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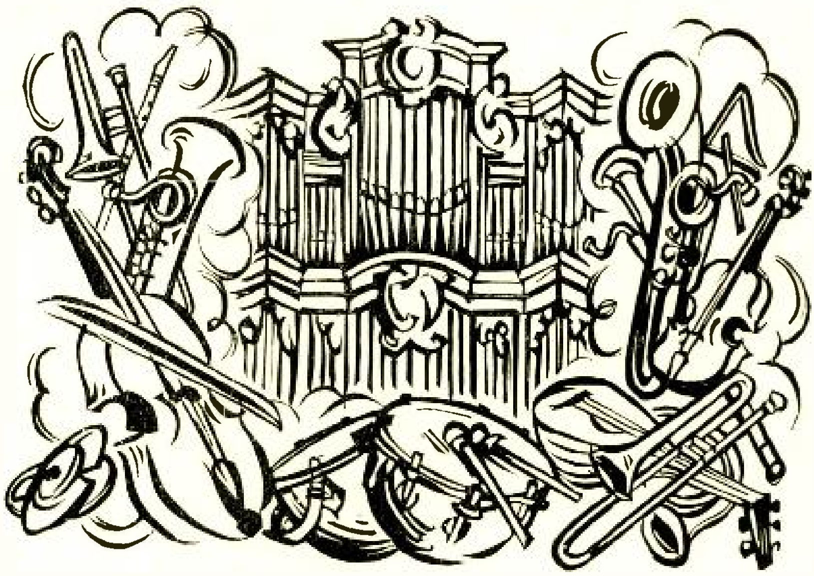
Installing a quartz crystal in a filter for the pilot channel of a coaxial-cable system



STEREOPHONIC RECORDINGS OF ENHANCED MUSIC

ON APRIL ninth and tenth, demonstrations of the stereophonic reproduction of music and speech were given at Carnegie Hall in New York City. That accomplishment was the culmination of a long series of researches by Bell Telephone Laboratories. The first step in the achievement was demonstrated in 1933, when a symphony concert produced in Philadelphia was transmitted over telephone wires to Washington and there reproduced stereophonically and with enhancement before the National Academy of Sciences. Subsequent researches by Dr. Fletcher and his associates, E. C. Wente, J. C. Steinberg, W. B. Snow, R. Biddulph, L. A. Elmer, A. R. Soffel and A. B. Anderson, have supplied the equipment and technique for recording such a production on film. With the coöperation of Leopold Stokowski and the Philadelphia Orchestra; of the Tabernacle Choir and organists in Salt Lake City; and of Paul Robeson and other artists, their music or drama was first recorded either in Philadelphia or in Salt Lake City. At a later audition, the artist or director was able to vary the recorded volume and to change the tonal color of the music to suit his taste. At will, he could soften it to the faintest pianissimo or amplify it to a volume ten times that of any orchestra without at all altering its tone quality, or he might choose to augment or reduce the high or low pitches independently. While he was thus enhancing the music which he had himself directed, his interpretation was being re-recorded on film as a permanent record.

Selections for reproduction, chosen to demonstrate the full capabilities of this system, are shown in the program reproduced below. From the choral numbers, vocal solos, organ, drama, and grand opera reproduced at Carnegie Hall, the audience gained an idea of the versatility of the stereophonic system. A stirring climax for the program was provided by the closing scene from "Götterdämmerung." For its fortissimo passages, Dr. Stokowski took full advantage of the tenfold increase of sound over that of the largest orchestra, and effectively used the individual control to make the soloist's voice clearly heard above the orchestra. That number, and orchestral works by Debussy, Strauss, and Moussorgsky, which formed the first part of the program, were played by the Philadelphia Orchestra under Dr. Stokowski's baton. In his enhancements, Dr. Stokowski has shown a grasp of the possibilities of the stereophonic system which comes from his long association with it and from his interest in this development of the musical art.

INTRODUCTION

F. B. JEWETT, *President*,
Bell Telephone Laboratories

HARVEY FLETCHER,
Director of Physical Research,
Bell Telephone Laboratories

ORCHESTRA

Night on Bare Mountain . . *Moussorgsky*
Moonlight . . . . *Debussy*
Tales from the Vienna Woods . *Strauss*
Pictures in an Exhibition . *Moussorgsky*
The Philadelphia Orchestra,
LEOPOLD STOKOWSKI, Conducting

CHORUS

Come, Come Ye Saints . . . . *Clayton*
Hear My Supplication . . . *Archanghelsky*
The Tabernacle Choir of Salt Lake City
J. SPENCER CORNWALL, Conductor
FRANK W. ASPER, Organist

DRAMA

The Emperor Jones (Scene II) . *O'Neill*
Played by PAUL ROBESON

ORGAN

Toccata in F . . . . *Widor*
FRANK W. ASPER, Organist

Westminster Chimes . . . . . . *Vierne*
ALEXANDER SCHREINER, Organist

ORATORIO

Excerpts from Elijah . . . *Mendelssohn*
The Tabernacle Choir
with HAROLD BENNETT, Soloist

OPERA

Brünnhilde's Immolation, from
Die Götterdämmerung . . . . . *Wagner*
The Philadelphia Orchestra,
LEOPOLD STOKOWSKI, Conducting
HAZEL HAYES, Soloist

Stereophonic Reproduction From Film

By HARVEY FLETCHER
Director of Physical Research

SYMPHONIC music heard over radio or the loudspeakers of sound-picture systems, although very satisfactory, fails to produce in several respects the effect received by one listening to the original production in an auditorium. A full symphony orchestra utilizes air vibrations at nearly all the frequencies the ear can hear, and it uses volumes of sound from about the lowest that can be heard in an ordinary auditorium to volumes one-hundred million times greater. The frequency range of such an orchestra, in other words, runs from the neighborhood of 40 cycles per second to perhaps 14,000 cycles, and the volume range extends from about 30 db above the threshold of hearing to 110 db, a total range of 80 db. In contrast with these ranges, radio and sound-picture systems usually have frequency ranges only 5,000 to 8,000 cycles, and volume ranges from 35 to 50 db. Moreover a listener in an auditorium receives an added effect from the distribution of the sound in space, a recognition of different sounds coming from different sources.

These limitations have long been recognized by the Laboratories, and some years ago an improved sound-reproducing system was developed. The result of this work was the stereophonic system demonstrated in Washington and Philadelphia in 1933.* Besides reproducing practically the complete frequency range of the orchestra

*Record, *May*, 1933, *p.* 254.

and an enhanced volume range, this system went further in interposing frequency and volume control between the pick-up microphones and the loudspeakers to permit the conductor to secure effects unobtainable from the orchestra alone. The music was picked up by three microphones spaced across the front of the stage, and the output from each microphone was carried through its own channel and control equipment to one of three loudspeakers spaced across the stage of the auditorium where the reproduction took place.

In the demonstration seven years ago, the music was reproduced at the same time at which it was being played but at a distance from the orchestra. On April ninth of this year a new stereophonic system was demonstrated in New York City, into which another set of steps has been introduced. The music is recorded on film, and is then available for reproduction from the film at any time. Four sound tracks are placed on a single film; one is used for each of the three program channels, and the fourth serves for a control signal. A section of the film is shown in Figure 2.

This recording on film might seem a simple thing to do. With music and sound so universally recorded on film for sound pictures, there would seem little difficulty to those not technically familiar with sound-picture systems in recording and reproducing a three-channel stereophonic program. The facts are, however, that ordinary

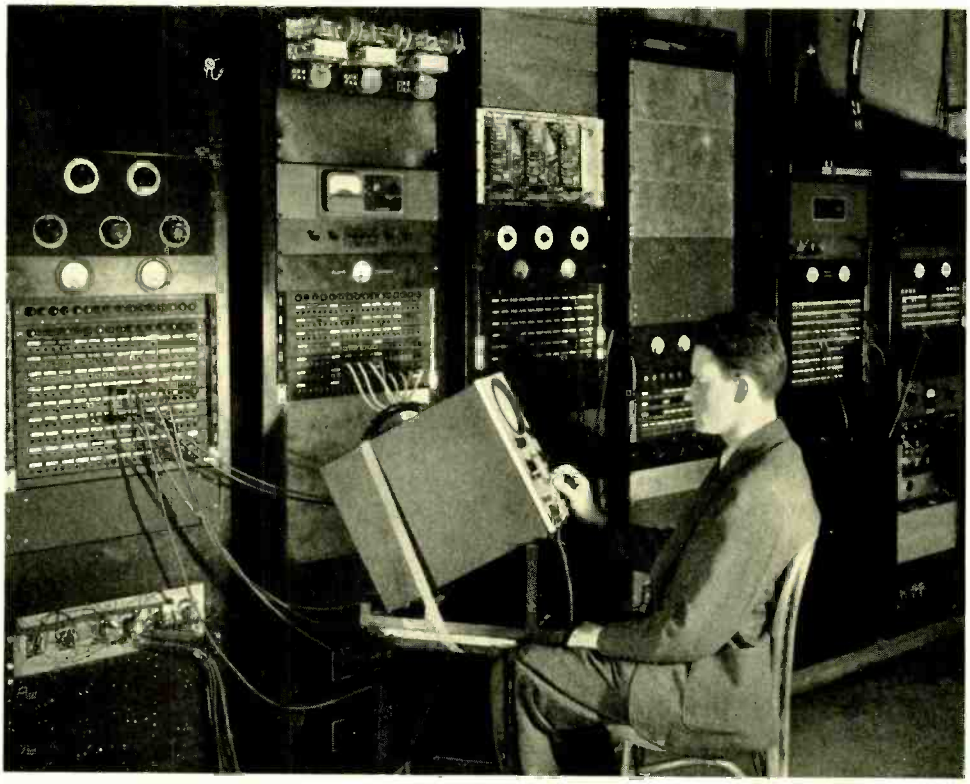


Fig. 1—Recording amplifiers, low-level reproducing amplifiers, and equipment for compressing and expanding the volume range

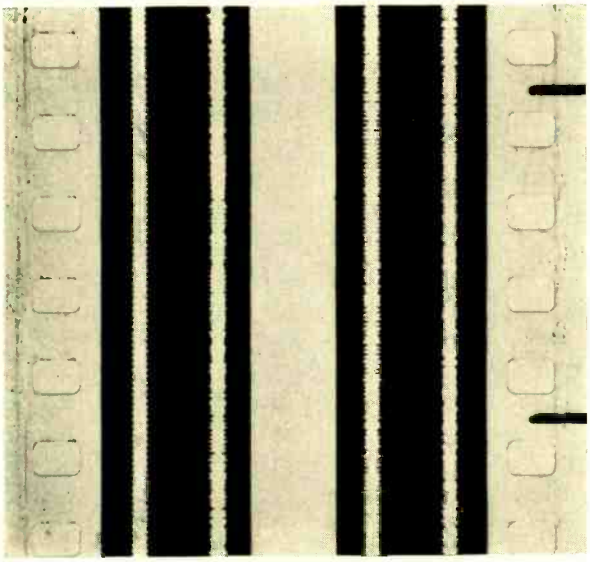


Fig. 2—Enlarged photograph of the positive film used in the final reproduction

In addition much greater precautions had to be taken to reduce noise and distortion. An extremely quiet system is required so that music at very low volumes, much lower than used in sound-picture systems, is not marred by the noise, and this is made more difficult because of the wider frequency range, which gives a wider band for the entrance of noise. In addition there is the matter of increased volume range. The maximum volume range that can be placed on a film is less than 50 db, while the stereophonic system, with the 10-db increase and decrease provided by the enhancement control, requires a range of 100 db. At the very outset, therefore, the recording of music for stereophonic reproduction seems faced with an insuperable obstacle.

recording and reproduction places no such demands on the equipment as does the stereophonic system. Sound-picture systems transmit a frequency range of less than 8000 cycles, while the stereophonic system employs a band nearly twice as wide. The entire recording and reproducing system had to be designed for this greater range.

