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Rotating sphere on which the positions of sunspots are marked

Hearing-Test Machines at the World's Fairs

By F. A. COLES
Commercial Products Development

AT THE Bell System exhibits at the New York and San Francisco Fairs, hearing tests have been given to a large number of visitors.* When the exhibits were planned it was evident that in the interests of both uniformity and economy the tests should be carried forward by mechanism. Accordingly, equipment was designed to employ phonograph records as the source of sound and a crossbar switch to make the necessary changes in volume. Eighteen similar units of this sort were installed in New York and four in San Francisco.

Two kinds of hearing tests are used, a "Words" and a "Tones" test. In both, a group of seven visitors are seated in separate sound-proof booths, each equipped with a telephone receiver over which the instructions and tests are given. The "Words" test consists of two series of two-digit numbers, which become progressively fainter in steps of from 3 to 6 db until they can no longer be heard by the average person. The number of two-digit figures heard correctly indicates the acuity of the listener's hearing. Similarly, in the "Tones" test the listener hears five series of single-frequency tones one octave apart, beginning at 440 cycles. Each series consists of one, two or three tone pulses and each succeeding series is sounded from 6 to 10 db fainter than the previous one until the pulses are too faint to be heard.

A reliable and economical method of giving high-quality audiometer tests to large groups of people was attained by recording the words and sounds on "hill and dale" disc records and reproducing them with a standard high-gain amplifier. The recordings were made at a constant level and attenuation is introduced by switching resistance networks or pads

*RECORD, *December*, 1939, *p.* 98.

into the system between the amplifier and the listeners' receivers. This provides a flexible method of adjusting the attenuation and prevents record scratch or noise originating in the amplifying system from disturbing the listener, particularly for very faint sounds. The pads are mounted on a crossbar switch, each point of which corresponds to a chosen attenuation. The crossbar contacts are closed by a selector switch, which is operated in turn from a cam geared to the turntable. A notch on the edge of the record fixes its position on the turntable and synchronizes it with the crossbar switch.

To provide the attendants with full information and control of the machines, each one is equipped with a remote-control starting mechanism, an automatic stop, and signal lamp circuits to indicate the operating position at all times. When the starting button is operated an auxiliary motor lifts the pickup from the record and places it at the starting point. The turntable and synchronized mechanism are then started automatically. At the end of the test, the turntable is stopped automatically and a "ready" lamp is lighted to signify preparedness for another test. During the test, an "in progress" lamp is lighted in each of the hearing booths.

The machines are enclosed in steel cabinets with hinged doors, both front and rear, for accessibility. The upper part is a compartment sealed to prevent dust from accumulating on the record and on contact surfaces of the synchronizing cams, selectors and crossbar units. In the lower section are mounted an amplifier, a rectifier unit and other power apparatus. At the New York Fair, eighteen machines were installed in the equipment room and in San Francisco, four machines were used. Previously a laboratory model had been placed in the museum of Science and Industry in New York City for field trial. A photograph of one of the cabinets is shown on the opposite page.

The output level of the machines is checked carefully each day with a special test record and the transmission efficiency of all receivers is measured at frequent periodic intervals to ensure accuracy.

With these machines the hearing of over 1,500,000 visitors was tested during 1939 at the Bell System exhibits of New York and San Francisco Fairs.

Terminal Circuits for the J Carrier System

By R. A. LECONTE
Carrier Telephone Circuit Development

THE terminal circuits of a carrier system have as their essential function the translation of the voice-frequency signals originated by the subscriber into signals occupying the frequency position selected for transmission over the line, and of retranslating the received carrier signals back to voice frequencies. The J carrier system, applicable to open-wire lines, utilizes frequencies from 36 to 143 kc, and in this band provides twelve channels in each direction, those for one direction occupying a 48-kc band width in the range between 36 and 84 kc, and those for the other, a 48-kc band between 92 and 143 kc.

Instead of shifting each voice channel by one stage of modulation to the frequency location it will occupy on the line, three modulating steps are employed. Like the other broad-band systems*—the K system for cables† and the coaxial system*—the J system uses twelve channels that have been placed in the band from 60 to 108 kc by the channel modulators.† This twelve-channel group is then modulated as a unit in two steps to place it in the proper frequency position for transmission over the line. At the receiving end, a similar pair of group modulations brings the twelve channels to the 60-108-kc band, and the channel demodulators then split them back into the twelve voice-frequency bands.

Two modulating stages are required to place a channel group into either of the transmission bands, because the group band from 60 to 108 kc overlaps the two transmission bands of the J system, which are 36 to 84 and 92 to 143. The first stage of modulation, with a carrier of 340 kc, shifts the 60-108-kc channel group to frequencies well above the final bands,

*RECORD, *April*, 1937, *p.* 242.
†RECORD, *April*, 1938, *p.* 260.

*RECORD, *May*, 1937, *p.* 274.
†RECORD, *May*, 1938, *p.* 315.

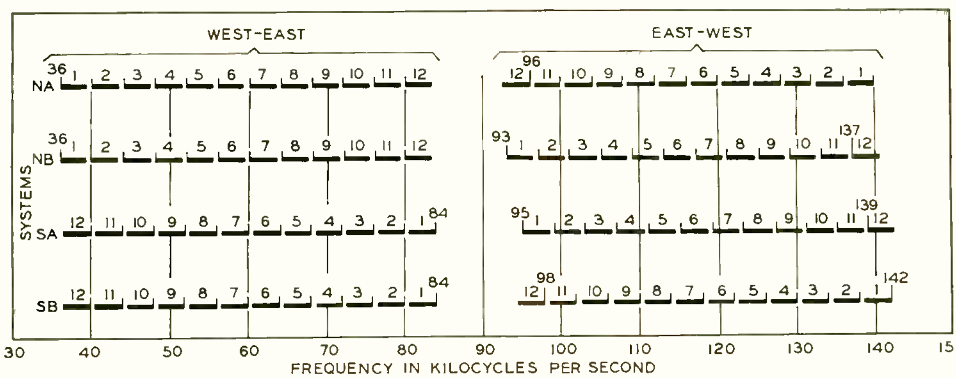


Fig. 1—Four frequency allocations are provided for the J2 system

and gives a wide separation between the wanted sideband and most of the undesired modulation products, which can then be more easily suppressed. A band filter selects the upper sideband of this first modulation, which extends from 400 to 448 kc. The carrier selected for the second group modulation then determines not only the frequency shift down to line frequencies but also the manner in which the channels are placed on the line. In the J1 system only a single frequency allocation is provided and, as a result, only one carrier for each direction of transmission is required for the additional modulating step.

Four frequency allocations are provided for the J2 system, as already described.* They are designated the NA, NB, SA, and SB allocations, and are shown in Figure 1. For west-to-east transmission in the NA and NB allocations, a 484-kc carrier places the channel group between 36 and 84 kc. For the SA and SB allocations, on the other hand, the group is still brought between 36 and 84 kc but a 364-kc carrier is employed, and the channels are placed on the line in inverted frequency relation—the lower line frequencies of any channel corresponding to the higher voice frequencies. For the east-to-west direction, a 308-kc carrier in the second group modulator, for the NA allocation, and a 306 kc for the SB allocation, places the group between 92 to 140 or 94 to 142 kc respectively with inverted channels. With a 541-kc carrier for the NB allocation and a 543-kc carrier for the SA allocation, the channel group positions on the line become 93 to 141 and 95 to 143 kc respectively, the channels being in direct frequency relation to the voice channels. The modulation scheme for east-to-west transmission is indicated in Figure 2 for the NA allocation, and a block schematic of an east terminal of the NA type is given in Figure 3.

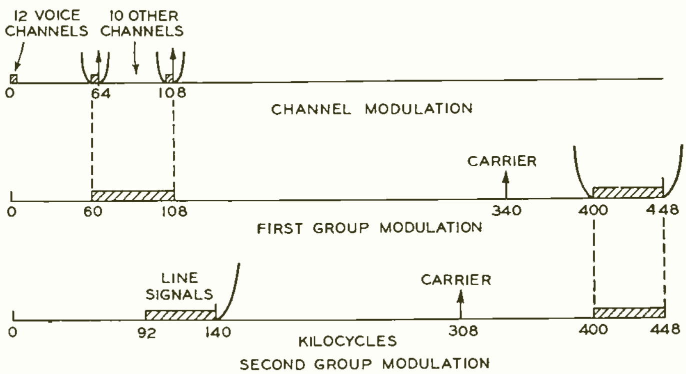


Fig. 2—Modulating scheme for east-west transmission of an NA *J2 carrier system*

At the receiving end, group demodulators shift the line frequencies in exactly reverse fashion. The carrier of the first stage of group demodulation being the same as that of the second group modulator at the distant transmitting end, while the second demodulation uses the 340-kc carrier which is common to both directions of transmission and to all frequency allocations. All these group frequencies are harmonically derived from the 4-kc fundamental used to generate the carriers for the channel modems—either directly or after modulaton with a 5-kc source. The carrier generators and the distributing circuits for the channel carriers have already been described in the Record.* The production and distribution of the seven group-carrier frequencies will

*Record, *April*, 1940, *p.* 226.

**May*, 1938, *p.* 315; *July*, 1938, *p.* 364.

be described in a forthcoming article.

Before the channel group goes through the various processes that will place it on the line in the proper frequency range and at the proper level, pilot-channel signals are added to it. These signals are used for automatic control of the gains of the repeaters along the line and at the distant terminal. The J1 system employs a single pilot for each direction, located approximately in the middle of the band. With the J2 system, however, which was designed for a greater range and flexibility of regulation, two pilots are employed for each direction, one at the lower and one at the upper end of the band, controlling independently the flat and slope gains.

