BELL LABORATORIES

RECORD

VOLUME XXX NUMBER 12 DECEMBER 1952

Line Insulation Testing

J. J. PAUER
Outside Plant Development

Moisture is one of the most frequent causes of service impairment in subscriber lines, but the effects of such faults are often intermittent; they appear in damp weather and disappear in dry weather. These transitory faults are usually, but not always, of the "light" variety causing minor interference with service such as noise or reduced transmission level. Cable sheaths that have developed fine cracks or sheath openings in one way or another admit moisture during periods of rain or excessive dampness, and the insulation resistance of the paper coverings on the wires decreases. Drop wire that has become abraded or otherwise deteriorated may likewise show a drop in insulation resistance of varying degree under rainy or damp conditions. Leaks may appear at cable terminals or on interior wiring in the presence of excessive moisture. After the rainy or damp condition has ceased, such faults usually disappear. Until they have been found and the trouble cleared, however, they are likely to reappear in aggravated form with recurring dampness until the circuit becomes unusable.

As part of a preventive maintenance procedure, it has been common practice for many years to test lines during rainy or damp weather so as to locate trouble before it becomes serious. The majority of the troubles disclosed by such tests can be cleared during ordinary work-day schedules, thus aiding in the reduction of peak work loads and in more efficient scheduling of test bureau and repair force man-power. Until recently such tests were made from the switchboard in manual offices by connecting a voltmeter, in series with a known battery, to the subscriber jacks. The voltmeter reading was then translated into a measurement of insulation resistance. Dial areas were tested at the local test desk by dialing the subscriber numbers and reading the insulation leakage on the test desk voltmeter. Tests in panel offices could also be made from the final frame by means of portable testing equipment. The voltmeter type of testing was slow. Only a small portion of an office could be tested during a typical rainy period, and thus the effectiveness of the test was limited. It was long recognized that if an entire office could be tested during a rain, the preventive maintenance work could be concentrated upon the neediest cases, and the maximum benefit would be obtained.

A number of devices to accomplish this purpose were tried. At the end of the war, an electronic test set suggested by the Southwestern Bell Telephone Company was made generally available. It proved satisfactory, but had no provision for detecting certain types of moisture-caused circuit trouble, and there were some types of central office circuits with which it could not be satisfactorily used. Recently, therefore, the Switching Engineering and Outside Plant Development Departments collaborated in the development of an additional test circuit for incorporation in the set, and modified some of the existing circuits to make them universally applicable. With these modifications the set is now being manufactured by the Western Electric Company under the name of the Rapid Line Insulation Test Set. Such a set is shown in use in Figure 1.

In testing subscriber lines for low insulation resistance, the test set is connected to the tip, ring, and sleeve terminals of the subscriber circuit by means of a test shoe, which is moved manually over the intermediate distributing frame terminal blocks as indicated in the illustration. This particular photograph was taken in a manual office, but the test set is also adaptable to panel and step-by-step offices. The sleeve lead of the test shoe is used for determining whether or not the line is in use. If it is, no test is made on that line and the shoe is moved on. If the line is not busy, however, current flowing over the sleeve lead operates a relay in the test set that connects the tip and ring leads through for the test. The circuit by which the manual office test set determines whether or not the line is busy is shown in the simplified schematic, Figure 2. If the line is busy, the 140-ohm and 35-ohm resistances in the set and corresponding switchboard cord and line sleeve resistances in the central office circuit form a bridge network in approximate balance. The current flow through the supervisory relay of the set is then not sufficient to operate it, and the tip and ring leads of the line are not connected through for the test. If the line is idle, on the other hand, central office battery sends current through the supervisory relay of the set. The cut-off relay of the line under test is effectively in series with the supervisory relay of the set and operates to disconnect the central office equipment from the line. Also, the supervisory relay of the set operates a relay that connects the tip and ring leads of the line through to the test circuit.

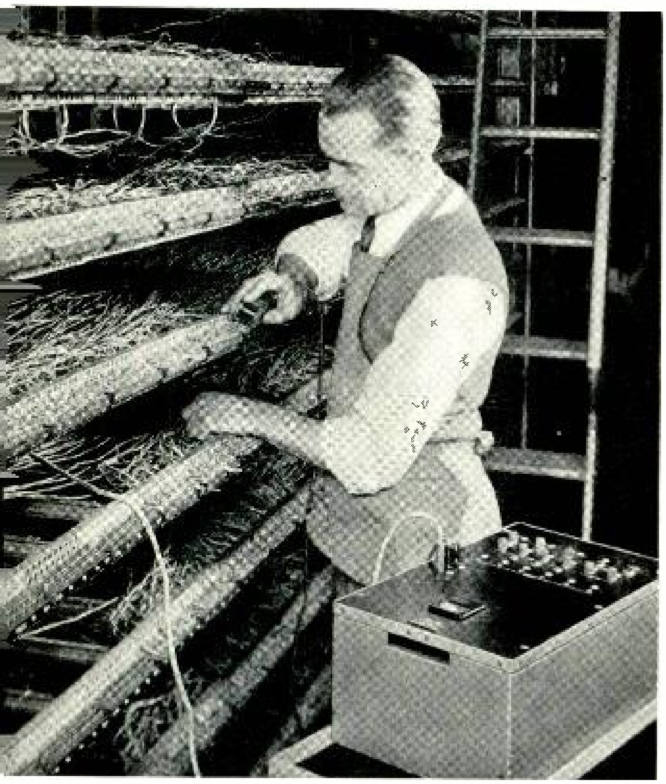


Fig. 1—The rapid line insulation test set in use in a central office.

A basic schematic of the testing circuit is shown in Figure 3. The grid of the detector tube is normally held at a negative bias of about 1 volt by the voltage-dividing resistances across the test battery C1. The 47,000-ohm and 1,000-ohm voltage-dividing network with a 49-volt test battery is used for 48-volt central offices. When a subscriber line containing a low resistance fault is connected to the tip and ring contacts of the test shoe, it shunts the 47,000-ohm part of the voltage divider, thus increasing the current to the 1,000-ohm portion. This increases the negative bias of the grid, and thus decreases the current flow in the plate circuit of the detector tube. The decreased current flowing in the plate of the detector, in turn, decreases the negative bias of the grid of the amplifier tube, and thus increases the plate current in the output circuit. The circuit is so designed that the current in the plate circuit of the amplifier tube is roughly inversely proportional to the shunt resistance of the faulty subscriber line. Three polarized relays are used to operate red, yellow, and green signal lamps with their associated buzzers that indicate the relative magnitude of the fault resistance on the line. The relay and signal circuits are so arranged that only the signal corresponding to the fault resistance locks in.

The test set is adapted to making tests in

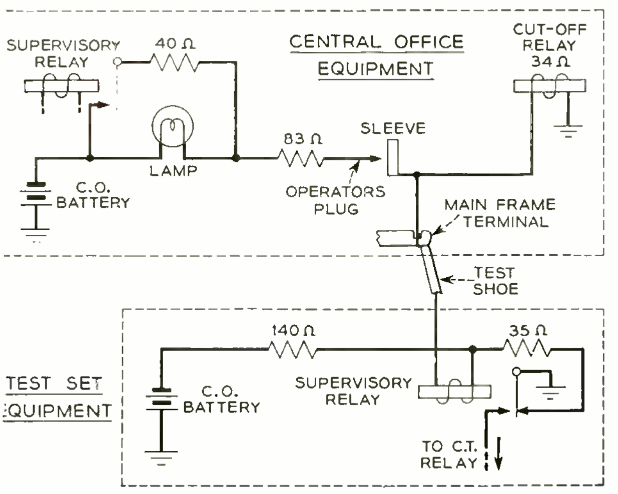


Fig. 2—Simplified schematic of circuit used to detect busy lines in the test set used in manual offices.

four fault resistance ranges, each of which is further divided into red, green, and yellow resistance bands as given in Table I. In Figure 3 only the voltage dividing resistances used in the least sensitive range (A) are shown. Increased sensitivity for the B, C, and D ranges is obtained by providing other resistances that can be switched into both sides of the voltage divider while maintaining the 47:1 ratio used for 48-volt offices. For 24-volt offices at 23.5:1 ratio is used.

In addition to being adjustable as to sensitivity, the test set is also flexible as to the type of test. Tests can be made for short circuits (leakage between ring and tip sides of a line), short circuits and ring grounds (leakage between the ring and tip sides of the line and between the ring side and ground), or for FEMF (foreign potential of the same polarity as the central office battery). These latter faults are caused by leakages, usually in a cable, to either the tip or ring conductors of the line under test from the ring conductors of other service pairs in the cable, which usually have battery connected to them in the central office. These different tests are made by operating keys on the test set to change the input circuit.

The input circuit for the short circuit test is shown at (a) of Figure 4, and is the same as that of Figure 3. With this type of input circuit, the test circuit will respond principally to short circuit leaks RSC. A leakage to ground from either side, such as RG or TG, will have no effect as it will not cause current to flow through either of the voltage dividing resistances. If both RG and TG leakages are present and are low enough in resistance, they will decrease the effective resistance of RSC.

With an input circuit as shown in (b) of Figure 4, the test set is made responsive to grounds on the ring lead as well as to short circuits. This circuit is like that of (a) except that the grid of the detector tube is grounded. Either a short circuit or a ring ground will appear in shunt with the 47,000-ohm resistance, and thus decrease the negative bias on the detector grid. A tip ground has no effect since the tip lead is already grounded. The test battery C1 has the same polarity as, and about 1 volt more potential than, the central office battery. This prevents the capacitance of the line from discharging when it is connected by the test shoe, and thus minimizes transient effects.

This circuit is essentially that suggested

TABLE I — TEST RANGES AND SIGNALS OF LINE INSULATION TEST SET

Test Range	Red Signal	Yellow Signal	Green Signal
	Fault Resistance — Megohms		
A	0.043	0.067	0.150
B	0.260	0.400	0.900
C	0.900	1.400	3.200
D	1.800	2.800	6.300
Buzzer Pitch	High	Medium	Low

TABLE II — CLEARED TROUBLES DETECTED BY LINE INSULATION TESTING

	Cable and Terminal	Drop Wire	Station	Other
	Percent Detected by Various Types of Test			
FEMF Tests	77.4%	5.3%	12.9%	19.5%
Short-Circuit Tests	7.4	66.0	18.4	21.0
Short-Circuit and Ground Tests	15.2	28.7	68.7	59.5
TOTAL	100.0%	100.0%	100.0%	100.0%

by the Southwestern Company. The addition of the FEMF feature resulted from Laboratories field studies of exchange plant maintenance, which showed that the most common symptom of incipient cable trouble is the presence of a high resistance leak from the tip, ring, or both sides of a pair to the ring side of another pair. As the ring leads of pairs are usually connected to the central office battery, this fault is commonly referred to as "crossed battery."

The input circuit for this FEMF test is shown at (c) of Figure 4. The difference here is that the regular grounded central office battery is employed in place of the test battery C1 used with the input circuits (a) and (b). Under these conditions the test circuit responds principally to resistance RX which shunts the high resistance side of the voltage divider. Leaks between the ring and tip of the pair under test have no effect since the tip and ring sides of the line are short circuited at the test set. Leakages to ground have little effect, since they shunt the low side of the voltage divider. When the FEMF test is made, the line capacitance must first be discharged before connection to the test circuit is completed in order to avoid transient effects. This is done by a series of operations performed by a relay circuit that delays the closure of the line to the detector, thus permitting the line to reach a stable condition. This additional operation makes the FEMF test somewhat slower than the other tests. In general, testing speed depends on the type of test, the traffic load, and the number of trouble signals picked up. Under favorable conditions, short-circuit and short-circuit-and-ground tests can be made at speeds around 8,000 to 10,000 lines per hour, while the comparable figure for the FEMF tests is around 3,000 lines per hour. The test shoe is run over the terminals rapidly, and when a lamp lights – indicating a fault – it is moved back to identify the particular line in trouble.

A comprehensive program of line insulation testing includes all three types of tests. Short-circuit tests made during or immediately after rains primarily detect the effects of deteriorated drop-wire insulation, or wet tree contacts on open wire lines. Since such

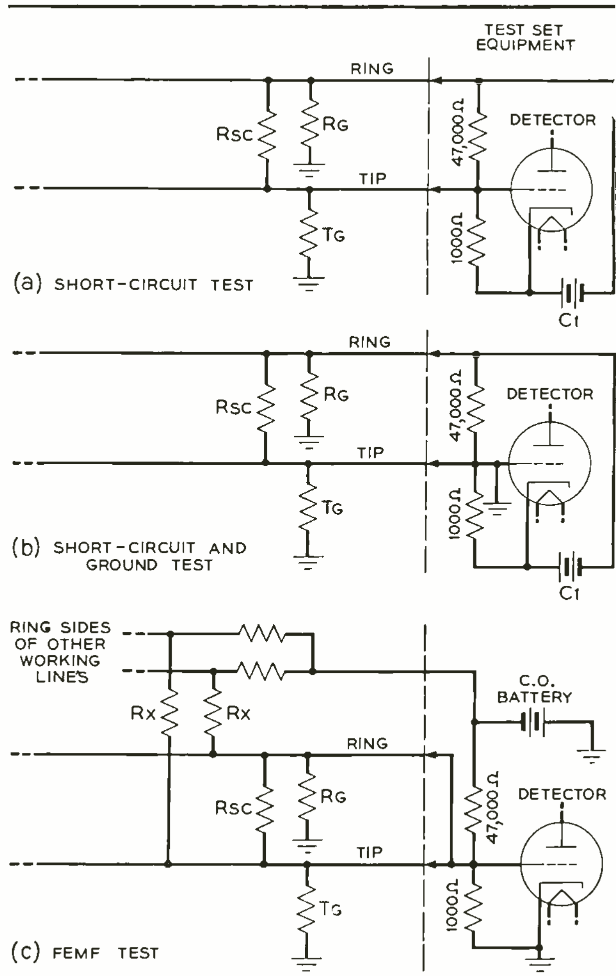


Fig. 4—Input circuit of the test set; at (a) for short circuit tests; at (b) for short circuits and grounds; and at (c) for FEMF test.

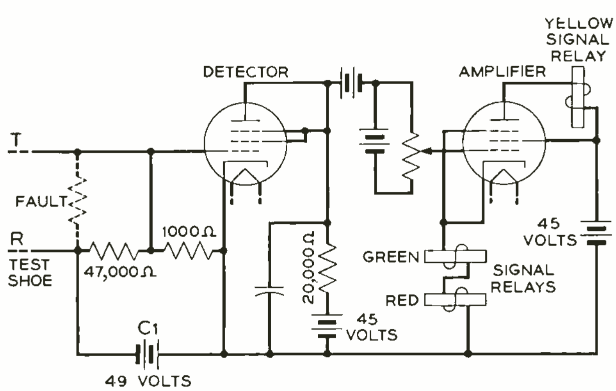


Fig. 3—Basic schematic of the testing circuit.

troubles involve only a single pair, they are not accompanied by crossed battery leaks. These wet weather tests are usually made using the least sensitive or A range test, since it is desirable from a service standpoint to concentrate attention on those cases most likely to cause trouble. This test range is also desirable from an economic point of view, since it tends to obtain the maximum life of the plant. More sensitive short-circuit tests, the B and C ranges, are used when there is not enough rain for an A range test.

Short-circuit-and-ground tests are not very selective. They will detect any deteriorated insulation, and they are used primarily during dry weather to detect faults on inside wire and station equipment. The most productive time for making these tests is during periods of humid weather when subscribers' premises are not heated. The defective insulation effects of drop wire are then minimized since the wires are not actually wet, and short circuits or ring grounds of wire and equipment troubles are not overshadowed by leakages in other parts of the plant.

The FEMF test is used primarily to detect cable troubles, and takes advantage of the fact that when there is a drop in atmospheric temperature, the air inside the cable contracts, causing a partial vacuum that allows outside air to be drawn in through any sheath openings. As the air is drawn in, the air-borne moisture is absorbed by the paper insulation on the conductors next to the sheath opening, and the insulation resistance between these conductors is lowered. These troubles can be separated from the drop wire or station troubles since a number of pairs are usually involved, all showing crossed-battery leaks. Such tests are usually made in the early morning, during dry weather, using the most sensitive range. Cable temperatures are lowest then, and cable trouble indications are less likely to be masked by other troubles.

Although each type of test has a primary purpose, troubles in all parts of the subscriber plant are detected by every test. Wet weather short circuit tests, for example, though aimed primarily at drop wire and open wire troubles, will indicate some station and cable troubles as well. This increases the effectiveness of the over-all test program. The inter-relation of these tests, as demonstrated in a twelve-month testing program conducted in a city having 60,000 subscribers, is indicated by Table II. Cable and terminal troubles were detected predominantly by FEMF test, drop wire troubles by short-circuit tests, and station troubles by short-circuit-and-ground-tests.

