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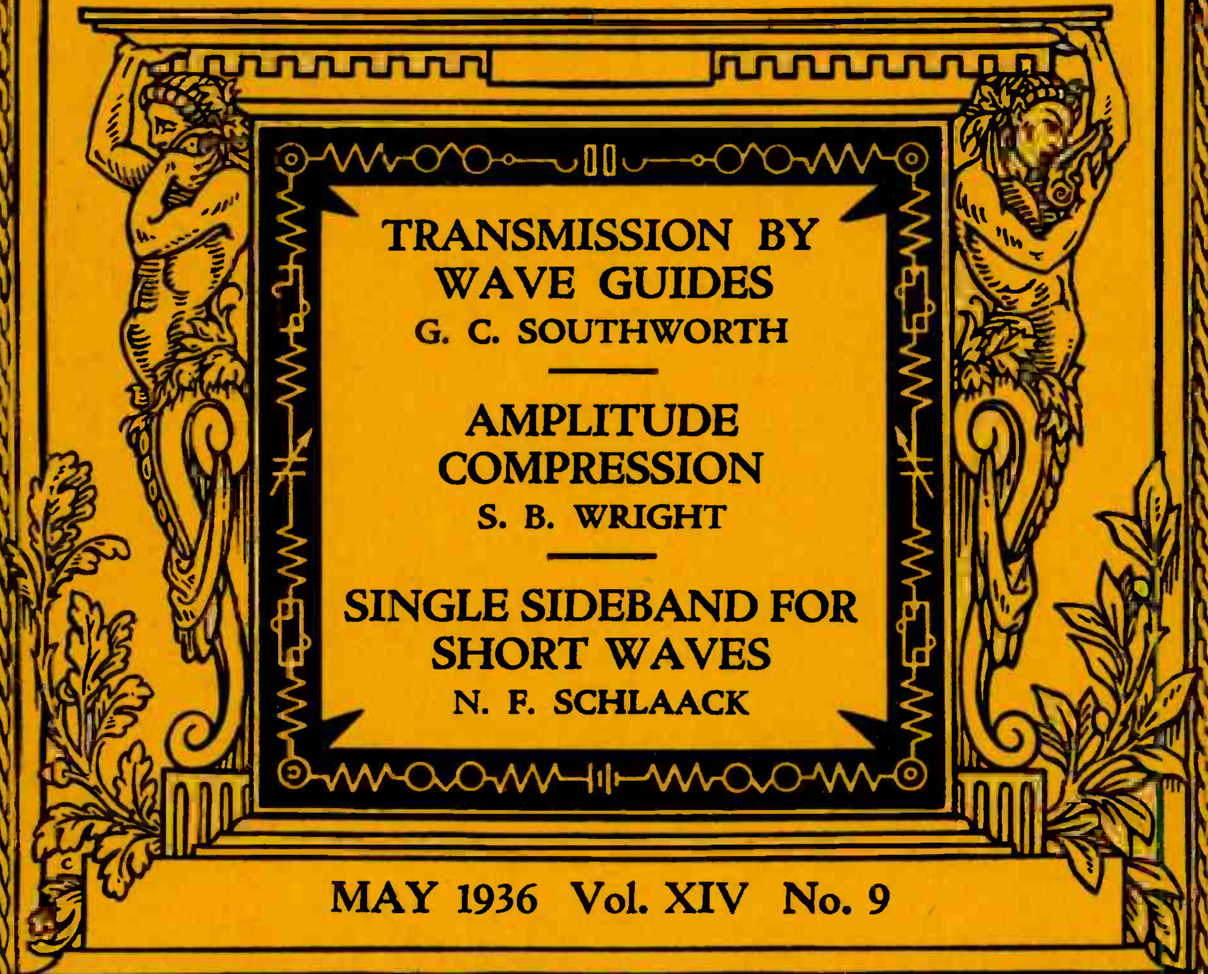