The seemingly impossible task of recording a program having a volume range of 100 db on a film that will receive only a 50-db range was accomplished by use of compression and ex-

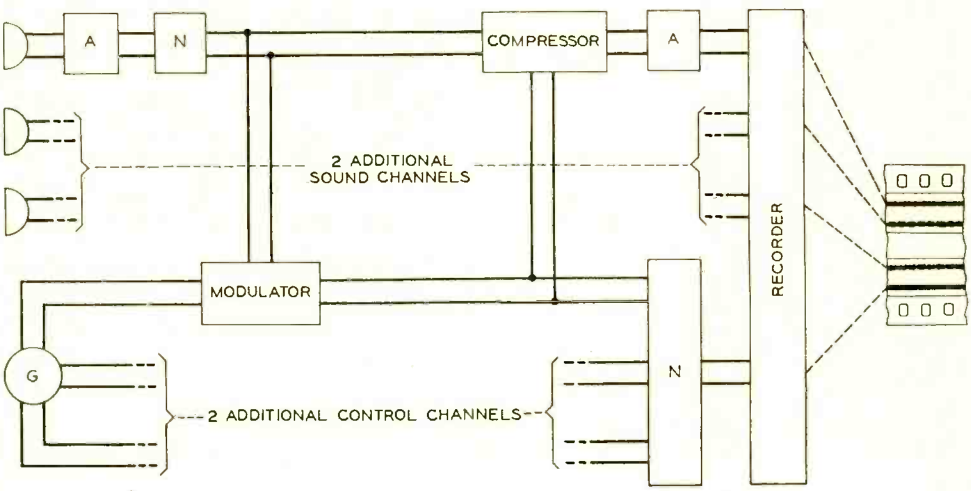


Fig. 3—Block schematic of

pansion devices performing functions similar to those used on certain transoceanic radio channels. The music as it is picked up by the microphones is passed through a compressor, one being provided for each channel. These allow the music currents to pass to the recording equipment in their normal volume range if below about 45 db; higher volumes are reduced by the compressor so that the limit of the film recording is not overstepped. At the same time a record is made on another track on the film of just the time and extent of these reductions. At the reproducing end the music currents generated in photoelectric cells from a light beam passing through the film are carried through an expandor before reaching the loudspeaker. The action of the expandor is controlled by a signal obtained from the additional light track. At any point where the original program was reduced in volume by the compressor, this signal will cause the expandor to increase the volume by just the right amount. In this way the full 100-db range in volume is reproduced by the loudspeakers without exceeding the 50-db range that is available on the film.

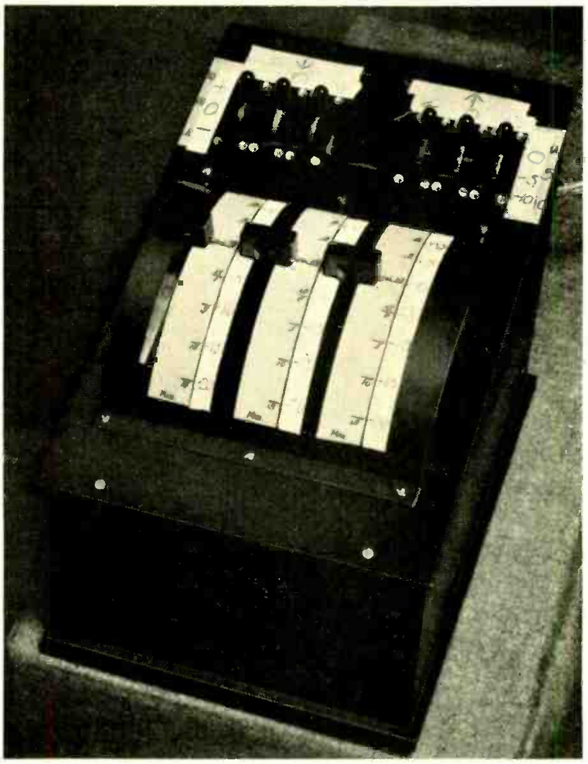
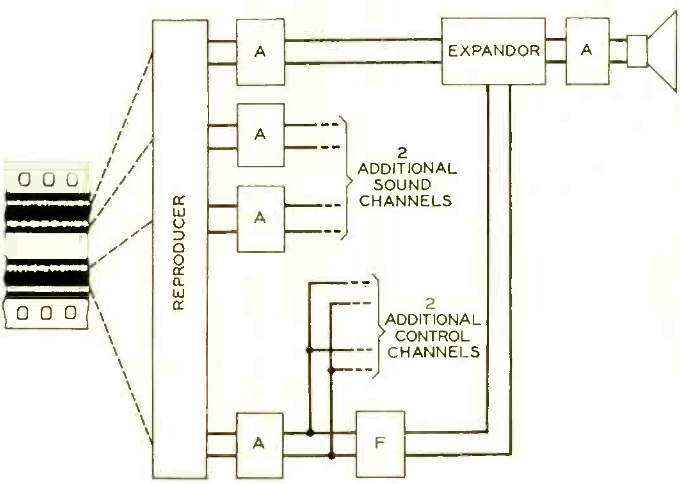


Fig. 4—The enhancement control unit of the stereophonic system provides both volume and frequency control at the discretion of the conductor



the stereophonic system

The main elements of the system are indicated on the block diagram shown as Figure 3. To control the compressor at the recording end, a small amount of the program current is taken from the circuit just ahead of the compressor and is rectified. This rectified current modulates a single-frequency current, which then controls the compressor and also forms the signal placed on the fourth track on the film. Since there are three channels, and the amount and time of compression will vary from one to another, three control signals must be recorded on the film, one for each of the three channels. These are all recorded on the same track on the film by allowing the three rectified currents to vary independently the strength of three alternating currents of different frequencies. These modulated currents control their respective compressors and are then combined and recorded as the fourth track.

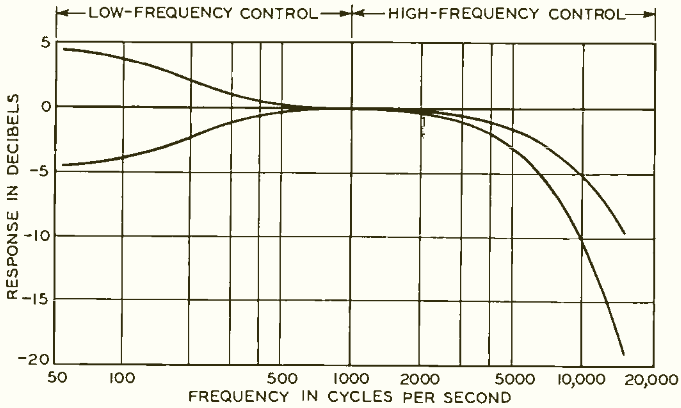


Fig. 5—Frequency characteristics of the stereophonic system obtainable by manipulating the six keys that are located on the top of the enhancement control unit

After the film has been made, if the music is then to be enhanced, it is reproduced while the original conductor listens and manipulates the enhancement controls to modify the frequency and volume ranges of the three channels and thus to secure an effect that more nearly suits his interpretation. The enhancement control unit is shown in Figure 4. At the top are six keys used to control the frequency composition—there is one for each channel for adjusting the high frequencies, and one for each channel for the low frequencies. Each key has three positions and gives the control indicated by Figure 5. The three handles on the front of the control unit are for adjusting the volumes of the three channels. As the handles are moved up from the normal position, the volume is increased, and as they are moved down, the volume is decreased. As the conductor listens to the reproduction of the original recording, he manipulates these controls, and another film record is made of the enhanced program.

A block schematic for this phase of the operation is shown in Figure 6, which shows only one channel, however. The changes in frequency characteristics brought about by the enhancement control are secured by the insertion or removal of electrical filters, marked N1 in Figure 6, in the circuit for each channel. The volume control modifies the current of the auxiliary channel, which is used to control the action of the expandors. Both networks, N1 and N2, are inserted in the circuit ahead of the point where the monitoring circuit is taken off, and thus modify the program as heard by the conductor as well as the currents used for making the new film. On the new film, the three program sound tracks are the same as on the original film except for the frequency modifications brought about by the filters. The control track, however, has been modified by the manipulation of the enhancement control so as to cause greater or less expansion when the program is subsequently reproduced. The new film made as a result of this process thus represents the enhanced program, and is the one used.

Besides the compressors, expandors, and filters required for this new system there has been a considerable amount of incidental development of the associated parts. There had to be provided, for example, a carefully designed source for the three signal frequencies used to control the expandors, and narrow band-pass filters to separate the three frequencies at the reproducer so that each would control its own expandor. Other developments were required to secure accurate timing. The signals must cause the expandors to act at exactly the same point on the film that the compressors had acted during the original recording. In addition practically every piece of equipment had to be studied and partly re-designed to reduce noise and distortion that in other circumstances would be unobjectionable.

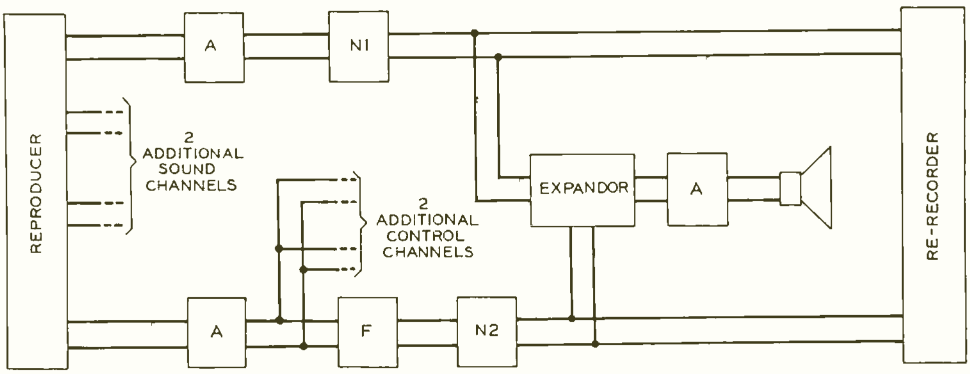


Fig. 6—Block schematic of circuit used for enhancing and re-recording

Intertoll Dialing With Step-by-Step Selectors

By R. R. SWAIN
Toll Facilities

WITH the introduction of dial service some years ago, dials were required at certain positions of both local and toll switchboards. They were needed at the "A" switchboard positions* in dial offices so that when assistance was needed in completing a call, the operator would be able to dial the required number. They were also needed at certain positions of the toll board to give the operators access to the lines of the local subscribers. Where large volumes of traffic were involved, keysets were provided at the operators' positions instead of dials. These were used at "B" switchboards† in panel offices, and at other switchboards‡ where considerable traffic was handled. Dialing at "A" switchboards and toll switchboards in step-by-step areas was subsequently extended to the handling of short-haul toll calls with the development of the step-by-step tandem systems. The development here reported is a further step in the provision of equipment for handling toll calls on a dial basis. The switching equipment uses selectors of the step-by-step type similar to, but differing from, those used in the tandem system.

