent Developments in Electron Tubes was the subject of the out-of-hour lecture given by S. B. Ingram at West Street on March 20 and Murray Hill on March 23. This lecture was a survey of some of the newer types of tubes which have become available as tools to the circuit designer in recent years through work at the Laboratories. Microwave tubes for radio relay systems, repeater tubes for coaxial systems, gas tubes for switching, and beam tubes for pulse modulation and the storage of elec-

Send the Record to Europe

It has been suggested that the RECORD would be of interest to European relatives or friends. If, after you have finished with your copy, you should wish to send it to a friend or relative, place it in an envelope (E-1547) and attach 7 cents in postage.

trical signals were included. A cold-cathode gas-filled stepping tube capable of chopping pulses at rates as high as 1,000 pulses per second was also demonstrated.

On April 3 at West Street and at Murray Hill April 6, W. O. Baker presented the fifth in the series of informative out-of-hour lectures. The title of this lecture was *Polymers: The Molecules in Men, Trees and Telephones.* Understanding of the technical properties of many solids such as plastics and rubber has been greatly aided by knowledge of their chemical structures. Engineering and special chemical work has been done at the Laboratories on many of the materials made up of polymers, but recently our research and development effort has been directed at polymer science as a unified field. Work in this field has resulted in understanding of polymer solids like Polyethylene, polyamides—popularly known as nylons, polymer molecules of novel sizes and shapes with new extrusion and flow properties; and polymers which, through the application of new techniques, can be converted to semi-conductors and used as microphone elements and resistors.

Tied for first place in the Bell System Postal Chess Tournament, now in its fourth annual round of competition, are left to right, J. C. Crowley and C. L. Sappet of Whippany. H. J. Reeve of Murray Hill, and W. C. Babcock of West Street are also successful competitors in the tournament.

Jersey Suburbs Begin to Use A.M.A.

Laboratories people who live in the North Jersey suburbs are beginning to have the advantages of one of their big development programs as automatic message accounting goes into use there. With the cutover of a No. 5 crossbar office at Cranford, subscribers were enabled to dial all telephones in the suburban area north of Monmouth County and all telephones in New York City, a total of over 4,000,000. This is the largest direct-dialling area in the country. A.M.A. with similar privileges will be added to existing crossbar offices in Caldwell, Nutley, Leonia, Fort Lee, and Plainfield before this summer is over, and will be included in new No. 5 offices at Hackensack, Englewood and Paterson during this year.

Margaret Welsh and Marie Seibel, new operators at Whippany, with Louise Norback their supervisor.

To reach a New Jersey telephone in the direct-dialling area, the user dials the listed number. To reach New York City telephones, the user dials "1-1" followed by the listed number. Details of the call are recorded automatically on paper tapes which are sent to the A.M.A. center at Newark to be processed into subscribers' bills.

First New Jersey area to be given A.M.A. was Camden; until the network center was ready its tapes were processed in the original center in Philadelphia.

LIFE MEMBER CLUB LUNCHEON

Eighty-three members of the Life Member Club of the Frank B. Jewett Chapter of the Telephone Pioneers of America attended the third meeting of the season on March 16 at West Street. Luncheon was served in the auditorium, after which the West Street Choral Group, under direction of R. P. Yeaton, entertained the Club. Highlights of the meeting were a talk by Ralph Bown, in which he set forth the pattern of electrical communication development during the past century, and an explanation by J. S. Edwards of phases of the Bell System pension plan.

C. W. Lowe, chairman of the meeting, presented a Life Member certificate to C. N. Hickman. Under Pioneer practices, anyone who retires after sixty with twenty but less than twenty-one years of service may upon application become a Life Member. Dr. Hickman enjoys the distinction of being the first member to qualify in this manner.

American Physical Society Meets at Oak Ridge

During the American Physical Society meeting on March 16-18 at Oak Ridge, Tennessee, papers were presented by the following Laboratories members: E. A. Nesbitt, *Magnetostriction of Permanent Magnet Alloys;* P. W. Anderson, *Theory of Antiferromagnetism;* and H. J. Williams, *Recent Experiments on Ferromagnetic Domains and Domain Walls.* At the session on *Semiconductors,* G. L. Pearson gave a paper, of which W. H. Brattain was co-author, on *Changes in Conductivity of Germanium Induced by Alpha-Particle Bombardment;* W. L. Bond, *The Technique of Cutting Germanium Filaments;* F. S. Goucher, *The Quantum Yield of Electron-Hole Pairs in Germanium;* H. C. Montgomery, *Noise in Germanium Related to Fluctuations in Hole Concentration,* of which W. Shockley was co-author; G. L. Pearson, *The Magneto-Resistance Effect in Oriented Single Crystals of Germanium;* H. Suhl, *Measurement of Magneto-Resistance of Germanium in Very Intense Magnetic Fields;* and G. K. Teal and J. B. Little, *Growth of Germanium Single Crystals.* K. G. McKay also attended this meeting of the Society.

News Notes

O. E. Buckley gave a talk entitled *Some Observations on Industrial Research* on March 6 at the annual dinner of the American Patent Law Association in Washington. At the invitation of Dr. W. F. Russell, President of Teachers College, Columbia University, Dr. Buckley was one of a group of industrial leaders who were guests at the college on the evening of March 9 for an inspection trip and discussions acquainting them more fully with the work and objectives of this branch of the University. Between March 11 and 19, Dr. Buckley visited Sandia, Los Alamos, and White Sands, New Mexico, and stopped at the Hawthorne Works of the Western Electric Company on the return trip. On March 23, in the Long Lines auditorium, Dr. Buckley addressed a luncheon gathering of the Telephone Pioneers Life Member Club, which includes the membership of the Gifford and Hall Chapters of the organization. Dr. Buckley spoke on some of the current developments in Bell Telephone Laboratories.