For the west-to-east direction, 64- and 104-kc pilot signals, coinciding with the carrier frequencies of channels 12 and 2 respectively of the channel group, are introduced. These signals, after the frequency shifts in the two stages of group modulation, appear on the line at 40 and 80 kc for all west-to-east frequency allocations, although because of the inverted frequency relation referred to above, the 40-kc line pilot corresponds to the 104-kc terminal signal for the NA and NB, and to the 64-kc signal in the case of SA and SB systems. It is essential to prevent frequencies sufficiently near the pilots from coming through the pickoff selective filters and interfering with the operation of the pilot control. This is done, at west terminals, by inserting—ahead of the point where the pilots are introduced—a band-elimination filter presenting suppression peaks at 64 and 104 kc, which suppress not only the carrier leaks of channels 2 and 12 but also low channel frequencies which may result from various signaling pulses.

In the east-to-west direction, in order to obtain the same line pilots for all 4 frequency allocations despite their different frequency shifts, it is

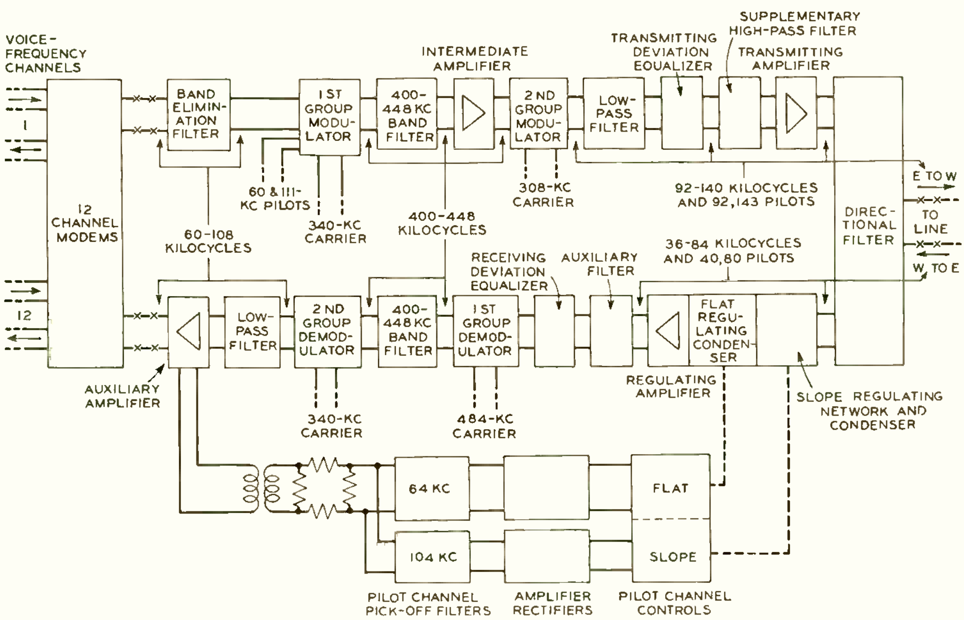


Fig. 3—Block schematic of an east terminal of an NA *J2 system*

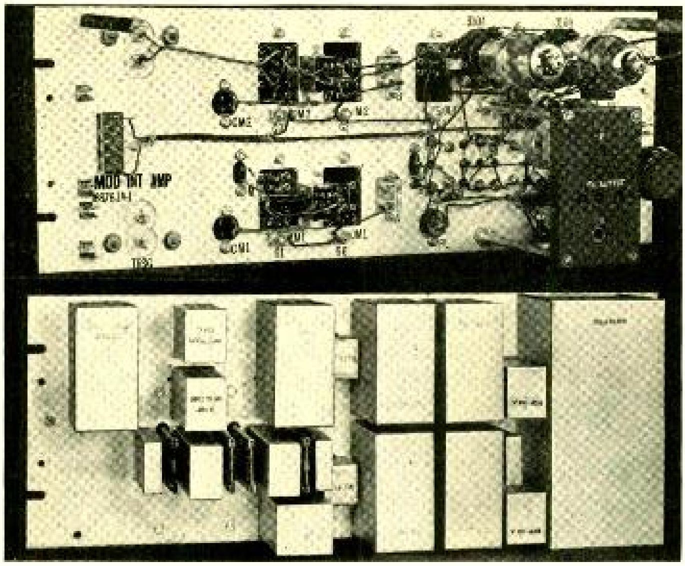


Fig. 5—Group modulator and intermediate amplifier panel for the J2 system

necessary to select two frequencies outside the channel group, 92 and 143 kc. This allows the use of the same pick-off circuits for all frequency allocations, so that the repeaters are the same on all systems. Because of the various frequency shifts involved in the group modulation for the different east-to-west frequency allocations, four frequencies, 58, 60, 109 or 111 kc, are required to obtain 92 kc on the line, but the same terminal frequencies can also be used for the production of 143 kc. Thus only two sets of terminal frequencies are required for the two pilots of the four east-to-west allocations, 58 and 109 kc for the NB and SB allocation, and 60 and 111 kc for the NA and SA allocations. This simplifies the pilot supply. No interference with pilot operation by carrier leaks or low channel frequencies is to be expected for east-to-west transmission, because the pilots at their nearest point—92 kc for the NB and 143 for the SB allocations—are 1 kc from the carrier outside the channel band. A band-elimination filter is still inserted ahead of the group modulator, however, to provide additional suppression to the channel carrier leaks. Otherwise these steady tones reaching the line might be induced in adjacent systems of different allocations appearing as 1-, 2- or 3-kc steady tones of sufficient magnitude to be disturbing.

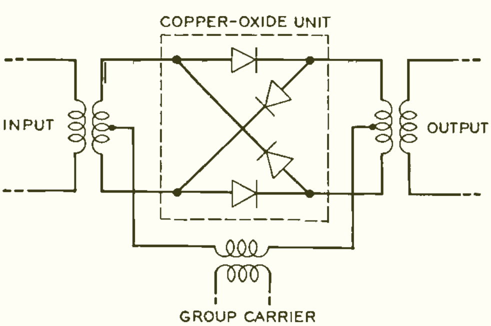


Fig. 4—Simplified schematic of copper-oxide modulator used for group modulation in the J carrier-telephone system

Pilot-supply oscillators with distribution busses for the supply of any one of the three pairs of required pilot signals, 64 and 104, 58 and 109, and 60 and 111 kc, are mounted in the same bay as the carrier generator and channel carrier-frequency busses.

Group modulation is very simply obtained with a double-balanced copper-oxide modulator as indicated in Figure 4. This modulator, when controlled by a carrier of high power as compared to the signal, acts as a double-pole double-throw switch operating at the carrier rate. The input coil of the first group modulator in the J2 system is actually a hybrid coil. The channel signals are introduced through one set of terminals, while the conjugate terminals are used for the introduction of the pilot signals.

At the output of the band filter following the first group modulator, the signal has reached a low level, and to maintain a satisfactory signal-to-noise ratio, amplification is introduced between the band-pass filter and the second group modulator. Beyond the second group modulator is a low-pass filter that separates the desired lower sideband from the other modulation products. This filter, together with the two group modulators and the intermediate amplifier, is mounted on a single panel as shown in Figure 5. At the lower right of the front of this panel—shown in the lower part of the upper photograph—a jack is provided for filament activity tests.* These tests may be made while the amplifier is in service.

*Record, *June*, 1939, *p.* 316.

After the twelve-channel group has been placed in the frequency location desired for line transmission, its level must be raised to provide a satisfactory signal-to-noise level in the open-wire repeater section. The amplifier employed is very similar to the line amplifiers used at the repeater stations, except that it is equalized to give flat transmission. The output of this amplifier is delivered to the line through the directional filters, which separate the frequencies for the two directions of transmission. The level differences between outgoing and incoming frequencies can be much greater in J2 than in J1 systems. As the directional filters were developed for J1, additional discrimination between wanted and unwanted frequencies is required for J2 systems. This is obtained at an east terminal by a supplementary high-pass filter in the transmitting branch and an auxiliary band-pass filter in the receiving side. The supplementary filter is required only at an east terminal; together with the directional filters, it prevents unwanted modulation products of the second group modulator in the 36 to 84-kc range from appearing in the receiving branch as near-end crosstalk. At a west terminal an auxiliary high-pass filter is used in the receiving branch. Distortion introduced by these and other terminal filters is corrected by deviation equalizers.

The receiving terminal consists of similar equipment but arranged to modulate in

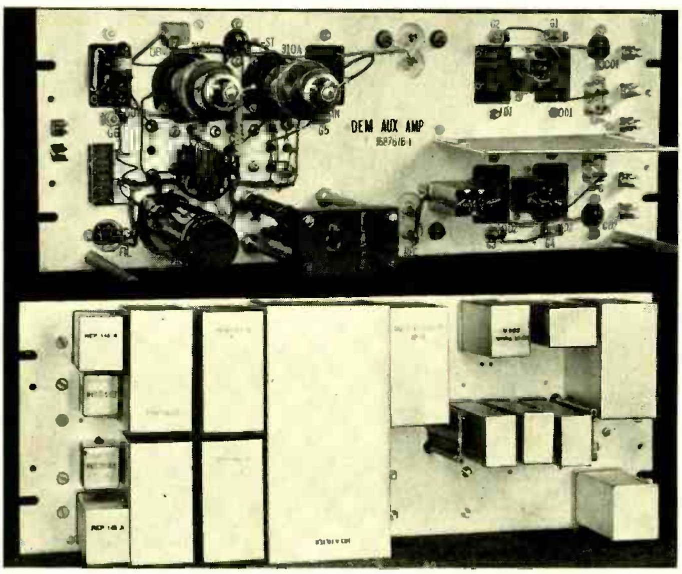


Fig. 6—Group demodulator and auxiliary amplifier panel for the J2 system

the opposite order so as to translate the line frequencies to those of the channel modems. The first group demodulator in an NA east terminal employs a carrier of 484 to obtain a lower sideband of 400 to 448 kc from the transmitted line band of 36 to 84 kc. A band filter then separates the lower sideband and passes it to the second demodulator, where the 340-kc carrier provides a lower sideband from 60 to 108 kc. A low-pass filter then separates this band from the unwanted frequencies, and an amplifier brings the level of the signal—reduced by passage through the demodulators and filters—to the desired level for the input to the channel modems. As at the transmitting terminal, the two demodulators, the low-pass filter, and the amplifier are mounted on a single panel shown in Figure 6.