The longer haul toll traffic has been handled over ringdown trunks. With such trunks, signals are limited. An operator can only call an operator at a distant office or recall her on an established connection. At the incoming end of such a trunk an operator is required to establish the connection to the subscriber's line, and to pass reports back to the originating office should the line or the paths to it be busy. As the proportion of subscribers with dial service increased, it appeared that for these long-distance calls also there would be an advantage in eliminating the inward operator, and in providing means to enable the outward operator to dial over the toll line, or intertoll trunks as they are now called, to secure a connection to any subscriber's line, and to receive visual signals indicating when the called party answered, or when busy conditions were encountered.

The short-haul tandem system, which had been designed to handle large-volume traffic as economically as possible, lacked a number of features required for a system to be used as part of our national toll network. Its trunks were not arranged for two-way operation, for example, nor did they provide means for resignaling an operator at the distant end, who had been called in to assist on a more complicated type of call, such as a delayed person-to-person call on which the called party has reported ready. In addition, intertoll trunks must meet more stringent requirements for repeater balance and for impedance matching between toll and switching trunk, and must provide automatic control of switching pads used to adjust the loss on various types of calls.

*Record, *Aug.*, 1931, *p.* 576.
†Record, *Aug.*, 1931, *p.* 162.
‡Record, *Nov.*, 1930, *p.* 131.

Modification of the tandem system to provide these additional features was considered, but it was found the requirements could be more economically met by the development of a new system for the longer-haul traffic. It has been found practicable to design this new system so that calls may be completed either from it over existing tandem circuits or from tandem circuits over it, and so that completing trunks to the local offices may be used jointly by both systems.

The provision of an intertoll dialing system requires means for associating a dial with any intertoll trunk, and for permitting supervisory signals sent back from the terminating office to be received at the outward positions. Suitable arrangements must also be made for passing the dial pulses and supervisory signals between the originating and terminating offices. In addition, dial switching trains must be provided to permit connection from an intertoll trunk to dial subscribers' lines, to operators' positions, or to other intertoll or tributary trunks. No. 3 toll switchboards* are designed for dialing and receiving supervisory signals on both ends of the cords, so that they can more readily be arranged for intertoll dialing than the No. 1 toll boards, which require modifications of the outward positions.

*Record, *November*, 1930, *p.* 131.

The signaling methods so far provided are applicable only to cable or open-wire intertoll trunks suitable for composite signaling, but this includes the great majority of the trunks 150 miles in length or less and many up to 300 miles in length. The type of signaling involved and the switching arrangements employed, will be described in subsequent articles. For very long trunks, and trunks derived from carrier or coaxial facilities, a voice-frequency signaling circuit is under development.

The essential elements of an intertoll dialing system are indicated schematically in the diagram. From information posted at her position, the outward operator can determine whether the trunk group required for a call is equipped for intertoll dialing, whether the exchange area being called requires digits prefixed to the station number to indicate the local office, and if so, how many letters of the office name are used as part of the dialing code. If the number of the called party has been furnished, the operator merely plugs into an idle trunk to the desired point and dials. On station-to-station calls she need not remain "cut-in" on the connection to time the start of the conversation, since the answer by the called

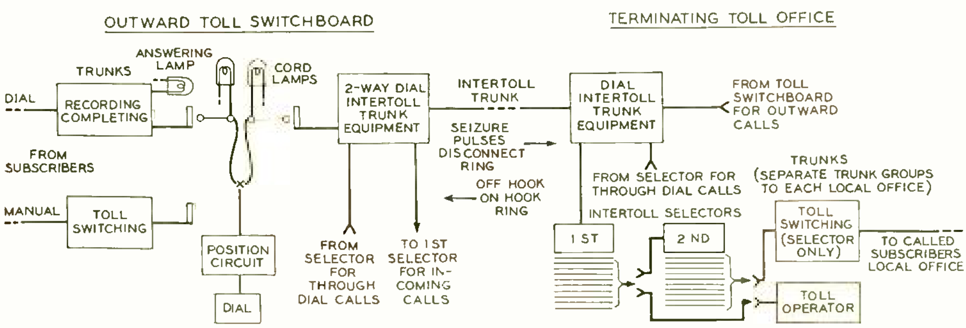


Fig. 1—Essential elements of an intertoll dialing system

station will be indicated to her by the extinguishing of a lamp associated with the cord she is using for the call. A busy line or path will be indicated by a flashing of the cord lamp. When the called number is not given, the operator must obtain it either from a directory, or by dialing an information operator at the terminating office.

If the call requires switching at the distant toll office, either to a tributary of that office or to another toll center, information at the originating operator's position gives her the code she must dial to reach the second link and indicates whether the second link is equipped for dialing or for ringdown operation. Since with a link-type community office at the terminating end, or a larger office employing incoming senders, the switching equipment may not be ready to receive the call immediately, a lamp is associated with the dial at the outward position to indicate when the distant office is ready to receive the dial pulses. This lamp is lighted only while the terminating equipment is ready to receive pulses, and should it go out, the operator will stop until the lamp relights.

To help the operator in completing connections involving two intertoll trunks in tandem, distinctive flashing signals are provided. They are controlled from the selectors at the intermediate point, and they are used to indicate a busy condition after the code has been dialed. If the operator holds the first trunk, as is done with ringdown operation, the signal will change when a trunk in the second group becomes idle, and she may then attempt to complete her connection.

Intertoll dialing is more efficient than ringdown operation. The service also is faster because a connection can be established as quickly by the outward operator as it would be over a ringdown circuit after the order has been passed to the inward operator. There are also fewer errors because equipment failures are less frequent than human errors, and in addition there is some reduction in total intertoll trunk time per call. Since the spring of 1938, intertoll dialing has been introduced on a number of groups in the territory of the Ohio Bell Telephone Company, and has proved very satisfactory.

It would be highly desirable to be able to complete calls by dialing into large multi-office cities, most of which use panel switching equipment for local service, but studies indicate that for this field crossbar switches would be more economical. The facilities described above use step-by-step switches, and were developed for installation in all new or existing dial cities except the very large ones. An arrangement that will employ crossbar switching equipment is now under development for the larger cities.

Printing Techniques in Analytical Chemistry

By H. W. HERMANCE
Chemical Research

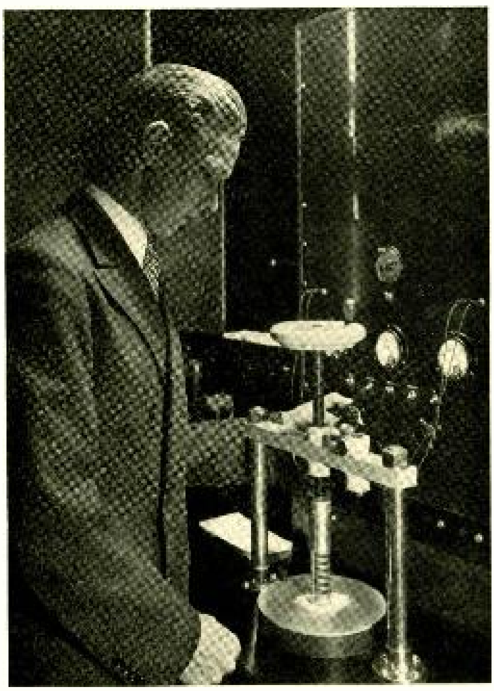
ONE of the simplest and most familiar ways of identifying an unknown substance is by the formation of a colored product at the end of a prescribed chemical routine. The substance is dissolved in a suitable medium, the necessary intermediate treatments are carried through, and finally the color of the liquid in the test tube is characteristically transformed by the addition of a specific reagent.

Color reactions have great versatility, but the relatively crude technique by which they are employed often curtails their advantages, especially where speed and delicacy are essential. Thus, in order to obtain sufficient material for test, the specimen often has to be destroyed or damaged beyond further usefulness. Much time may be consumed in the solution of the specimen, removal of excess dissolving agent, and the intermediate transformations necessary before the final test is applied. Where many tests are to be made daily, the analyst's performance is limited.

For example, an engineer may wish to know if a small proportion of chromium is contained in a steel specimen. Following one of the time-honored schemes of qualitative analysis, the analyst files off a portion, say a tenth of a gram, dissolves it in nitric acid, and evaporates away most of the excess. Then he makes the solution strongly alkaline with caustic soda, adds sodium peroxide, and boils. After this the precipitated iron hydroxide is filtered off and the filtrate is acidified and tested for the chromate ion by any of a number of standard tests. All this may take from a half to three-quarters of an hour, and it requires a rather fully equipped laboratory. Further, the finer details of structure rarely can be differentiated chemically; if such an analysis is attempted, the only approach is a repetition of tedious local treatments with the dissolving agent in minute quantities. Success then is largely a matter of the manipulative skill of the operator.

A partial answer to the desire for simplification with increased sensitivity and delicacy is found in the method of contact printing, long known but little used until recently. In principle this technique differs from others essentially in that the initial solution, intermediate reactions, and final formation of the colored end product are all carried on within the tiny cells formed by the pores of paper or other inert medium which is pressed into close contact with the specimen surface. These little cells limit lateral diffusion, so that each contains only the end product derived from the corresponding small area of the specimen. A print of the surface is produced in which any variations in composition are mapped on the paper by corresponding differences of color or of color intensity. Since the products are concentrated in a thin layer and observed against a favorable background, very little of the sample need be used. In many cases the damage is so slight that the specimen is still usable.

Printing methods usually involve two processes: first, material is transferred in its original configuration from the specimen surface to the paper. There it is converted to a colored product, recognition of which follows from the conditions of the test. Sometimes this process occurs simultaneously with the transfer, but more often it is necessary to remove certain substances which would interfere, as well as to convert the remaining material to a form suitable for the final color reaction. To this end, the paper containing the undeveloped print is immersed in various liquid reagents and washing media, but the process must be so devised that throughout these treatments, the material under test remains "fixed" on the paper fibers in the form of a mildly insoluble compound. Otherwise it would diffuse or wash out and the distributive pattern would be lost. The details of the method vary greatly with the kind of information desired and the nature of the surface to be examined.