Dr. Chih Meng, Director of the China Institute in America, spoke before the International Relations Group on March 16 in the Arnold Auditorium. His subject was *Chinese American Cultural Relations.*

F. J. Singer participated in the Dayton-Springfield Business Office Supervisors Conference at Dayton.

At a Conference of the Solid State Research Group in the Arnold Auditorium on March 22, E. A. Nesbitt spoke on *Magnetostriction of Materials of High Coercive Force* and H. J. Williams on *Recent Studies in Domain Patterns.* On April 5 at a similar conference, W. A. Yager and J. K. Galt discussed *Properties of Single Crystals of Nickel Ferrite.*

Four Lectures were given by Laboratories men during a joint course on *Fundamentals of Automatic Control Circuits,* sponsored by the New York section A.I.E.E., Communication Division, and the New York section I.R.E. On March 27, W. Keister gave the *Introduction* to the course; on April 10, C. E. Shannon lectured on *The Mathematics of Switching;* on April 17, G. R. Frost on *Functional Building Blocks of Switching Systems;* and on April 24, A. E. Ritchie on *A Telephone Switching System as an Example of the Application of the Switching Art.*

Hostesses who served at the Life Member Club Annual Luncheon of the Telephone Pioneers are, left to right, first row, Ruth Miller, Patricia Lampeter, Jean McDonald, Dolores Iannone, and Rita Tornvall; second row, Anne Schieferstein, Julia Klos, Elaine Blusch, Helen Meiser, and Mary Sullivan; third row, Elizabeth Keane, Anita Kostaski, Margaret Naughton, Grace Wagner, and Elena Benvenga; and fourth row, Marian Eich, Mildred Malone, Eleanor Fischer, Gertrude Alefeld, and Jane Ulrich.

J. D. Struthers, G. K. Teal and J. A. Burton attended the Oak Ridge meeting of the American Physical Society.

RETIREMENTS

Among those retiring from the Laboratories are V. W. Langborgh with 45 years of service; John Davidson, 38 years; B. B. Webb, 37 years; Helmuth Eckardt and M. E. Ellis, 32 years; and T. J. O'Neil, 31 years.

JOHN DAVIDSON, JR.

Before John Davidson, Jr., joined the Engineering Department of the American Telephone and Telegraph Company in 1911 he had graduated from Tulane (B.E. 1906) and Cornell (E.E. 1909), and had held three engineering jobs for brief periods with General Electric, Allis-Chalmers and Carnegie Steel. His first job with A.T.&T. was on multi-line service observing which he studied in operation at Kansas City.

Mr. Davidson had an active part in the development of equipment arrangements for the early Type-A and B carrier systems. He also contributed largely to the development of signaling and switching arrangements for the early toll line dialing installations. Under his guidance the No. 3 type toll board was developed to replace the No. 1 toll board as a Bell System standard. He also supervised the introduction of DC key pulsing for toll board operation.

Mr. Davidson's toll group was responsible for solving many signaling problems in the 20-cycle field. They also made the first studies of cordless toll boards, straightforward toll lines, call circuit toll lines, recording-completing trunks, track distributing systems, and a.c. supervisory and dialing systems.

For a time Mr. Davidson took charge of power development in the D & R. When the D & R came to West Street in 1934 he soon transferred back to switchboard work.

During World War II, Mr. Davidson worked on radars—notably a highly portable one for the Marines to spot airplanes from the ground.

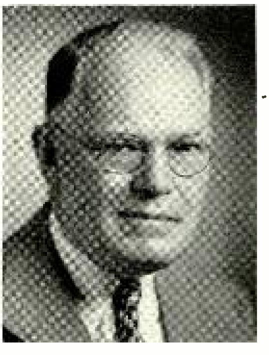
After the war Mr. Davidson returned to telephone work and made important contributions in the field of auxiliary services, particularly the No. 23 operating room desk to handle information, intercept, rate and route traffic on a crossbar call distributing centralized basis. Another was the No. 12 service observing switchboard to display the numbers set up by the operators on nation-wide operator toll dialing and to permit a careful scrutiny of the performance of operator toll dialing facilities.

In retirement, Mr. Davidson will be kept busy by his two children, three grandchildren, his wife and many hobbies. He is a photographer, furniture repairman, wood and metal worker of sorts and he plays some golf. He is a resident of Montclair and much interested in civic affairs.

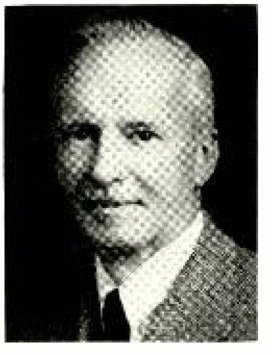
BAYARD B. WEBB

On an October afternoon in 1915, three young engineers of the Laboratories were sitting in the AT&T testroom at Washington, listening to play-by-play reports of the World Series. They had worked all night; expected to work that night. A telegrapher handed them a message from another wire. It told how a few hours earlier the voice of one of them had been heard in Paris by radio from Arlington.

That man was Bayard Webb, who had graduated from Union College three years earlier, and had immediately joined Western Electric. After the customary year on the student course, he was assigned to amplifier development and later to supervise their operation in several eastern cities. Then came the transatlantic tests, and later the United States' entry into World War I. One war-time project of the Laboratories was to set up a laboratory in Paris for the Signal Corps, to be staffed by some sixty engineers and scientists, many of them from West Street.



JOHN DAVIDSON, JR.



B. B. WEBB

Mr. Webb had to procure everything needed, from instruments to bolts and screws and on to include a library.

Later in the war Mr. Webb took charge of manufacturing design in Western Electric's vacuum tube shop, then managed by the Research Department. When it was proposed to centralize all research services, Mr. Webb took charge. He had already decided that his career was to be in business management. Success of the idea in its early days was due largely to his energy and diligence; staff engineering is now an accepted feature of Bell Telephone Laboratories management.

Appointed Purchasing Agent in 1921, Mr. Webb by 1924 was able to give a good deal of time to setting up practices to be used when the Laboratories became a corporation late that year. Two years later he became Commercial Relations Manager, a job which he held until retirement. In that post Mr. Webb was responsible for business contacts with our two customers – Western Electric and AT&T – and through Western with the many government agencies which sought our services during World War II. His war-time work load was so great that his staff grew from about 60 to 250 people.