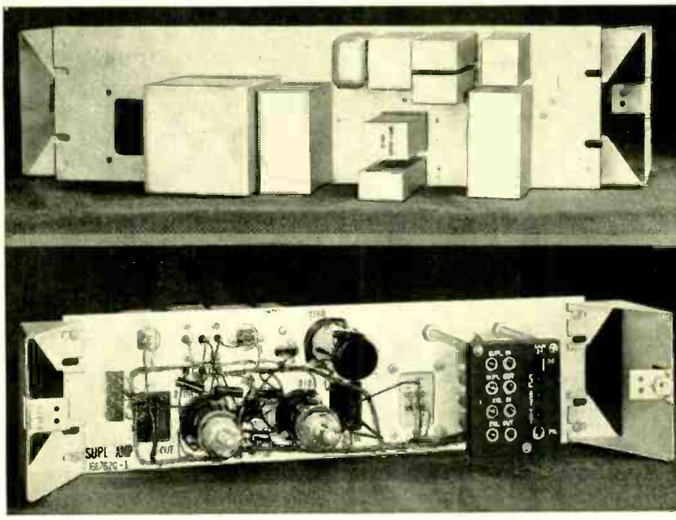


Fig. 7—Supplementary amplifier for the J2 system

Ahead of the first demodulator in the receiving side is the regulating amplifier that automatically brings the level of the signal up to the proper value for the input of the first demodulator. This amplifier, together with its equalizing networks and regulating condensers, compensates for the attenuation changes—variable both with time and with frequency—which transmission over the preceding section of open-wire line has inflicted on the signals. The amount of gain is varied automatically under control of the two pilot frequencies. These are taken off at the output of the amplifier just ahead of the channel modems through a hybrid output transformer. Under extreme weather conditions, it is possible in the J2 system to extend the range of regulation by patching in an additional amount of fixed gain, or equalization, or both at the same time. This is supplied by a two-stage supplementary amplifier and equalization equipment shown in Figure 7.

Despite its apparent complexity, this twelve-channel terminal is easy to maintain. This is due in no small part to the simplicity and stability of copper-oxide modulators and to the harmonic production of carriers from a single source. Because of this inherent reliability, jacks for maintenance and patching are provided only at two points in the carrier part of the terminal: between the channel and the group circuits, and between the group circuits and the line equipment. The operating experience already obtained with type J systems indicates that these new broad-band systems not only afford a convenient and economical means of obtaining additional circuits on certain open-wire lines, but at the same time provide a high grade of service.

Telephone Facilities for Airport Traffic Control

By C. W. HALLIGAN
Local Central Office Facilities

IN RECENT years the United States Civil Aeronautics Authority has established a number of control offices at the larger airports of the country to coördinate more effectively the rapidly increasing air-line traffic. These offices, known as airway traffic-control centers, not only regulate the inward and outward movement of planes at the local airport, but also control traffic at other airports within the control area, which averages 1,200 miles of civil airways, and follow and regulate as necessary in the interest of safety all aircraft flying within the control area. They must thus be in constant communication with a number of points at the local airport, such as the dispatchers' offices of the various air lines, the control tower, the Weather Bureau station, and any Army or Navy air station that may be located at the airport. In addition they must be able to communicate with other airports in the area, and have access to the local PBX board in the airport and to the nearest central office.

To meet the needs of these control centers, special features are required which are not available in the ordinary intercommunicating arrangements furnished for Bell System use. Until recently these facilities were designed and provided locally to meet the specific needs of each control point. This practice resulted in considerable variation in the arrangements used at different control offices, and recently the Civil Aeronautics Authority in collaboration with representatives of the American Telephone and Telegraph Company and Bell Telephone Laboratories have reviewed the general requirements with a view to standardizing arrangements that would provide the special features required and be flexible enough for use in all the control offices located throughout the country.

As a result of these discussions, a new key equipment was designed at the Laboratories and placed on trial in the airways traffic-control office at the Newark Airport. It satisfactorily met the general requirements of the Civil Aeronautics Authority, and was standardized as the 102A key equipment. It is based on the 101 type key equipment already described in the Record,* and to a large extent uses the same key and lamp equipment. A number of circuit modifications were needed, however, to meet the special requirements encountered.

In a large airport where an airways traffic-control office would be located, there would be a number of commercial air lines, each with its dispatcher's office, a control tower for the airport from which the arrival and departure of planes is controlled, an airport PBX, and a local Weather Bureau station. The control office would require lines to all these points and to the nearest central office, and also would require lines to other airports in the area under its jurisdiction, including any military airdromes of considerable activity. A typical arrangement might be as indicated schematically in Figure 1. In addition to the ordinary telephone facilities, conference service is required over the lines from the control office to the dispatchers' offices and to the control tower to permit close coöperation.

In the traffic-control offices, there will be a number of key equipment positions, and in general all of the lines will be multipled to all of them. However, one or more of the key equipments may be for use by supervisors, and for this service the equipment is arranged so that the supervisor may connect his telephone set to any of the other positions, and hear the conversation going on or take part in it. None of the incoming lines terminate at the supervisors' positions.

An arrangement for a typical con-

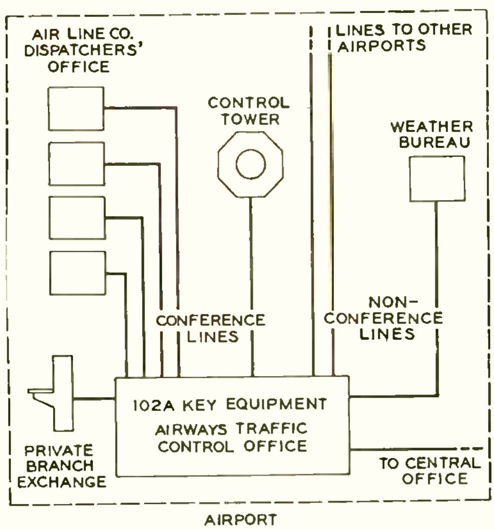


Fig. 1—Diagram indicating points with which the 102A key equipment provides communication

trol office is indicated in Figure 2. Prominent in such an office is a map table on which a record is kept of all plane movements on the airways in the control area, and a flight-progress board used to record the positions of all planes in flight together with coded reports regarding weather conditions, altitude, etc., as received from the planes. Facing the flight-progress

*August, 1937, p. 370.

board are attendants assigned primarily to the actual control of flights within the control area. At the communication desks are the attendants concerned primarily with routine communications to and from the distant airports located in the same area.

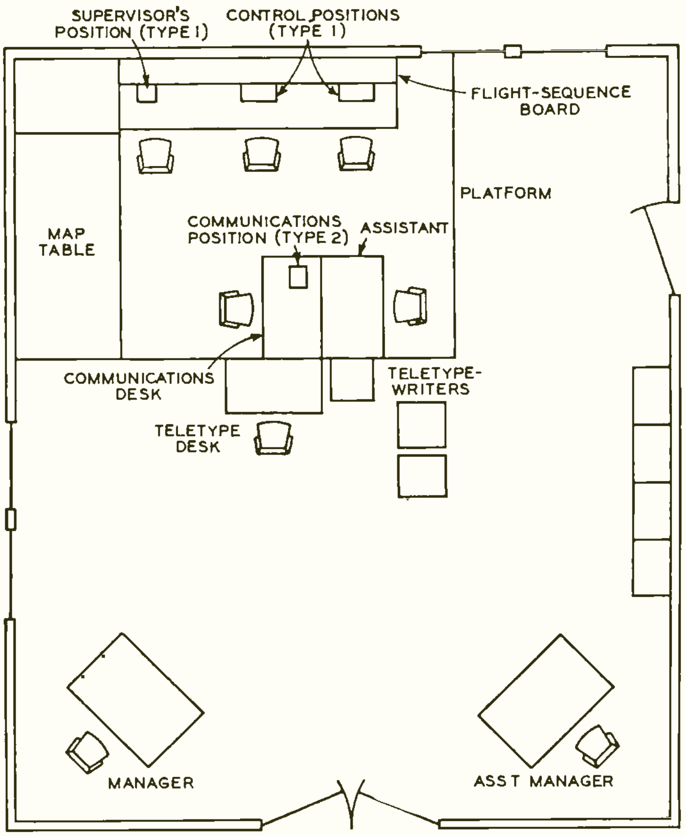


Fig. 2—Typical layout for an airways traffic-control office. A photograph of the arrangements at the Newark office is shown at the head of this article

In outward appearance, the 102A key equipment is very similar to the 101 type already described in the Record.* The key equipments employ ten-line key units which may be assembled in groups of from one to four. Figure 3 shows a three-unit assembly, with only two units installed, used at the flight-progress board at Newark. Each line key has access to two lines, and in the first unit there is a key used for flashing or ringing in one position and for holding in the other. It is common to all the lines terminating in the position. Each line key controls two lines—being moved up for one line and down for another. Line lamps and supervisory lamps are associated with the key positions corresponding to conference type lines and lines to distant airports, and line lamps and holding lamps are associated with the key position corresponding to central-office or PBX lines and local non-conference lines.