TRANSMISSION BY WAVE GUIDES

G. C. SOUTHWORTH

AMPLITUDE COMPRESSION

S. B. WRIGHT

SINGLE SIDEBAND FOR SHORT WAVES

N. F. SCHLAACK

MAY 1936 Vol. XIV No. 9

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In this Issue

Volume 14—*Number* 9—*May*, 1936

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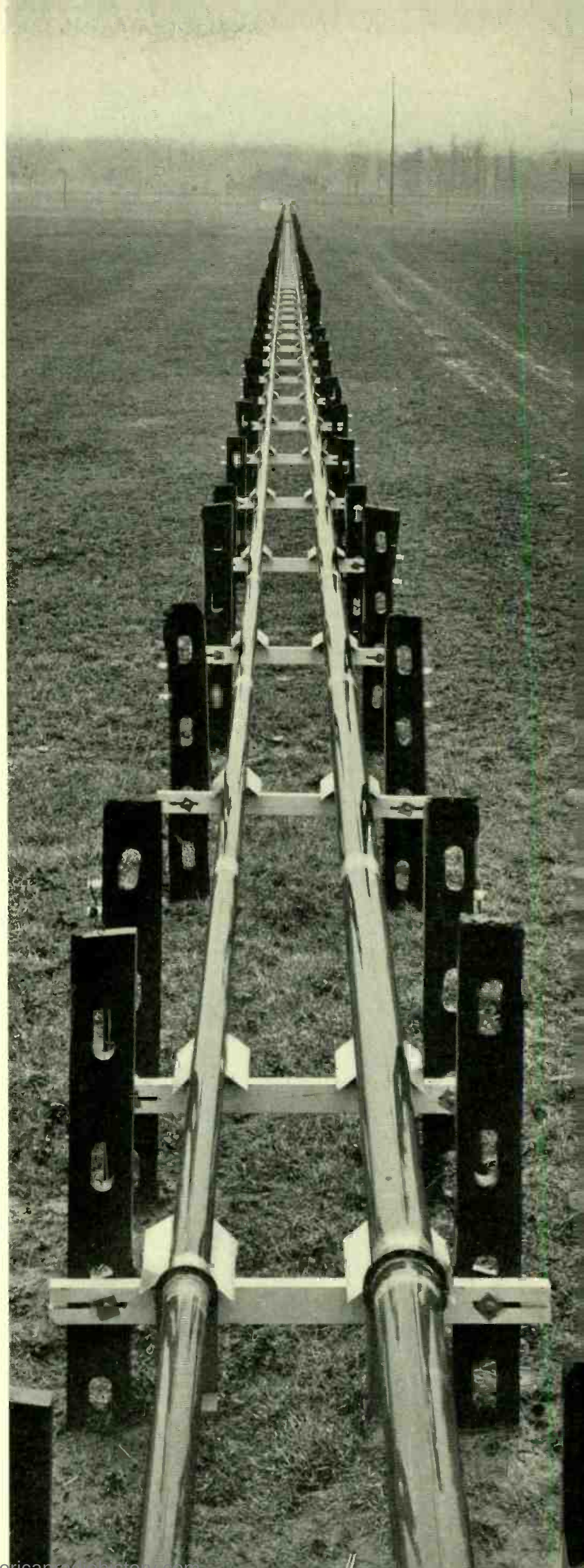
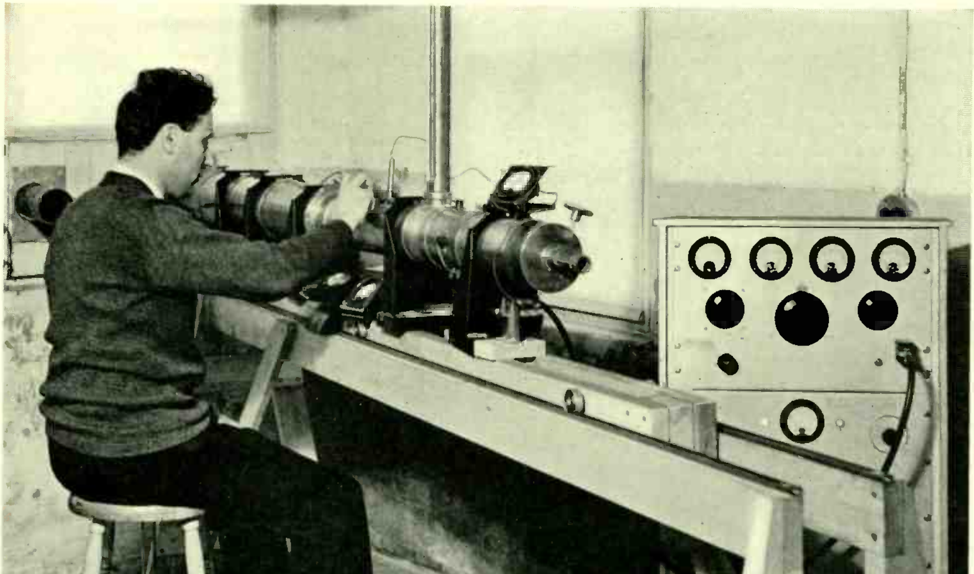
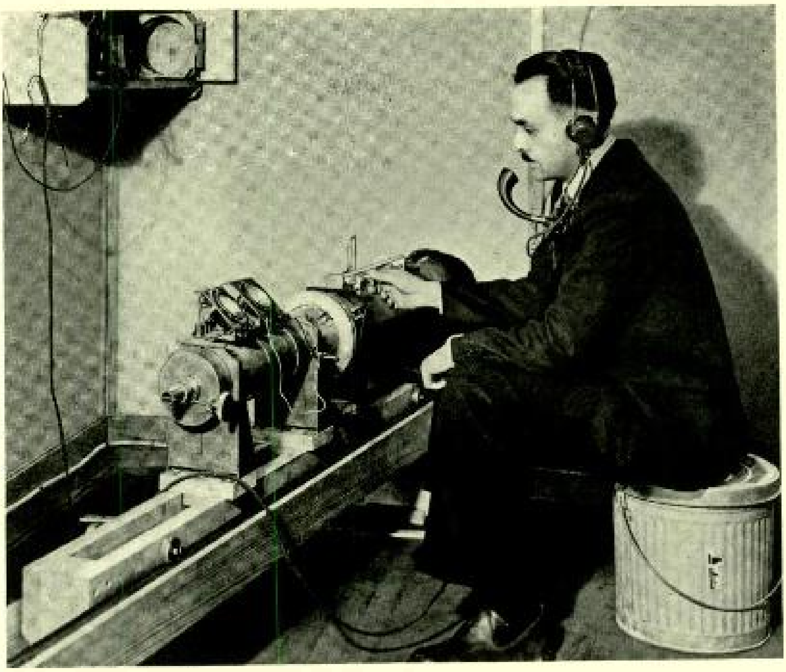
Experimental wave-guides at the Holmdel Laboratory