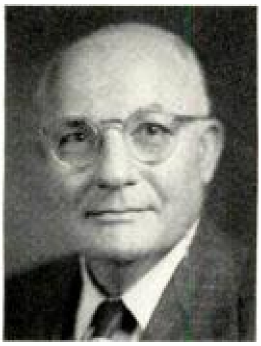
Mr. and Mrs. Webb will move from the city to Geneseo, New York, their permanent home. They expect to travel abroad, and of course to spend some time enjoying the company of his six children and as many grandchildren.

Victor W. Langborgh

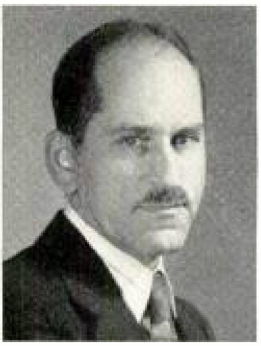
A month before he was fifteen, Vic Langborgh decided he was through with school and got himself a job at the Clinton Street works of Western Electric in Chicago. That was in 1904, and now Mr. Langborgh, after forty-five years of service, is the last West Street survivor of the Clinton Street crowd. He progressed from files to blueprints to drafting on telephone power plants; and when he came to us in 1917 he took over power drafting on the then forthcoming panel offices. Eventually that job went to Hawthorne, but Mr. Langborgh remained to work on current engineering of power supplies. In the thirty years that followed he has worked on hundreds of power equipment designs for toll offices that have required something different from standard practice. Recently he has specialized on power for the new No. 3CL toll switchboard.

"Vic" has always been active in sports—in his younger days he was a wrestler and a first-rate boxer; and he still plays tennis and bowls in the Laboratories league. He and his wife expect to sell their home on Staten Island and move south, maybe to Florida. Their one regret is leaving behind their son, a Public Service engineer, their daughter-in-law and, very important, their grandson.

V. W. Langborgh



M. E. Ellis



Helmuth Eckardt

Thomas J. O'Neil

Helmuth Eckardt

Starting as a messenger with the Engineering Department in 1917, Helmuth Eckardt shortly thereafter transferred to the Transmission Branch where he worked on testing of telephone receivers. He attended Cooper Union during this time and received his B.S. degree in 1922. From 1922 to 1929 he was successively engaged in transmitter and audiphone development and the development of wax-disc recording. In connection with the latter he spent several months at the Camden plant of the Victor Company making high-fidelity records with our Laboratories apparatus.

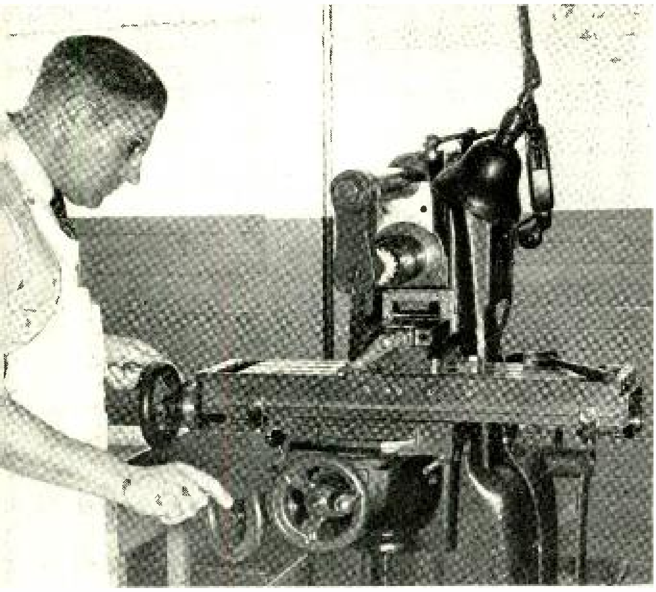
In 1929 Mr. Eckardt transferred to the Commercial Products Development Department where he was in the sound picture laboratory responsible for disc recording. Several years later he transferred to the group working on the acoustic treatment of telephone booths and on methods for reducing noise in typewriters and billing machines. This group also acted as consultants to other departments on questions of acoustic treatments. Since 1940, in the Station Apparatus Development Department, he has been concerned with telephone instrument development.

During the war, he worked on microphones for battle announcing systems and on other acoustic projects.

First on the Eckardts' list of things to do in retirement is a trip to the national parks, where Mr. Eckardt will find plenty of subjects for his camera and canvas. Returning to Towaco, his home town, he will enjoy his other hobbies, which include landscape painting, carpentry, four children and three grandchildren.

Milton E. Ellis

Another man who will not be at a loss for things to do is Milton Ellis, of Power Service. When the W.P.A. was giving courses in painting pictures, Mr. Ellis took it up and did so



N. B. Balcom operating a milling machine in the Development Shop at the Whippany Radio Laboratory.

well at it that he can sell all the pictures he paints. His wife studied ceramics, and now both are proficient in that art as well. When they have established their home in Lacanada, near Los Angeles, they expect soon to build up a business of their own.

Entering the Laboratories in 1918, after ten years with New York Central, Mr. Ellis was successively in the plant maintenance group, power-room foreman, fire marshal of the sound picture laboratory and then went back to the Plant Department as foreman of the mechanical group. In 1941 he was placed in charge of mechanical and electrical power service equipment at the West Street properties.

Thomas J. O'Neil

When Mr. O'Neil came to work in Systems Drafting in 1918, he brought with him the nickname "Tip," and so he has always been known to Laboratories people. The circle is large, because Tip has been one of our athletes, first in basketball and later as a bowler. During his first five years Tip rose through various drafting grades, and in 1923 became an engineer working on specifications for equipment for field trials. To be mentioned among these jobs are the radio receiving station at Buenos Aires, the No. 4 toll test frame at Philadelphia and the No. 3 toll switchboard and terminal equipment for the fourth Key West-Havana cable. Between 1932 and 1941 he drew on his long years of experience as draftsman and engineer to prepare drafting standards for equipment drawings. Returning to engineering, he took part in the work on "L" carrier and additional Key West-Havana terminal equipment.