The successful application of line insulation tests with resulting service improvement and reduced over-all maintenance effort has led to the development of automatic line insulation testing equipment for crossbar dial offices. This automatic equipment is rack mounted, provides a higher testing speed — approximately 12,000 lines per hour — and uses a new detecting arrangement having a maximum sensitivity of 10 megohms as compared to 6 megohms for the portable set described in this article. Automatic rather than manual operation is necessary in crossbar offices since in these offices the circuits never appear together in such a manner that a test-shoe of the type employed with the manual set can be used.

THE AUTHOR: J. J. Pauer, a member of the outside Plant Development Department since 1949, is currently working on a project for the Signal Corps. Mr. Pauer joined the Laboratories in 1929, spending the next few years in the General Service Department. In 1935 he became a member of the Station Apparatus Department, where he developed testing apparatus and practices for use by the operating companies. He continued in this work until 1949, except during World War II when he was assigned to the development of sonar apparatus. From 1949-51 he worked on line insulation testing as a method of exchange cable maintenance. Mr. Pauer received a B.S. degree in E.E. from Newark College of Engineering in 1938.

Cable Dance Damper

Steady transverse winds occasionally whip aerial cable, especially the smaller sizes, into slow but sustained oscillations with frequencies in the order of one cycle per second. This is called "dancing." Given a favorable combination of wind direction and velocity, span length, and other controlling factors, amplitudes may build to destructive proportions.

In a gale of fifty miles per hour, the second harmonic, which is usually the most energetic mode of vibration, may build up an oscillation having an amplitude of more than a foot in a short span of cable, and of four feet or more in a long span. Unchecked, this motion may lead to fatigue failure of the cable sheath and strand, torn out pole supports, and even poles snapped in two. This type of violent cable vibration is rare.

F. V. Haskell and R. M. Riley of Outside Plant Development have designed the readily adaptable damper shown in Figure 1 for use in spans where a tendency to dance has been observed. The damping action is produced by a weight which floats on a spring inside an hermetically sealed cylinder of slightly larger diameter than the weight (Figure 2).

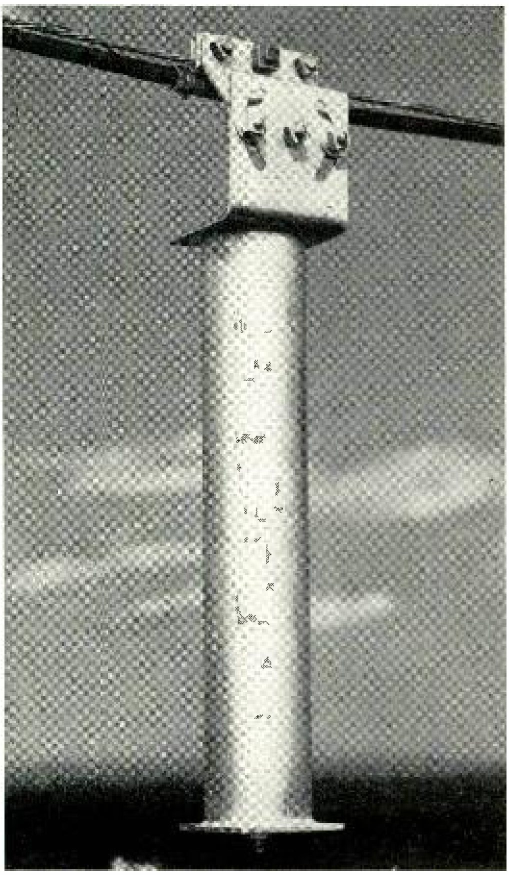


Fig. 1—B cable damper is bolted to strand, then adjusted to hang vertically.

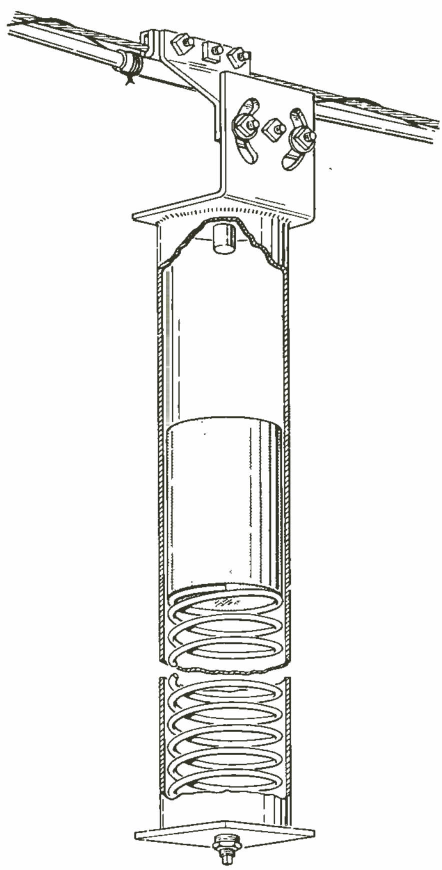


Fig. 2—Interior of cable damper.

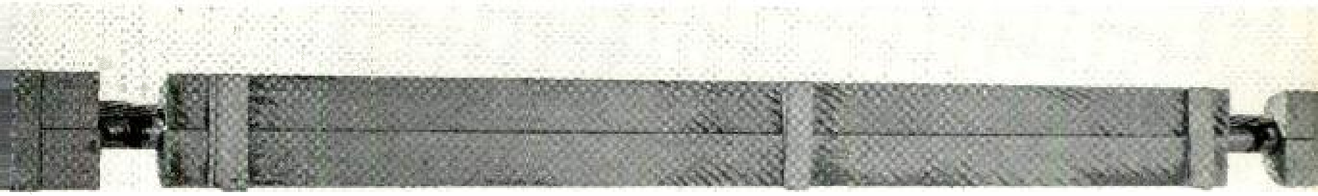


Fig. 3—Usually it takes winds of gale force to set the heavy mass of a long cable span in destructive vibration; and usually winds don't blow that hard at Outside Plant's Chester laboratory where cable spans are subjected to many kinds of tests. Enclosure of a test cable in wooden air-foils of semi-circular cross section (as illustrated above) steps up the air lift so that the effects of a 50-mph wind may be studied in 15-mph breezes, to investigate devices like the new B cable damper.

As the cylinder moves up and down in response to the cable movement, the weight tends to remain stationary because of its inertia, and air is forced to flow in the clearance space between the weight and cylinder wall. The resultant frictional energy loss damps the cable motion. The damper has a natural period of about one second. Its resonance characteristic is flattened by the air resistance in such a way as to make the damping effective over the range of vibration periods encountered with the 100- to 600-foot cable span lengths in the Outside Plant. One or two dampers are installed per span in the area subject to dancing, the number of dampers depending upon the span length.

Development of these dampers is part of a comprehensive laboratory program to investigate the causes of and provide remedies for cable dancing, with the ultimate aim of designing a type of over-all cable line structure that will not be subject to violent dancing due to wind.

New Microwave Route—Kansas City and St. Louis

A microwave radio relay route is planned between Kansas City and St. Louis to supply hundreds of long distance telephone circuits as well as television channels. The new system, a joint project of Southwestern Bell and A T & T Long Lines, is scheduled for completion by the end of next year.

Eight radio relay stations, with antennas varying in height from 100 to 300 feet, will be built along the 260-mile skyway. A new link will augment existing cable and wire lines now furnishing communication to that area, and will interconnect at Kansas City with coaxial cable to Omaha and a new radio relay route stretching south into Texas. At St. Louis it will tie in with coaxial cables extending east and south and with the planned radio relay system to Chicago.

Six radio channels are planned initially, two for telephone message use, two for television and one in each direction for maintenance and protection. The two video channels will provide another route to Kansas City, which is now connected to the Long Lines nationwide network by coaxial cable out of Omaha.

Recovery and Repair of Telephone Apparatus

A. B. REYNOLDS
Specifications Engineering

Every working day of the year, a large amount of apparatus is removed from the Bell System telephone plant for a variety of reasons. Much of this apparatus is repaired and re-installed. It is the responsibility of the Repair Groups of the Laboratories to recommend the requirements for the repair of this apparatus before it is again placed in service.

Actually the term "repair" does not adequately describe the objectives desired and the work done. The word "repair" seems to imply the restoration to normal of apparatus that has failed or become damaged in service. Some apparatus is, of course, removed on this account, but the bulk is removed for other reasons; in the case of station apparatus, the discontinuance of service or change of residence; or, for central office apparatus, equipment rearrangement or change from manual to dial operation. Like a new car, a telephone set becomes a "used" set, and a possible candidate for the repair routine if, for any reason, it is taken out of service after any use, however brief. In the returned apparatus, all vintages of manufacture and all degrees of the effects of service are found. The condition of the apparatus, however, is usually such that a large percentage can be made suitable for further service with a reasonable repair or conversion expense.

Reconditioning of the apparatus is done most often by the Western Electric Distributing House Repair Shops, although some of the apparatus may be repaired by the Telephone Companies in their own storerooms. Whether the repair should be made in the Distributing House Shop or at the point of use is primarily a question of economics.

As a part of their Telephone Division, Western Electric has twenty-nine Distributing Houses, each comprising a warehouse and repair shop, situated at strategic locations throughout the country, employing a large organization that deals with many items. At least one of these distributing houses is in the area of each Bell Telephone Company. Its function is to serve the needs of the Telephone Company in whose area it operates, by maintaining stocks of new and used apparatus and equipment, by handling the Telephone Company's orders for such material, and by receiving and repairing or disposing of used apparatus returned to it by the Telephone Company.

Besides repairing apparatus returned by the Telephone Companies, the repair shops also do other special jobs ordered by the Companies, such as assembling and wiring special switchboards. Although the personnel and management of these shops report to the Distributing House Manager, there is a central organization in New York under the Engineer of Shops which not only supplies the needed technical information, but outlines work and inspection methods and makes recommendations with regard to all shop equipment.

Apparatus received for repair by the Distributing House is first examined and classified. Repairable apparatus that can be reused by the Telephone Company is known as the Company's Class "C" stock. The objective of Class "C" repairs is to secure the full measure of satisfactory service life expected when the apparatus was purchased, and the repair requirements must be consistent with both those for new apparatus and for field maintenance.

From time to time the occasion arises

Fig. 1—Portion of a distributing house repair shop—assembly line for hand telephone and telephone set repairs.

for a widespread conversion of old style apparatus — to introduce an improvement or to keep abreast of the changing times. These changes, while sometimes made in the field, are usually made in the Distributing House Repair Shops and such apparatus returned to the Distributing House also is identified as Class "C". When the change to ten cents for local calls from a pay station was made in 1951 in New York City, for example, many of the modifications in the coin collectors were made right at the customers' premises, although a great number were made in Western Electric's New York and Brooklyn Distributing House Repair Shops.

Another class is composed of apparatus for which there is no demand on the part of the Company removing it. If a demand exists for it in some other area of the Bell System, or from a non-associated telephone company, it is purchased by the Western Electric Company, and either resold to another Bell Company "as is" for reuse, or returned to the Manufacturing Department to be repaired, and offered for resale. If the apparatus is returned to the factory for repair, it becomes known as Class "AH" material after repair. Apparatus that is not repairable, or for which no demand exists, is junked and the junk value less a charge for handling, is credited to the Telephone Company.

Formulation of requirements for Class "AH" (factory resale apparatus) differs in several respects from Class "C". Class "AH" apparatus has been disposed of by an Associated Company before completion of its useful life; when repaired and resold, it must give as good performance in service as equivalent new apparatus. It is sold with, or in lieu of, new apparatus, at a price of 75 to 85 per cent of that for corresponding new apparatus. Although Class "C" apparatus requirements may be less stringent than the requirements for new apparatus, Class "AH" may differ from new only in appearance, residual life, or in other ways that will not affect maintenance or service.

Some apparatus is in sufficiently good condition to be repaired by the Telephone Companies in their own storerooms. This class of reconditioning is performed under a "Recovery" specification which applies only to completely equipped station apparatus. Although some reconditioning is done by the Telephone Companies, most of the recovery and repair work is done by the Distributing House Shops.

Requirements that apply to recovered and repaired apparatus are prepared by the Laboratories. These include repair expedients that may be employed which would result in the apparatus differing from the accepted construction for new apparatus, modifications considered desirable to bring the old apparatus into agreement with more recently manufactured devices, and the operating values that the repaired apparatus should be capable of meeting. Although operating requirements may not be so severe as the corresponding ones for new apparatus, they must not be less severe than the rejection values used for field maintenance.

Requirement specifications for Class "C" repair are distributed both to the Western Electric Company, and, through the A T and T, to the Telephone Companies, so that both Western Electric and the Telephone Companies will have a statement as to the requirements that the repaired apparatus may be expected to meet. The intent is, of course, that each Telephone Company shall adopt, for use in its relations with the local Distributing House, the System's recommended requirements. If these were not available, each Telephone Company would have to prepare its own instructions to the local Distributing House. This is done to some extent now, but the necessity for it is greatly minimized by the existence of the standard practices giving System recommendations. These requirements are not mandatory, and may be deviated from if the local companies do not concur, but they summarize the experiences of many organizations and areas of the System so that, as may be expected, they are very generally followed except when peculiar local conditions necessitate departure.

Recovery and repair necessitates consideration of many financial, technical, and administrative aspects of the Bell System's business. The large amount of apparatus removed and its very great value makes this Laboratories activity of considerable importance; first, as an effort toward achieving the System's aim of economical service of high quality and second, as a source of information and experience to be used as an aid in deciding upon features to be included in future new designs.

The value of the apparatus and equipment reclaimed is relatively large. Reused apparatus constitutes about 10 per cent of the material used in the Bell System for plant additions and maintenance.

THE AUTHOR: A. B. REYNOLDS has been in charge of the repaired station apparatus group since 1942. After he was graduated in 1919 from Massachusetts Institute of Technology, he worked for General Electric Company for about a year and a half. In 1921 Mr. Reynolds came to Bell Laboratories, spending several years preparing manufacturing specifications for telephone apparatus and instruction bulletins for care and operation of such apparatus. He went into design work in 1925, particularly the design of telephone apparatus, such as rheostats, panels, and mounting plates. Since 1928 he has been a member of the repaired apparatus and specifications engineering groups, where requirements for the recovery and repair of telephone apparatus as well as for station maintenance are developed.

High-Speed Machine for Fatigue Studies

G. R. GOHN
Metallurgical Department

Experience has shown that to obtain data of greatest usefulness to the materials engineer and to the designer, physical tests should simulate service conditions as closely as possible. It is highly impracticable, however, to make tests on each individual design of parts, such as flat type contact springs, which are used in a wide variety of telephone apparatus. Many of these springs are subjected to millions of cycles of stress during their normal life, and it is therefore important that their fatigue life at various stresses be known. To obtain such data, test specimens especially shaped for flexure tests, have been mounted on machines that bend the specimens at fairly rapid rates, thus providing fully satisfactory information for design purposes.

In these machines, the amplitudes through which the specimens are bent are representative of those to be expected in service. These amplitudes may also be varied to obtain fatigue data for different unit stresses, and the specimens may even be "notched" in the stressed section to determine the extent to which tool marks or other abrupt changes in cross-sectional area may shorten the life of the spring.

Fatigue machines for testing flat springs have been in use for more than twenty-five years. Those commercially available, however, are not suitable for bending studies on

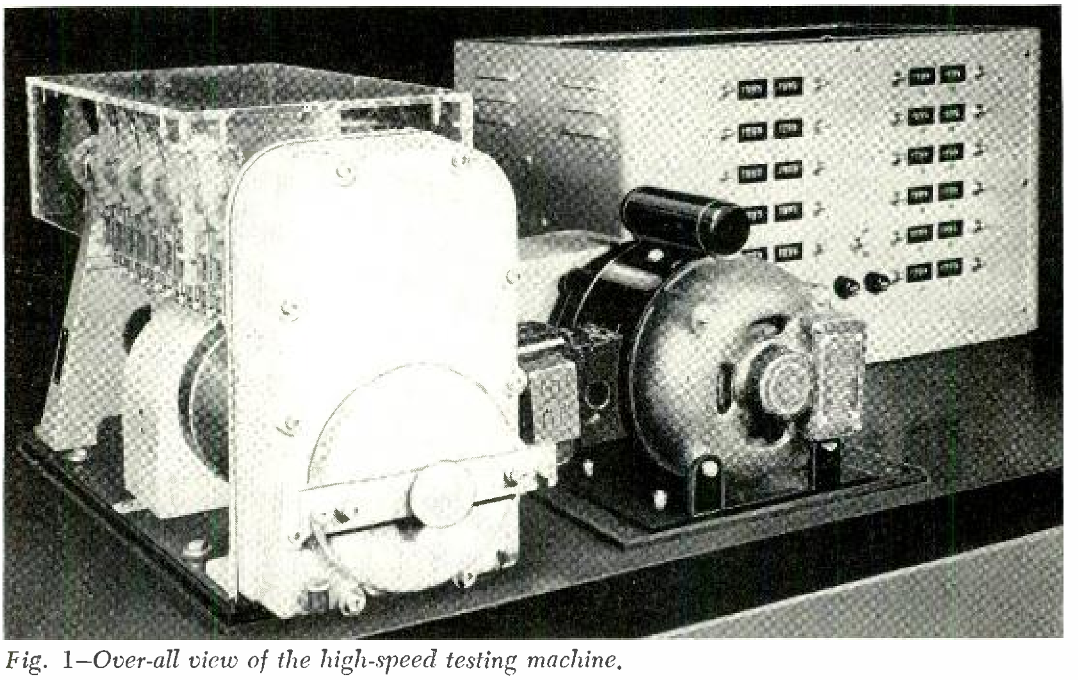


Fig. 1—Over-all view of the high-speed testing machine.