C. W. Mattson adjusts the voltage used to make the electrographic print

The surface material may exist as a superficial deposit, distributed either at random or according to some significant pattern on a substratum of entirely different composition. Dust, salt spray, finger-prints, residues of spilled liquids, blood stains, sublimates, or exudations of various sorts or metal transferred by friction, might occur on almost any kind of surface and would represent this class of deposit. Continuous coatings, purposefully applied, such as metal platings, lacquers and other finishes, would form another class. Then there are films formed on a surface by chemical interaction between that surface and atmospheric agents which contain the original surface components in combination with new elements: tarnish and corrosion belong to this class. Lastly, if the condition of the interior of a specimen is to be studied, suitable abrasive treatment may be employed to expose a surface which will yield information concerning its composition and homogeneity.

Transfer of the material to the paper is accomplished by methods based on physical, chemical or electrochemical solution. When the material is water-soluble, intimate contact with the moistened reagent paper suffices for the test. Thus the sodium chloride normally on the finger ridges is easily made to reproduce those ridges as a print on silver chromate paper. Physical solvents other than water may be used similarly, although the examples are fewer.

In most cases, however, the surface must be brought into solution through chemical transformation. The choice of dissolving agent then calls for more critical consideration than in ordinary analysis. The excess cannot be removed easily. Solution should be rapid and yet uniform to insure against loss of print detail through lateral diffusion. It must be so controlled that only a very thin layer of the surface is attacked. Often the action is required to be selective so that only certain substances are brought into solution, leaving the base material intact. Finally, the agent has to be selected to avoid a condition inimical to the full development of the color-producing reaction.

Such requirements are often met by using certain salt solutions of slight acidity or alkalinity or by employing other salts having properties which make them highly selective in their dissolving action on certain substances. Thus, sulfide tarnish films on silver and copper are not readily attacked, even by relatively strong acids—the use of which would be prohibitive anyway because of the impairment of the lead-sulfide printing reaction. Potassium cyanide, however, dissolves these substances readily, liberating the sulfide ion for reaction with the lead carbonate reagent where excess cyanide does not interfere in the slightest degree.

Most metallic surfaces, on the other hand, lend themselves to a simpler and more effective method of solution which has the outstanding advantages of rapidity and perfect control. Electrolytic solution is the basis of the process, first used by Glazunov in 1929 to obtain prints of steel specimens.

Paper containing a suitable electrolyte is sandwiched between the surfaces of the specimen and an inert metal such as platinum. The specimen is connected through a rheostat to the positive pole of a 2-6 volt battery; the inert plate, to the negative pole. When connection is made, metal ions pass from the specimen into the paper at a rate controlled by the current and

H. V. Wadlow washes out the excess reagent after the print has been developed

in quantity proportional to the time. Solution is uniform and rapid and the electrical field maintained helps to prevent lateral diffusion, giving very sharp prints. The paper may contain the color-producing reagent, but if this is impracticable because of interfering effects, the ions entering the paper may be fixed there by a suitable precipitant in the form of basic or other insoluble salts, and the colored print obtained later by development with suitable reagents.

Illustrative of the step-by-step

printing technique is the detection of lead in brass. Leaded brass is a common commercial grade which occasionally needs to be differentiated from the non-leaded variety. To do this quickly, a print of the surface is made electrolytically with paper dipped in sodium carbonate-sodium nitrate solution. Copper, zinc, lead, and traces of iron and manganese are fixed as insoluble basic carbonates where the metal touches the paper. The excess electrolyte is washed out with water and there is left the undeveloped print containing these salts. The paper is then dipped into a potassium cyanide-potassium carbonate solution and again washed. This removes the copper and zinc salts. It is dried and dipped into a solution of potassium dichromate in acetic acid, then washed thoroughly. This final treatment converts the basic lead carbonate to yellow, insoluble lead chromate, while the iron and manganese are dissolved and washed out. The yellow color is characteristic enough for most purposes, but its nature may be confirmed by treatment with sodium sulfide which converts it to brown-black lead sulfide. Tin does not interfere in these reactions.

Detection of chromium by electrolytic printing is simple and rapid, in contrast to the cumbersome process described in an earlier paragraph. The specimen surface is brought into contact with paper soaked in sodium nitrate-phosphate solution and a positive potential of 4 volts is impressed for a few seconds. Chromium is indicated by a deep yellow color and is confirmed by adding to the print a drop of diphenyl carbazide solution in acetic acid, when a magenta color shows the presence of the chromate ion. Thus, in a single operation solution of the specimen, oxidation of the chromium to chromate, and its separation and detection are accomplished in one or two minutes.

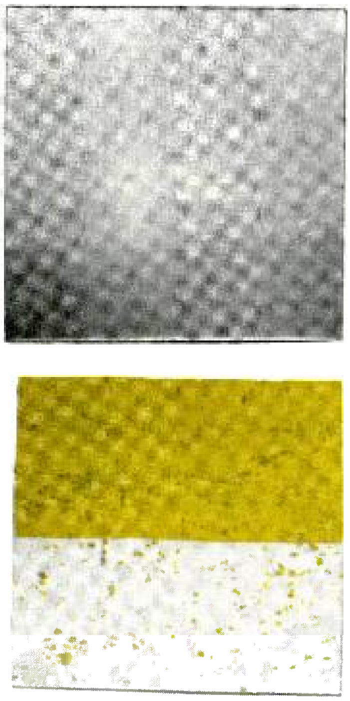
The "electrographic" method, as it has been called by Glazunov, has come into much use in our Microchemical Laboratory in the past three years. It has provided the answer to numerous requests for rapid qualitative tests and has become a valuable diagnostic and research tool.

The Elliott Cresson Medal

of The Franklin Institute of Philadelphia has been awarded to R. R. Williams "in consideration of his researches upon vitamin B_1*, including its isolation in the pure state in quantity sufficient for further chemical study, the identification of its segments, and its synthesis in quantity." The award will be made at the Medal Day exercises of the Institute on May* 15.

ELECTROGRAPHIC PRINTING

Examples of analysis by means of electrographic prints suggest the usefulness and versatility of the method described on pages 271 and 272 of this issue of the RECORD. Prints are made either in the micro-analytical laboratory or, by means of portable equipment, in the field. Portable printing equipment used for an extensive study of contacts in a telephone central office is shown in the photograph that is reproduced on this page.



Tinned Brass Sheet

Print made on antimony sulfide paper. The brown spots and lines show porous areas and scratches in the tin plate where the brass has been exposed. The tin surface has been rendered passive by the use of a sodium phosphate electrolyte, while the brass, which is not affected, reacts to form copper sulfide. One-half of the print has been treated to remove the yellow antimony sulfide, showing the brown spots against a white background.

Tests of this type may be used as a control of sheet plating processes and would detect poor specimens where a chemical analysis of the plate in milligrams per square inch might have shown that specification requirements had been met.

Nickel-Palladium Duplex Metal Rod

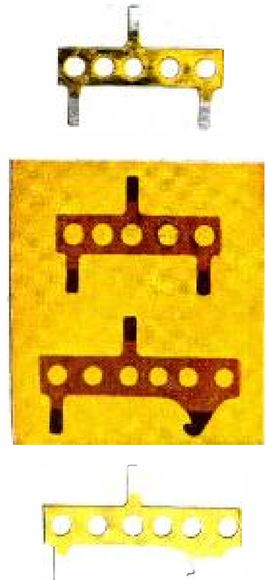
Electrographic print made on dimethylglyoxime paper. The red color of the print is produced by the reaction of nickel with the dimethylglyoxime reagent. The yellow color is that produced by the reaction with palladium. The differentiation of the two metals was not possible by visual examination but was readily detected by this rapid electrographic print.

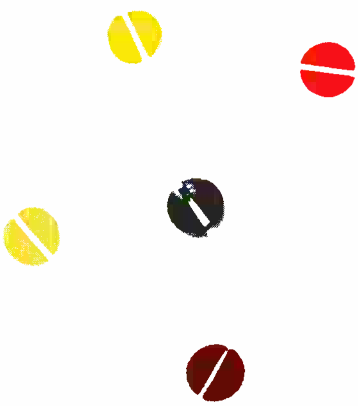
Lead-Dipped Lugs

Electrographic print on zinc sulfide paper. The brown-black print of lead sulfide, remaining after treatment has removed interfering sulfides, indicates the nature of the coating. Since the lugs are sometimes solder-dipped, an electrographic test for tin using ammonium molybdate reagent paper is also made. In this test the molybdate reagent is reduced by the tin salts to "molybdenum blue." A negative test in this case indicated lead dipping.

Section of Silver-Plated Panel-Bank Terminal Strip

On this print, made on yellow antimony sulfide paper, black silver sulfide shows the parts of the terminal that have been plated with silver. The white brass surface appears as chocolate-brown copper-antimony sulfide. The upper specimen shows the effect of poor masking of the strip during plating; there are areas of silver on the inner surface. The lower specimen shows proper masking, with only the terminal receiving the silver plating.



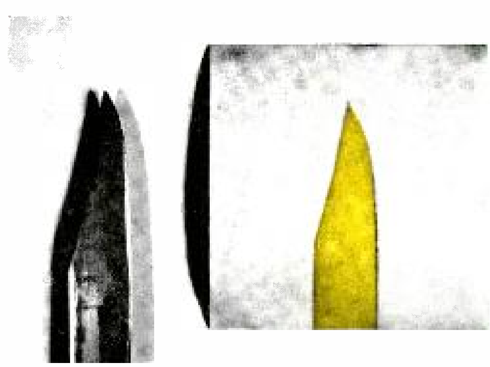


Screw Heads Plated with Various Metals

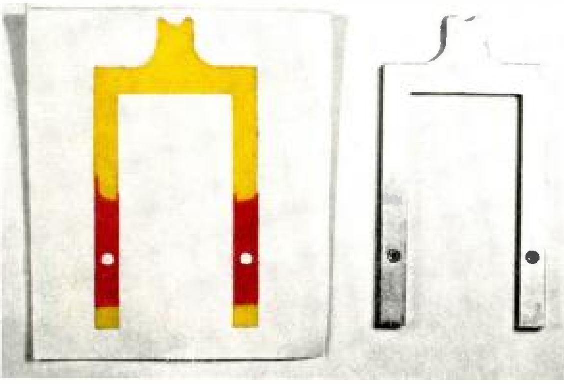
These electrographic prints illustrate rapid identification of various metals. Chromium is identified by conversion of the yellow sodium chromate to brown-red silver chromate; zinc, by conversion of the white zinc sulfide to orange-yellow antimony sulfide; cadmium, by conversion to yellow cadmium sulfide; nickel, by direct formation of the bright red nickel dimethylglyoxime compound.