G. C. Southworth holding one of the resonant chambers used for tests of wave-guide transmission. Behind him are the two experimental transmission lines



A. P. King at the sending end of the experimental wave-guide at Holmdel. The receiving end, with A. E. Bowen, is shown in the photograph on the opposite page



Electric Wave Guides

By G. C. SOUTHWORTH
Radio Research

IN the early days of electrical communication, it seemed axiomatic that there must be a completed circuit to permit the flow of electric current or power. A return path, either in the form of another wire or the earth, was apparently essential. With the advent of radio this seemingly fundamental law was broken, because for radio transmission no return path in any ordinary sense is required. Radio, however, was very evidently a distinctly different type of transmission. The radio waves simply traveled in all directions through space as does light or radiant heat.

Researches in Bell Telephone Laboratories have disclosed a new form of transmission for high frequencies. It is unlike radio because the waves are not broadcast through space but follow a physical guide comparable to a wire. No return path, however, is required of the kind that is commonly assumed in the usual case of transmission. With an ordinary concentric conductor, such as is used for feeding a radio antenna, the outer tube forms one side of the circuit and the central conductor the other. If, however, instead of operating such a structure at a frequency of about a million cycles, approximately the average frequency for broadcasting, a frequency of two-thousand million cycles were employed, it would be found that the central conductor could then be completely withdrawn and still the structures would be able to transmit power. It would be necessary, of course, to provide a suitable means for launching the waves, and the form of transmission would be radically different.

In this example the pipe would have had to be at least 4½ inches in diameter, but if the pipe had been filled with an insulating material having a dielectric constant of 4, a 2¼-inch pipe could have been used, while if the dielectric constant had been 9, a 1⅛-inch pipe could have been used. As a matter of fact, the outer pipe itself may also be done away with, and the transmission will take place along a wire or rod of insulating material, and the attenuation will be least when the resistivity of the insulator, acting as a guide, is the greatest.

Incredible as these phenomena may seem at first sight, they are readily explicable on mathematical principles that have been known for many years. As early as 1897 Lord Rayleigh obtained solutions for certain differential equations occurring in electrical theory that indicated that wave power could be propagated through either hollow metal pipes or through dielectric rods. So far as is now known, no experimental work was attempted at that early date. As often happens in science these principles were independently discovered by others. In particular, a group of workers in Germany studied this problem, and published several papers. They were Hondros and Debye in 1910, Zahn in 1916 and Schriever in 1920. Also our own J. R. Carson in 1924 and R. V. L. Hartley in 1931 gave thought to this problem. Both Zahn and Schriever did a small amount of experimental work