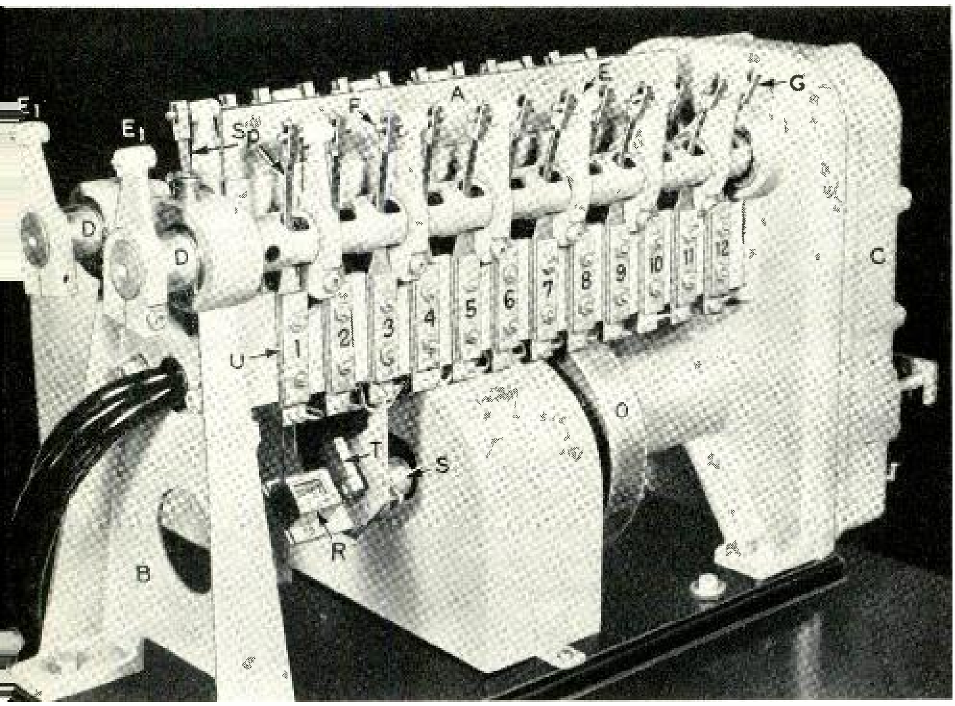


Fig. 2—With the Plexiglas cover removed, showing the test specimens in place.

A – T-shaped rail
B – bracket
C – mechanism housing
Sp – specimens
D – rock shaft
E – rocker arms
F – deflecting pins
G – U-shaped boots
R – mechanical counter
S – Telechron motor unit
T – cam-operated switch
U – specimen clamps

sheet metal within the 0.010-inch to 0.040-inch range of thickness normally employed in the manufacture of flat springs, when the flexure is always in one direction (unsymmetrical bending). Machines built and used in the Laboratories, although capable of unsymmetrical bending, are limited to operating speeds of 900 cycles per minute. However, the bending arcs obtainable with these machines can be changed only with considerable difficulty from one which completely reverses the stress in the springs during each stress cycle, and they lack sufficient amplitude to permit testing in the stress range corresponding to service conditions.

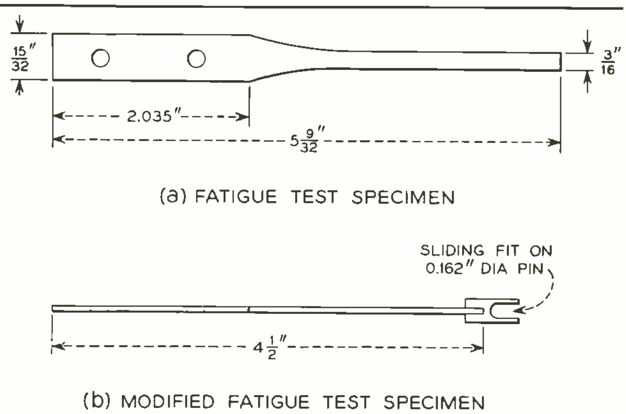


Fig. 3—Test specimens are cut to the dimensions shown in (a), and modified for use in the machine by providing a "boot" on the right-hand end, as shown in (b).

To permit evaluation of the fatigue characteristics of test specimens under unsymmetrical bending, and to obtain the test data more quickly, a new high-speed machine has been developed by the author and the late E. R. Morton. This machine can be operated at speeds up to 3,000 cycles per minute as compared to the maximum of 900 for the earlier machines. A total of twenty-four specimens can be tested simultaneously, and by adjusting the deflecting arms, as many as twelve different initial stresses can be used.

One of the early considerations in the design of the new machine was the problem or reducing the effects of vibration. To operate at high speed, it is necessary that oscillating parts have as little mass as possible and that they be counterbalanced wherever practicable. This led to the use of rotating shafts, carrying deflecting arms, instead of the earlier reciprocating arms to flex the test specimens.

Another problem in high-speed operation is lubrication. The millions of high-speed operations which this machine performs made necessary a lubrication system that would give completely satisfactory service under extended periods of operation of the machine. A splash and gravity feed system was developed which has proved fully adequate; in fact, during operation of the machine, the oil supply to the bearings maintains such a film of oil that it was necessary to install auxiliary contacts held against the ends of the rocker shafts to provide continuity of the electrical circuit used for monitoring instead of depending upon the machine "ground".

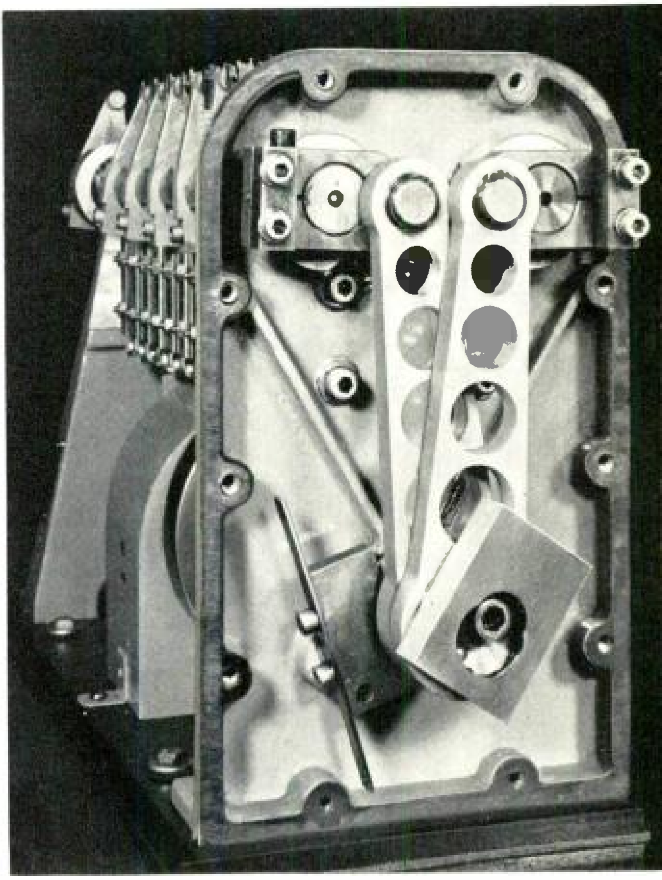
An over-all view of the new machine is shown in Figure 1. In this view, the test specimens are covered by Plexiglas for the protection of personnel; in Figure 2, the cover has been removed to show the deflecting mechanism. Specimens of the metal to be studied, which simulate, in major dimensions, the usual size of springs used in telephone apparatus, are cut to the shape and dimensions indicated in Figure 3.

As is evident in Figure 2, the machine consists essentially of two hollow rocker shafts and a mechanism for oscillating them. Mounted on each rocker shaft are six deflecting arms that engage U-shaped details fastened to the ends of the test specimens, which extend through openings in the rocker shafts. A maximum of twelve test specimens may be clamped to each side of the machine, and each rocker arm drives two specimens by means of a common deflecting pin.

An important feature of the deflecting arm is the location of the center line of the rocker shafts with respect to the active length of the test specimens. This center line is located at about one third of the active length of the specimens from the clamping edge, which corresponds to the center of rotation of the ends of the specimens. This is essential for large deflections, such as those used in unsymmetrical bending studies. If a test spring were to be deflected about its clamped edge, the point of loading, as measured along the spring, would be different for each increment of deflection, thus invalidating the fundamental premise upon which the design of all bending machines is based—that the ratio of the moment aim to the width of the specimen in the critical section, is constant.

Inside the end housing, Figure 4, an eccentric bushing on the end of the crank shaft drives the connecting rods that in turn oscillate the rocker shafts. This eccentric bushing can be rotated to change the stroke of the rocker shafts to obtain the desired deflection of the test specimens. A counterweight as indicated in Figure 4 maintains balance independently of the stroke. The crank shaft also carries a counterbalance, which has an oil slinger fastened to it. This slinger throws the oil around inside the housing; some of it falls on the upper ends of the connecting rods, in the crank shaft sleeve bearing, and into oil pockets and holes in the rocker shaft bearings. Lubrication at the opposite ends of the rocker shaft is obtained by felt packed oil cups.

Fig. 4—End housing of the machine with the cover removed so as to show the actuating mechanism.



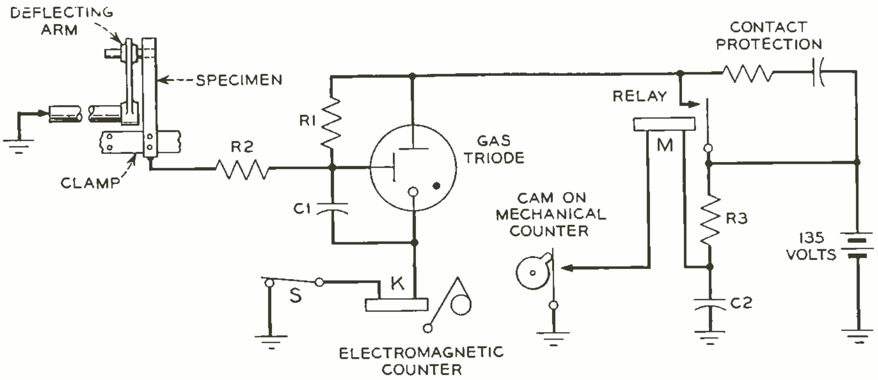


Fig. 5 — Schematic circuit of the electronic counter.

Counting of the number of oscillations (in thousands) of the machine is accomplished by a mechanical counter that can be seen in Figure 2, driven through a gear reducer from the main shaft.

Monitoring of the individual specimens is done by using the electronic circuit of Figure 5. So long as the test specimens are unbroken, the electromagnetic counters K are inactive. Each time the mechanical counter shaft makes a revolution, a cam on that shaft closes the circuit to the relay M. This momentarily connects a 135-volt positive battery to the starter anode of the cold cathode tube through the resistance R1, but the tube is held below the firing voltage because the starter anode is also grounded through the resistance R2 and the associated

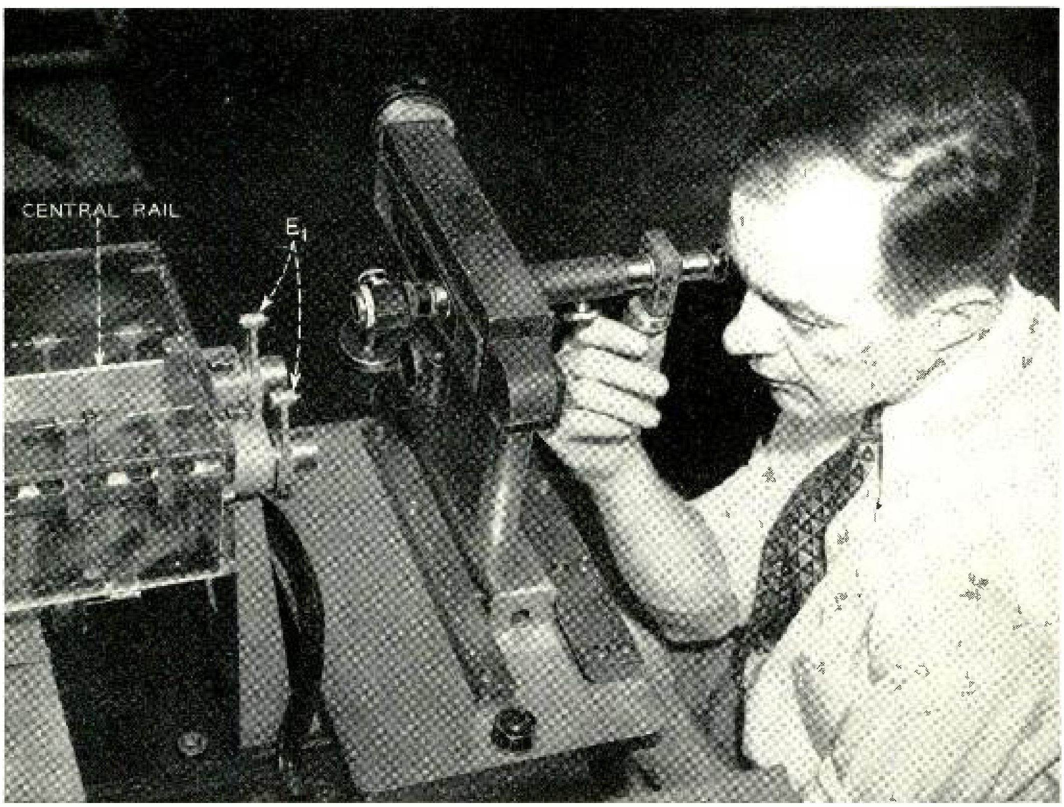


Fig. 6—J. P. Ahrens measuring the deflection (stroke) of the fatigue testing machine with a cathetometer.

test specimen. Capacitor C_1 sustains the starter anode potential against the variations in contact between the deflecting arm pin and the "boot" on the end of the specimen, or against false operation from transient contacts between broken ends of a test specimen after a failure occurs.

When a test specimen breaks, the circuit to ground through the specimen and R_2 is opened, and the voltage on the starter anode, no longer restrained by the drain to ground, rises to a point where the tube fires. This causes ionization in the tube, permitting a discharge between the main anode and the cathode large enough to operate the electromagnetic counter. The difference between the mechanical counter reading and that of the electromagnetic counter gives the number of cycles (in thousands) to failure of a test specimen. After the readings are taken, a switch S in the eletromagnetic counter circuit can be opened so as to conserve the life of these counters. In addition, the duration of closure of relay M is limited to conserve battery and tube life by operating relay M through discharge of capictor C_2, which is slowly recharged through resistor R_3.

To accurately determine the deflection of the specimens at testing speeds, an extra rocker arm E_1, Figure 2, is mounted on the end of each rocker shaft. A 1/16-inch ball is cemented at the center of each deflecting pin. When a spot of light from a small bulb is thrown upon this ball, a streak of light is produced that has very sharp terminations at the extermities of the movement. By means of a cathetometer (a very accurate traveling microscope) the total movement of the rocker arms can be measured and thus provide a dynamic calibration for the machine. Figure 6 shows J. P. Ahrens measuring this distance with the cathetometer.

Having thus determined the range of the deflection, the rocker shafts are set so that the calibrating arms E_1 are at the central or neutral point. The positions of the rocker shaft arms that deflect the specimens are then located as required by loosening the locking screws on the split collar of the arms and rotating them on the rocker shaft until the deflecting pins have the proper offset. The offset, which can be varied from zero to a maximum of one inch, can be checked by measuring the displacement from the central rail, either by means of a special micrometer or with a vernier caliper.

THE AUTHOR: George R. Gohn, a member of the Chemical and Metallurgical Research Department, has been in charge of fatigue and creep studies since 1945. He was graduated from Otterbein College in 1926 with a B.A. degree. In 1929 he received the degrees of B.S. in Engineering and Metall. Engr. from Columbia University. That year he joined the Laboratories. His work has been concerned with the investigation of the physical properties of metals, the application of die casting processes to the manufacture of Bell System apparatus, the development of specification requirements for procurement of non-ferrous metals, and the study of creep and fatigue properties of metals.

Sequence Signaling

A. E. BACHELET
Switching Systems Development

In the TD-2 radio relay system*, most of the repeater stations are normally unattended. An alarm circuit connects all such stations with an alarm center to which alarms are automatically sent when anything happens that affects or might later affect the continuity or quality of the service. These coded alarm messages are sufficiently detailed to indicate the nature and seriousness of the situation. On receiving this information, three courses are available to the maintenance staff. They may schedule a visit to the station at the earliest convenient time; they may dispatch a maintenance man at once; or they may send to the affected station, over another line, coded signals that will cause corrective steps to be taken immediately. To make it possible to select any of the unattended stations from the alarm center, and to transmit to the selected station any of a number of possible orders, a selective signaling system with a large number of codes was nec-

* RECORD, *October*, 1950, *page* 442.