Segment of a Knife Blade

Dark brown smears on the print of the blade (made on zinc ferrocyanide paper) indicate that the knife has been used to cut copper or brass. The character and distribution of the smears distinguish the copper as external rather than alloyed with the steel blade. Tests of this sort may be used to detect vandalism or possible sabotage.



U-Type Relay Armature



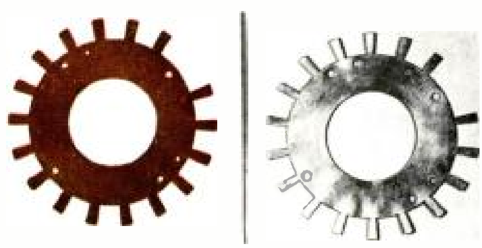
The armature is first plated with nickel and then with chromium. The print was prepared electrographically with the specimen surface in contact with dimethylglyoxime-barium hydroxide paper. When made anodic, the chromium dissolves directly to form yellow barium chromate while the nickel reacts with the dimethylglyoxime to give a red compound. Thus the distribution of the two metals is mapped and the exposure of nickel through the chromium plate is clearly revealed.

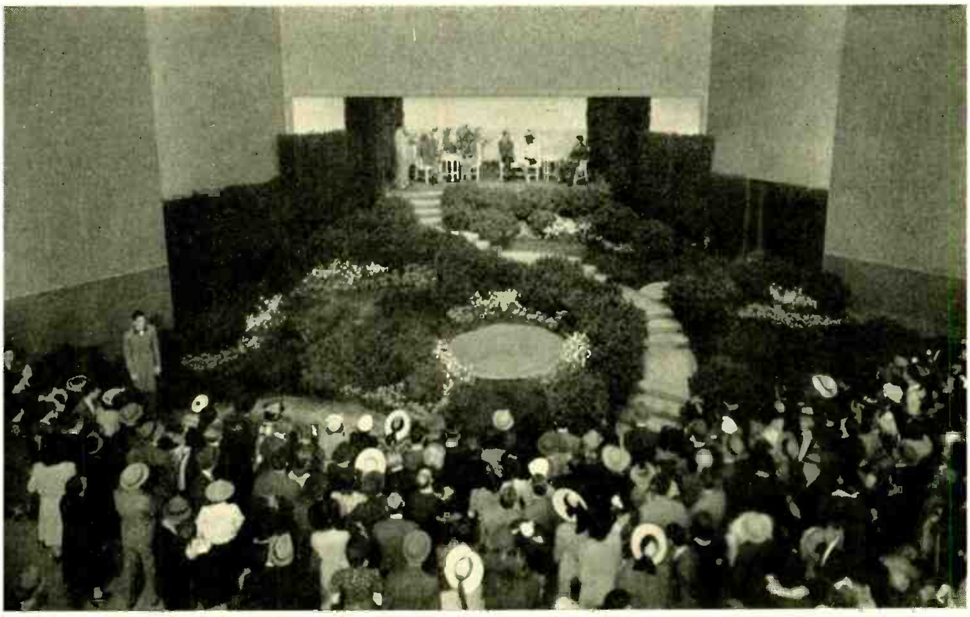
Zinc Plated Part

Zinc forms no colored compounds suitable for its direct recognition. A two-step process therefore is used. The surface is dissolved anodically and the resulting print is treated with sodium sulfide. This stage is shown in the upper print. If a white area occurs on the print, the excess sulfide is destroyed by washing with dilute acetic acid and the partially dried print is treated with cadmium-chloride solution. If zinc was originally present in the white area, this will now be yellow due to replacement of zinc sulfide by the more insoluble cadmium sulfide. Specificity lies in the fact that zinc sulfide is the only white sulfide which would behave in this way. The cadmium sulfide color reveals its presence in the lower print.

Silver-Plated Brass Cam

Electrographic print on antimony sulfide paper. The silver-plated cam has been subjected to a wear test to determine the stability of the plate. The continuity of the black silver sulfide on the segments indicates that the silver plate has not worn through.





Audition Demonstration

By R. A. CUSHMAN
Commercial Products Development

IN THE fundamental plan for the Bell System Exhibit at the New York World's Fair, participation by the audience was considered essential. To apply this to a demonstration of auditory perspective and magnetic tape recording—two important contributions of the Laboratories—it was decided to hold successive interviews with members of the audience and reproduce them from tape recordings. That the platform might not be empty during the reproductions, the interlocutor and his group were replaced by lay figures. Electrical and mechanical arrangements for this involved considerable ingenuity, both in the planning stage and as construction proceeded.

Technical requirements for the audition exhibit were dictated by considerations of good showmanship and presented a number of design problems. For example, no microphones, loudspeakers, control or other equipment should be visible from the audience area; no screen or glass should separate the talkers on the platform from the audience; the conversation, normally carried on at rather small volume, must be projected with sufficient level to be easily understood at any point in the audience area in spite of normal audience noise. A two-channel stereophonic system was selected with a view toward maximum naturalness rather than empasizing localization of the sound source. A standard theater system of two-element loudspeakers was installed above the upper corners of the proscenium opening on each

Fig. 1—Attendants put lay figures in the seats of the second platform

side, and hidden by motion-picture screening. The tiny openings in the screen were invisible from a distance but presented little obstruction to the sound from the loudspeakers. The microphones were located just back of the loudspeakers near the ceiling of the platform area, out of sight of the audience. Each microphone was placed in a large box-like baffle made of layers of muslin stretched on a framework. The baffles were highly directional, which serves two purposes, first, to provide satisfactory sound pick-up at a distance of twelve to eighteen feet, and second, to make them relatively insensitive to sounds entering the platform space from the audience area. In spite of the excellent acoustic design* of the auditorium, both as to shape and to the acoustic treatment, some small part of the sound projected by the loudspeakers found its way through the opening of the proscenium arch into the platform space. This space also required careful design to prevent the reflection of stray sound toward the sensitive region of the microphones while presenting the maximum direct sound from the talkers. It is readily seen that this system is novel in several respects as a pure public address system in addition to its reproduction of speech.

Each performance began with the selection of a group of five people who were ushered into an anteroom where, with an interlocutor, they decided on the subject of conversation. As soon as the platform was vacated, it was moved into the wings, and the group took their places on the chairs. When the previous demonstration had been completed, the platform was rolled back into view of the audience, and the interview began. Visible to the interlocutor but to no one else

*Acoustic design of the entire building was done by engineers of Electrical Research Products, Inc.

was a large voltmeter connected to a potentiometer driven by the recorder; thus the pointer indicated elapsed time. When about two minutes had passed, the interview was concluded, and the party walked down a path to take seats on a bench. Meanwhile attendants (Figure 1) had set up lay figures on a second platform which came into view as the first one was withdrawn. The interview was then played back to the audience and to the particular group which had made the recording.

Fig. 3—One of the magnetic-tape recorders

Two identical recording-reproducing channels were used to give auditory perspective; one of these is shown in Figure 2. From the microphone the sound signals were transmitted through amplifiers to a "baffle equalizer," which corrected the response characteristics of the microphone-and-baffle combination. Next to that was the dialogue equalizer, used because the speech level projected to the audience was considerably higher than that produced on the platform by the talkers. Its higher loss at the low end overcame the guttural sound of speech at high level. During the recording cycle the horn system was used to reënforce the speech so that after passing through the limiting amplifier the circuit divided two ways, one to the public address system and one to the recording machine. The limiting feature in the amplifier prevented overload of the tape under unusual circumstances, such as loud laughing, and was not called into play during the usual recording. The horn

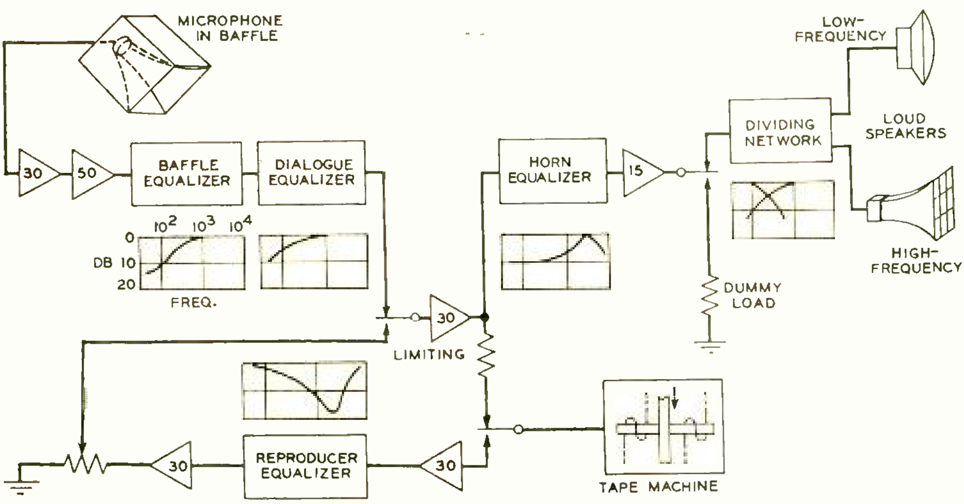


Fig. 2—Schematic diagram of one audition channel

equalizer, the characteristic of which is shown, was adjusted so that the combination loudspeakers projected a flat frequency characteristic to 7000 cycles. The amplifier, dividing network and loudspeakers were characteristic of a good theater installation. At any time that recording or reproducing was not actually taking place, the horns were disconnected from the circuit and a dummy load placed on the output of the amplifier.

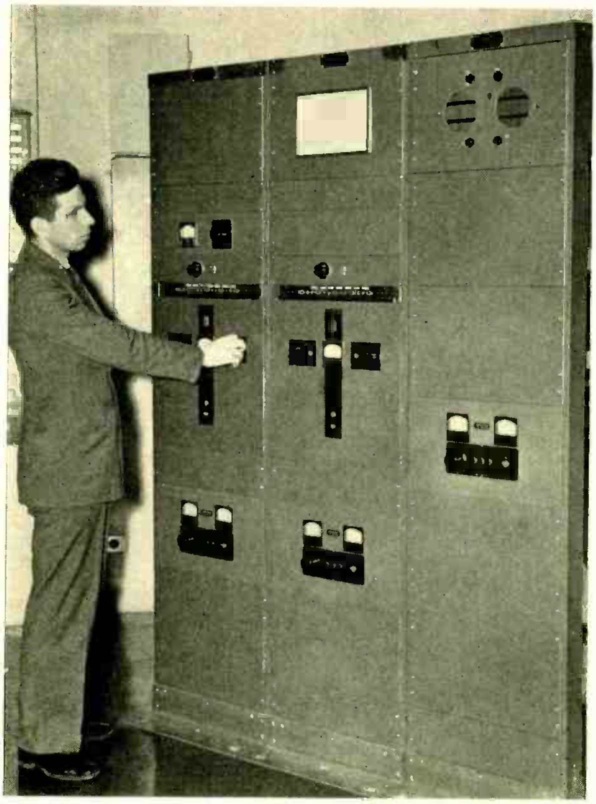


Fig. 4—The first two panels (from the left) mount amplifiers Channels 1 and 2 respectively; on the right-hand panel are monitoring loudspeakers and the announcer's emergency amplifier

During reproduction of the conversation the relays in the center of Figure 2 made contact downward with the result that the signals from the tape went through an amplifier to a reproducer equalizer, the function of which was to compensate for the normal frequency characteristic of tape recording. Signals were then transmitted to another amplifier, volume control, the limiting amplifier (which in this case operates like an ordinary amplifier), and to the loud-speaking system on the stage.