During the war, Tip acted as liaison with Western Electric's Bayonne shop; then worked on A.M.A. accounting center equipment, and finally was an expediter on the contracts placed outside by the Development Shops at West Street.

News Notes

K. K. Darrow attended the meeting of the American Physical Society, March 16-18, at Oak Ridge, Tennessee. Dr. Darrow addressed the staff of the National Bureau of Standards in Washington on *Theories of Rectification.* He also attended the M.I.T. Electronics Conference, March 30-April 1, in Cambridge.

L. A. Wooten, J. J. Lander and N. B. Hannay attended the M.I.T. Physical Electronics Conference, where Mr. Hannay presented a paper, *Conduction Processes in Oxide Cathodes.*

H. A. Birdsall attended a meeting of A.S.T.M. Committee D-9, on electrical insulating material, at Old Point Comfort, Virginia.

G. T. Kohman and C. A. Bieling visited the Pennsylvania Salt and Manufacturing Company and the Smythe Toxicology Laboratories in Philadelphia in connection with a joint study of the toxic effects of gases for use in pressurized cables.

G. M. Bouton and D. T. Sharpe visited the Mountain States Telephone and Telegraph Company to discuss cable sheath problems.

"Where is the thing you hit to make it skip a letter? I'm new around here."

I. V. WILLIAMS and W. BABINGTON attended spring meetings of the A.S.T.M. at Pittsburgh. Mr. Babington discussed die casting at Frankford Arsenal, Philadelphia.

A. C. WALKER gave an address on *Growing Crystals* and also showed a motion picture on crystals to the New York Mineralogical Club at Columbia University.

F. G. FOSTER has been elected an Ordinary Fellow of the Royal Microscopical Society of London. Mr. Foster attended the spring meetings of the A.S.T.M. in Pittsburgh.

F. J. SCHNETTLER and A. G. SOUDEN visited the School of Ceramics, Rutgers University, to attend a Symposium on Ceramic Dielectrics.

W. A. SHEWHART addressed the Mathematical Statistics Colloquium at Columbia University on February 15 on the subject *The Statistical Viewpoint in Engineering Experimentation.* On March 9 he was guest speaker at a meeting of the Mathematics Colloquium of Carnegie Institute of Technology and that evening was guest of honor at a dinner celebrating the tenth anniversary of the founding of the Pittsburgh Quality Control Society, now the Pittsburgh Section of the American Society for Quality Control.

The Journal of the Acoustical Society for March, 1950, contains the following articles: *The Perception of Speech and Its Relation to Telephony by* HARVEY FLETCHER and R. H. GALT; *The Speaking Machine of Wolfgang von Kempelen by* HOMER DUDLEY and T. H. Tarnoczy; and *Loudness Patterns—A New Approach* by W. A. MUNSON and W. B. GARDNER.

L. A. MEACHAM, ANN CODDINGTON, PHYLLIS TAYLOR and BROCKWAY MCMILLAN played "The Wobble Organ" on March 10 during a "Fathers' Night" meeting of the Parent-Teachers Association of New Providence. On March 31 they entertained at a social evening at the First Methodist Church of Chatham. Mr. Meacham invented "The Wobble Organ."

A. G. JENSEN presented a paper entitled *Compromises Necessary for a Color System to Fit a 6-Mc Band* at the Television Symposium during the recent I.R.E. Convention. At the invitation of the Federal Communications Commission, he appeared as a witness during the current color television hearings in Washington. On this occasion he read this same paper into the record and followed it with a detailed discussion of the resolution capabilities of the different color television systems.

A. B. CRAWFORD attended a conference at Sandia Base, Albuquerque, New Mexico. He also discussed microwave propagation problems and antennas with telephone engineers at Los Angeles and with engineers at the Naval Electronics Laboratory at San Diego.

RECENT SPEAKERS at Deal-Holmdel Colloquiums were C. R. Townes of the Department of Physics, Columbia University, who spoke on *Microwave Spectroscopy* on March 10 at Deal, and C. C. CUTLER who spoke on *Traveling Wave Tubes* on April 7 at Holmdel.

AT WINSTON-SALEM, E. W. HOLMAN, F. A. WOLFE and A. D. HALSEY consulted with engineers regarding the use of a new pulse scanning test set; D. T. BELL and W. E. KAHL discussed problems which had arisen during production of some new transmission networks; and C. T. GRANT investigated special filters.

R. A. SYKES, M. D. FAGEN, E. S. PENNELL, and B. S. WOODMANSEE conferred in Belmont, Massachusetts, with representatives of the Richard D. Brew Company on ultrasonic delay lines.

Model railroaders P. Mallery and R. Schuster work on the roadbed for a portable TT gauge layout in Section 1K at West Street as J. N. Walter, H. J. Braun and H. H. Hagens, chairman of the Club, look on. Built noon hours, the 4 x 8 table folds and makes its own carrying case. There is a scale mile of mainline single track and another scale half-mile of sidings in the layout.

O. MYERS and R. H. GRANGER attended a section meeting of the A.I.E.E. at Philadelphia. While there they delivered a talk on what relays do in crossbar systems and gave a demonstration of the No. 5 crossbar system.

B. SLADE and R. M. C. GREENIDGE, at the Plaskon Company in Toledo, discussed the molding of flat-type resistances. They also went to Hawthorne on resistance matters.

W. M. Bacon was in Detroit March 29-31 to discuss problems concerning the General Motors and Ford 81C1 teletypewriter switching system installations.

R. S. Caruthers, L. R. Montfort and L. Pedersen, with C. S. Thaeler of O & E, visited various points in Florida and Georgia in connection with a survey of facilities required for preliminary field tests relative to a projected new telephone system.

R. L. Tambling returned to New York early in April after spending several weeks at Key West, Florida, and Havana during which he supervised the testing of the carrier terminal equipment installed for a Key West-Havana submarine cable.