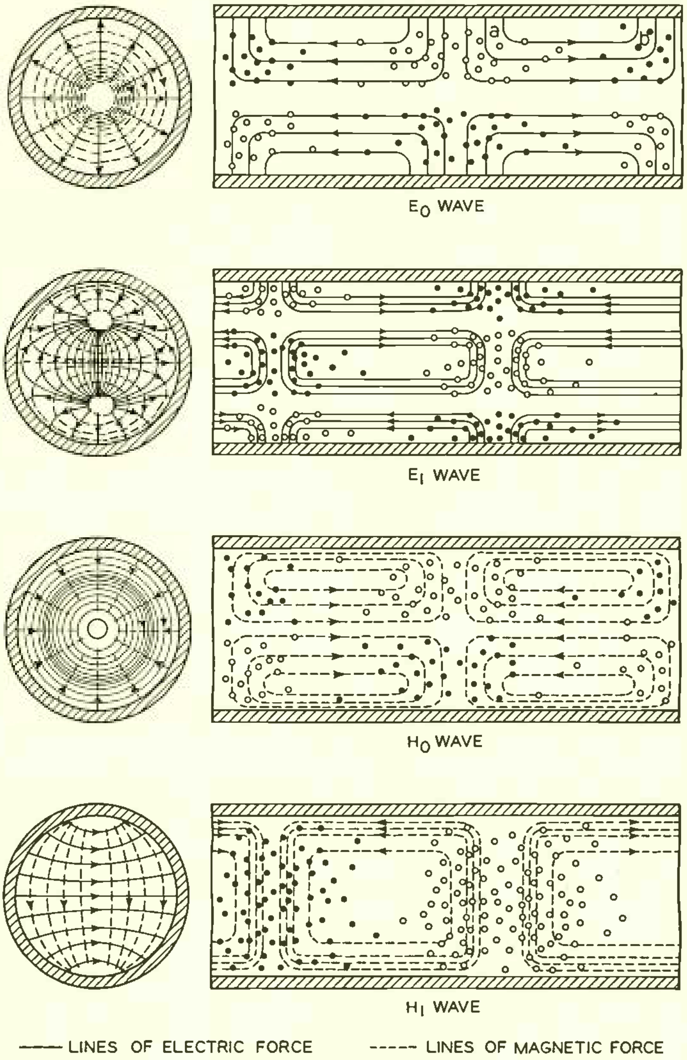


Fig. 1—Schematic representation of electric and magnetic fields for four types of wave-guide transmission

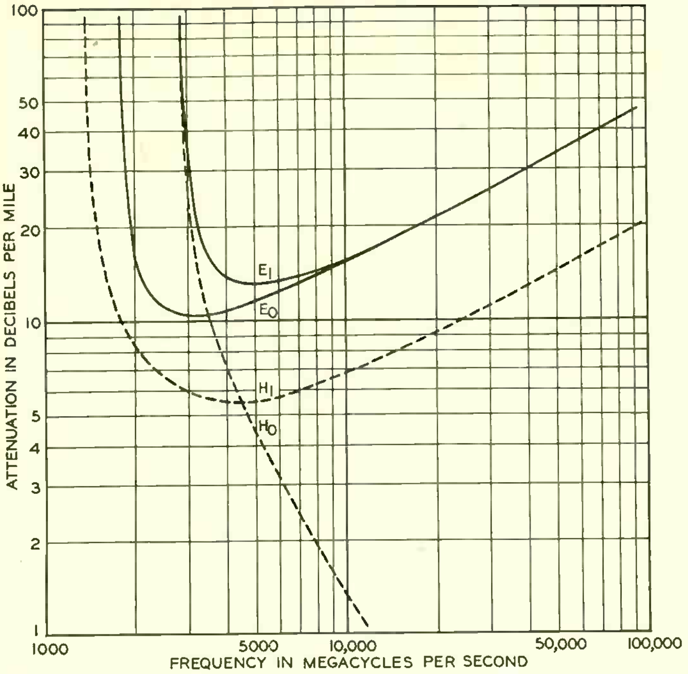


Fig. 2—Attenuation characteristics for four types of wave-guide transmission

but it related mainly to the form of wave guide consisting of insulation alone, and dealt with just one of the many types of waves that may be propagated. The published literature indicates that their work was dropped at that point.