To provide conference service, the lower positions of the keys are wired in a multiple arrangement so that any number of lines connected to the lower positions may be connected to the telephone set at the same time. The upper positions, however, are connected in series, and are used for the non-conference lines. The multipled lower positions are connected at the end of the upper series chain, so that while all the lower-position lines could be connected together for a conference, the operation of any one of the keys to the upper positions would connect the telephone set to that line and disconnect it from all the lower-position lines.

*August, 1937, p. 370.

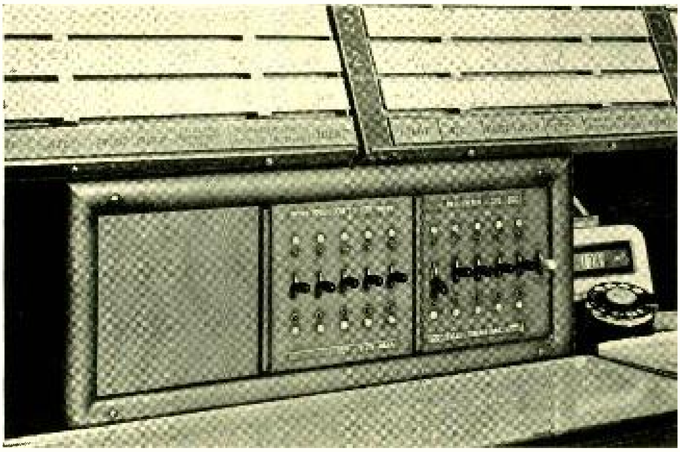


Fig. 3—Two of the 102A key equipments installed in a three-unit assembly at Newark

the subscriber set at that station is connected to the line. An incoming call to the key equipment is always announced by a flashing line lamp and by the operation of a common audible signal. On the lines to distant airports and on the conference lines, the circuits are arranged so that the supervisory lamps will light at all of the key equipment positions to indicate an incoming call, or they may be arranged so that the distant station may dial a digit to select only the supervisory lamp at a given position. This dialing feature enables the distant station to select the particular position handling the type of traffic in which he is interested, and is of particular value in the larger airports where the traffic in different

The supervisors' positions are similar in appearance to the others, but the upper and lower positions of the keys are for talking and monitoring, and not for choosing one of two lines. There is a key for each of the other positions in the office and only one lamp—to indicate when the position is busy—is used for each key.

The operation of the 102A key equipment on central-office and PBX lines is identical with that of the 101 key equipment. On all local intercommunicating lines, calls are originated at the key equipment by operating the common ringing key. With conference lines, any number may be rung simultaneously by throwing their respective keys and operating the common ringing key. On the lines to distant airports, a call is originated by voice; the distant stations are equipped with loud speakers bridged across the line at all times, and the loud speaker at a given station is disconnected when

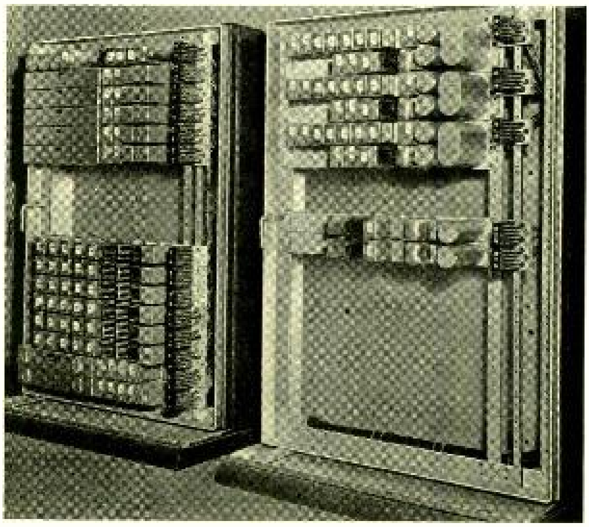
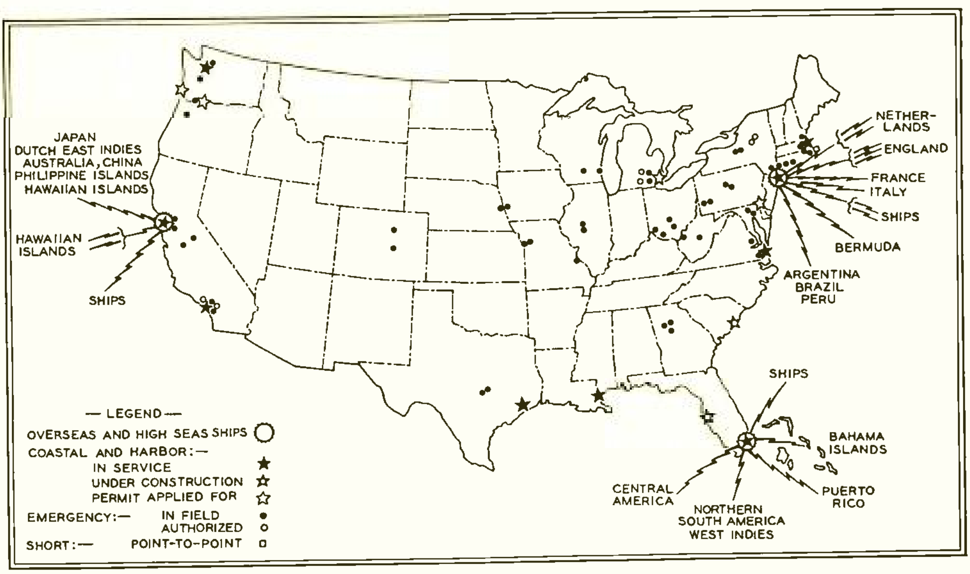


Fig. 4—In Newark, two of the apparatus cabinets are required because of the large number of lines and positions that are needed for this airport

directions is handled by different attendants. On conference-type lines the supervisory lamps also serve to indicate which stations have answered when a number of them have been rung simultaneously by the attendant. After a call has been answered, or when a line is busy on an outgoing call, the line lamp will light steadily as a busy signal. An intermittent buzzer signal is furnished on incoming calls on all except conference-type lines, and a separate buzzer with a distinctive tone is employed for the lines to distant airports to distinguish these calls from others. On the conference-type lines, the buzzer signal follows the switchhook at the distant station so that calls on these lines may be distinguished from others.

As with the 101 type key equipment, the incoming lines may be multipled to as many as twelve positions although present requirements indicate that the control offices will rarely require more than four positions. The relay equipment for the incoming lines, the attendants' telephone circuits, and the common circuits required for the installation are all arranged for mounting in standard metal apparatus cabinets as shown in Figure 4. A regulated battery power plant, which maintains the battery supply voltage within the limits of twenty to twenty-five volts to insure satisfactory transmission on conference connections, is also furnished in a steel apparatus cabinet.

Installations of the 102A key equipment are now in operation to serve thirteen control areas in the country. Additional control offices will be provided with this equipment in 1940.



Bell Telephone System's Overseas, Marine and Emergency Point-to-Point Radio Services in Use on April 1, 1940

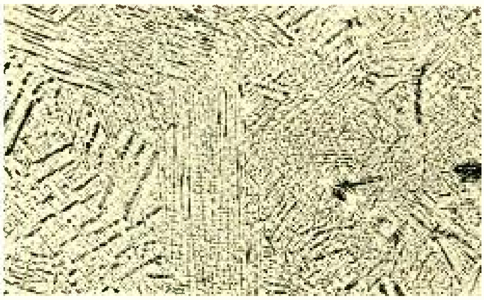
A Wiping Solder With Improved Handling Characteristics

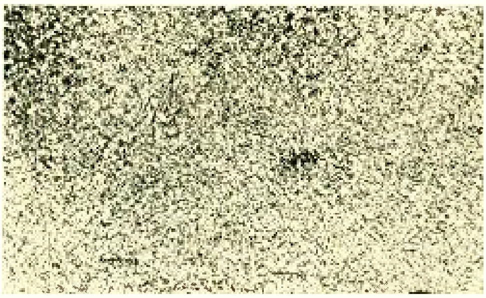
By EARLE E. SCHUMACHER
Associate Research Metallurgist

THE large lead sleeves that go over splices in telephone cable are joined to the sheath by "wiping" solder, so named in description of the manner in which it is applied. The splicer first pours molten solder over the areas to be covered, to heat them to a temperature at which the solder will wet them. He then catches some of the semi-molten mass of solder in a cloth and wipes or molds it into place. To anyone watching, it seems a simple enough operation; however, it requires considerable skill on the part of the splicer and an exacting balance among the properties of the solder. For instance, the satisfactory solder should melt and handle at temperatures below those of the parts to be joined otherwise holes would be melted in those parts. This property is secured by alloying lead with tin. Such an alloy has the two further properties of readily wetting lead when hot, and of being about as strong when cool. As a lead-tin alloy cools, part of it solidifies while the rest is liquid, and it is during that "mushy" period that the splicer forms the mass with his wiping cloths. The period should be reasonably long and during it the tendency for the joint to drain liquid metal or break apart should be a minimum. Finally there should be no undue oxidation at the higher temperatures sometimes encountered in practice.

With this knowledge of the requirements, it would appear at first sight that the quest for a better solder would be simple: merely produce an alloy which retains or improves upon the present desirable properties of lead-tin while eliminating those that are objectionable. The fact is that this task proved to be extremely difficult, and comprehensive experimentation was necessary. An interesting story could be told about the different alloys that were made during this study: how one added element affected one property and another another. It is sufficient to say that an alloy was finally developed whose properties closely approximate those sought.