In the magnetic-tape recorder-reproducer, shown with cover open in Figure 3, a separate tape was associated with each channel. Synchronism between the channels was maintained by winding the two separate tapes simultaneously from the left-hand reel to the right-hand reel, one tape going through the near recording units and the other tape passing through the far recording units. This method is simple and no difficulty was experienced in maintaining synchronism of a higher order than is necessary for stereophonic reproduction.

When the interlocutor stopped the recording of the conversation on the platform by pushing a button, the tape drive was stopped by the release of a forward driving clutch. The tape was then rewound at high speed by the operation of the left clutch which connected the nearly empty left-hand reel to the rewind motor. This clutch was finally released by a cam-operated contact before the tape was completely unwound from the right-hand reel. The control relays ensured that the tape could then be driven only in the forward direction, and that the circuit of Figure 2 was switched for reproducing. A contact, closed when the section of the platform carrying the manikins was in position in full view of the audience, started the reproducing cycle. The reproduction continued until its elapsed time had been equal to the recording time. The tape then rewound automatically as before. It was necessary to interlock mechanically and electrically all these operations to take place in a definite order to relieve the interlocutors of control sequence and to protect the equipment from control errors.

Since this equipment was in operation for thirteen hours a day and seven days a week, three of the machines were installed, the nominal arrangement being that one was in use, one stand-by and the third available for maintenance and test. The amplifying equipment associated with these machines was mounted on the three relay racks shown in Figure 4.

During the twenty-nine weeks of the New York World's Fair, about 110,000 persons took part in the auditions, while many times that number enjoyed the demonstrations.

Stereophonic Recording

A new high in the science of recorded sound was reached at Carnegie Hall last night when the Bell Telephone Laboratories demonstrated their latest results in stereophonic recordings, with emphasis on the problems of "position" and "enhanced" music. . . .

When the lights went out all one saw was a gossamer veil hung across the stage, with a soft red glow playing on it. Then things began to happen. An eerie flute sounded thinly from the distance; a crowd bellowed thunderously; horses galloped by; thunder rumbled; a man talked as he walked from one end of the stage to the other. Then the whole width, breadth, and depth of a symphony orchestra spread out its wings and went into action.

It sounded real, spread out in space. The full depth of the stage seemed crowded with spatially distributed sound. But it all came from a set of sound boxes and horns, each functioning separately and in unison in a broad, electrically controlled dynamic scheme. Dogged research in electricity, acoustics, dynamics had chalked up one more miracle—spread-out sound, coming straight from the source with no hint of crowding.

Mr. Stokowski's orchestra sounded very much its multiple self, and with the "enhancing" of between-the-lines nuances, even more than its flesh-and-blood self.

Drums were at one end, flutes at another and in between one "heard" other instruments clear across the stage. Shading emerged beautifully, solo passages rang out brilliantly. There was no blurring, no congestion. Pianissimi were the merest hush, and fortissimi had the impact of a cannonade.

The trick of giving orchestral music "position" in recordings and weaving in nuances between nuances is now a perfected fact. . . .

Louis Biancolli in the N. Y. World-Telegraph, *April* 10, 1940.

Contacts for Crossbar Apparatus

By B. F. RUNYON
Dial Apparatus Development

IN THE dial systems used by the Bell System previous to crossbar, many of the contacts were of base metal and of the sliding type. Such contacts are employed on step-by-step switches, on panel banks, and on sequence switches. One of the distinctive features of the crossbar system is the use throughout of precious-metal contacts of the "percussion" type, the two elements of the contact being brought together head-on as with a relay. While this permits a slight desirable sideways motion of the contacts, the motion is quite different from that in devices in which the contacts slide over each other. In the panel system such "percussion" contacts are found chiefly on the relays, and number around 150,000 per office, while in the crossbar system they are employed on the crossbar switch and on the U, Y, and multi-contact relays, and number around a million and a half. With such large numbers of contacts involved, it is obviously desirable to use as little precious metal as possible.

Twenty-five years ago all precious-metal contacts were made of platinum, and were attached to the springs by riveting. They were of the point and disk form shown at A in Figure 1. Spot-welding replaced riveted contacts in 1913, and resulted in large savings in material as is indicated at B. Since then, further savings in material have been made by changing the shapes and sizes of the contacting elements.

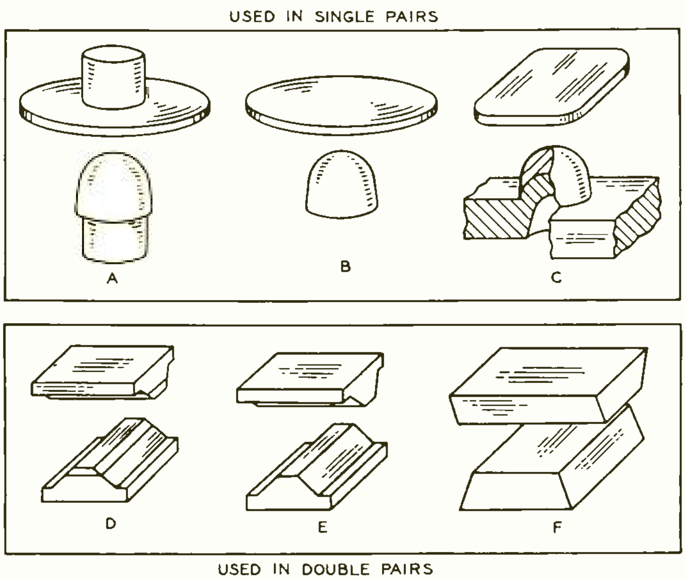


Fig. 1—Forms of precious-metal contacts that have been used in the Bell System

In the design of contacts, there are several factors that must be taken into consideration. In the first place enough metal must be provided to give a satisfactory life. Each time a contact makes and breaks an electrical circuit, a small part of the metal is lost, so that life is at least roughly proportional to the volume of metal available for erosion. In the second place a pair of contacts must have sufficient height to provide enough spring clearance to allow for adjustment and to insure that the springs will not touch. As a final consideration, at least one contact of a pair must be large enough to insure contact regardless of normal manufacturing variations of the position of the contacts on the springs and of the alignment of the springs themselves.

It was from a consideration of this last requirement that the "bar" type of contact, used on crossbar apparatus, was developed. Some years ago a joint study was made with the Western Electric Company to determine the variations in positioning and alignment that actually occur in practice. The contacts of several thousand relays were examined, and the exact spot at which the point and disk touch was determined. The distribution of these points of contact on the disk is shown in Figure 2. This disk is .09 inch in diameter, but it will be noticed that over large areas no contact registration was made. As a matter of fact practically all the contacts fell within the area of a rectangle .05 by .07 inch indicated by dotted lines, which occupies less than sixty per cent of the area of the disk.

To make the nature of this distribution more evident, a block model was made. Square prisms, each with the cross-sectional area of one square of Figure 2 and with a height proportional to the number of contacts made over that area, were erected on a circular base representing the .09 disk of the fixed contact. A photograph of this block model is shown in Figure 3.

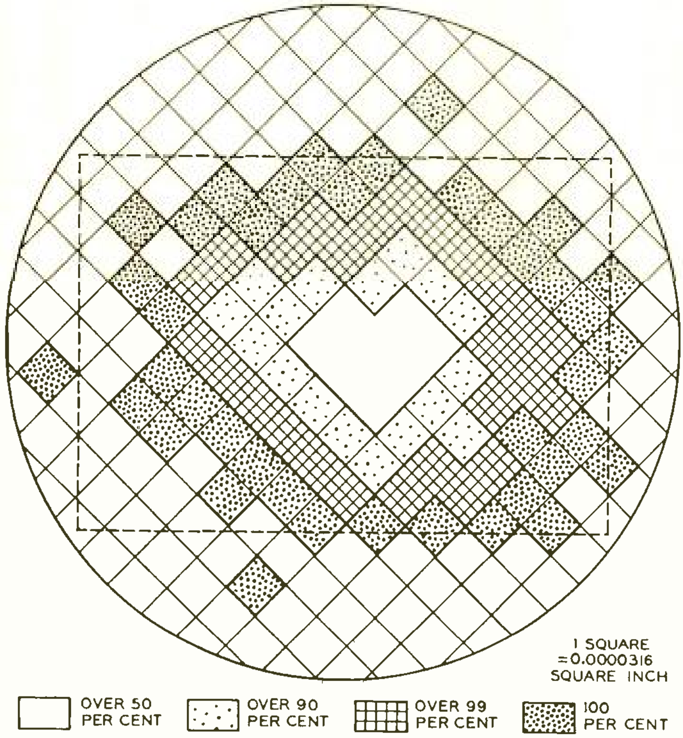


Fig. 2—Distribution of contact on a .09-inch disk

Since these studies had shown that the area of contact was approximately rectangular, the disk contact was changed to the shape shown at c of Figure 1, and made of the same thickness as the disk, which had proved adequate to give the desired life. Electrical wear may occur at either the point or the disk, depending on the circuit or the polarity. Since contacts are not generally poled so as to wear chiefly in one direction, there is no advantage in making one contact member any thicker than the

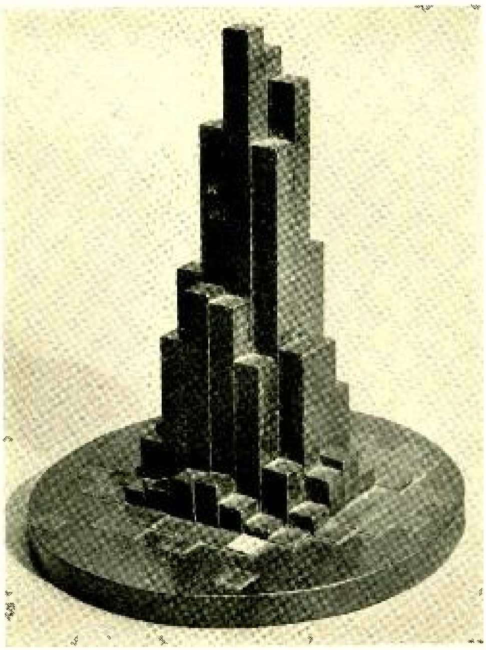


Fig. 3—Block model of contact distribution

other. A further economy in precious metal was thus secured by embossing the spring for the point contact, and placing sufficient contact metal over this embossing to equal approximately the thickness of the disk. This resulted in a contact of the general form shown at C in Figure 1.