In 1931 the author resumed some experimental work on this subject, which he had started in 1920. This has now been expanded slightly and moved to our Holmdel Radio Laboratory where long wave guides may be constructed. Some details have been given in the April, 1936, issue of the Bell System *Technical Journal*. Throughout this experimental research there has been considerable work done by members of the mathematical groups, notably by J. R. Carson, Sally P. Mead, and S. A. Schelkunoff, who also have a paper in the Bell System *Technical Journal* for April. Sometimes experiment has suggested analysis. Sometimes analysis has suggested experiment. As in military operations so in experimental research, greatest progress is made when the efforts of line and staff are complementary.

The analytical work of Rayleigh and others has now been greatly amplified. The extensions which have been added to the theory include calculations of characteristic impedance, attenuation, and inductive effects into neighboring wave guides, and particularly the discovery that, theoretically at least, one of the many waves that may be transmitted through a hollow pipe becomes progressively less attenuated as its frequency is raised. This remarkable property appears altogether unique in the field of electrical transmission.

These electric waves that are guided through hollow pipes and dielectric rods are moving configurations of electric and magnetic fields. Mathematical theory indicates that in cylindrical guides these two fields may be associated in many different ways to provide a wide range of types of waves. Four of these are shown in Figure 1. They may be generated by any source of sufficiently high frequency, such as a Barkhausen or a magnetron oscillator. To set up any particular type of wave it is necessary, of course, to provide an appropriate launching mechanism. If the E_0 wave is desired, the source may be connected between the outside shell of the guide and a rather large central disc perpendicular to the principal axis. For H_1 waves the source is connected between diametrically opposite points on the inside of the pipe.

Wave guides behave somewhat like wire lines in that they have a definite characteristic impedance and a definite attenuation. Also waves travel through them with a velocity that may be predicted with considerable accuracy. The calculated attenuations of the four principal waves are of particular interest. They are shown in Figure 2 for the special case of a five-inch hollow copper pipe.

It will be noted that all waves suffer infinite attenuation at or below certain critical frequencies, and that with an increase in frequency this attenuation decreases very rapidly. For three of the types of waves it approaches a minimum, and then increases for higher frequencies. For the wave that has been designated as H_0 this attenuation appears to decrease indefinitely with increase of frequency.

Not all of the calculated characteristics of wave guides have yet been verified experimentally. In particular, no information is yet available on the very interesting H_0 wave except near cutoff. At present, the author, together with A. E. Bowen, A. P. King, and J. F. Hargreaves, is working at the Holmdel Radio Laboratory measuring the attenuations. For this purpose two hollow copper pipes are used, which are four inches and six inches in diameter and 1250 feet long. These pipes are shown in the frontispiece to this issue.

In much the same way that a pair of wires may resonate to waves traveling along their length, or an air column may resonate to certain sound waves, so may a short section of wave guide be made to resonate electrically to the frequencies which it is able to propagate. In its role as a resonator it behaves as if it were a coil and condenser, sometimes in series with an electromotive force, and sometimes in parallel. These resonance effects are very pronounced and may be

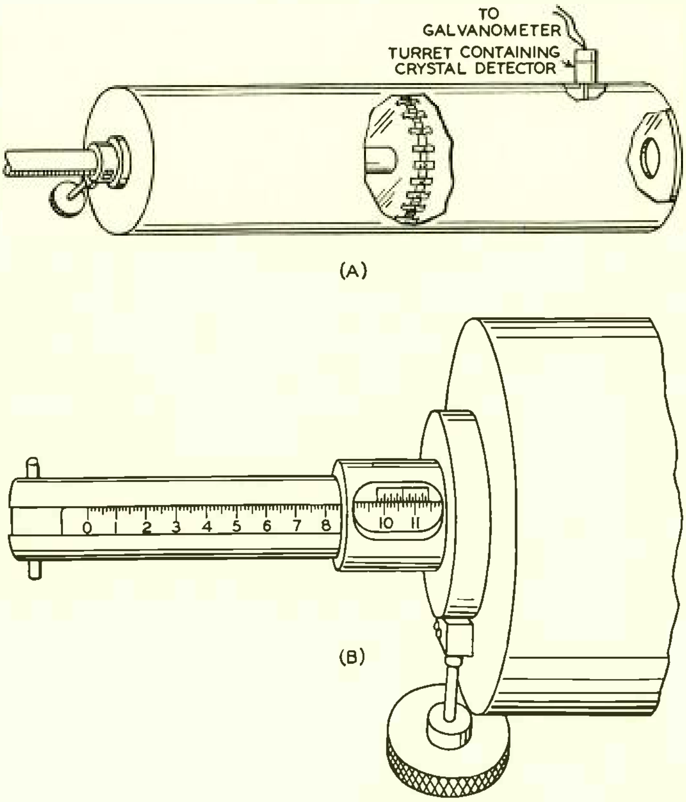
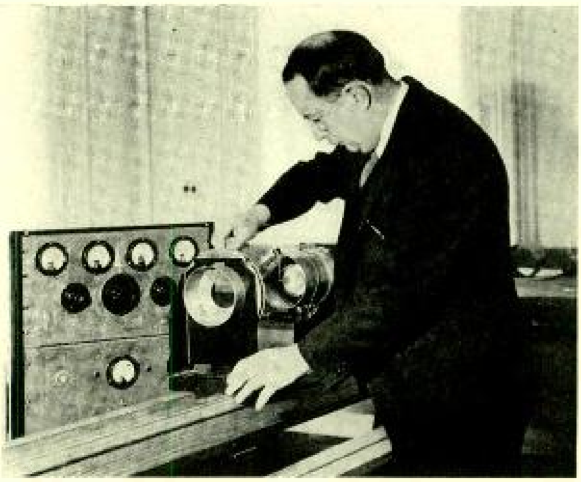