The new solder has a nominal composition of 37.25 per cent tin, 0.10 per cent arsenic and the balance lead. This addition of arsenic would seem to be a small quantity to effect such a modification in properties, were it not that researches of recent years have shown how much the properties of metals and alloys can be changed by additions of small quantities of other metals. Metallurgical theory indicates that the added arsenic combines with tin to form a high melting compound, probably Sn_3As_2. This compound is the first material to freeze out from the melt and provides a very large number of small nuclei around which the lead-rich solid solution deposits, forming a correspondingly large number of crystallites. Without this seeding action of the arsenic compound, standard solder commences to crystallize at relatively fewer locations and thus a given amount of solidified material is distributed as coarser crystallites, fewer in number. Since





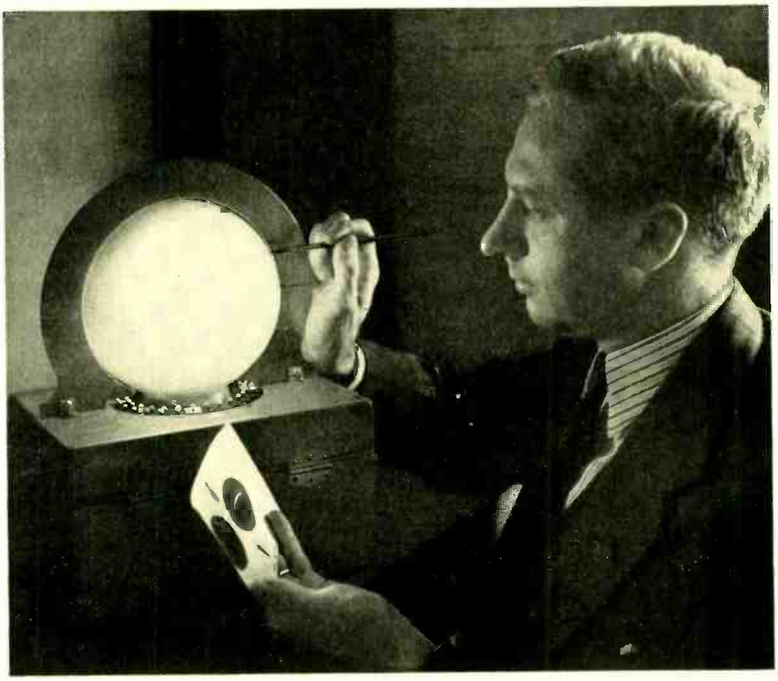
Above, a 38-62 *per cent wiping solder, cooled slowly, sectioned and etched. Below, the same alloy with* 0.1 *per cent arsenic added*

the finer crystallites in the new solder have a relatively greater ratio of surface area to volume and, being much smaller, pack more closely, there is appreciably less tendency for drainage of liquid metal. This source of leaky joints is therefore minimized.

Since less total solid phase is required in the new alloy to retain the liquid solder, molding of the joint can be commenced sooner and since finer grains are formed the mass does not become solid as soon, thus permitting manipulation to continue longer. Some splicers who have used the new solder refer to it as having a "buttery" or "velvety" feel during its manipulation, another way of saying that it is extremely moldable. An analogue may make this behavior clearer. Ordinary solders when partially solidified may be compared to a coarse sand and water mixture, the lead-rich crystallites, which separate out on freezing, corresponding to the sand particles, and the liquid metal to the water. The arsenic-bearing solder on the other hand may be compared to modeling clay whose solid phase is in a very fine state of subdivision. Modeling clay as is well known is much superior to a sand-water mixture in moldability. With the arsenic-bearing solder the forming period is increased and in addition the formability is improved. Both of these features are a direct consequence of the finer texture.

The tendency of ordinary solders to easy oxidation has already been mentioned. The tendency of the new solder to oxidize even at temperatures appreciably higher than ordinary working temperature is small. This facilitates the wiping operation.

To determine whether any health hazard was involved in using the new solder, an investigation was made to determine whether arsenic or arsenic compounds volatilize from this alloy under the conditions encountered in practice. The result was negative, showing that no hazard is introduced by substituting the arsenic-bearing solder for standard solder.



Spots on the Sun

By A. L. DURKEE
Radio Transmission Engineering

SPOTS on the disk of the sun were observed by Galileo early in the seventeenth century, and since that time they have been watched with considerable regularity. Careful records of their number, size, grouping, and location have been kept, and form the basis for estimates of activity in the sun. It has been found that the average number of spots varies periodically, rising and falling like the waves of the sea, although very much more slowly. This sunspot-activity cycle averages about eleven years in length, but it is not uniform. Intervals between peaks as short as seven years and as long as seventeen years have been observed.

Records also have been kept of certain terrestrial phenomena that appear to be affected by variations in solar radiations or emanations. It has been found, for example, that the intensity of the earth's magnetic field sometimes fluctuates violently, and that the magnitude and frequency of occurrence of such disturbances correspond approximately with the cycle of sunspot activity. With the development of electrical communication over wire circuits during the last century, it was discovered that these systems, particularly those using ground return, also are subject to periodic disturbances, chiefly caused by variations in the ground potential from place to place, and that the frequency and severity of these disturbances likewise tend to follow the sunspot cycle. With the advent of short-wave radio transmission, serious disturbances of this medium were found to occur from time to time. Radio transmission is affected by variations in the ionization of the upper portion of the earth's atmosphere, and this ionization is subject to disturbance by solar emanations associated with sunspots. Because of its interest in all forms of electrical communication, the Bell System was naturally interested in these phenomena, and some years ago undertook an extensive investigation of earth currents to determine the manner in which they varied and to discover any correlation that might exist between them, sunspot activity, and radio disturbances. Wherever there is ground current, there is a fall of potential along its path, and the resulting difference in electrical potential between two points can be measured. Three locations are selected approximately at the corners of a right triangle as indicated in Figure 1. By measuring simultaneously the potential difference between A and B and between C and B, it is possible to calculate the direction of the greatest potential drop and its value.

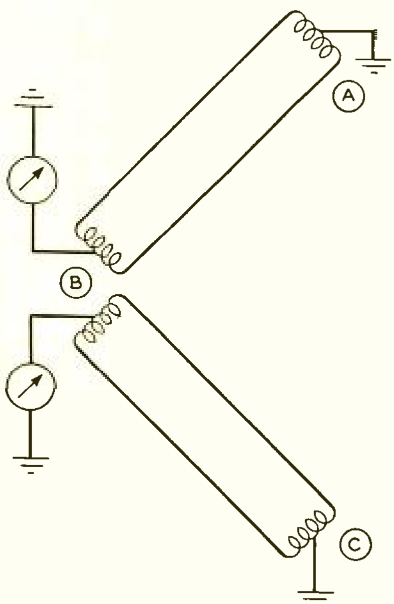


Fig. 1—Method of measuring ground-potential difference in the early studies

Studies of this sort were made over extended intervals at a number of places in the country. The variation was found to differ somewhat at different places. At all points, however, there was a rise and fall in the average earth-current activity that followed the sunspot cycle.

At the present time ground-potential measurements are carried on by Bell Laboratories at Netcong, Deal and Holmdel, New Jersey. Netcong is a receiving station for short-wave transoceanic channels, and a continuous record is kept with a graphic meter of the ground-potential difference between it and Stroudsburg, Pennsylvania. These records are sent to the Laboratories periodically for analysis.

Photographs of two sections of this record are shown in Figure 2. The recording circuit is arranged so that should the potential approach the full scale reading of the chart, a change would automatically be made to increase the range of the meter tenfold. While the full scale of the upper chart of Figure 2 is ten volts, a potential difference of this amount would cause the chart scale to be changed to 100 volts. It would remain at this setting for thirty minutes, when it would automatically return to the lower scale if the potential then was less than ten volts. The lower chart of Figure 2 shows a similar section of chart beginning on the morning of March 24, 1940. At about 8:42, the potential difference rose to ten volts negative and at once switched the scale to 100 volts, which is the value