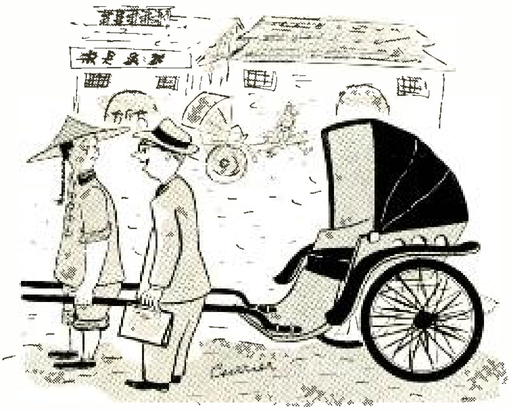
J. N. Shive spoke on *The Semiconductor Photoelectric Effects and the Phototransistor* in New York before a specialized electronics meeting on April 11 of the New York section, A.I.E.E., Communication Division.

W. H. Edwards, J. R. Erickson and W. O. Arnold studied the use of 102A key equipment under actual operating conditions at the Cleveland C.A.A. Air Route Traffic Control Center.

G. A. Pullis, R. E. Staehler and N. A. Newell measured line noise at Harrisburg resulting from a telegraph and low-frequency induction and its effect on single frequency signaling.

A. A. Hansen visited the Philadelphia toll office in connection with studies of mercury-type relay performance.

M. E. Maloney and D. J. Van Slooten visited Albany to discuss installation of special equipment to check on the possibility of irregularities in operation of the A4A system.



"My good man, we could use you at Murray Hill!"

C. Breen and A. A. Hansen were in Buffalo on field trials of simplified maintenance facilities for No. 5 crossbar offices. Mr. Hansen also visited the Rochester toll office in regard to single frequency maintenance studies.

C. V. Taplin visited the Buffalo central office on No. 5 crossbar maintenance problems.

S. P. Shackleton was one of a panel of five members of the New York Engineers' Committee on Student Guidance who participated in a seminar class discussion in the Graduate School of New York University, March 10.

A. J. Busch, F. A. Korn, R. L. Lunsford, J. G. Ferguson, R. E. Hersey, K. M. Fetzer, O. J. Morzenti and L. J. Purgett attended a conference at Hawthorne.

J. J. Lukacs visited Centerline, Michigan, in connection with No. 5 crossbar.

C. W. Haas visited Buffalo and is now at Cleveland in connection with No. 5 crossbar.

May Service Anniversaries of Members of the Laboratories

50 years
Margarita G. O'Brien

45 years
Abraham Chaiclin
O. H. Kopp

40 years
W. L. Deisel

35 years
A. S. Fritz
J. P. Schafer
F. A. Wolfe

30 years
T. E. Battaglia
G. H. Bogart
S. J. Brymer
Emil Dickten
J. M. Hayward
Frank Lohmeyer
E. G. D. Paterson
G. R. Stilwell
Alfred Herckmans
Walter Kalin
Mary Kirby
T. L. Oliver
Frank Rehak
Max Schrauth
George Scott
Fred Sindlinger

25 years
R. P. Booth
Wilheim Gnorich

20 years
W. B. Angerole
N. J. Brendel
Patrick Clifford
M. W. Frick
E. L. Gartland
C. R. Geith
K. P. Hansen
W. S. Henneberger
H. E. Hill
O. E. Larsen
S. A. Levin
W. J. Reber
D. H. Ring
J. C. Schoenenberger
L. W. Stengel
A. B. Thomas

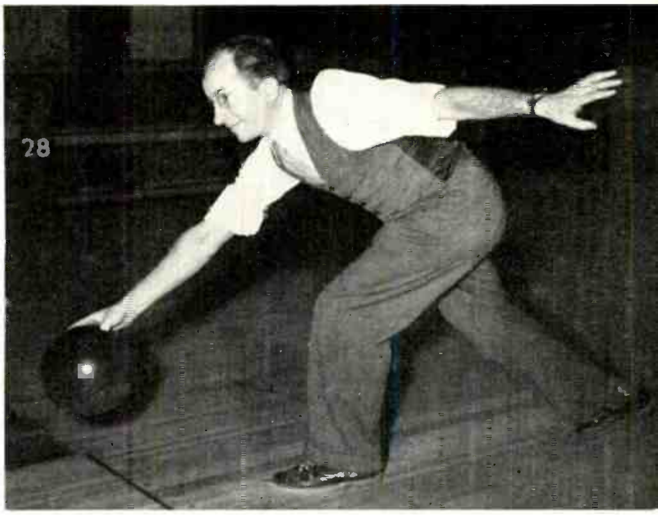
15 years
Margaret Higgins
R. F. Huebner
E. G. Morton
W. G. Pfann
J. H. Riley
E. G. Walsh
Joseph Weltert
W. L. Whinn

10 years
R. T. Lynch
Mozarta Libby

New York Bowlers

At the scoreboard are, left to right, A. Uhl, E. W. O'Hara, H. Keefer, keeping score, J. J. Shindle, D. F. O'Sullivan, F. Balacek, R. W. McKenzie, and S. N. Foster.

L. A. Yost and W. L. Hardardt.



An action shot of F. J. Majorossey

J. F. Hurley, William Seegar, Edward Pobolek, James Marshall and H. A. Rosenbohn in green ribbon ties they wore on St. Patrick's night when the RECORD *cameraman visited the bowling alleys.*

RECENT DEATHS

Vivian Kilpatrick
1900-1950

H. M. Bascom
1883-1950

John Bane
1881-1950

Vivian Kilpatrick, April 7

Shortly after she had been graduated from Adelphi College in 1922 with an A.B. degree, Miss Kilpatrick joined the Transmission Department as a clerk. In 1923 the group transferred to the Research Staff Department and the following year she became a supervisor of all secretarial and clerical work in that department. She became a Member of the Technical Staff in 1927 and in 1940 a Member of the Laboratories Staff. Miss Kilpatrick transferred to the General Service Department as a supervisor of transcription, stenographic and mimeographing services in New York in 1945. Last November all secretarial services under the New York Area Management were added to her responsibilities. She was a member of the Transcription Supervisors Association.

Henry M. Bascom, March 14

When H. M. Bascom, formerly Director of Switching Engineering who retired in 1947, joined the Engineering Department of the New York and New Jersey Telephone Company in 1906, he then had seven years of communication experience with independent telephone companies. In 1909 he transferred to the Engineering Department of A T & T, where he soon became an expert on equipment for manual central offices.