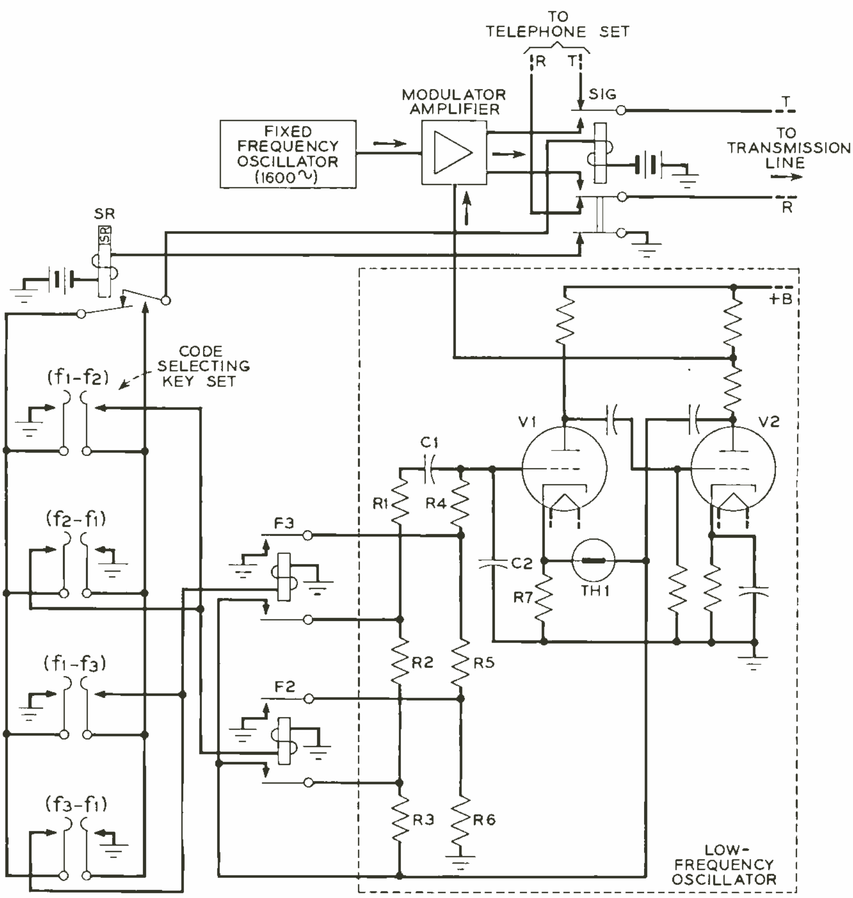


Fig. 1 — Simplified schematic of the transmitting terminal for sequence signaling.

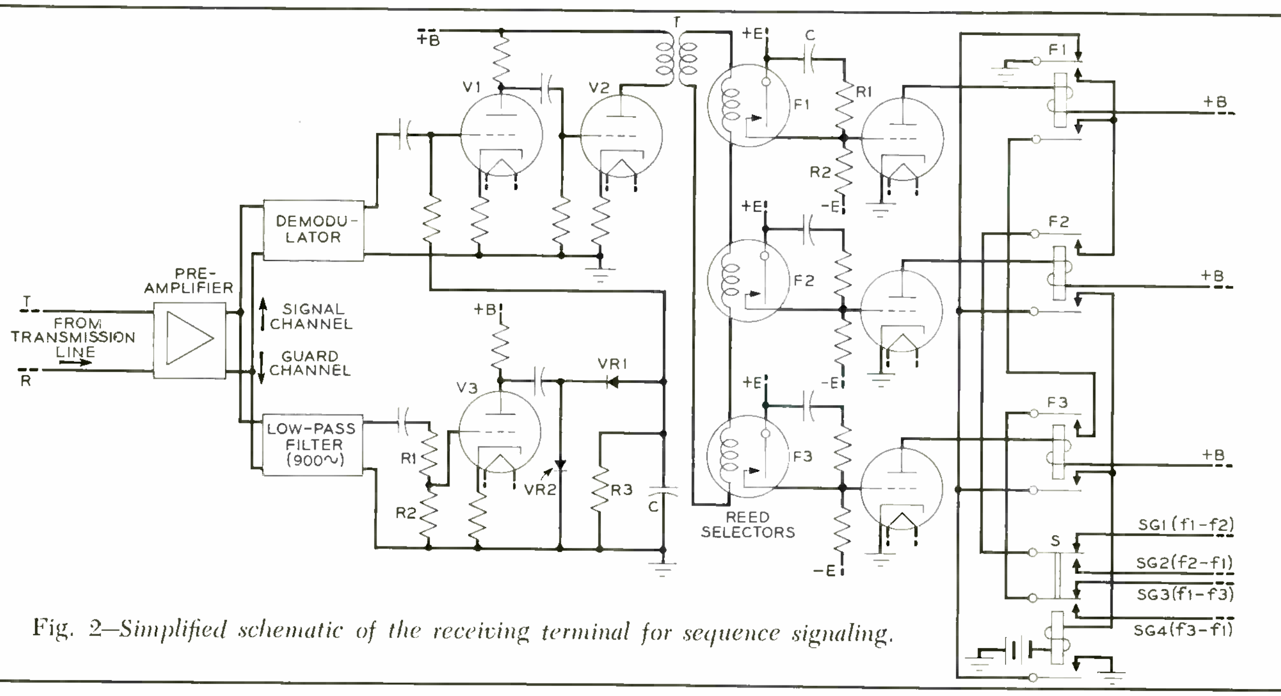


Fig. 2—*Simplified schematic of the receiving terminal for sequence signaling.*

essary. For this purpose a sequence signaling system was developed. It was designed not only for the TD-2 alarm system but for signaling stations on television networks, and is being used in both applications at the present time.

The codes used for this system consist of two signals sent one after the other. Such a method of signaling was indicated in a patent (No. 161,739) issued to Alexander Graham Bell in 1875. It is only in recent years, however, that advances in apparatus and techniques have made a system of this type capable of dependable and economical operation under commercial conditions. One of the major contributions to the success of such a system is the tuned reed relay*, which can be sharply tuned to a desired frequency. Other important contributions are the vacuum tube oscillator, electric filters, and semi-conductor devices.

In brief, the system is capable of generating a group of modulated tones at the transmitting end, of selecting two of them for each code, and of transmitting those selected one after the other. At the received end, tuned reed relays, each responding to only one frequency, respond to the received signals, and through a translating circuit places ground on one of a group of leads, of which there is one for each code in use.

For transmitting the sequence signals, a telephone order wire circuit is employed that parallels the alarm circuit in the TD-2 system and connects to all the unattended repeater stations. The signals are normally sent only when speech is not being carried by the circuit, but precautions are taken to avoid the presence of voice on the order wire from interfering with the reception of the signals. The signals are transmitted at somewhat higher level than average speech, and each is maintained for at least 200 milliseconds. The appearance of the two signals in sequence, and maintained at such a level and for so long an interval, would be very unusual in normal speech. To make doubly sure that speech will not operate the signaling circuit, a disabling circuit is incorporated in the receiver that disables the signal output circuit whenever the speech level becomes high enough to interfere. The chance of speech operating the signaling system is thus negligible.

Twelve separate frequencies are available at the transmitting terminal, and since there are 132 permutations of twelve things

* RECORD, *January*, 1950, *page* 2.

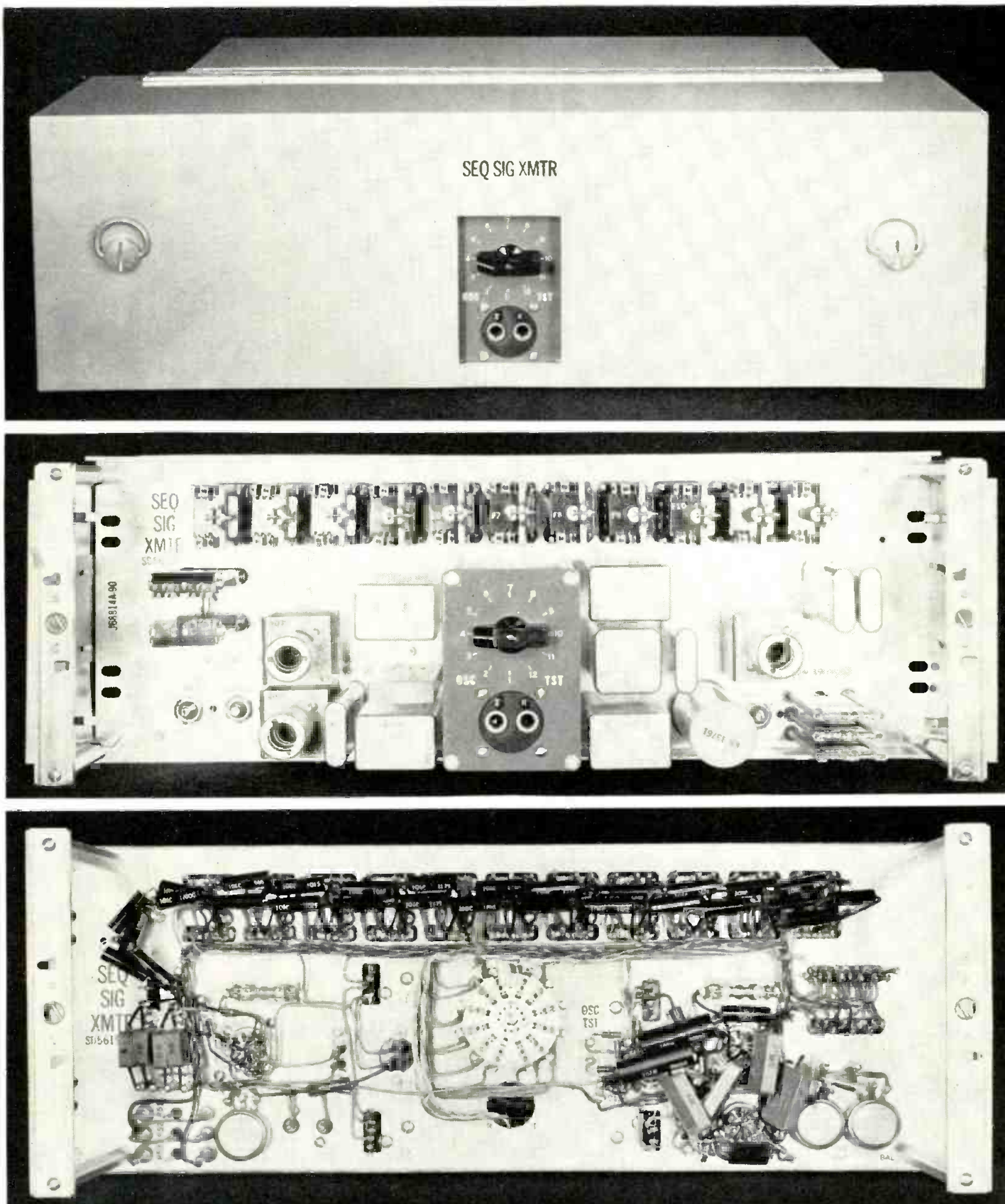


Fig. 3—Sequence signaling transmitter.

taken two at a time, 132 codes are possible. Only 120 of them are used with the TD-2 system, thus allowing ten codes for each of twelve stations. Each receiving station is arranged to accept only four of the twelve frequencies. Since there are twelve permutations of four frequencies taken two at a time, four frequencies are sufficient to give the ten codes available to each station.

At the transmitting terminal, a single Wien bridge-type oscillator is employed to generate any of the twelve frequencies, which are spaced 15 cycles apart from 277.5 to 442.5 cycles. The output of this oscillator is used to modulate a 1600-cycle carrier generated by a second bridge-type oscillator. The frequencies as sent over the line are thus in the band from 1157.5 to 2042.5

cycles. At the receiving station the signals are demodulated to their original values between 277.5 and 442.5 cycles. Such a method not only provides the low frequencies most suitable for operating the tuned reed relays at the receiving station, but gives frequencies for transmission that are within the frequency range of the line and yet higher than those that include most of the power in speech signals. It also has the advantage that any change in carrier frequency will not affect the frequency of the demodulated signals.

A simplified schematic of the circuit at the transmitting station is shown in Figure 1. The frequency of the low-frequency oscillator is changed in multiples of 15 cycles by shorting out one or more of the resistors in two of the bridge arms of the oscillator. To simplify the circuit, it is shown arranged for supplying only three frequencies. For all twelve frequencies there would be twelve resistors in each of the two bridge arms, there would be many more keys for selecting the desired combination and sequence of frequencies, and additional control relays would be required. The underlying principle of operation remains the same.

Normally, the order wire circuit is connected to the local telephone set through normally closed contacts of the SIG relay. When it is desired to send a signal over the line, the key for the desired code is operated. Assume, for example, that the code to be sent is f_2 followed by f_1. When the key for this code is operated, relays f_2 and SIG operate in series, the former adjusts the bridge to give an output signal of f_2,

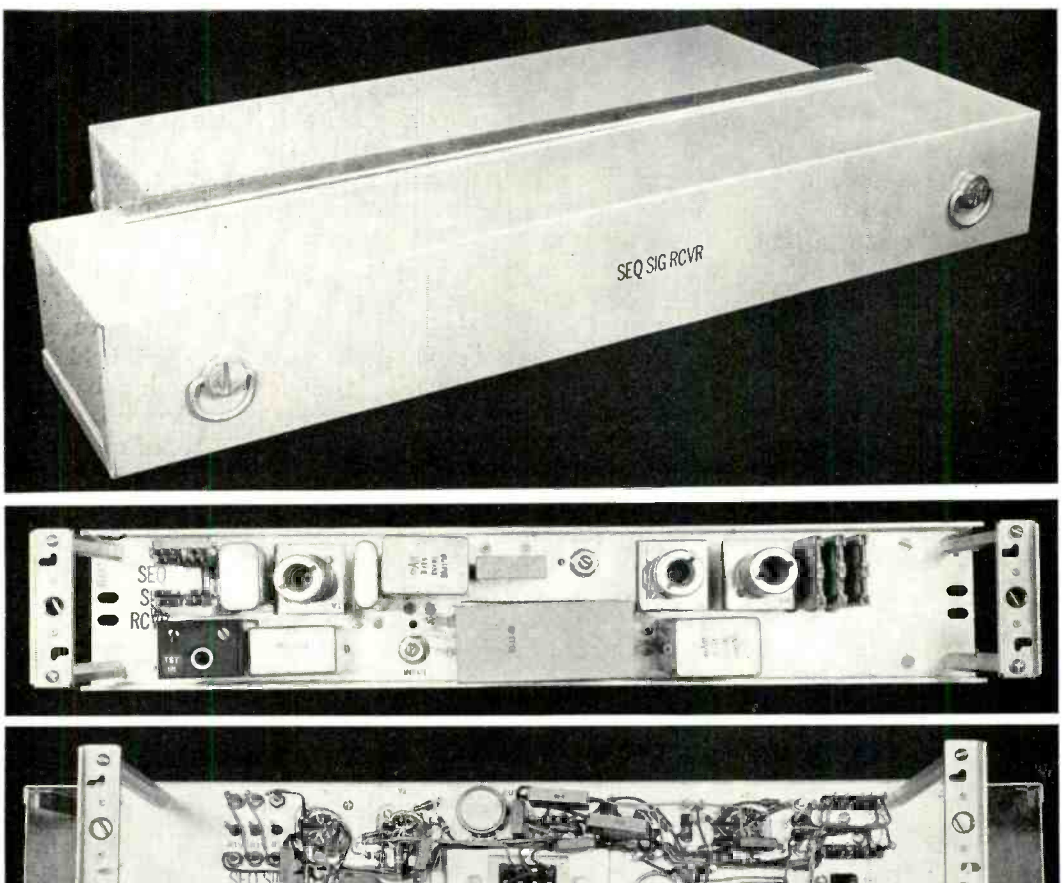


Fig. 4—Sequence signaling receivers.

and the latter connects the order wire to the signaling circuit. In operating the SIG relay opens the circuit to the winding of relay SR. This is a slow release relay, and thus for a brief interval only f_2 is sent over the line. When SR releases, relay f_2 is released, but relay SIG is held operated by the ground on the right-hand side of the key. When F2 releases, the oscillator shifts to frequency f_1, which in this case is the lowest frequency, and requires that none of the bridge resistors be shorted. This latter frequency remains on the line until the key is released, thus releasing SIG relay and restoring the circuit to normal.