A little study, however, will show that still further economy in contact material is possible. If one of the contacting elements is made in the form of a rectangle with sides of lengths A and B, as shown at the top of Figure 4, where A and B correspond to the dimensions determined from Figure 2, then the other contact element may be taken as a square of sufficient size to give the required contact volume. This may be taken as requiring a length C for the square. It is necessary, however, that full contact be made even under the extreme variations in position, that is when the center of the smaller contact falls on the boundary of the AB rectangle. The size of the large contact must thus be increased by C, as shown at (b) in Figure 4. Suppose now that the large contact be changed to a narrow bar C wide and A + C long, and that the small contact be changed

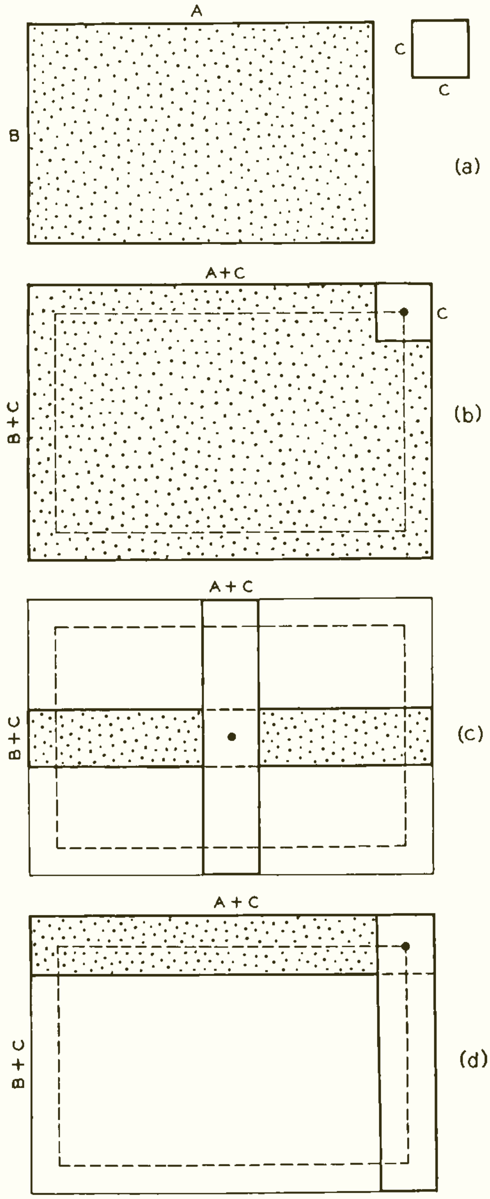


Fig. 4—Consideration leading to the use of bar type contacts

of a bar C wide and B+C long, with their normal positions crossing at the center of the large rectangle, as shown at C. It is evident that even with the maximum deviation in positioning, full contact will be available over an area C^2. By this change, however, an amount of contact metal equivalent to the area A×B has been saved. The amount of this saved area is evident if the two contact bars are placed in their extreme positions as indicated at (d). Contacts of this bar type are used throughout the crossbar system. They vary somewhat in form depending on the type of service. The more common types are shown in the bottom row of Figure 1.

Of the million and a half contacts in a crossbar office, over a million are used on the crossbar switches. Since these contacts appear in talking circuits, it was decided that they must be of a material that would not develop high resistance or noise. Palladium was felt, with all factors considered, to be the most satisfactory material for this purpose.

To reduce the amount of palladium required, the complete contact is generally made bimetallic, as shown at D in Figure 1. It is made by welding two tapes together—one of palladium and one of nickel. This bar is then cut in the lengths required for the contacts. The volume of palladium is only one-tenth of the total volume. For contacts that must make and break current millions of times, the entire contact is made of the same material, as shown at E and F.

In selecting contact materials for use in the crossbar system consideration was also given to silver. Investigation of its resistance and electrical wear characteristics disclosed that silver could be applied quite generally for relay contacts in signaling circuits. By using silver for most of the signaling circuits and palladium for transmission circuits it has been possible to obtain the best available assurance of quiet talking circuits without the expense that the universal use of palladium would entail.

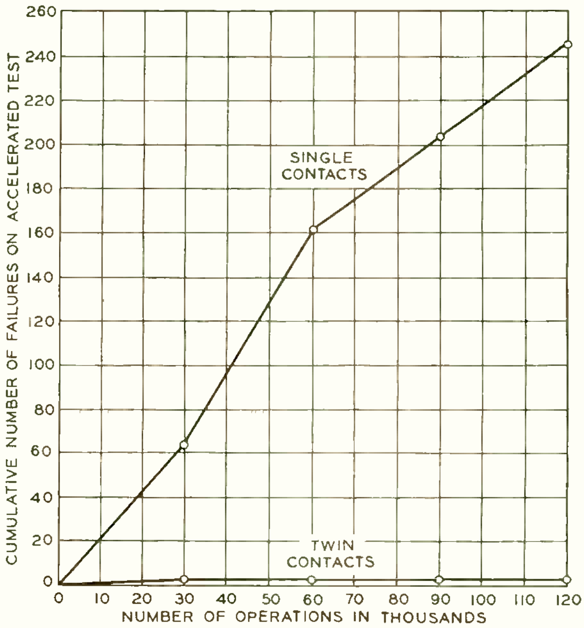


Fig. 5—Comparison of failures of twin and single contacts

Another feature of the crossbar system is the universal use of twin contacts to minimize the possibility of high resistance or open circuit resulting from dirty contacts. Under the simplest conditions, where the pressure of each contact of the twin pair is equal to that of the single contact it replaces, and where there is a random distribution of dirt, the theoretical degree of improvement can be simply expressed. If the probability of failure of a single contact is p, where p is less than 1, then the probability of two successive failures, or of the failure of two contacts in parallel, is p^2. Thus with a probability of failure for a single contact of .001, or once in a thousand times, the probability of failure occurring for twin contacts would be $.001^2$, or .000001, or once in a million times.

In the twin contacts employed, this full improvement is not ordinarily attained because the ideal conditions do not exist. In the first place the pressure between each of the twin contacts is only about half that used for single contacts; the total pressure is maintained about the same for both types. This results in a larger probability of failure for each of the twins than for the single contacts. In addition the distribution of dirt may not always be random, or the dirt on one contact may be thick enough to keep the other contact from closing. The results of some accelerated laboratory studies on twin contacts are given in Figure 5, and show an improvement of the order of fifty to one.

The wear that takes place when a contact opens or closes is due to the dissipation at the contact of a part of the energy stored in the system. Experience has shown, however, that the energy stored in the relay winding load will not give a true measure of the rate at which a given contact will wear out. Generally speaking, high-frequency discharges ranging up to several million cycles per second occur across contacts at the opening of an inductive load. With such high frequencies, the impedance characteristics of the wiring, as well as of the load winding, affect the character and consequently the destructiveness of the discharge that takes place across the contacts.

It has been found that these factors can be sufficiently taken into account for practical purposes by relating contact life to readily measurable characteristics of the contact load circuit. Thus it is possible to determine from the circuit conditions approximately what the life of a given contact would be. Where, because of severe conditions, the life of the contacts would be shorter than desirable, contacts such as those at E and F of Figure 1 are usually employed.

Transmission Features of the Weather Announcement System

By J. L. MERRILL
Transmission Standards

"UNITED States Weather Bureau forecast for New York City and vicinity: 12 noon temperature, 63 degrees, humidity 64 per cent; this afternoon, cloudy, increasing westerly winds; tonight, cloudy and colder, lowest temperature about 48 degrees, fresh west winds; tomorrow, fair and colder, fresh west winds." This spoken bulletin, furnished by the New York Telephone Company, is typical of the weather announcements now provided by some of the telephone companies. The announcements are changed at frequent intervals, and the ready availability at all times of "last-minute" weather predictions apparently fills a long-felt want if one may judge by the popularity of this service. Fundamental transmission considerations involved in the design of the weather-announcement system are essentially the same as those of the time-announcement system. New equipment, however, has been developed since the centralized time service was introduced about nine years ago, and has resulted in simplification of distributing circuits and in new arrangements for guarding the fidelity of the announcements.

Weather predictions come into the weather-announcing bureau by teletypewriter from the local United States Weather Bureau, and are at once recorded by the telephone companies' operators on magnetic tape machines. As a first step, therefore, it is necessary to insure that the record made on the tape is clear and of suitable volume and that throughout the announcement this volume remains constant within fairly close limits. Operators are selected who have suitable voices of not too low a volume, and they are instructed to read the announcement with their lips at a specified distance from the transmitter. If they get too close to it, large variations in volume will result from comparatively small changes in distance, while if they are too far from it, interfering room noise and reverberation become more noticeable.

The announcement is recorded on two machines simultaneously, but when it is completed, the attendant

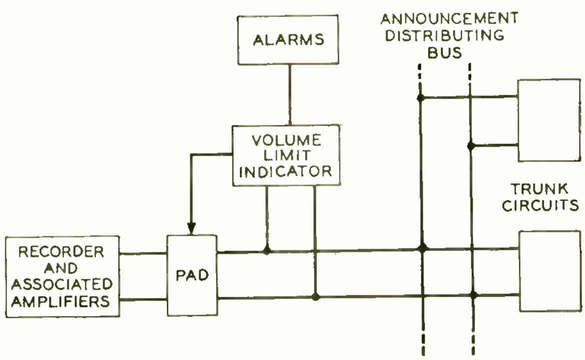


Fig. 1—A volume-limit indicator maintains a watch on the volume of the announcements at all times

operates monitoring keys, and listens separately to the announcements made on the two machines. During this monitoring, a volume-limit indicator is connected across the output of the tape amplifiers. If at any time during the announcement the volume is more than 3 db below the desired value for a definite interval, a lamp in the monitoring turret will light to indicate this fact to the operator. Each time the volume exceeds the desired value by 3 db, another lamp will flash. As the operator listens to the recording to make sure it is clear and correct, therefore, she has a visual indication in front of her to tell her if the volume limits have been met. If they have not been met, or if any part of the record is not clear or correct, the record will be removed from the tape and a new recording made.

As a result of these provisions, the volume of the announcement at the distributing bus in the announcing office is always within 3 db of the desired value when a new announcement is cut in. To insure that the volume remains within the required limits at all times, the volume-limit indicator remains connected to the circuit continuously. As shown in Figure 1, it is associated with an alarm circuit and a pad in the announcing circuit. Should the volume drop more than 3 db below the desired volume, the indicator will remove this pad from the circuit, thereby increasing the volume by from 2.0 to 3.0 db. This arrangement is provided principally to take care of a slight decrease in volume that sometimes occurs shortly after the tape is put in service on a new announcement. Should the volume drop as much as 9 db subsequently, the indicator will disconnect the tape machine and substitute the stand-by machine. At the same time it will give an alarm to attract the attention of the maintenance force so that any trouble may be rectified at once.