With the formation of the D & R in 1919, Mr. Bascom became Local Central Office Development Engineer responsible for all local central office apparatus and equipment, manual and dial, and for PBX switching. When that department merged with the Laboratories in 1934, he continued the same responsibilities, with the title Local Facilities Director of the Systems Development Department. For several months in 1938 he was in Europe studying technical developments there. In 1940 Mr. Bascom became Director of Switching Engineering, at the same time taking over the telegraph development group. This group undertook the development of world-wide teletype radio communication systems and the development of the Mark XX radar during World War II.

Mr. Bascom was responsible for the development of composite signaling circuits which automatically compensated for variations in earth potentials.

About seventy patents are evidence of Mr. Bascom's specific contributions to telephony. It is significant that, in many of these, he had joined with others whose thinking he stimulated.

At the outset of the machine switching program he became intimately connected with its development. His judgment entered into the many important decisions made during the stages of initial development, trial installation and final refinements of the panel system. He was also engaged in the development of the crossbar system, being responsible for establishing the operating requirements that are involved. Yet his keen power of analysis and his success in devising apparatus and methods of operation contributed greatly to the manual system. Recognizing certain economic limitations in available common battery switchboards for small central offices, he initiated in 1931 the development of a low capacity and low cost manual board now known as the No. 12 switchboard.

Through his wide personal acquaintance in the Associated Companies, he had a very broad and comprehensive understanding of the needs of those companies and had an unusual ability to translate their needs into definite requirements so set up that apparatus and equipment could be designed. In addition, he had the faculty of applying advances in related arts to improvement of the apparatus and equipment used in the telephone plant.

Following his retirement in 1947, Mr. Bascom joined the Stromberg-Carlson Company as chief engineer. In 1949, because of ill health, he relinquished his duties, but remained on the staff as a consultant.

JOHN BANE, March 15

When Mr. Bane joined the Western Electric Plant Department at West Street in 1912, all steam for power and heating purposes was generated in the building's own power plant. At that time he was a fireman. In 1923 when the generation of electric power was discontinued, he engaged in maintaining boiler room equipment. He continued in that work until his retirement in October, 1946.

New Spraying Area at West Street

Modern spray booths and baking ovens have recently been installed in the 3E section of the West Street building. This equipment enables the Development Shops to handle a wider variety and size of telephone apparatus and parts than was heretofore possible. The two water-wash spray booths each have three stainless steel panels instead of the customary iron panels for water curtains.

The two new drying ovens in the area provide electrically heated and filtered circulated air. This makes it possible to handle ordinary drying or high baking finish requirements with ease. An air intake system with a capacity of 12,000 cubic feet of filtered and heated fresh air per minute gives adequate exhaust and ventilation for the spray booths and for supplying air to the entire operating area.

"The Telephone Hour"

NBC, Monday Nights, 9:00 p.m.

May 8	*Bidu Sayao*
May 15	*Pia Tassinari and Ferruccio Tagliavini*
May 22	*Elena Nikolaida*
May 29	*Polyna Stoska*
June 5	*Todd Duncan*
June 12	*Jose Iturbi*
June 19	*Igor Gorin*
June 26	*Zino Francescatti*

The color system used on the walls and on the equipment, with the well distributed fluorescent lighting, provides an attractive place for the finish operators to do their work.

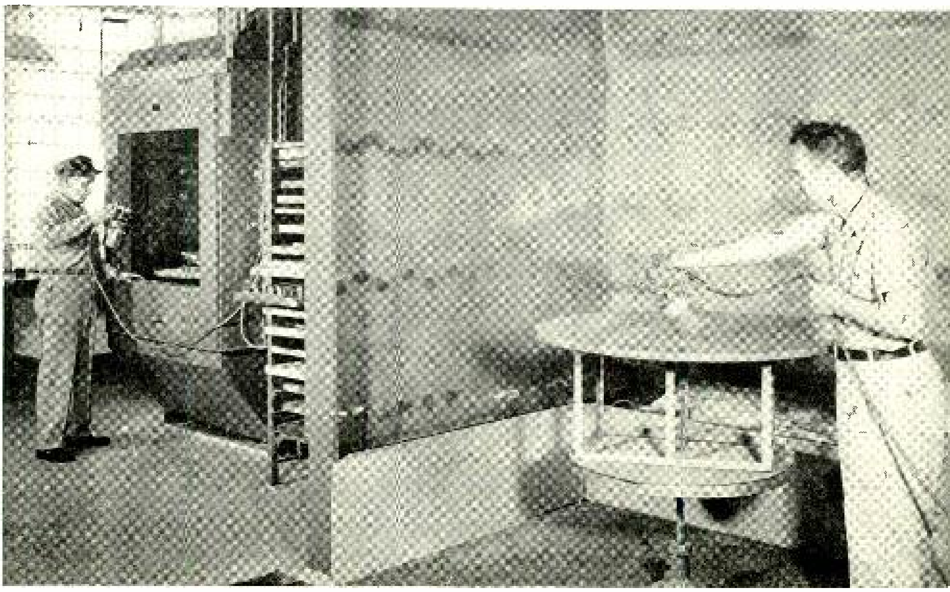
News Notes

N. J. EICH and J. L. GARRISON visited the Western Electric Company at Haverhill in connection with the production of experimental models of packaged amplifiers.

E. G. ANDREWS attended the Rutgers meeting of the Association for Computing Machinery at New Brunswick on March 29.

R. MUELLER visited Troy, March 6-10, in connection with field installation of new type relays in the Troy No. 5 crossbar office.

R. H. GUMLEY, G. H. DOWNES, T. A. MCCANN and C. SCHNEIDER visited Albany on March 23 in connection with new type relays. Mr. Gumley, Mr. Schneider and C. G. MCCORMICK observed apparatus at Philadelphia in connection with apparatus studies at the Philadelphia accounting center on March 8.



Carl Stone, metal sprayer, left, spraying small telephone parts; and Thomas Smith of the Wood Finishing Shop, right, finishing a restaurant table top in the new spraying area at West Street.