At the receiving station, the circuit is arranged as indicated by the simplified schematic of Figure 2. The incoming signals are first applied to the preamplifier and then passed to the demodulator and to the guard circuit. From the demodulator, the low frequency signals pass to the two-stage amplifier, and then through the windings of the three reed selector relays in series, and one of them will vibrate. To secure a steady output current, the contacts of each vibrating reed relay are shunted by a capacitor and resistor in series, and the resulting loop is connected to the grid of a vacuum tube and to a negative potential to ground through R2 as indicated at the right of Figure 2. When the relay contact is open, as when the relay is not vibrating, the grid of the associated vacuum tube is biased negatively below cut-off, and thus no current flows through the tube. Capacitor C will be fully charged under these conditions. When the relay contact closes at the first vibration, current from +E flows to ground through R2, thus raising the voltage on the grid above cut-off. During the same period, C discharges. As the contacts of the relays open, current will continue to flow in R2 to recharge the capacitor. As long as the relay vibrates, therefore, voltage of the grid of the associated tube will remain above cut-off, and the tube will conduct.

When the first frequency of the code is interrupted, and the second is applied, the relay for the second frequency will begin to vibrate and result in a current in its output circuit in a similar manner. Vibration of the first relay does not stop at once, however, but decays exponentially, and continues to open and close its contacts for a short time, thus maintaining current in its output circuit for this period.

To translate such a sequence of frequencies to a ground on one of the required number of signaling leads, the translating circuit shown at the right of Figure 2 is employed. Assuming again the same code – f_2 followed by f_1 – relay F2 is operated at the arrival of the first frequency. Operation of F2 operates S, thus connecting the signaling lead SG2 to a spring on relay F2. When the second frequency f_1, of the code arrives, relay F1 is operated, thus placing ground through a front contact of F2 on to the signaling lead SG2. Since F2 is held operated after the f_2 frequency has been removed, ground remains on the SG2 lead long enough to operate an associated relay.

To prevent a random combination of voice frequencies from operating the signaling circuit, the guard channel in the lower

THE AUTHOR: For most of his twenty-nine years with the Laboratories, A. E. BACHELET has been engaged in the design of circuits, including signaling circuits for the maintenance of microwave relay systems and electronic circuits for dial telephony. Mr. Bachelet joined the Laboratories in 1923. His first assignment was in the toll switching group, where he conducted development work for improving toll lines for use of the rapidly growing broadcast industry. In the early thirties he also carried on studies of gas tubes as relay devices. During World War II he engaged in an electronic development project. From 1945 to 1947 Mr. Bachelet helped in the development of signaling for radio telephony, and currently is associated once again with a special project for the government.

part of Figure 2 is provided. The 900-cycle low-pass filter in its input blocks the signaling frequencies, which are all above 1150 cycles, but admits the speech frequencies that contain most of the speech energy. Frequencies that pass through the filter are amplified by the tube V3 and rectified by varistors VR1 and VR2 in its output circuit. As a result, a dc potenial appears on the capacitor C, and is applied to the grid of V1. The greater this voltage, the less will be the gain of V1. The leakage resistor R3 and the value of C are so chosen that when the voice reaches a level so high that it might undesirably operate the signaling circuit if the proper combination of frequencies were present, tube V1 will be disabled, and no signaling frequencies will be accepted.

Sequence signaling provides a means of fast and dependable signaling for a large number of connected stations. The use of a combination of two frequencies for each code greatly decreases the possibility of chance operation, while the application of the two frequencies in sequence doubles the number of codes possible from a given number of frequencies. It also requires only one low-frequency oscillator at the transmitter, while two frequencies transmitted simultaneously would require two.

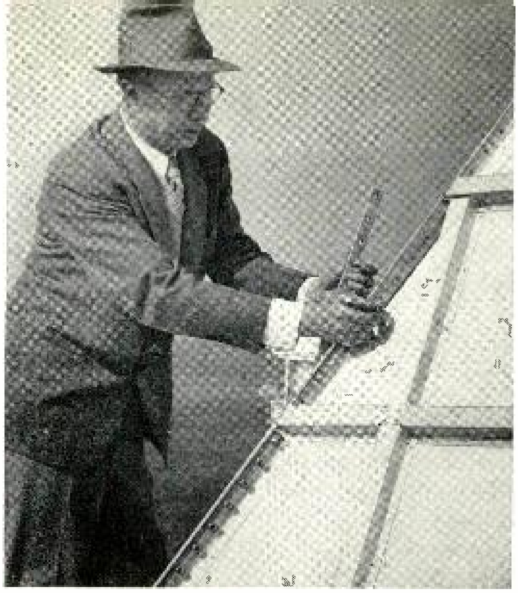
1953 Toll Construction Program

Plans outlining a large 1953 construction program have been filed with the Federal Communications Commission by A T & T Long Lines and thirteen Associated Companies. The cost of the projects involved is estimated at about $32,000,000. Construction and installation proposed will provide some 3,000,000 channel miles of telephone facilities, about 680,000 miles of telegraph channels for private line telegraph and teletypewriter exchange service and extensive additions to radio and television networks. Increased telephone traffic along the companies' principal routes and in the activities of defense industries, in addition to other related programs for the Armed Services, has produced further demands upon existing toll message and private line facilities. To make adequate provision for the present message volume and for expected increase in toll message use, it is estimated that a total of 39,000 telephone circuits will be needed for the 1953 requirements.

The program contemplates equipping of coaxial tubes in cables already built, or under construction, to provide for more telephone and television service. It is planned to equip four coaxials on the Philadelphia-Chicago route with a newly designed carrier system which will more than triple the number of telephone circuits provided by the system now in use. Also outlined in the application is a cable project that provides for construction of a coaxial cable between Newark, New Jersey, White Plains, New York, and New Haven, Connecticut. The installation of this route is part of the Long Lines decentralization plan for the establishment of routes by-passing larger cities.

Long Lines will bear a large part of the cost outlined in the application. Other companies participating in the program are Bell Telephone Company of Nevada, Bell Telephone Company of Pennsylvania, the Diamond State Telephone Company, Illinois Bell, Michigan Bell, New England Telephone and Telegraph, New Jersey Bell, New York Telephone, Ohio Bell, Pacific Telephone and Telegraph, Southern Bell Telephone and Telegraph, Southern New England Telephone, and Southwestern Bell Telephone Companies.

New Putty Keeps In Radio Waves



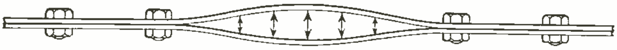


Fig. 1—Electric field across a gap between two metal plates will send off radio waves. The gap may be due to a bend, as here, or it may be caused by a film of oxide, or both.

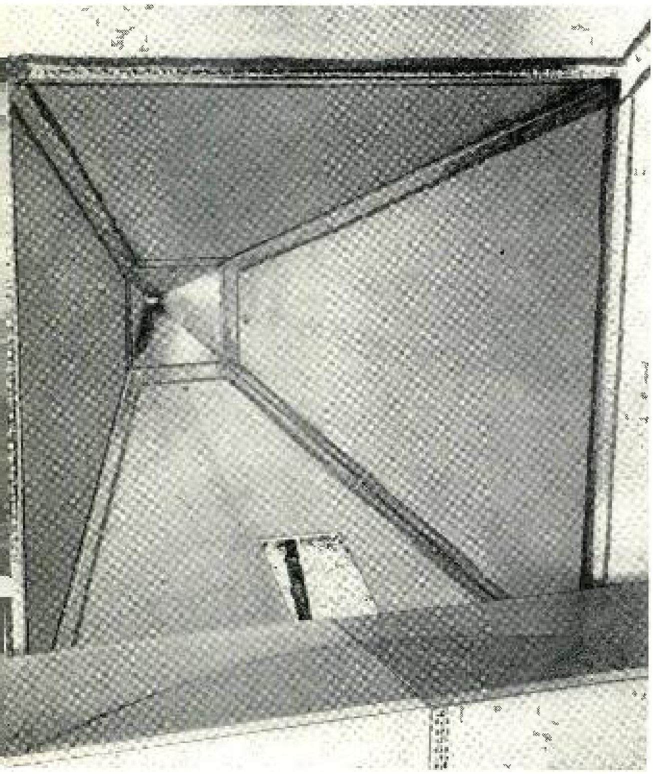


Fig. 2—In this picture of a partly assembled TD-2 antenna horn, the dark stripes at the joints are putty. Putty is also applied over the outer edges of the joints.

The TD-2 directional radio antennas are now puttied together. The sections of duralumin horns for radio relay stations must be carefully jointed to prevent microwave leakage. In small waveguide systems the brass jointing surfaces can be machined flat enough to ensure complete contact of the two contiguous faces, but this smooth fit is not possible between the larger and more flexible duralumin edges. The sections are bolted together (above). Every inch of joint which does not make an electrically tight fit becomes a little antenna (Figure 1). Because there are receiving as well as transmitting horns on the same tower, there can be no leaks or the crosstalk margin will be exceeded. Tinsmithing of the duralumin sections and the closure of seams are critical.

Specifications for the putty were exacting. The material must effect a watertight seal, remain flexible and adherent, satisfactorily resist sunlight, and weather to the same color as aluminum. A number of rubber-like synthetics were tested in the Chemical Laboratories, and Thiokol, a polysulfide-rubber copolymer, was selected. To it were added a plasticizer and an accelerator to compound a putty which will remain flexible down to –40° F. To reflect microwaves, 50 per cent aluminum and 10 per cent carbon black powders were mixed in. The putty seals off the space between the flexible mating edges and forms conducting paths across the joints so that no line of electric force across an air gap can send off radio waves to cause crosstalk (Figure 2).

Accuracy Provisions in AMA

G. V. KING
Switching Systems Development

Although a high degree of dependability is sought and maintained in all telephone circuits and operating procedures, it becomes of dominant importance in the automatic message accounting system. If the bills presented monthly to customers are not accurate, the system producing them cannot be justified regardless of any favorable features it may possess. This need for accuracy was recognized, of course, at the very beginning of the development of the AMA system, and has been the guiding influence throughout.

Previous articles* have described various features built into the central office equipment to assure accurate central office tapes. Such features are provided in the individual relay circuits, which tell what is happening on each call, in the circuits for electrically transferring charging information through the numerous central office paths, in the timing circuits, and in the equipment for perforating the information in the central office tapes. Trouble entries are automatically made when an irregularity has been detected that might affect charging, and special testing facilities are furnished to aid in locating and clearing troubles. In accounting centers, which process the output of many central offices, accuracy provisions play an even greater role. Earlier articles on accounting center equipment have indicated some of these, and others are described in the present article.

Undoubtedly the most important accuracy aid is the 2-out-of-5 code. It is used extensively in both central office and accounting center design, and it has merits for electrical storage and transfer of information similar to those afforded in recording on paper tape. As has been described earlier, the records on the central office tapes, and on the numerous tapes prepared in the course of accounting center processing, consist of coded numbers perforated in successive lines across the tape. There is space for six digits in each line, and all except the first, or A digit, which is used only to aid in identifying information carried by the rest of the line, are perforated in the 2-out-of-5 code. In the space allowed for each digit there is room for five perforations, but of these possible five, two and only two are used to represent a digit. All the accounting machines are arranged so that during the reading, recording, or perforating of information they check that there are two and only two elements for each digit. Practically every type of trouble that could arise, such as defective paper, relay contact failures or open, and crossed or grounded leads, will result in fewer or more than two elements for a digit. This use of the 2-out-of-5 codes thus makes practically certain that the information on the tape is correct.

Another and very important over-all accuracy requirement is the proper identification of all AMA tapes. In the central office where the original tapes are made, a group of recorders perforate tapes for all calls handled by a marker group, which may serve more than one central office. There may be as many as twenty recorders in a group, and each recorder will perforate upward of 100 feet of tape a day. These tapes are removed from the recorders and sent to the accounting center periodically, and for a maximum recorder group there may thus be twenty reels with a total of nearly half a mile of tape for each day's business.

After each processing stage in the accounting center, new tapes are perforated until the printer is reached, which – as a final re-

---

* A bibliography of all articles in the RECORD is given on page 474 of this issue.

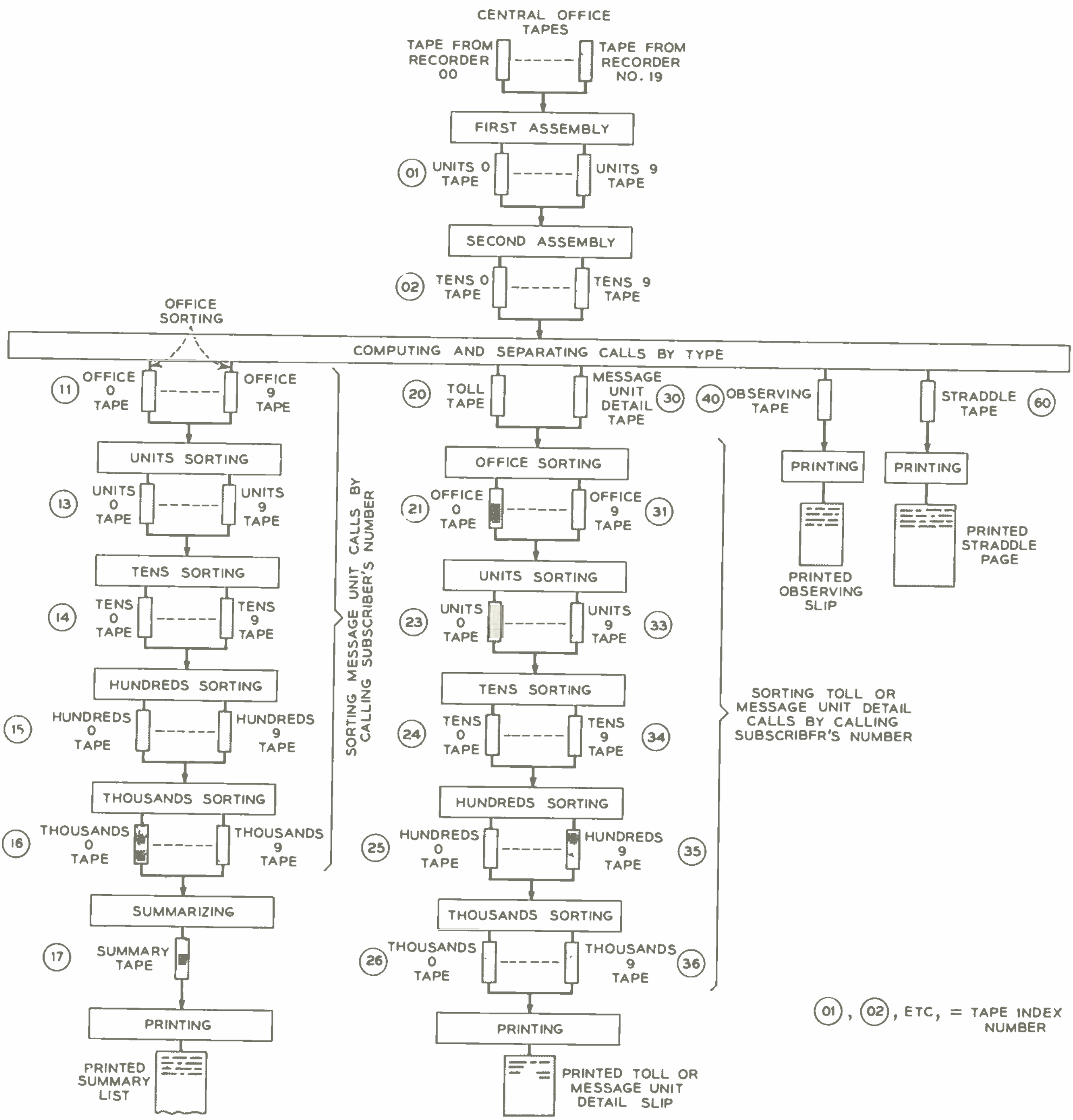


Fig. 1—Diagram showing the various stages in the accounting center process.

sult — prints a list by subscriber number of all calls made during the accounting period. The various stages in the accounting center process are indicated in Figure 1. The central office tapes are spliced together consecutively in order of their recorder numbers, and are then processed through the first assembly stage. The ten output tapes of this stage are spliced together in order and processed through the second assembly stage. This operation produces ten new output tapes on which all of the elements of a call are adjacent. These ten tapes are then spliced in 0 to 9 order and processed through the computing stage, which computes chargeable time on all calls, and message units on local calls. The output of this stage consists of ten message unit tapes, one toll tape, one message-unit detail tape, one observing tape, and one straddle tape.

Each of the message unit tapes containing calls from one central office are processed separately through the remaining stages. This consists of sorting by the calling subscriber's number, summarizing all the message units for the billing period for each subscriber, and printing a list of message units chargeable to each subscriber. Each of the other tapes from the computer contains calls from all of the offices in the marker group. The observing and straddle tapes go to the printer without sorting. The toll and message unit detail tapes are sorted by calling office and by the calling subscriber's number, and then go to the printer.