Fig. 3—One form of resonant chamber used in connection with wave-guide transmission

simply demonstrated by a cylindrical chamber such as that shown in Figure 3.

The open end of a guide may be made to radiate wave power much the same as sound waves issue from a pipe. To enhance this effect the pipe may be expanded into a cone, thus producing an electrical horn. Tests show that it may function much the same as an acoustical horn, and accordingly may be used as an efficient radiating load for the generator to which it is connected.

The question naturally arises as to what use wave guides may be put. This is a difficult question at this early day. Wave guides have definite limitations. The diameter of the hollow pipe that may be used is directly proportional to the wavelength. For a pipe that is at all convenient in size, the frequencies are the highest that have yet been tried out for radio. It is true that the diameter of pipe might be reduced if it could be filled with a suitable insulator. At this point we are met with a conflicting difficulty of producing at reasonable cost the necessary medium that will incorporate high dielectric constant with sufficiently low losses. It is true too that low attenuation could probably be had with much smaller pipes by the use of H_0 waves, but this calls for an even higher range of frequencies. For long-distance transmission, the situation is that the art at these extreme frequencies is not yet at a point which permits a satisfactory evaluation of practical use. For transmission over very short distances, however, or for use as projectors of electric waves, or as selective elements under certain conditions, the use of wave guides has definite possibilities.



Some of the experimental apparatus employed for wave-guide transmission

A "Hit" Suppressor

By J. H. BELL

Telegraph Development

ONE of the advantages of operating telegraph systems over cable conductors instead of open-wire lines is the relative freedom from a form of interruption known as "hits." These may be caused by atmospheric disturbances, by wires swinging together or in contact with trees, or by men working on the lines. Even with the best possible outdoor maintenance such interruptions cannot be entirely eliminated. The majority of these interruptions are of very short duration, existing for only a fraction of a second.

On a hand-operated telegraph circuit, a skilled receiving operator is able to interpret the signals correctly despite the presence of occasional faults of this nature. On a teletypewriter circuit, however, which prints six letters or figure characters per second—each character comprising a combination of seven signal impulses—an interruption of a hundredth of a second or less may result in the printing of a false character. A wrong letter in an English word would probably not affect the interpretation of the message. Where groups of figures or code words are transmitted, however, as on many private telegraph circuits used extensively for business and news distribution, hits assume greater importance. As a result it is desirable to limit their effect to the leg or branch of the line on which they occur.

About sixty per cent of the telegraph circuit mileage is now in cables, free from such interruptions, so that a real improvement in service would result if the unavoidable line interruptions occurring on the open-wire sections of long networks comprising both open-wire and cable could be kept out of the cable sections. A news distributing circuit, for example, may extend from Boston to St. Louis entirely in cable, but with open-wire branches running to outlying stations at some distance from the main cable route. If some device that would eliminate interruptions could be inserted at each point where the open-wire lines connect to the cable, the hits could be restricted to the sections in which they occur, and would not affect transmission over the main cable circuit except when transmission is taking place from the open-wire branch. Since the flow of traffic on news distribution circuits is almost entirely to the outlying stations, this would eliminate practically all of the "hit" interruptions.

Such a device, known as a hit suppressor, has recently been developed by the Laboratories. It is connected into the system in association with a single-line telegraph repeater as shown in Figure 1. It prevents short hits on the open-wire lines from affecting telegraph transmission over the cable route except on those comparatively rare occasions when one of the branch stations is transmitting.