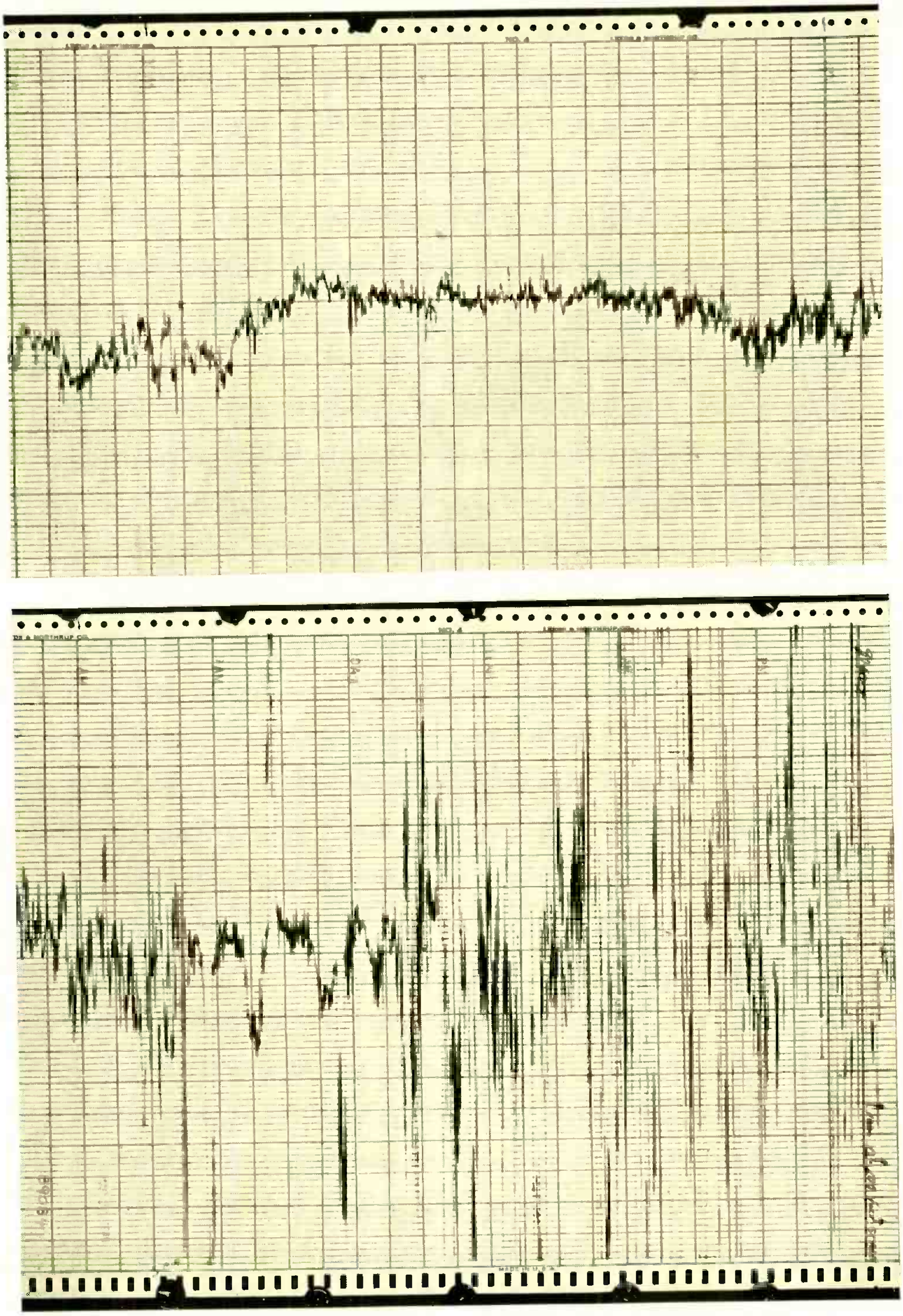


Fig. 2—Sections of record of ground-potential difference between Netcong and Stroudsburg: above, on a normal day; below, on March 24 (at 8:42 A.M. the scale of the graphic meter was automatically changed from 10 *to* 100 *volts)*

from then on. This marked the beginning of a greatly disturbed period which affected nearly all forms of electrical communication.

To study the correlation of such disturbances with the sunspot ac-

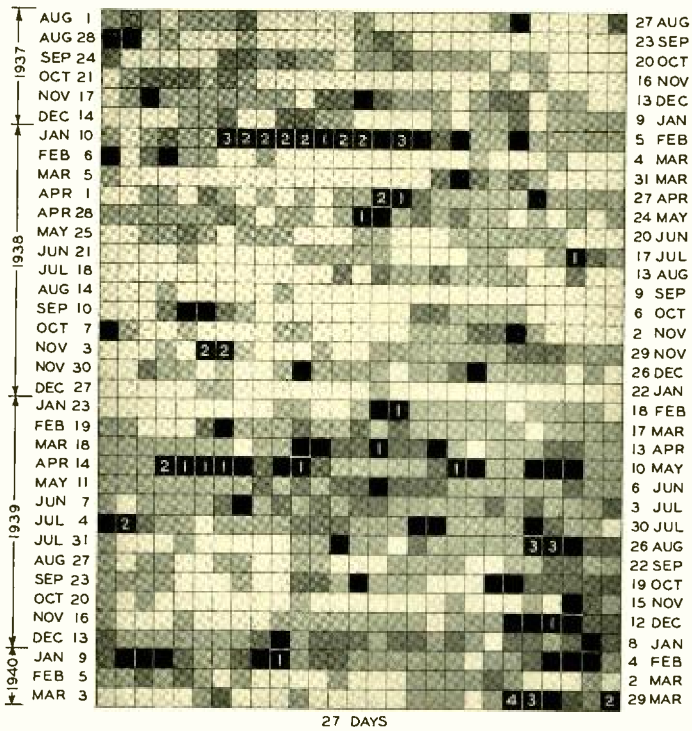


Fig. 3—Chart of radio conditions, TD figures, from August, 1937, to date

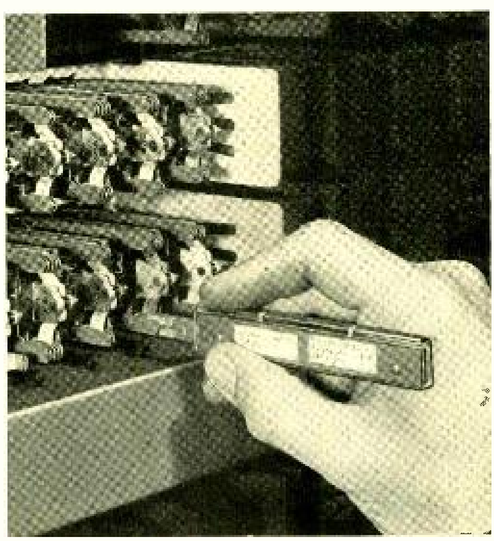
tivity, the Laboratories takes a photograph of the sun's disk at noon of every day the sun is visible. The sunspots revealed in these photographs are marked on the globe shown in the picture at the head of this article. This is a hollow glass sphere rotated by clock work at the average rate of rotation of the sun, which is about one revolution in twenty-seven days. The globe is lighted from the inside, and the spots are marked in ink at the approximate positions. Around the rim of the base on which the globe is mounted are two concentric rows of holes, one hole in each row for each day of the twenty-seven-day solar period. Pins with heads colored to represent the conditon of short-wave radio transmission are inserted in these holes. Since there are two rows of holes, there is a record of radio conditions for fifty-four days. Each day as the rotation of the globe brings a pin in line with a fixed arrow representing the present day, the rear pin at that position, representing conditions fifty-four days ago, is removed, and the front pin is moved back into its place. A new pin is then put in the front row to represent the conditions of the present day. In this way a fifty-four-day record is available of the sunspots and radio conditions. As a result their visual comparison is made simple.

Data concerning short-wave radio conditions are secured from field-intensity measurements made daily at Netcong on the various transoceanic channels. These readings are combined to secure an average measure of the transmission disturbance, which is known as the TD figure. The variously colored pins correspond to certain ranges of TD figures. For a more detailed analysis extending over a longer period, a record is kept in chart form. A three-year section of this chart is shown in Figure 3. This chart is 27 squares wide and thus each horizontal row corresponds to one of the circles of pins around the base of the globe. On the actual chart four types of designations are used: white squares, light gray squares, dark gray squares and black squares. These represent no disturbance, slight, moderate, and severe disturbances, respectively. In addition, the black squares may carry numerals from 1 to 4 to indicate still greater disturbances. It will be noticed that the badly disturbed days of March 24 and 25 lie on a part of the twenty-seven-day solar cycle that has been more or less disturbed for nearly a year. August 22 and 23, which fall on the same part of the twenty-seven-day cycle, were seriously disturbed, as were December 7, 8, 9, and 10, and February 1, 2, and 3. The immediately preceding period, February 27, 28, and 29, was particularly quiet, however, as were April 20, 21, and 22, not shown on the chart.

Although the severity and frequency of occurrence of these periods of radio disturbance, excessive ground-potential differences, and variations in the earth's magnetic field tend to follow the eleven-year sunspot cycle, the peak of sunspot activity appears to occur about two years before the corresponding peak of radio and other terrestrial disturbances. One plausible explanation for this is that the active areas on the sun, which move to progressively lower solar latitudes during the course of the eleven-year cycle, are most effectively directed toward the earth a few years after the sunspot activity has passed its peak of intensity. There seems also to be a rather poor correlation between the appearances of particular sunspot groups and individual terrestrial disturbances. It is possible that the sunspots are merely one manifestation of some deeper solar activity, and that the terrestrial disturbance is another effect of this activity. There is some promise that useful predictions of these disturbances will eventually be possible and in searching for the key to them it is important to keep careful record of all the associated phenomena that are involved.

Cleaning Contacts

In maintaining relays it is sometimes necessary to remove small amounts of precious metal which build up slowly from one contact to another during the break periods. The tool shown was developed to restore the contacts of either single or bifurcated springs to their original condition by filing off the metal to a definite thickness. It has a channel-shaped handle of transparent plastic in which are mounted two metal blades. Each blade is equipped with a replaceable file and is insulated from the operator's hand. The handle holds two designation strips which indicate the contacts for which each blade is intended.



The "Vu" and the New Volume Indicator

By S. BRAND
Toll Transmission Development

IN THE operation of many communication circuits, particularly those associated with public address and radio broadcasting, it is frequently necessary to know the strength of the transmitted speech or music waves. Sometimes this is to be able to judge the comparative loudness of the speech and music as they will be eventually heard in loud speakers. More frequently it is to aid in controlling the strength of these waves to values satisfactory for transmission over the particular system involved: that is, so that on the one hand they are neither so strong as to be noticeably distorted in passage through amplifiers and loading coils nor, on the other hand, so weak as to fall too close to the level of noise.

Speech and music waves, however, are of such erratic and variable nature that their strength cannot be measured and expressed in any simple manner in terms of the ordinary units, such as volts, amperes, or watts. In the early days of the first public-address circuits, with their vacuum tube amplifiers subject to overload distortion, the modern idea of "volume" was developed to permit the simple expression of the strength of these exceedingly complex waves, examples of which are shown in Figure 1. The device used for measuring volumes is known as a "volume indicator," and its readings have customarily been expressed in terms of decibels above or below a particular reading chosen as the zero or reference volume.

The largest field of use of volume indicators in the Bell System is on the program transmission networks. Since the operation of these networks involves volume measurements in the plants both of the Bell System and of the broadcasting companies, it is particularly important that these organizations agree on the exact standards and technique involved in such measurements. The National Broadcasting Company, the Columbia Broadcasting System, and Bell Telephone Laboratories, therefore, instituted a coöperative project to determine in detail what these standards should be. As a part of this work they set out to develop a new volume indicator to meet their joint requirements, taking advantage of the latest advances in the art. An extensive investigation followed, in the course of which other large users of volume indicators were also consulted. As a result of these investigations, a new volume indicator and a new term for expressing volume were standardized in May, 1939. They were adopted by the Bell System and the participating broadcasting companies at that time, and it is hoped that they will soon come into general use.