Since there is a tape from each recorder of each marker group for each collection period, and tapes from each accounting

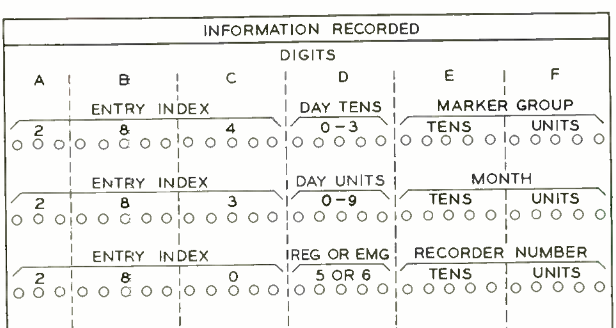


Fig. 2—Tape identification entries punched in the tapes at a central office.

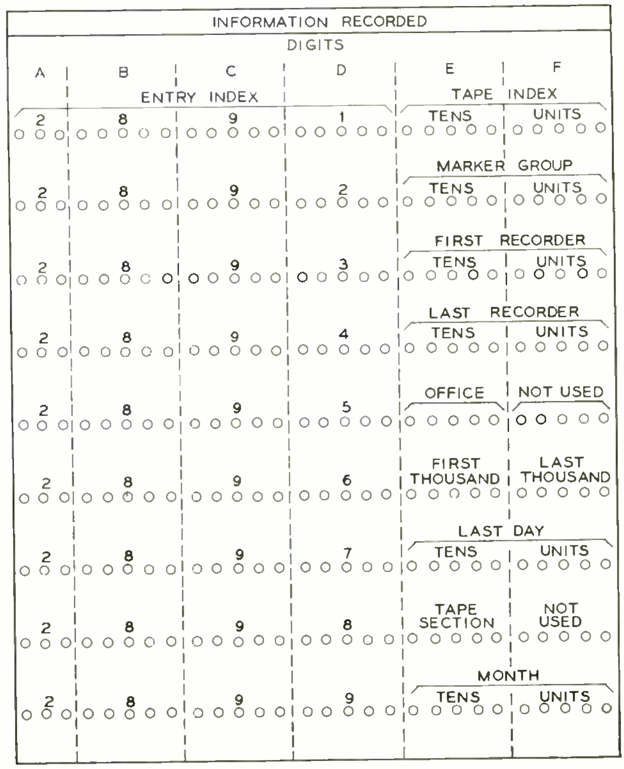


Fig. 3—Tape identification entries punched in the tapes in an accounting center.

stage, there is a very large number of tapes in an accounting center all the time. The need for the proper identification of each tape is therefore obvious. This identification is of two forms. To permit the accounting center attendants to identify the tapes so that the proper ones will be supplied to the proper machines at the proper time, each tape is marked on its outer end by a rubber stamp or by an associated tag. The other or more basic identification of the tape, however, is carried by a group of identification entries perforated at each end of each section of tape. In general, this information is required to make sure, when processing calls made by a particular group of subscribers in a particular period of time, that all tapes containing such calls are included, that no tape is processed twice, and that tapes containing calls made at another period or by other subscribers are excluded. The machine attendants get their instructions as to which tapes to process from assignment slips, which also give information

Bibliography of Bell Laboratories Record Articles on AMA

Automatic Message Accounting, *C. F. Seibel* . . . . September 1951, page 401

Basic AMA Central Office Features, *D. H. Pennoyer* . . . . . . October 1951, page 454

The AMA Tape Perforator, *P. B. Drake* . . . . November 1951, page 504

No. 5 Crossbar AMA Translator, *T. L. Dimond* . . . . February 1951, page 62

Recording on AMA Tape in Central Offices, *D. H. Cahill* . . . December 1951, page 565

The AMA Timer, *W. C. Jordan* . . . . March 1952, page 122

Code Patterns in Telephone Switching and Accounting Systems, *J. W. Dehn* . . . . January 1952, page 9

Central Office Equipment for AMA, *P. W. Sheatsley* . . . . April 1952, page 173

Basic Features of the AMA Center, *John Meszar* . . . . . . February 1952, page 70

The AMA Reader, *F. C. Kuch* . . . . June 1952, page 237

The AMA Assembler, *Glen G. Drew* . . . . May 1952, page 227

The AMA Computer, *A. E. Hague* . . . . July 1952, page 289

Tracing Time Backward in AMA, *A. E. Joel* . . . . November 1952, page 422

The Sorter for AMA, *F. N. Rolf* . . . . July 1952, page 299

The AMA Summarizer, *George Riggs* . . . . August 1952, page 321

The AMA Printer, *T. A. Marshall* . . . . September 1952, page 368

Accuracy Provisions in AMA, *G. V. King* . . . . December 1952, page 471

Test Tapes for AMA, *L. A. Kille* . . . . September 1952, page 349

A Test Unit for AMA Perforators and Readers, *A. R. Bonorden* . . October 1952, page 398

as to the settings of the various checking dials on the processing machines. As the tapes are "read" by the various machines, their identification entries are checked against the information set on the dials, and should the information be found not to check, the machine will stop and give an alarm. By this means all tapes are checked for marker group, month, and day. The central office tapes and the assembler tapes are also checked for recorder number. In addition, the accounting center tapes are checked for stage of processing and, after office sorting, for the office index.

Tape identification entries are of two general types: one is perforated in the tape at the central office and is used only at the first assembly stage; the other is perforated in all tapes made at the accounting center. The central office tape identification entries, shown in Figure 2, are characterized by a three-digit entry index each starting with 28, which defines the nature of the information in the remaining three digits. The D digit of the 284 line together with the 283 line identifies the day and the month during which the calls recorded on the tape were made. The E and F digits of the 284 line identify the marker group in which the calls originated. The identity of the marker group together with the recorder number, which is perforated in the 280 line, completely identifies any central office tape for a particular day.

These identification entries are used by the assembler only for the first assembling stage. In perforating new tape, however, the assembler and all the other accounting center machines perforate an identification entry of the type shown in Figure 3. Here a four-digit entry index beginning with 289 and comprising the digits A to D, inclusive, is employed to indicate the information carried by the E and F digits of each line.

The stage of processing, or tape index, is indicated by entry 2891 of Figure 3. This is a two-digit number. The first digit indicates the type of tape – message unit, toll, etc. – while the second digit gives the processing stage. These tape indexes are marked beside the various stages in Figure 1.

To insure that all tapes are included and that no tape is processed twice, each machine requires that the tape sections which it reads be in numerical sequence. The central office tapes are checked for recorder number sequence (280 entry) and the accounting center tapes, for tape sections 0 to 9 (2898 entry). If complete agreement is obtained during the tape identity checking, the machine proceeds, otherwise it stops and signals the attendant, who then takes corrective action.

Operating procedures have been set up which further safeguard accuracy. All central office tapes for each marker group are spliced together in recorder-number sequence. Accounting center tapes which are to be processed as one run are also spliced together. This splicing tends to prevent tapes being processed twice, since a long tape, after it has been read, will have its starting end toward the inner or center of the reel and could not be processed again without rereeling. A short unspliced tape might not be on a reel, and processing it again could be done in error.

Other checks are made which are peculiar to the type of machine. The computer deals with individual elements which make up a call: the initial entry, the answer and disconnect entries, hour entries, and various entries that indicate cancelled or straddled conditions. Since many of these entries are not always present on a particular call, failure to register any of them and hold the information until needed would not be detected, and would result in inaccuracies unless safeguards were introduced. The loss of the answer, the disconnect, or an hour entry would result in loss of revenue if the call lasted longer than the initial charge period. Since the purpose of the cancel entry is to prevent the computer from charging for the particular call or for overtime, the loss of such an entry might overcharge the customer. To prevent these inaccuracies, the computer registers this type of entry in two places, completely independent of each other. In one place it merely registers the type of entry, but in the other the actual information contained in the entry. The circuitry is such that when the information is to be used, if an entry is registered in one place it must also be registered in the other or the machine will not proceed. If the entry had been registered in only one place, a circuit failure such as an open lead, might have dropped it out, and the machine would have no way of knowing that this had happened.

THE AUTHOR: GERALD V. KING, Switching Systems Development Engineer, is currently in charge of the development and testing of crossbar tandem circuits. Mr. King was graduated from Carnegie Institute of Technology in 1920 with a B.S. degree. After a year with Westinghouse Lamp Company, he joined Western Electric's Installation Department, and in 1923 became a member of Western's Engineering Department, now Bell Telephone Laboratories. He made studies of customer orders for step-by-step and manual systems until 1926, spent six years in the design of private branch exchanges and community dial offices, and from then until World War II worked on fundamental circuit development of local and toll crossbar systems. During the war years he worked on military projects, and since 1944 has been concerned with the design and development of AMA accounting centers, central offices, and crossbar tandem office equipment.

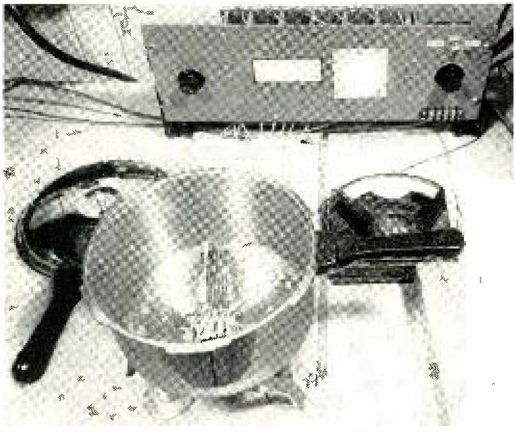
The probability of two faults that would drop out both entries is negligibly small, however.

In printing the information in the final stage, the standard teletypewriter code is not used since it is a five-element code using from one to four elements to represent a digit. It thus lacks the advantages of the 2-out-of-5 code. A new code was devised for the printer, therefore, in which each digit was represented by two elements.

In addition to the self-checking features, test tapes are provided for each machine. These consist of input tapes which contain entries and combinations of entries for checking all the operating features, and output tapes which contain the entries that would be perforated by the machine if it were in perfect working order when the input tape was processed. To test a machine, the input test tapes are processed, and the output tapes thus obtained are automatically compared in the tape comparer with standard output tapes. If the tapes are identical the machine has done its job accurately and correctly.

As a result of these provisions for insuring accuracy, the report on the accuracy test of an installation in Philadelphia stated: "There were no overcharges of any kind. Undercharges occurred amounted to 0.078 per 10,000 messages, or 0.00078 per cent."

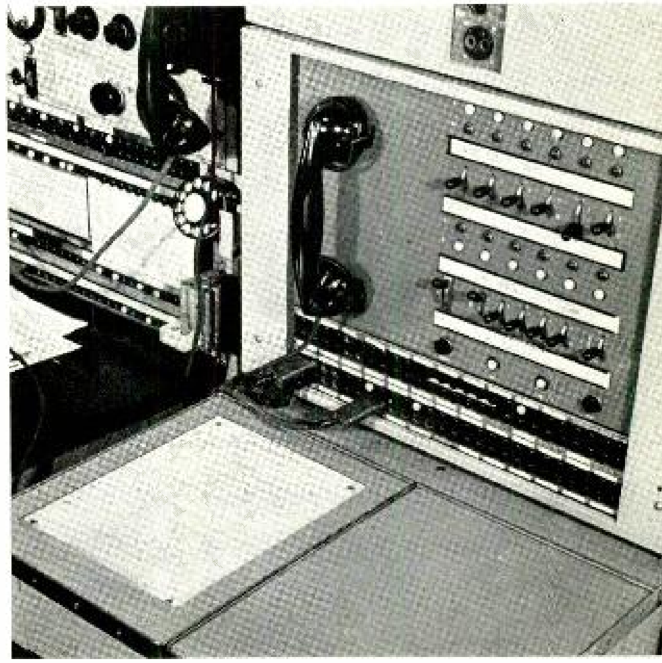
Research in a Saucepan



In a laboratory at Murray Hill, the kitchen art, which has often benefited from the products of physical science, comes to the aid of an experiment with relays. An ordinary pressure cooker supplies a ready-made gas chamber for the study of arcing between relay contacts in organic vapors which may turn up in telephone exchanges. The object of the study is to determine which contact metals stand up best.

Inside the pressure cooker is mounted a relay with twelve sets of contacts using twelve different contact metals. Electrical connections to external test equipment are made through sealed terminals in the bottom of the cooker. A predetermined amount of an organic liquid such as turpentine is evaporated in the cooker, and the relay is operated with each set of contacts discharging a capacitor. An oscilloscope monitors the contacts, and the number of operations before arcing begins is recorded for each set. The study is being conducted by a group under the supervision of L. H. Germer.

Alarm and Control Features of the TD-2



G. A. PULLIS
Switching Systems Development III

Three types of stations are used in the TD-2 microwave radio relay system: terminal stations where the relatively low frequency signals delivered by telephone or television terminal arrangements are changed to microwaves and microwaves are changed to low frequencies; main repeater stations, attended either part or full time, where signals are amplified and also picked off or fed in from branch circuits as required; and unattended auxiliary repeater stations which serve as boosters only. With the stations separated an average of approximately thirty miles, some sort of alarm system is necessary to insure proper operation and to give warning when trouble develops. In a cross-country network, many of the unattended stations are necessarily located in uninhabited or inaccessible places, often making the use of physical alarm lines a difficult problem. To overcome this difficulty radio channels are sometimes used for the alarm and order circuits. Some type of voice-frequency alarm system is preferable, therefore, since the radio carrier must be modulated in order to transmit intelligence. The C1 alarm and control system was developed to meet this situation.

Associated with a group of unattended stations is a fully attended station called an alarm center. This station must be conveniently located, and is frequently in a central office in a city near but not necessarily on the radio route. All alarms from the group are received at this station. When a condition requiring attention arises at one of the unattended stations, a bell rings at the alarm center, and a red lamp on the lamp panel of the receiving bay lights to indicate the particular station originating the alarm. Figure 1 shows the lamp and key panel where alarms are indicated and where orders are originated by operation of the order keys. The attendant noticing the alarm presses the transfer button which cuts off the bell and transfers the alarm indication from the red to the white lamp, leaving the red lamp free to report further alarms due to other troubles at the same station.

To determine the specific type of trouble that has occurred at the unattended station, the attendant operates an order key, and then pushes the start button, sending an order to the station to report all circuit conditions at that time. Over a period of about thirteen seconds the answer to the order is flashed on a ground-glass screen in the

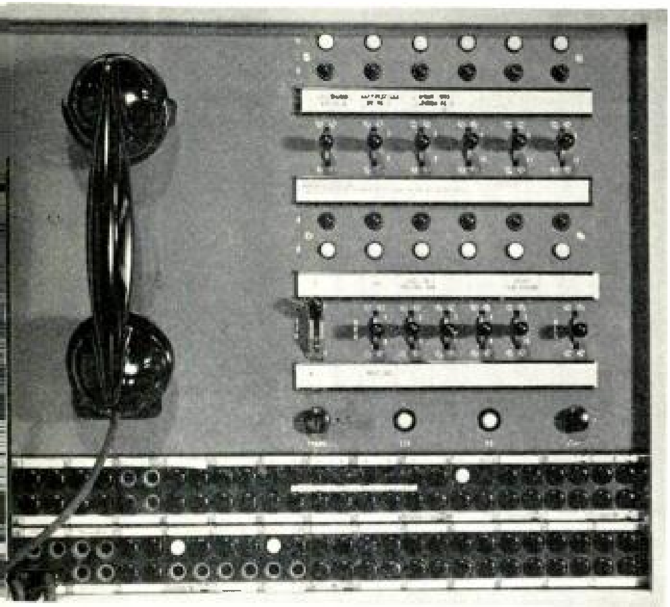


Fig. 1—Lamp and key panel in bay. Red and white alarm lamps may be seen above and below station switches.

surface of the writing desk by the lighting of several of sixty lamps under the screen. The various lamps are identified by placing a form such as shown in Figure 2 over the screen. If desired, the attendant may mark each square where a lamp is lit, giving a permanent record of the trouble.

The top six lamps indicate the station reporting, and the two lamps marked GROUP A and GROUP B indicate which of the two possible alarm circuits the station is on. This information must agree with that of the lamps already lighted on the lamp and key panel or there is trouble in the alarm system and the information is not reliable. The first of the two rows of lamps marked synchronization is lighted at the beginning of the report and the second row is lighted at the end of the report. If both rows show the pattern ON, ON, OFF, ON, ON, then the circuit was synchronized with the unattended station and all is well. If the patterns are not identical, something is wrong with the alarm circuits and the trouble must be found and corrected.

Some of the troubles at the station sending the alarm can be corrected temporarily by sending an order over the system while others must be handled by a maintenance crew sent to the station. In case of power failure, for example, the system at the station automatically goes on battery operation but the attendant may order the station to start a gasoline engine and have the emergency power unit take up the load.