A very much simplified schematic of a single line telegraph repeater is shown in Figure 2, where the light lines are the four connections taken to the hit suppressor. Signals coming in over the line from the toll repeater actuate relays A and B and pass back through a contact of relay C. The operation of relay A opens and closes its contact and thus sends open and close signals over the branch line through windings of relays C and D. It is important that these two relays do not operate under the influence of these currents, for if C, for example, does operate, it will open the incoming circuit and cause a false signal. Under normal conditions C and D will not operate, but a "hit" may cause them to do so. With signals flowing in the opposite direction, that is from the branch to the main circuit, relays C and D should, and do, operate, while relays A and B do not. The function of the hit suppressor is to insure that the main line circuit, passing through the contact of relay C, is not opened when signals are flowing to the branch or open-wire circuit.

This is accomplished by the two relays comprising the hit suppressor. These are shown in connection with the single-line repeater in Figure 3. Here the hit suppressor circuit is shown in heavy lines and the single-line repeater circuit in light lines. Again the schematic is considerably simplified. What the hit suppressor does is to place a short-circuit around the contact of relay C while signals are being transmitted to the branch circuit. After the signals have ceased to flow for a second or two, the short-circuit is removed so that signals may be transmitted out from the branch circuit if desired.

Relay F has two windings: one connected to a contact of relay D and the other to a contact of relay B. When the signals are flowing from the main line to the branch circuit, relay D does not operate, and the circuit of the S winding of relay F is open as indicated. The contact of relay B, however, opens and closes with the signal pulses. A spring on the armature of F holds the contact open when no current is flowing in the M winding, but when current flows in M, the contact closes. The armature of relay F thus follows the signal pulses, only in an opposite sense: during a marking signal the armature of F releases and during a spacing signal it closes.

Relay E also has two windings: one permanently connected between bat-

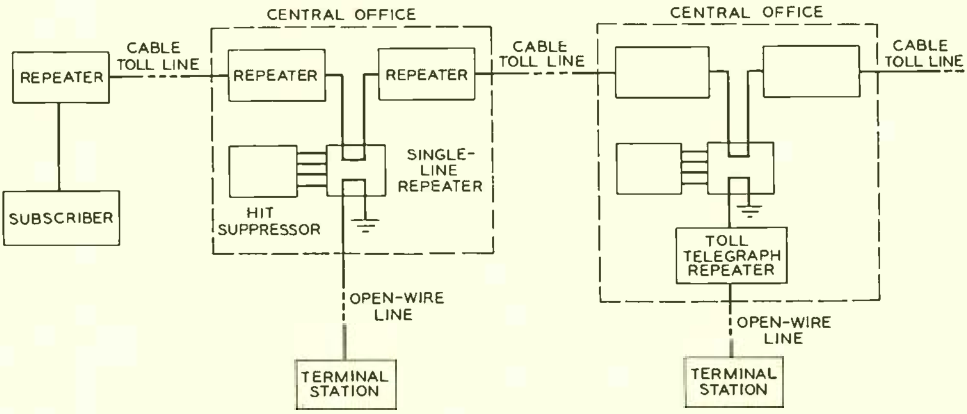


Fig. 1—The hit suppressor is connected into the system in association with the single-line telegraph repeater at all points where open-wire branch lines are connected

tery and ground, and the other connected between battery and ground through a contact on F. A condenser is connected to the ground side of this winding through a resistance. The S winding tends to hold the contact open and the M winding is designed to overcome the effect of the S winding and to close the contact. When the contact on relay F is closed, therefore, current will flow through the M winding of E and the contact will close. At the same time the condenser discharges to ground through the contact of F. The operation of E places a short-circuit around the contact of C so that hits when they occur cannot affect the signals on the main line.

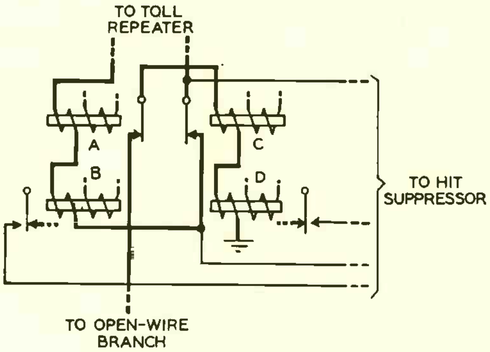


Fig. 2—At branch points a single-line repeater is employed to allow the signals passing over the main line to be repeated over the branches. The hit suppressor is connected to these single-line repeaters by four leads

During the marking signal in the main line, relay F releases, and thus opens the direct ground connection to the M winding of relay E. At the moment of opening, however, the condenser is in a discharged state, and as a result charging current at once starts flowing into it through the M winding. The capacity of the condenser and the value of the associated resistance are such that relay E will be held operated for a period of one or two seconds—far longer than necessary to hold E operated during the very short marking signal in the main line. Thus while relay F operates with the signal pulses in the main line, relay E operates at the first spacing signal and remains operated until about two seconds after the signals in the main line cease.