The fact that the volume is correct

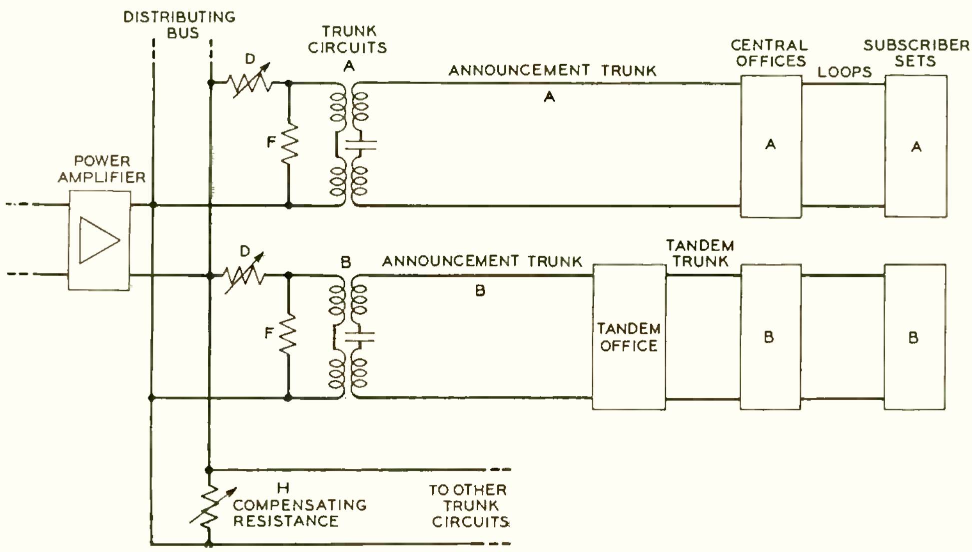


Fig. 2—A predetermined voltage within specified limits is maintained on the distributing bus, each trunk circuit being adjusted to maintain satisfactory volume at the distant central office

at the bus in the weather-announcing bureau does not necessarily mean, however, that it will be the same for all those who listen to it. The announcement may be requested by a subscriber in the same office as the weather-announcing equipment, by a subscriber at some other office reached by a trunk from the weather-announcing office, or by a subscriber in an office that is reached through a tandem office. Between the announcing equipment and the subscriber, therefore, there may be a subscriber loop plus an announcement trunk which may be anywhere from a few feet to about fifteen miles, or a loop plus tandem trunk plus an announcement trunk, as shown in Figure 2. The various loops and trunks will be of widely different types and lengths, so that the transmission losses of the various circuits may differ by considerable amounts.

There are two major requirements that control the design of such a distribution system. First, the volume of the announcement at the subscriber's station must be suitable regardless of the length or type of the connecting circuit. Satisfactory volumes will be obtained if the speech volume received by the subscriber calling the service is comparable to that which would be received on an average call from another subscriber whose line is terminated in the same central office. Since the subscriber loops are already designed to certain loss requirements, the desired speech volume can be obtained by maintaining the volume at the central office of the calling subscriber within certain limits.

To adjust for the differences in the length and types of trunks, each trunk is equipped at the announcing bureau with a network consisting of resistances D and F, shown in Figure 2. The voltage on the distributing bus is made higher than that necessary to give satisfactory volume at the most distant office, and the network for

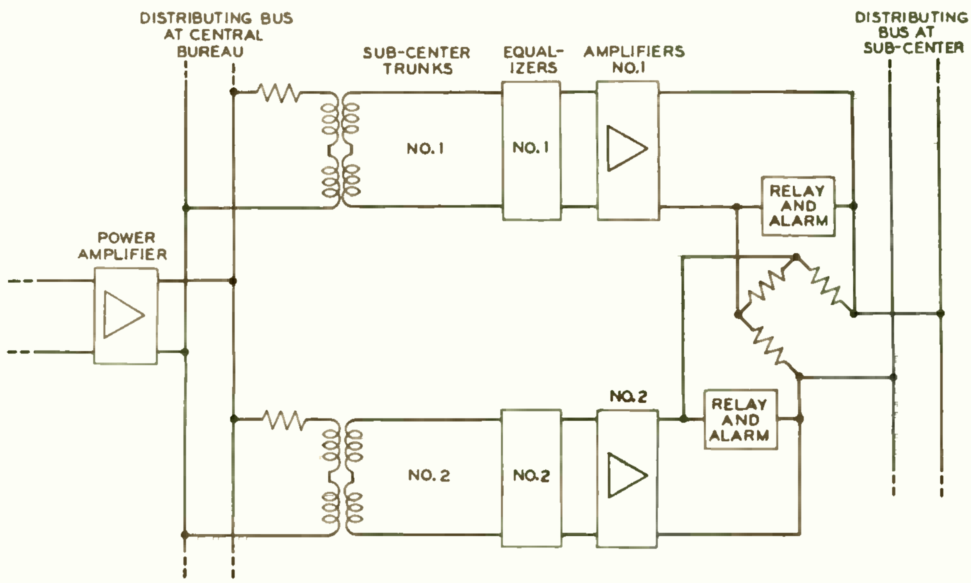


Fig. 3—Sub-centers, at some distance from the announcement bureau, are supplied by two trunks and amplifiers

each trunk is then adjusted to give the desired volume at the terminating central office. The announcement trunks are used only for weather announcements, and so need be adjusted for loss only when the system is installed. In adjusting trunks to tandem offices, a compromise value of loss for the tandem trunks is used.

The second requirement is that subscribers listening to the weather announcements cannot hear or talk to each other. This is brought about by the same networks, which give a loss of about 40 db between the distribution bus and the terminating central office. The voltage on the announcement bus is high enough so that with this loss in the circuit the proper volume is obtained at the central office. Between any two subscribers, however, there are two networks in series, and since a talker's volume is much lower than that maintained on the distributing bus, the loss interposed forms a practically complete barrier between subscribers.

As already noted an approximately constant voltage is maintained at the distribution bus but this voltage will tend to vary somewhat depending on the impedance of the combined group of outgoing trunks. To provide for changes in the size of this trunk group, which may be required from time to time, the compensating resistance H is connected across the bus. This resistance is adjustable and is changed as required to maintain the desired output impedance.

Another factor that will tend to affect the constancy of the bus voltage is the variation in the number of trunks in the group in use from moment to moment. With a large number of trunks connected, that is, a large number of people listening to the announcement, the impedance tends to drop, while with few trunks connected, it will rise. The D and F resistances are connected to the circuit all the time, and the variation caused by the disconnection of a trunk is a function of the loss of this network. By providing a relatively large loss in the D-F pad, this variation in impedance is made small. The network D-F serves a triple purpose, therefore. It provides a means for adjusting the volume at the distant central office, it prevents subscribers from hearing each other, and it reduces the variation in output impedance of the distributing bus as the load varies.

Where there are a number of central offices grouped closely together but at a considerable distance from the weather-announcing bureau, a sub-center is formed. The arrangement provided is indicated in simplified form in Figure 3. Two trunks are provided to the sub-center and each is equipped with an amplifier and equalizer at the sub-center. Both amplifiers feed the distributing bus at the sub-center through a bridge network. A relay operating an alarm is connected across the output terminals of each amplifier. Under normal conditions, the load is carried equally by the two trunks and amplifiers, but if one trunk or amplifier is disabled, the load will be carried by the other with a resulting decrease of 6 db in volume. Under these conditions, however, the alarm on the unoperative trunk will operate since the speech voltage across its controlling relay is obtained only through the bridge network, which introduces a loss of about 20 db.

Equalizers are used on the longer trunks to correct the frequency distortion. On all the shorter trunks, distortion of all types is ordinarily within satisfactory limits.

Contributors to this Issue

Since Harvey Fletcher came to the Laboratories in 1916 he has been identified with many important investigations which have made him one of the foremost authorities in the field of speech and hearing. As Acoustical Research Director he was in charge, for a number of years, of groups working on fundamental problems relating to sound, including aids to the hard-of-hearing. Dr. Fletcher is now Director of Physical Research and in this capacity has charge of research work in acoustics, electronics, magnetism and vibrating systems. He graduated from Brigham Young University in 1907 and received the Ph.D. degree from the University of Chicago in 1911.

H. W. Hermance joined the Laboratories in 1927 with prior experience in chemical analysis gained in toxicological and criminological work. He had also worked with the Crucible Steel Company and had spent four years with Procter and Gamble developing analytical methods for controlling the quality of raw materials and manufactured products. During this period he carried on part-time study at Newark Technical School and later at Columbia University. From 1925 to 1927 Mr. Hermance was at Kearny working on the analytical control of materials. Since coming to the Laboratories he has specialized in microanalytical methods and has had a prominent part in developing the techniques and laboratory facilities for this relatively new phase of analytical chemistry.

B. F. Runyon received the B.S. degree from Northwestern University in 1923. After teaching for three years, he joined the Apparatus Development Department of these Laboratories. His first work was on electrolytic condensers and copper-oxide rectifiers, but in 1934 he was put in charge of a group engaged in the design and engineering of precious-metal contacts. At the present time he is in charge of a group investigating base-metal contacts.

R. R. Swain, after receiving the B.S.E. and M.S. degrees from the University of Michigan in 1927, worked for the Department of Engineering Research of that institution for about six months and then

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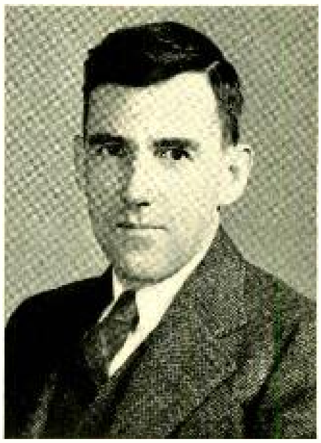

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R. R. Swain

J. L. Merrill

R. A. Cushman

for the General Motors Research Corporation for almost two years. In late 1929 he joined the D. and R. Department of the American Telephone and Telegraph Company, where he associated with the toll equipment development group, and subsequently came to the Toll Facilities Department of the Laboratories in the merger of the D. and R. He worked initially on miscellaneous toll switchboard problems, later on straightforward toll line and cord-ended switchboard studies. For the last six and a half years, he has been engaged primarily in cost studies and development requirements for the intertoll dialing system.

J. L. Merrill joined the D. and R. Department of the American Telephone and Telegraph Company in 1930 just after receiving the degree of M.S. from the Pennsylvania State College. He worked on transmission problems related to special services in the exchange area. Since coming to the Laboratories he has been with the group engaged in local transmission development problems.

R. A. Cushman joined the Laboratories in 1929 following a five-year period at the University of Nebraska where he had been Assistant Professor in Electrical Engineering. Previous to that time he had two years of sales engineering experience and a year of teaching at Cornell University, where he was granted M.E. and M.S. degrees. In the Radio Development Department he spent eight years in the design of transatlantic radio and high-power broadcasting equipment. More recently he has been in charge of a group designing recording and reproducing equipment and systems in the Commercial Products Development Department.