All alarms and indications are sent from the unattended stations to the alarm center over a VF alarm circuit. Answering orders are sent to the unattended stations over the usual VF order circuit. A maximum of six unattended stations may be connected to a single alarm circuit while twelve stations may use one order circuit as shown in Figure 3. If an alarm center handles from seven up to its maximum of twelve stations, two alarm circuits are required. Each station on one alarm circuit is assigned one of the six frequencies: 1100,

C1 ALARM RECORD

SERIAL NO ______

DATE ______ ACTION TAKEN ______
TIME RECEIVED ______ A P ______ BY ______
SENDING OFFICE ______ TROUBLE FOUND ______
RECEIVING OFFICE ______ DATE OK ______ TIME ______ A P ______ BY ______

	A	B	C	D	E	F
	STATION IDENTIFICATION					
1	1	2	3	4	5	6
	SYNCHRONIZATION-START					GROUP A
2	ON	ON	OFF	ON	ON	
	SYNCHRONIZATION-STOP					GROUP B
3	ON	ON	OFF	ON	ON	
	LOW MICROWAVE OUTPUT E-W OR N-S CHANNELS					
4	1	2	3	4	5	6
	LOW MICROWAVE OUTPUT W-E OR S-N CHANNELS					
5	1	2	3	4	5	6
	LOW MW OUTPUT BRANCH CHANNELS					
6	A	B	C	D		
	DISCH FUSES	DISTRIBUTION FUSES			OBSTR. LIGHTS OFF	
7	12 V, 24 V 130 V 250 V	RADIO 12 V 130 V 250 V	ABS 24 V 130 V	MISC 24 V 130 V 115 AC	BOTH TOP	SIDE OR ONE TOP
	COM'L AC PWR.		HIGH-LOW VOLTAGE			
8	FAIL	RESTORE	12 V	24 V	130 V	250 V
	GAS ENGINE			RECT FAIL	H-L FLOAT	
9	FAIL	OPER.	LOW GAS	12 V 130 V 250 V	12 V 24 V 130 V 250 V	OPEN DOOR
	HIGH-LOW TEMP.			TUBE COOLING FAIL		
10	CRYSTAL OVEN	ROOM	WG LOW GAS PRESSURE	ONE BLOWER FAIL.	AIR FAILURE	
	A	B	C	D	E	F

Fig. 2—Report form placed over lamp panel in writing shelf and marked to agree with lighted lamps.

1300, 1500, 1700, 1900 or 2100 cycles and an oscillator at each unattended station applies this tone to the alarm circuit continuously until an alarm occurs. An alarm of any sort will interrupt the tone, and either a break or short in the alarm crcuit itself will also remove the tone and send in an alarm, making the system self-protecting.

The C1 alarm system requires three major groups of equipment, each group having components at both the alarm center and the unattended station. Figure 4 shows the arrangement. Group I includes the alarm oscillator, individual alarm circuits, and part of the alarm sending circuit at the unattended station, and filters, relays, amplifiers, lamps, and a warning bell at the alarm center. Group II comprises a scanning circuit, part of the alarm sending circuit, and

This oscillator maintains the station tone on the alarm circuit through a timing circuit. If an alarm condition occurs, a relay in the troubled circuit releases, grounds a lead to be scanned later, and trips the timing circuit. The timing circuit interrupts the tone on the line for ten seconds and then reapplies it so that any further trouble in some other part of the station may report a subsequent alarm. Meanwhile, at the alarm center the continuous tone is picked out by a filter tuned to the frequency for that station and holds a relay operated. When the timer cuts off the tone this relay releases, but the alarm circuits do not operate until after a five second delay. This prevents false alarms due to line noise or temporary interruption of the tone.

When an alarm occurs, a lamp marked

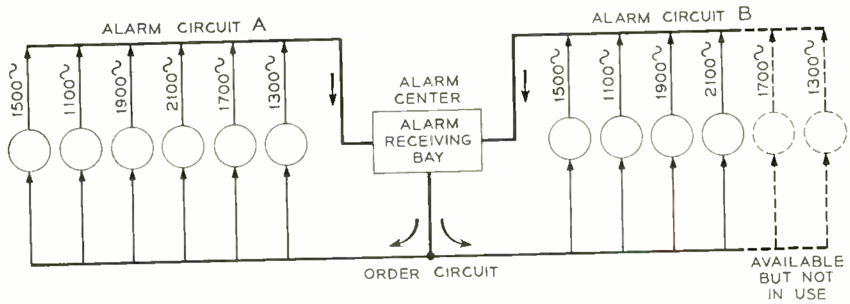


Fig. 3—Typical arrangement of unattended stations and their alarm center.

three oscillators with frequencies of 900, 700 and 5-cycles at the remote station, while the alarm center utilizes 900-cycle and 700-cycle filters, relays, a scanning circuit, and the lamp panel in the writing shelf. Group III is the sequence signaling circuit and uses the order circuit normally supplied for speech between the alarm center and the unattended stations for maintenance purposes. This sequence signaling system, which was described previously,* is composed of the keys on the lamp and key panel, a sending director, and a sequence signaling transmitter at the alarm center, and a sequence signaling receiver and director at the distant station.

The Group I oscillator operates on the frequency assigned to its particular station.

PS (permanent signal) on the lamp and key panel also lights. This lamp being lighted indicates that the tone is off the line, and it remains on until tone is reapplied to the line by the timing circuit. Failure of the lamp to go out indicates trouble in the station oscillator, timing, or sending circuits, or that the alarm circuit itself is at fault.

Group II components form the heart of the C1 alarm system. The particular type of trouble existing at the unattended station is of importance in directing the maintenance crew and in determining their itinerary, since certain troubles demand immediate action while others may be deferred until later. This information is obtained through the Group II components and the process called scanning. When the order to report all circuit conditions is received, it starts

* See *page* 464.

three oscillators at the unattended station, with frequencies of 900, 700 and 5-cycles. The 5-cycle oscillator consists of a resistor-capacitor timing circuit and associated relays to give a rectangular wave output, which pulses the 900-cycle oscillator and controls the scanning circuit operation. The 900-cycle signal is applied to the line each time the 5-cycle oscillator pulses, and controls the operation of the scanning circuit at the alarm center, while the 5-cycle oscillator controls the scanning circuit at the remote station directly. In this way, the scanning at the alarm center, operated by the 900-cycle pulses, is synchronized with the scanning at the unattended station by this means. The 700-cycle oscillator is only applied to the line when a lead being scanned at the unattended station is grounded. This 700-cycle pulse causes the lamp being scanned at the alarm center at that time to light.

Scanning is the process of testing, or "looking at," a group of leads one at a time. At the unattended station, the alarm leads are normally open and the scanning connection has no effect. Where the relay in a troubled circuit has operated, that lead will be grounded and, when scanned, will cause the 700-cycle tone to be applied to the alarm line until the scanning connection shifts to the next lead. At the alarm center another scanning operation is going on simultaneously, connecting to the lamp leads one at a time. When the 700-cycle pulse is received, power is applied by means of the scanning connection to the lamp being scanned at that time, giving an indication of the particular trouble.

In the C1 system, each scanning circuit consists of two counting chains of relays where one chain counts "units" and the other counts "tens." The "units" chain counts up to eight, releases, and counts again until it has gone through seven counts. The "tens" chain is really an "eights" chain,

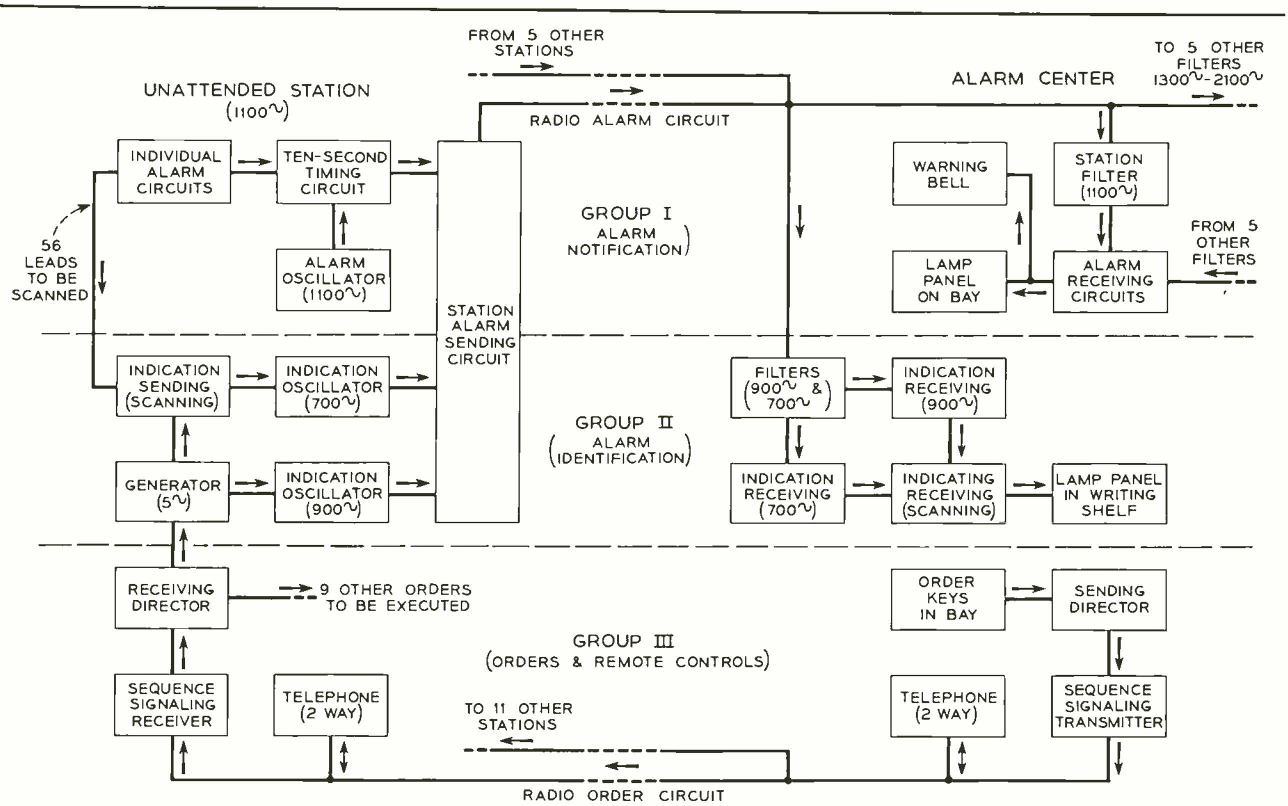


Fig. 4—Block diagram of complete alarm system for one unattended station and the alarm center.

since it counts the number of times the "units" chain has gone up to eight. The total possible with the two-chain counter is 56, or seven times eight. Circuits of counting chains have been described in earlier issues*; the resultant scanning is analogous to rotary switch systems. Figure 5 shows two rotary stepping switches that may be used to represent scanners at two different stations. As the first switch is stepped from contact to contact, a 900-cycle pulse is sent over the line to step the second switch is synchronism with the first switch. When the contact being scanned at the remote station is grounded, a 700-cycle pulse is sent over the line and causes the lamp being scanned to light. Of the 56 leads scanned, one is a no-alarm indication, three are used for a station identification code, and ten for synchronization checks. The remaining 42 leads may be used for alarm or other indications for 42 different circuits at the unattended station.

In the event that the trouble was of transitory nature and corrected itself, the no-alarm lead will be grounded and the original alarm signal will be removed from the panel when this lead is scanned near the end of the cycle. At the end of the scanning cycle the INDICATION SENDING and INDICATION RECEIVING circuits return to normal, but the lamps in the writing desk remain lighted until the attendant has marked his record sheet and operates a key to turn them off, ready for scanning at a later time. Remote control operation and orders, such as

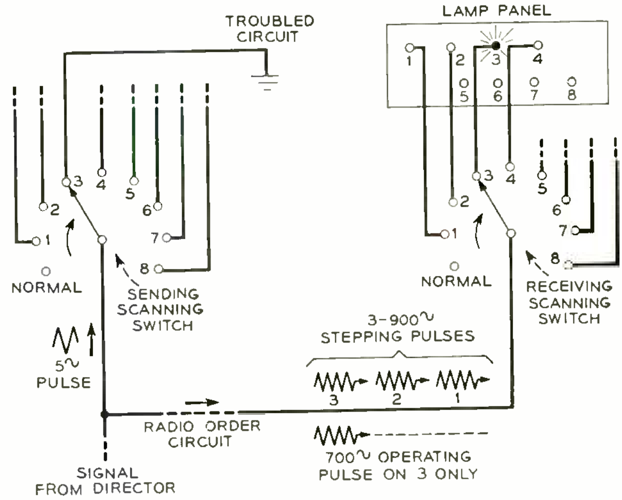


Fig. 5—Simplified scanning arrangement using stepping switches. The actual scanning is done by relay counting chains, but operation is analogous to switches shown for simplicity.

that to scan all circuits for trouble, are transmitted by the sequence signaling code over the local order circuit using Group III components.

Although the C1 system was designed primarily for use with the TD-2 system it may be used with any system requiring the number of alarm indications, alarm identifications, and remote controls discussed above. Through the simple process of preparing a new record sheet to agree with the alarm and indication assignments required, a record of the circuit conditions in any system can easily be obtained.

* RECORD, *June* 1929, *page* 400 *and July*, 1948, *page* 291.

THE AUTHOR: G. A. PULLIS joined the Laboratories in 1920 as a technical assistant, and with the transmission instruments group first engaged in transmitter and receiver studies. In 1928 he transferred to the toll systems development group, where he worked on the development of voice-frequency signaling for both ringdown and dialing circuits. Later he developed line and balancing circuits, and composite signaling and dialing circuits for dialing and d-c signaling over trunks between toll offices or between operating offices and community dial offices. During World War II he was engaged in military developments. This was followed by the design of remote-control alarm, and order-wire arrangements for the TD-2 Microwave system. For the past two years he has again been concerned with special government work.

For Doing Two Things at Once

Margaret Bagley wearing the 53-type set.

A new telephone set, the type 53, has recently been developed to fill the gap between the handset and an operator's headset. Shaped somewhat like the conventional handset, it also carries a headband, and is light enough to be worn comfortably on the head.

At small PBX's there is often insufficient traffic to keep an attendant busy all the time, and thus other duties are often assigned. When the traffic is light and only an occasional call is to be answered, a handset would be most convenient. During busy periods, on the other hand, where there is a steady succession of calls, an operator's set would simplify the attendant's work. By providing a telephone set that may be either held in the hand or worn on the head, the advantages of both types are secured. When the set is to be used as a handset, the headband is swung back out of the way, but it may readily be swung back at any time when needed. By rotating the headband mounting, the set can be arranged for use with either ear.

The 53 set is not limited to use at PBX's, however. Wherever a telephone user must have his hands free for writing during some calls and does not need them for other and perhaps shorter calls, the 53 set should prove helpful. Assume, for example, that the set, with its headband turned back out of the way, rests on a desk at the Stock Exchange. A broker, picking it up to answer a call, wishes to record an order. He swings the band over his head, freeing both hands, and makes notes. If the next call requires only a short reply, the broker can use the device as a handset.

Devised by J. F. Dalton and W. G. Turnbull of the Station Apparatus Department, this new set uses the same receiver and transmitter elements as the present 52 type operator's set.

The 53 A head telephone set.

TV and Radio Coverage of Election Day News

In cooperation with the Associated Companies of the Bell Telephone System, A T & T Long Lines made additional communications facilities available to the nation's television, radio, and press association networks that aided in the remarkably complete Election Day news reporting. The addition of these facilities aided in enabling the broadcasters and news agencies to bring to the public the fastest, most comprehensive news reporting of any presidential election in history.

On-the-spot election programs were transmitted over almost 30,000 miles of intercity television channels to 111 television stations in 67 cities. Some 2,800 channel miles of network TV were temporarily added to existing facilities, one of the most important of which was eastbound between Chicago and New York. This channel made available, with channels already in service, three separate TV networks between New York, Chicago, and Washington.

Other facilities included a channel from Los Angeles to Denver, by way of Oakland, California, making it possible for two TV programs to be carried over the network to Denver at the same time; a third westbound channel from Chicago to Omaha, Nebraska; and a third westbound channel from Oakland to San Francisco. In addition to making available more TV channels along existing routes, facilities were provided to permit nation-wide connection of TV and radio broadcasts from the headquarters of both the presidential and vice presidential candidates on election night. Provisions were also made to maintain continuous operation of the temporary and regularly established facilities until the final results were known.

To aid the major press networks in their extensive coverage of the election, the Bell System greatly augmented facilities furnished the press for gathering and distributing news locally and nationally. A tremendous volume of election news and results was gathered by the press associations and distributed by them to the country's 1,750 daily newspapers, 2,000 radio broadcasting stations and 111 television stations. Extra circuits were put into service extending to key election cities, and some of the main coast-to-coast trunk routes were paralleled to assist the press associations in this task.

J. W. McRae Elected I. R. E. President

J. W. McRae has been elected President of the Institute of Radio Engineers for 1953.

Mr. McRae, a native of Vancouver, B. C., received the B. S. degree in Electrical Engineering from the University of British Columbia in 1933, the M. S. degree in 1934 from the California Institute of Technology, and the Ph. D. from the same institution in

J. W. McRae

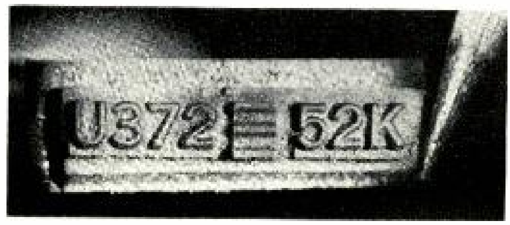
1937. He joined Bell Laboratories in 1937 and was first engaged in research on transoceanic radio transmitters. After nearly four years in the Signal Corps during World War II, where he attained the rank of Colonel and received the Legion of Merit for his services, he returned to the Laboratories and in 1947 was appointed Director of Electronic and Television Research. He became Director of Transmission Development in 1949 and in 1951 was appointed Vice President. Mr. McRae is a Fellow of the I. R. E., and a member of the A. I. E. E., and Sigma Xi.