The volume indicator consists of a milliammeter operated through a copper-oxide rectifier, and mounted on a panel that includes an attenuator and the connecting circuit. A complete volume indicator thus includes an attenuator and a meter, and the volume is normally read from the attenuator—the meter serving primarily as an indicator. In the new meter, the zero point of the scale is set at about two-thirds full-scale deflection, to give a maximum useful scale while preserving sufficient margin for overswings of the pointer. With speech or music on the circuit, the pointer of the meter will be constantly moving, and in program practice the attenuator is set so that the maximum swings of the pointer will reach approximately zero, neglecting perhaps one or two overswings per minute. An effort has been made to design the meter so that the motion of the pointer is not too rapid, so as to avoid eyestrain, and yet rapid enough to indicate changes in volumes reliably.

In normal operation, the attenuator of each volume indicator on a circuit is adjusted so that the meter deflects to the 0 point on its scale when the volume is the maximum permissible at that point in the circuit. The meters of all the volume indicators

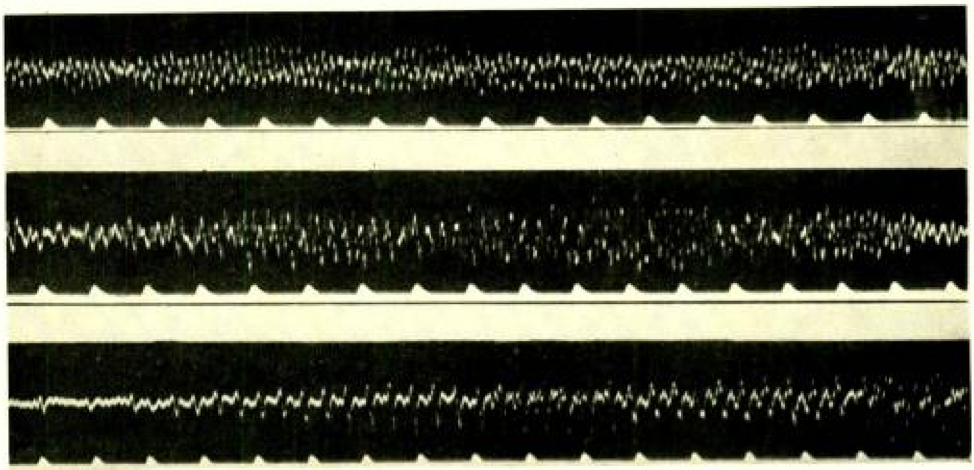


Fig. 1—Typical speech and music, showing the extremely complex wave form

should therefore show the same deflections, if there is no trouble, even though the volumes are not the same at each point.

With the new standard, volume is measured in "vu" (pronounced as single letters), a logarithmic unit that measures volume above or below a specified level. This reference level, or 0 vu, signifies no precise electrical quantity, but represents the volume at the point of measurement when the new volume indicator gives a reading of zero. It is specified, however, that the volume indicator be calibrated to read 0 vu on 1 milliwatt of 1000-cycle power in a 600-ohm resistance. With 1000-cycle power, therefore, 0 vu represents 1 milliwatt, but with speech and music, there is no direct correlation between vu and milliwatts. An important part of the development was the determination of the best dynamic characteristics for the new instrument. As a result, it is specified that with a sudden application of a 1000-cycle wave that will give a final deflection of 0 vu, the needle will reach 99 per cent of 0 vu deflection in 0.3 second, and that it will overshoot 0 vu by not less than 1 per cent nor more than 1.5 per cent.

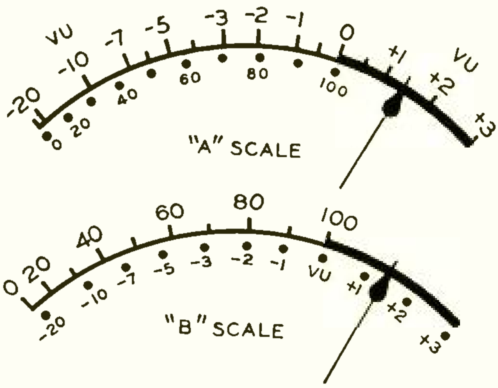


Fig. 2—The meter used with the volume indicator may have either of two scales: one with the vu markings more prominent, and one with the per cent markings more prominent

The volume-indicator meters are provided with a second scale in addition to the "vu" scale. This scale is proportional to voltage, and is marked from 0 to 100 from the position of rest of the pointer to the 0 vu point on the first scale, with no markings beyond 100. This scale is preferred by the broadcasting companies for most purposes. One hundred per cent may correspond to full per cent modulation of the distant radio transmitters, or to the maximum volume which is allowed to be sent into the connecting Bell System program circuits.

To permit ready correlation between volume indicators, whether in the plants of the broadcasting companies or of the Bell System, all instruments are provided with both scales. However, two arrangements of the scales are available, as shown in Figure 2, depending upon which scale is to be most frequently used. In one, known as the A scale, the vu markings are given greater prominence by being made larger and placed above the scale arc. In the other, known as the B scale, the positions are reversed and the percentage scale is made the more prominent. The meter with the A scale is available both with and without an illuminated dial, and so the meter may be obtained in three forms. The Western Electric KS-8208 and KS-8207 meters have the A scale with and without illumination respectively, while KS-8218 meter specifies the illuminated B scale.

The attenuator has eleven steps, each of 2 db. The lowest point is marked +4 vu and the highest +26 vu. As already pointed out, the specifications require that the volume indicator read 0 vu at 1 milliwatt of 1000-cycle power in 600 ohms. The meter is not sensitive enough, however, to deflect to the 0 point on the vu scale on 1 milliwatt. It will deflect only to the −4 vu position. For this reason the position of the attenuator for no loss is marked +4 vu. With the dial at this position and 1 milliwatt of 1000-cycle power applied, the reading of the volume indicator is thus the +4 vu of the attenuator and the −4 vu of the meter, giving a net of 0 vu.

The volume-indicator panel with which the meter is used comes in three forms, known as the 752, the 753, and the 754 type volume indicator. With the 752 and 753 types, a 10½-inch brass panel is used, but the latter number includes a non-magnetic housing for portable use. The 754 type consists of the 10½-inch panel fastened to a 19-inch brass panel for relay rack mounting. Each of these types is available with three circuit arrangements, designated by letters A, B, or C following the code number. Code A, the simplest arrangement, is shown in the upper diagram of Figure 3. The meter itself has an impedance of about 3900 ohms, and the resistances R2 and P1 provide an additional impedance of about 3600 ohms, making the input impedance to the indicator about 7500 ohms. This is high enough to permit the indicator to be bridged across a line for monitoring. The resistance of about 3600 ohms must be used in series with the meter to obtain the proper dynamic characteristics. The potentiometer P1 provides calibrating adjustment for slight variations of the meters.

The code B indicator is arranged with a key to permit a circuit like code A or one as shown in the middle diagram of Figure 3 to be used at the option of the operator. The repeating coil in the latter diagram increases the sensitivity of the indicator by 10 db, and when it is used, 10 vu must be subtracted from the indication of the attenuator. This circuit has an input impedance of 600 ohms, and therefore should not be bridged across a line.

The code C attenuator provides a key that selects a circuit like code A or like the lower one in Figure 3. This latter circuit includes a 20-db pad to allow measurements of higher volume. When it is used, therefore, it is necessary to add 20 vu to the indications of the attenuator. For 0 vu indications on the meter, the total range of the code A volume indicator is thus from +4 vu to +26, for the code B using

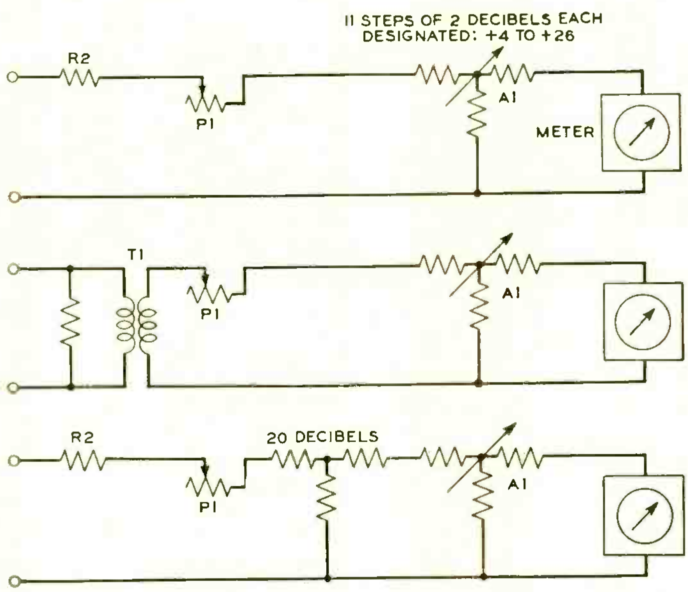


Fig. 3—The three circuits available for the vu indicator

600-ohm termination from −6 to +16, and for the code C using the 20-db pad, from +24 to +46 vu.

The appearance of the volume indicator is evident in Figure 4, which shows a type 754B volume indicator. The 752B is just like this but with the wide mounting panel removed. To secure the high sensitivity desired, magnets of special steel had to be used, and magnetic material adjacent to the magnets will affect their fields. It is for this reason that the panels themselves are made of non-magnetic material.

Although this new volume indicator is designed primarily for measuring volumes, and will be used chiefly for this purpose, it may also be used for measuring transmission losses and gains with single-frequency power. The standard sending power for most transmission measurements in the Bell System is one milliwatt. Since the volume indicator is calibrated with one milliwatt, it may be used as a receiving device for such measurements, and losses and gains may be read directly in decibels from its vu scale. Moreover, the characteristics of the instrument are very flat with frequency. Between 35 and 10,000 cycles the variation is not more than 0.2 db, and not more than 0.5 db from 25 to 16,000 cycles. Measurements may be made at other frequencies than 1000 cycles, therefore, without serious error.