C. O. Parks visited Baltimore in connection with preliminary tests on the A4A toll system.

C. A. Lovell, H. O. Siegmund, H. M. Knapp, D. C. Koehler and C. F. Spahn visited Hawthorne in connection with relay developments.

J. R. Irwin visited the step-by-step office in Trenton on contact studies.

J. J. Kuhn and J. F. Baldwin were at the Point Breeze plant to discuss the manufacture of switchboard plugs.

L. J. Cobb went to Indianapolis in connection with the introduction of quality control procedures applicable to the new telephone set.

M. Salzer went to the Teletype Corporation, Chicago, and the No. 5 crossbar offices in Westlake, Ohio, and Centerline, Michigan, in reference to the KS-13834 perforator.

A. F. Bennett visited the Northern Electric Company, Ltd., in Montreal and addressed groups from that company and the Bell Telephone Company of Canada on the subject of the new 500-type telephone set.

W. L. Betts, at Fort Wayne, discussed the motor generator sets to be used on the L3 carrier system.

O. A. Hanna attended an organization meeting at Chicago of a new subcommittee under D-7 of the A.S.T.M. on standard methods for testing wood crossarms.

A. H. Schirmer attended a meeting of the Correlating Committee of the Electrical Section, National Fire Protection Association, in Chicago in connection with the revision of the National Electrical Code.

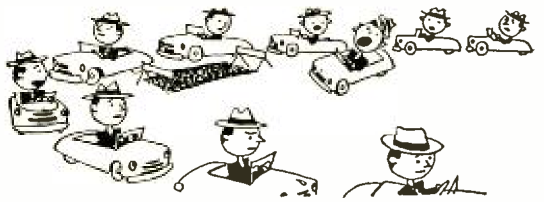
D. W. Bodle, with A T & T and Bell Telephone of Pennsylvania people, made an inspection trip to investigate recent lightning damage to the toll line between Honesdale and Narrowsburg, Pennsylvania.

T. C. Henneberger, J. W. Kennard and V. H. Baillard met with representatives of the New York Telephone Company at Cooperstown, New York, to discuss plans for an initial installation by the "prelashing" method of a new type of cable having polyethylene-insulated conductors and an alpeth sheath.

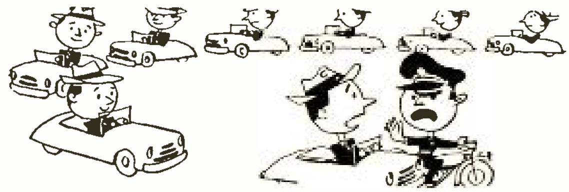
H. H. Spencer and G. W. Meszaros made tests at Key West, Florida, on the special power equipment to be used for energizing the repeatered submarine cable from Key West to Havana.

J. B. Kelly discussed selenium rectifier designs for the L1 and L3 carrier systems with engineers of the General Electric Company at Lynn.

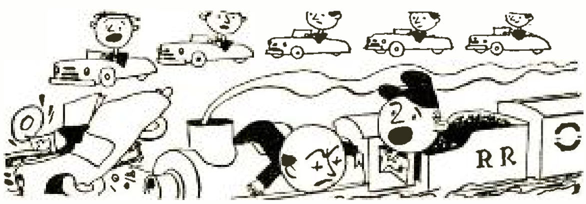
TEN LITTLE



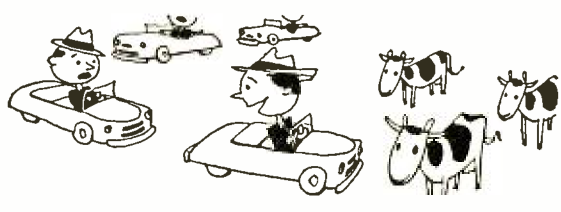
TEN little motorists, driving in a line; one tried to pass the rest . . . then there were NINE.



EIGHT little motorists, young and very deft; one tried to show his speed . . . SEVEN then were left.



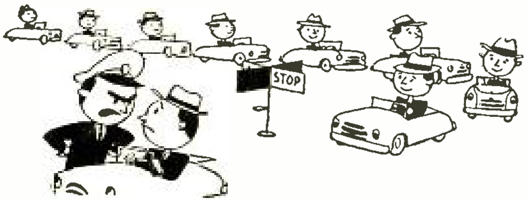
SIX little motorists, very much alive; one did not see a train . . . then there were FIVE.



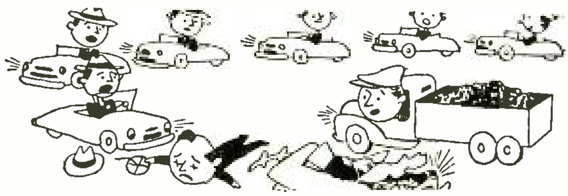
FOUR little motorists, coming from a tea; one faced about to chat . . . then there were THREE.

TWO little motorists, racing just for fun; one passed upon a crest . . . then there was ONE.

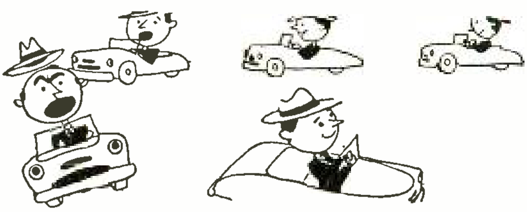
MOTORISTS



NINE little motorists, sadly we relate; one passed a traffic cop . . . then there were **EIGHT**.

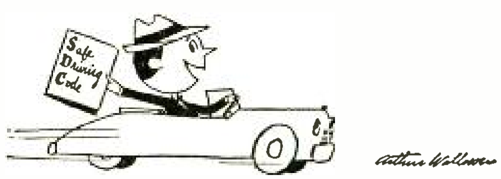


SEVEN little motorists, touring in the sticks; one failed to dim his lights . . . then there were **SIX**.



FIVE little motorists, driving in the rain; one skidded on a curve . . . **FOUR** now remain.

THREE little motorists, this is sad but true; one slumbered from fatigue . . . then there were **TWO**.