A Story about the Christmas Tree— and the Telephone Relay

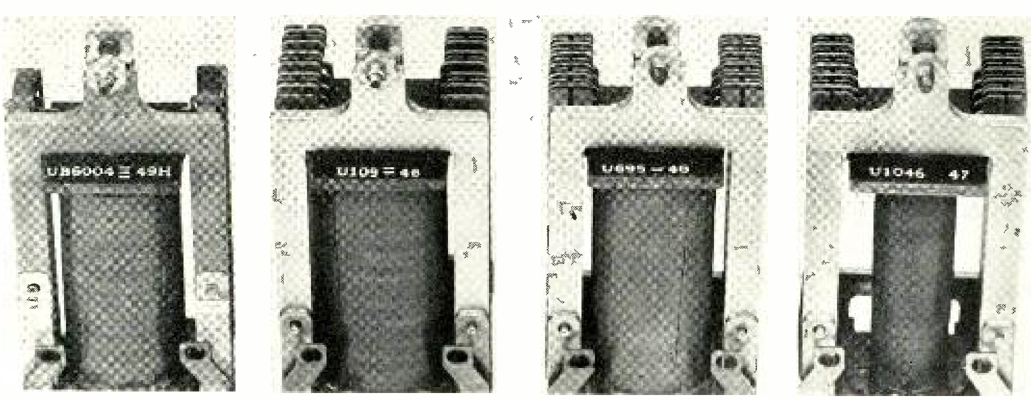
Some years ago, a Laboratories engineer hurried home from Western Electric's plant in Chicago to help in the preparations for Christmas. In the midst of the hustle and bustle to get the decorations and the tree, a young member of the family, who had reached the inquisitive age, interrupted the proceedings with the question "why do people cut down trees and bring them into the house at Christmas time?" Hedging a bit, her father suggested that they look in the encyclopedia and see if they could learn why. And this is what they found:

Many years ago in Egypt, long before the Christian era, the ancients used the palm tree as a symbol of the passing months. The palm is known to grow a branch every month, and a spray of the tree with twelve shoots on it was used at the time of the winter solstice festivities as a symbol of the year completed. So the Egyptians would bring a tree with twelve branches into the house and, as the months passed, at each new moon a branch would be cut off until, at the end of the year, the branches would all be gone and it was time to bring in a new tree.

It came to the engineer like a flash. Here was an easy and inexpensive way to mark the date of manufacture on relays. This troublesome problem, fresh in his mind from discussions at the Western Electric Company, required a method of indicating the year and quarter of manufacture. Some kind of rubber stamping was desirable, but to replace all the necessary stamps every three months—over 4,000 for U type relays alone—seemed somewhat expensive and wasteful. But the Christmas tree story suggested a happy solution. A rubber stamp having the year number and three horizontal bars could be prepared. This would be the marking for the first quarter. At the end of each quarter, one bar would be clipped off; two bars would show the second quarter; a single bar the third, and no



An enlarged view of a rubber stamp used in marking the relays. The stamp, as shown in the photograph, is for a U372 relay, manufactured in the first period (3 bars) of the year 1952. The letter K at the end indicates the place of manufacture, Kearny. (In making the above illustration the negative was reversed so that the numbers could be read directly.)



Several U relays showing date of manufacture markings. On the extreme left, the marking indicates that the relay was built in the first quarter of 1949 (the H means Hawthorne). The next relay was made in the second quarter of 1946, the third one from the left in the third quarter of 1946, and the last relay on the right in the final quarter of 1947.

bars for the final quarter. New stamps having the new year number would be needed at the first of each year.

Thanks to the story of the Christmas tree, this system of marking has been successfully used for a number of years.

A. I. E. E. Fall General Meeting

At the Fall General Meeting of the A. I. E. E., held this year in New Orleans, several papers were presented by members of the Laboratories. At the *Communications Switching Systems Session,* A. C. Keller gave his paper on *A New General Purpose Relay for Telephone Switching Systems.* At the same session, W. Bennett presented his paper, *Telephone System Applications of Recorded Machine Announcements.*

The session on *Wire Communications Systems,* with P. G. Edwards presiding, included papers on *The Type-O Carrier Telephone* by J. A. Coy and E. K. Van Tassel, and *Transposition Designs for Type-O Carrier Systems* by Miss E. Rentrop and L. Hochgraf. A. C. Dickieson presided at a session on *Radio Communications.*

Among the committee meetings held during the Fall Meeting, J. Meszar, Chairman of the Committee on Communication Switching Systems, called a meeting of his committee, A. C. Dickieson held a meeting of his Committee on Radio Communications, of which he is Chairman, and P. G. Edwards, Chairman of the Committee on Wire Communications, held a meeting of his committee at which L. R. Montfort, Secretary, attended. E. I. Green and J. D. Tebo were present at meetings of the Publication Committee and of the Committee on Technical Operations, of which Mr. Tebo is Vice Chairman.

Patents Issued to Members of Bell Telephone Laboratories During September

Anderson, J. R., and Keller, A. C.—*Magnetic Recording and Reproducing System*—2,612,566.

Bachelet, A. E.—*Telephone System*—2,609,455.

Bachelet, A. E., and Low, F. K.—*Pulse Counting and Registration System*—2,609,498.

Baker, W. O., and Winslow, F. H.—*Ball Bearing*—2,609,256.

Ball, E. T.—*Door*—2,608,727.

Barry, J. F.—*Soldering Apparatus for Piezoelectric Crystals*—2,608,745.

Brown, J. T. L., and Pollard, C. E., Jr.—*Relay*—2,609,464.

Carbrey, R. L.—*Pulse Code Modulation Communication System*—2,610,295.

Cutler, C. C.—*Multiplex Converter*—2,612,633.

Farkas, T. P.—*Impulse Counting Relay and System Therefor*—2,610,242.

Gerth, J. H.—*Test Set for Measuring the Angle Represented by Synchro Voltages*—2,609,435.

Goff, H. W.—*Perforating Recorder Signalling Device*—2,609,433.

Graef, R. P.—*Frequency Discriminator*—2,609,447.

Hall, O. C.—*Rotary Out-Trunk Switching Arrangement*—2,609,456.

Hecht, G.—*Selecting and Lockout Circuit*—2,609,454.

Keller, A. C., see J. R. Anderson.

Knapp, H. M., and Zupa, F. A.—*Shock Mount for Relays*—2,609,171.

Leed, D.—*Automatic Frequency Control Circuit*—2,610,297.

Low, F. K., see A. E. Bachelet.

Pierce, J. R.—*Cathode Ray Tube*—2,609,520.

Pollard, E. E., Jr., see J. T. L. Brown.

Rea, W. T.—*Half-Duplex Telegraph Repeater Including Break Feature*—2,609,453.

Rea, W. T.—*Electronic Telegraph Hub Type Repeater*—2,612,560.

Rea, W. T.—*Half-Duplex Telegraph Repeater*—2,612,561.

Sermeus, W. T.—*Partition*—2,609,436.

Skellett, A. M.—*Wave Generating Circuits*—2,609,508.

Smith, H. J.—*Camera*—2,608,920.

Winslow, F. H., see W. O. Baker.

Zupa, F. A., see H. M. Knapp.

Foreign Engineers Visit the Laboratories

The Laboratories was host to a group of ten engineers from European countries, September 26. These engineers were part of a team that was visiting the United States at the recommendation of the sponsoring societies of the Centennial of Engineering held in Chicago during September. With the help of the Advisory Committee, composed of the presidents of the A. S. C. E., A. S. M. E., A. I. Ch. E, A. I. E. E. and A. I. M. M. E., the National Management Council organized a six-week study tour for the engineers who were traveling under the auspices of the Mutual Security Agency (formerly E. C. A.).

Engineers from Europe visit the Laboratories.

Deal-Holmdel Colloquium

R. M. C. Greenidge spoke at the Deal-Holmdel Colloquium October 10, on the subject of *Printed Circuits and Packaging, Particularly at High Frequencies.* Mr. Greenidge's talk dealt chiefly with the adaptation of printed wiring and casting resin techniques to packaging of transmission apparatus components and assemblies. Methods of fabricating printed wiring and the types of casting resins and manufacturing techniques involved, were also reviewed. The talk was illustrated by a number of slides and samples.

Bell System Wins National Council's Highest Safety Award

Bell Telephone employees have an accident rate less than one-fifth of industry in general. This was revealed in October when the National Safety Council presented its award of honor to Bell System companies for their outstanding safety record during 1950 and 1951. This is the highest honor the Council can bestow, and the award was presented to the representative of each Bell unit at a ceremony held at A T & T headquarters in New York. In making the award, N. H. Dearborn, President of the Council, mentioned that during 1950 and 1951, telephone people established an accident frequency rate of less than one accident for each one-half million hours worked and that not only have telephone men and women had fewer accidents, but they also have had fewer of a severe nature. The rate for the latter is less than one-tenth that for other industries.

Bell System Gains

During the third quarter of 1952, the Bell System increased the number of telephones in use by 420,000, bringing the total in service to about 38,800,000. As the number of telephones increases, more calls are handled than ever before, both local and long distance, and there is no let-up in the heavy construction program required to provide additional lines and switching equipment. For the first nine months of 1952, the Bell System companies have spent about $900,000,000 for new construction.

Mobile Telephone Service in Oil Exploration Areas

In order to provide mobile service in the Williston Basin area in North Dakota and Montana, which is the scene of considerable oil exploration and drilling activity, the Northwestern Company and the Mountain States Company are establishing 152 to 162-mc stations at Williston and Tioga, North Dakota, and at Wolf Point, Culbertson, and Glendive, Montana, respectively. These five stations, for which construction permit applications have been filed, will make mobile service available throughout a large part of the Williston Basin.

The Mountain States Company is also planning to establish 152 to 162-mc mobile service in the western Colorado – eastern Utah oil areas, filing a construction permit application for a station at Vernal, Utah.

Trials Conducted of Relayed Trans-Atlantic Operation

One-way transmission tests from New York to Paris via a relay station at Bamako, French West Africa started October 24, looking toward possible establishment of a three-channel, relayed radio-telephone system via that route. The system would use existing equipment in the United States and France which would become available by discontinuing one of the present three-channel New York-Paris direct systems.

A New York-Amsterdam circuit relayed at Paramaribo, Surinam, is in full time commercial operation now, and a New York-London circuit relayed at Bridgetown, Barbados, is being tried commercially between 3 P. M. and 9 P. M. Daily. Comparisons are being made between the relayed and direct circuits to evaluate the advantages of the more southerly relayed routes.

Dr. Kock Lectures

W. E. Kock is one of the lecturers scheduled to speak in the A. I. E. E. New York Section, Basic Sciences Division Symposium on the *Science of Music and its Reproduction*. This symposium, consisting of six lectures, includes Mr. Kock's talk entitled *The Physics of Music and Hearing*, and will be given December 11.

Additional Facilities for Trans-Pacific Terminal

On the West Coast the Pacific Company will construct a 23-mile cable to provide additional land circuits serving the trans-Pacific radio terminal at Point Reyes, California. This will permit future expansion of trans-Pacific services. Trans-Pacific traffic continues to increase. In August it was running about 23 per cent above the same month a year ago. At the end of the war there were eight trans-Pacific radio channels handling about 100,000 messages a year. Now there are thirty channels handling about 350,000 messages annually.

D. R. Mason in France

D. R. Mason left last month for the University of Nancy in France under a Fullbright Fellowship which was granted to him last June. He will be assigned to the faculty in the Department of Chemical Engineering. During his assignment, which extends from October, 1952, to July, 1953, he will organize a course in chemical unit operations, illustrated where possible, by examples of American technique.

W. C. Tinus Appointed to Committee on Guided Missiles

W. C. Tinus, Director of Military Electronics Development, was recently appointed a member of the Committee on

Guided Missiles of the Department of Defense Research and Development Board. The announcement was made by Walter G. Whitman, chairman of the Board. Mr. Tinus has been associated with the Laboratories since 1928 as a radio and electronics engineer. He was graduated from Texas A & M College with a B.S. degree in electrical engineering. During World War II, he served as a radar expert on advisory committees to the Secretary of War and received the Navy Bureau of Ordnance award for development of the first fire-control radar in 1946. He is a senior member of the Institute of Radio Engineers and a member of the Army Ordnance Association. He has been associated with the Committee on Guided Missiles since September, 1949.

Professional Papers

During the month of October, a number of Laboratories people presented papers before professional and educational groups. Following is a list of the authors, titles, and place of presentation.

R. M. Ryder, *Mechanisms of Transistor Action*, R.T.M.A. Convention, Syracuse, N. Y.

W. Keister, *Switching Circuits for Automatic Control*, Newark College of Eng., Newark, N. J.

F. R. Bies, *Attenuation Equalizers*, Audio Engineering Society, New York.

R. E. Graham, *Flying Spot Scanner Design*, I.R.E. Symposium, Philadelphia.

R. I. Wilkinson, *Space-Time Relationship with Multiple Camera Installations*, S.M.P.T.E. Convention, Washington, D. C.

M. Sparks, *Transistor Physics*, Celanese Research Seminar, Summit, N. J.

J. E. Karlin, *Basic Relationships Between Different Scaling Methods*, Princeton University Seminar, Princeton, N. J.

R. M. Burns, *Science and Scientists in Telecommunications*, Lehigh Chapter of Sigma Xi, Bethlehem, and American Institute of Chemists, Philadelphia.

L. F. Koerner, *Development of Test Oscillators for Crystal Units*, Radio Association, Troy, N. Y.

R. W. Hamming, *Error Correcting Codes*, I.B.M., Poughkeepsie, N. Y.

Miss E. Rentrop and L. Hochgraf, *Transposition Design for Type-O Carrier Use*, A.I.E.E., New Orleans.

W. L. Bond, *Making Oriented Single Crystal Plates*, American Philips Co., Mt. Vernon, N. Y.

J. J. Ebers, (1) *Equivalent Circuits of Junction Transistors and* (2) *Four Terminal* p-n-p-n *Transistors*, I.R.E., (Columbus, Ohio, section) Columbus, Ohio.

R. D. Heidenreich, *Electron Diffraction and Microscopy of Metals*, A.S.M. Symposium, Philadelphia.

R. Kompfner, *Traveling Wave Tubes*, I.R.E., Philadelphia

W. P. Mason, *Shearing Wave Polarization In Liquids*, O.N.R. Symposium Brown University, Providence, R. I.

K. D. Smith, *Transistors Today*, A.I.E.E., Peoria.

W. O. Fleckenstein, *Elementary Switching Circuit Design*, Bell of Pennsylvania, Philadelphia.

P. Darnell, *Various Applications of Transistors*, American Radio Relay League, Albany.

J. J. Ebers, *Equivalent Circuits of Junction Transistors*, A.I.E.E.-I.R.E., Columbus, Ohio.

H. J. Williams, *Ferromagnetic Domains*, A.S.M. Seminar, Philadelphia.

P. Mertz, *Influence of Echoes on Television Transmission*, S.M.P.T.E. Symposium, Washington, D. C.

J. N. Shive, *Phototransistors*, Optical Society of America, Boston.

R. G. Treuting, *Plastic Deformation of Silicon and Germanium*, A.I.M.M.E., Philadelphia.

W. J. Merz, *Domain Movements in $BaTiO_3$*, National Academy of Science, Lenox, Mass.

I. V. Williams, *The Substitutions for Critical Materials*, A.I.M.M.E., Bethlehem, Pa.

J. A. Coy and E. K. Van Tassel, *Type-O Carrier Telephone*, A.I.E.E., New Orleans.

W. Bennett, *Telephone System Applications of Recorded Machine Announcements*, A.I.E.E., New Orleans.

A. C. Keller, *A New General Purpose Relay for Telephone Switching System*, A.I.E.E., New Orleans.

G. K. Teal, *The Chemistry of Transistor Materials, American Chemical Society*, New York.

D. Edelson, C. A. Bieling and G. T. Kohman, *The Electrical Decomposition of Sulphur Hexafluoride*, National Research Council, Lenox, Mass.

A. C. Keller, *The Economics of High-Speed Photography*, S.M.P.T.E. Symposium, Washington.

W. C. Ellis, *Orientation-Relationships in a Progressively Solidified Aluminum Ingot*, A.I.M.M.E., Philadelphia.

E. S. Greiner, *Some Thermal Properties of Germanium and the Constitution of Germanium-Gallium Alloys*, A.I.M.M.E., Philadelphia.