It is apparent that the principal feature of the new volume indicator is a copper-oxide-rectifier type of meter with the sensitivity and other characteristics desired for this type of instrument. The attainment of these qualities in a simple device has become possible through advances made in the design of such instruments. The new volume indicator requires no vacuum tubes, and consequently no power supply. It is rugged, comparatively inexpensive, and readily portable. These features, together with its acceptance as standard by other users, constitute the chief advantages afforded by the new instrument.

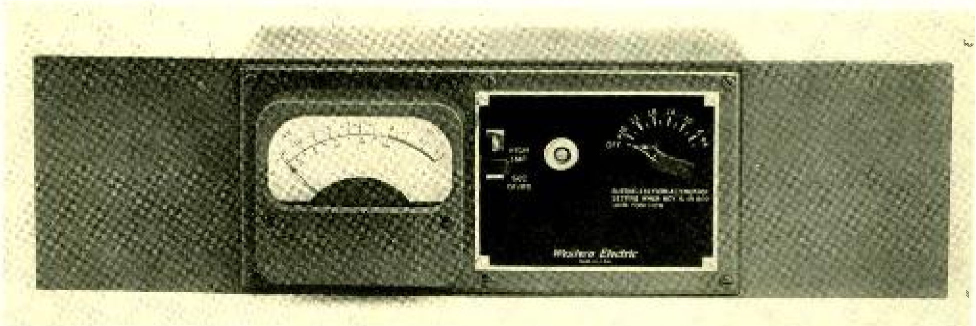


Fig. 4—The 754B volume indicator

The 1A Key Telephone System

By L. H. ALLEN
Private Branch Exchange Development

UP TO the present time, a business or residence subscriber requiring access to more than one telephone line has been equipped according to one of the standard wiring plans. Many of such plans are available; each has a number and includes a different set of features, such as means for picking up any one of a number of central-office, PBX, private, or intercommunicating lines, holding one line while using another, cutting off extension stations or ringers, or signaling on intercommunicating circuits. Each such numbered plan covered the arrangement for a particular number of lines, and specified the particular desk-mounted key and the other station equipment required. Very often, however, no numbered plan was available to meet the particular requirements of the subscriber, and as a result the Telephone Companies were forced to furnish many special installations, which were usually modifications of existing plans.

With the development of the combined telephone set, with all the usual station apparatus in one housing, it was decided to incorporate the keys for picking up and holding a number of lines in the base of a similar set. At the same time a flexible arrangement has been developed that provides the equivalent of the wiring plans on a feature basis. Instead of having numbered plans for various combinations of features, each feature may be selected as a unit, and the combination may be formed as desired. In this way almost any combination can be provided without any special engineering by the local teleaccessible for maintenance or adjustment. Lamp units are furnished when the features selected require them.

The features provided by the 1A telephone system permit calls to be answered or originated on from one to six central-office, PBX, intercommunicating, or private lines; calls to be held on from one to five central-office or PBX lines; extension stations or ringers, or the ringer in the set, to be cut off, or the ringer in the set to be disconnected, and a distant extension station or ringer connected; one or more extension stations to be disconnected from a line during conversation; and signaling on intercommunicating circuits or private lines. The ringer in a key telephone set may be used for one line only, or as a common ringer for all the lines.

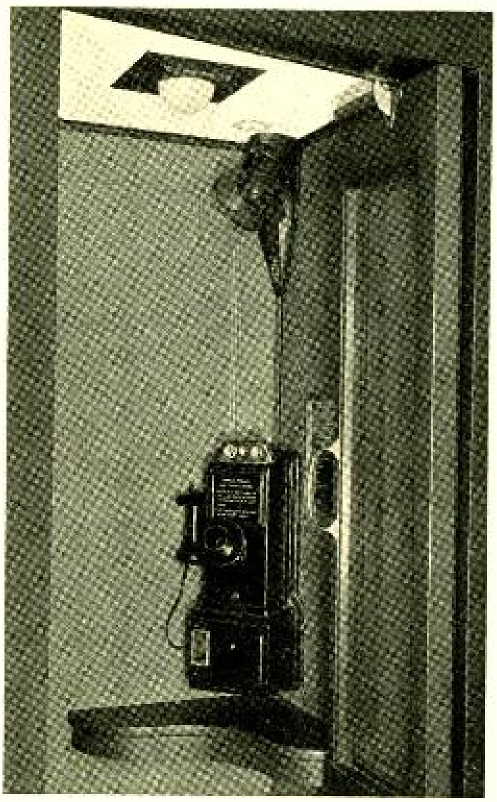
When the sets are arranged for automatic signaling with intercommunicating lines, an automatic-signaling intercommunicating line circuit is required. This circuit is intended primarily for use where there is one principal and one subordinate station, and is designed for signaling in one direction only. The buzzer of the subordinate station will be operated automatically when the handset at the principal station is lifted, and will be disconnected when the subordinate station answers. The buzzer cannot then be re-operated until both stations have hung up. A separate circuit will be required if the subordinate station is to be permitted to signal the principal station.

Booth-Ventilating Fans

Telephone booths cannot always be located advantageously from a ventilation standpoint and for these situations centralized air-circulating systems or individual electric fans may be provided. In the past, individual fans have been mounted on a bracket inside the booth at one corner of the ceiling. They have been equipped with metal blades and provided with wire guards.

A quiet fan with rubber blades has recently been developed. The fan motor is mounted between rubber cushions in a cast bracket and attached to the ceiling of the booth as shown in the illustration. A door-switch, which heretofore controlled the ceiling light, also starts the fan when the door closes. An "on-off" switch permits the patron to control the fan when the door is closed.

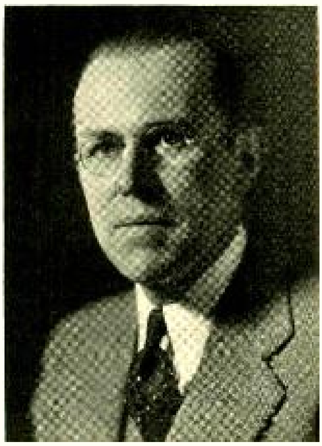
This ventilating fan gives a properly directed stream of air and circulates the free air in the booth more effectively.



Contributors to this Issue

Since Earle E. Schumacher came to the Laboratories in 1918 he has been engaged primarily in research studies on metals and alloys. Mr. Schumacher is now Associate Research Metallurgist and in this capacity is in charge of a group conducting metallurgical researches. He has a B.S. degree from the University of Michigan and was Research Assistant in Physical Chemistry in that institution from 1916 to 1918.

S. Brand received the B.S. degree from Trinity College in 1915. During the next two years, he attended Yale University Graduate School, leaving there in 1917 to join the U. S. Air Service, in which he served till 1919. In 1920, he joined the Plant Department of the Southern New England Telephone Company and in 1923 was transferred to the Development and Research Department of the American Telephone and Telegraph Company, coming to the Laboratories in the 1934 consolidation. He has been engaged mainly in transmission development work on circuits used for program transmission.



E. E. Schumacher

F. A. Coles joined the Laboratories in 1928 shortly after receiving the degree of B.S. from the University of California. Since that time he has been in the Commercial Products Development Department where he has been engaged in the electrical design of amplifiers and special audio-frequency equipment.

A. L. Durkee received the degree of S.B. in Engineering from Harvard University in 1930 and joined the Department of Development and Research of the American Telephone and Telegraph Company in July of that year. There, and as a member of the Transmission Development Department, his work has been largely on

S. Brand

F. A. Coles

A. L. Durkee

L. H. Allen

R. A. Leconte

C. W. Halligan

radio-transmission problems associated with the development of transoceanic radio-telephone circuits. The study of sunspots was undertaken in connection with an estimate of transmission disturbance conditions which radio circuits may experience in the next few years.

L. H. Allen graduated from the Massachusetts Institute of Technology in 1920, and after a short time with the Public Service Electric Company of New Jersey, he joined the Systems Development Department of what is now the Laboratories. During the next six years he engaged in a variety of developments for manual and dial telephone systems. From 1927 to 1936 Mr. Allen was engaged in fundamental circuit studies of telephone systems, such as economic studies of relay windings and the investigation of signaling. During 1936 he made time studies of the crossbar dial system, thus providing data for determining engineering equipment quantities. Since then, in the PBX development group, he has continued his previous responsibilities on subscriber circuits and also has been concerned with the design of key equipments, key telephone systems, and PBX circuits.

R. A. Leconte was graduated from the Electrotechnical Institute of Grenoble, France, and later attended the University of that city. Previous to the last war he was employed by Jacquet Frères and later by the Cie. Française Thompson-Houston; at the outbreak of the war he obtained an engineering commission and after a period at the front was sent to this country as a member of the French military mission. In 1922 he joined the Laboratories and, with the toll group, worked initially on amplifiers for program broadcasting circuits, and on repeaters for four-wire toll circuits. He is now engaged in the development of carrier systems.

C. W. Halligan received his B.S. degree in electrical engineering from Bucknell University in 1923 and his M.S. degree in 1924. After serving as an instructor in electrical and civil engineering at Bucknell for three years, he joined the Department of Development and Research of the American Telephone and Telegraph Company in 1926. He was associated with the toll switching group of that department until 1932, and some of the work done in that group served as a basis for a thesis for his E.E. degree which was granted in 1934. From 1932 to 1934 his work consisted mainly in studying inventions and patents presented for purchase to the A. T. & T. In 1934 when the D and R was consolidated with the Laboratories, he was transferred to the PBX and station facilities group, where he has been concerned with the development of subscriber's station and key-equipment switching arrangements.