ONE little motorist felt his life he owed, to always following the Safe Driving Code,

(*Courtesy of The Telephone Review.*)

C. T. Wyman visited Hawthorne for discussions of cable problems.

L. A. Leatherman discussed counter EMF cell equipment with the Gould Storage Battery Company at Trenton.

R. B. Bauer went to Chicago, Kansas City and St. Louis studying problems on No. 5 crossbar and A4A systems.

H. T. Langabeer and L. S. C. Neeb conferred on new designs of bus duct with the Frank Adam Electric Company at St. Louis.

R. R. Stevens and G. F. Schmidt visited Archer Avenue in connection with coin collectors.

J. M. Duguid went to the plant of the General Motors Corporation, Diesel Engine Division, in Detroit in connection with the newly designed series 110 diesel engines.

D. H. Smith observed the operation at the Plantation No. 1 crossbar office at Pittsburgh of the regulated exciter circuit which is under field trial at that office.

V. T. Callahan studied engine silencers at the Maxim Silencer Company in Hartford. He also conferred with engineers at the Hercules Motors Corporation in Canton, Ohio, on automatic diesel engine designs.

W. L. Black visited the offices of the Ohio Bell Telephone Company at Cleveland on the installation of a new type of announcement machine in the standard 3A weather announcement system.

L. B. Cooke attended several conferences in New York as consultant in connection with the acoustical and sound system requirements of the auditorium at 195 Broadway which has been remodeled.

R. A. Miller attended the Spring 1950 Executive Committee Meeting of the Transmitter Section of the Radio Manufacturers Association. Mr. Miller served as chairman of the Audio Transducer Design Technical Session at the 1950 National I.R.E. Convention held in New York on March 9.

H. M. Owendoff conferred with representatives of American Time Products Company in New York on problems in connection with a prototype model of the regulated frequency power supply for use with time-of-day machines.

H. J. Kostkos was in Philadelphia and Chicago on the installation of Bell System exhibits in science museums. Both of these museums contain numerous Bell Laboratories displays featuring such developments as microwave transmission, the Transistor, synthetic crystals, and the new telephone set.

Bell Symphony Orchestra to Give Concert

Playing in the newly enlarged and redecorated assembly room in the AT&T building at 195 Broadway, the Metropolitan Bell Symphony Orchestra will offer a full-length concert of classical and modern numbers at 8:00 p.m., June 1, for Bell System employees and their families. Free tickets to the concert may be obtained from orchestra members or by writing to the Metropolitan Bell Symphony Society, care of the General Service Bureau, Room 518, 195 Broadway, N. Y., or telephone EXchange 3-9800, Ext. 3298.

Among members of the Laboratories who are active in the orchestra are R. E. Anderson, R. D. Fracassi, J. C. Gabriel, W. A. Krueger, P. E. Mills, A. L. Whitman, L. N. St. James.

JOSEPH C. BERKA of the Plant Engineering and Construction Group was graduated from the College of the City of New York in the February, 1950, class with the degree of Bachelor of Electrical Engineering.

R. MARINO and J. E. CASSIDY were at the Patent Office in Washington during March relative to patent matters.

W. L. BOND presided at the session on crystals at the Columbia meeting of the American Physical Society.

DURING THE WINOCA CLUB'S second annual Burlington Variety Show, H. C. JAMES directed a minstrel *Auditioning for MacGregor* and H. A. DOLL, a show *Science and/or Music*. P. F. RECKENZAUN produced the playbill. The Show was given March 10, 11, and 13 at the Whitley Auditorium, Elon College, North Carolina.

R. M. BOZORTH is one of three American scientists who have been invited to attend the symposium at Grenoble, France, July 3 to 7, on *Ferromagnetism and Antiferromagnetism*. The invitation was extended by the Centre National de la Recherche Scientifique.

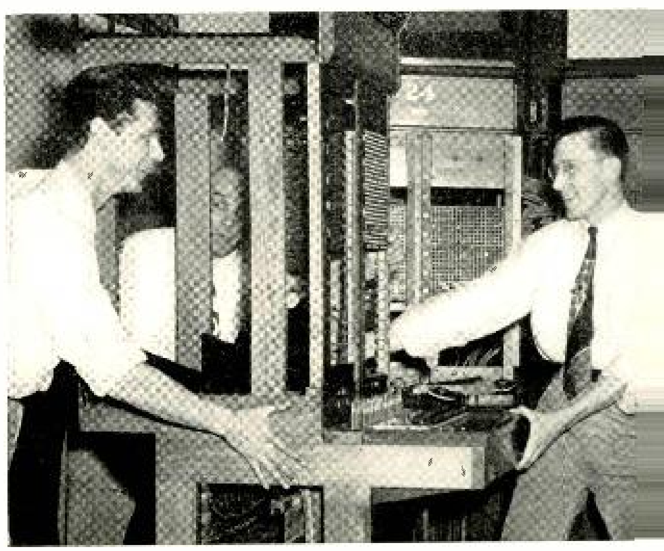
W. SHOCKLEY and J. BARDEEN have written on *Energy Bands and Mobilities in Monatomic Semiconductors* in *The Physical Review*, February 1, Letters to the Editor section.

J. R. HAYNES spoke to the Cleveland Physics Society and at the Harvard Physics Colloquium on *Drift Mobility and Life of Injected Holes and Electrons in Germanium*.

L. J. STACY and P. A. JEANNE visited Springfield, Missouri, to investigate ringing conditions on rural lines subject to severe inductive disturbances from power lines.

F. S. ENTZ, H. M. PRUDEN, A. K. SCHENCK, L. A. WEBER and G. A. PULLIS visited the Martinsville TD-2 station in connection with testing of the C1 alarm and control system.

E. ST. JOHN visited the Standard Electric Time Company, Springfield, Massachusetts, regarding electric stop clocks.



Rearranging of the PBX board in the telephone exchange at West Street to concentrate more lines per position accordance with New York Telephone Company practices, Thomas Condon, at the left, is shown disconnectin[g] position. Dismantling a position, are left to right, Thomas Condon, James Sharp and William Walter.