When the branch circuit is open, the armature of relay D moves to its back contact, causing current to flow through the S winding of relay F. The effect of this winding is opposite to that of winding M and is of greater strength. This makes it possible for the branch station to break in on the circuit at any time in order to transmit. It is necessary only to open the signalling key at the branch station for a period in excess of two seconds—to allow condenser current through

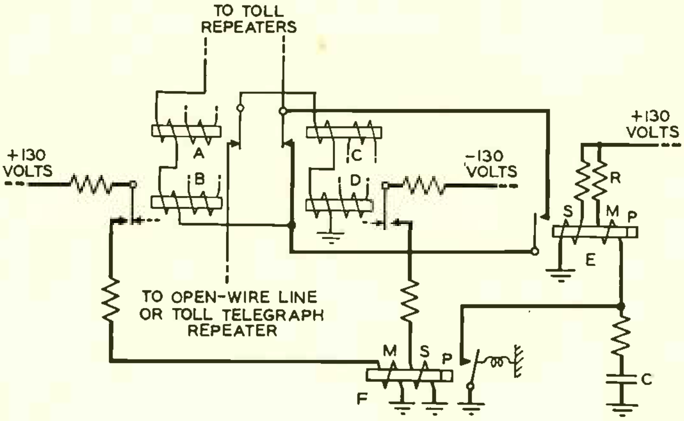


Fig. 3—The hit suppressor comprises two relays, E and F, which cause a short-circuit to be placed across the contact of relay C. The hit suppressor circuit is shown by the heavy lines

the M winding of E to cease flowing—when transmission may be begun.

The hit suppressor thus prevents short disturbances on the branch circuit from having any effect on the main line signals as long as the direction of transmission is toward the branch circuit. It is positive and rapid in its action, and has no detrimental effect on the signals transmitted.

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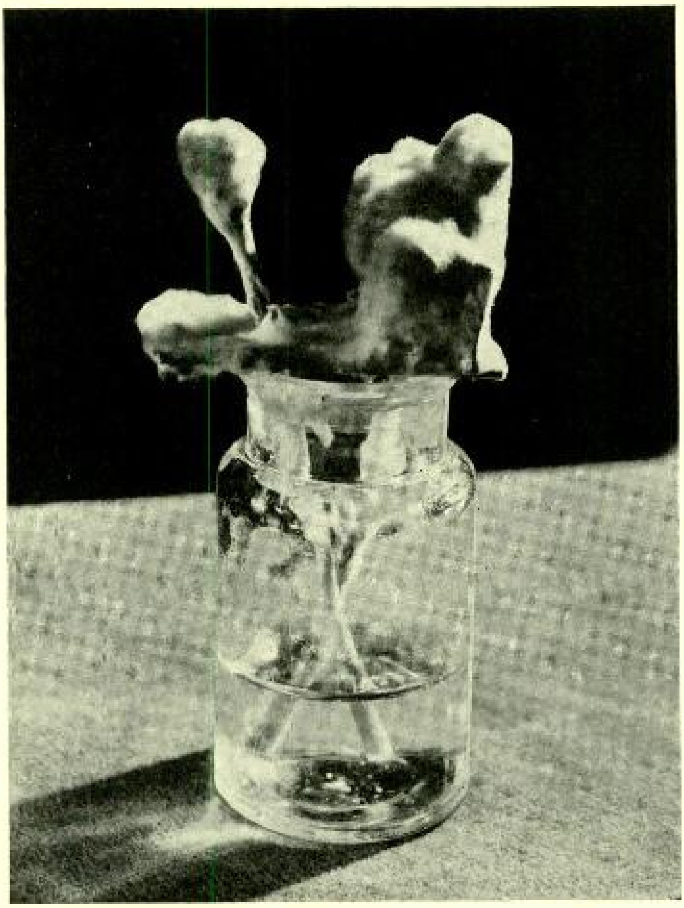
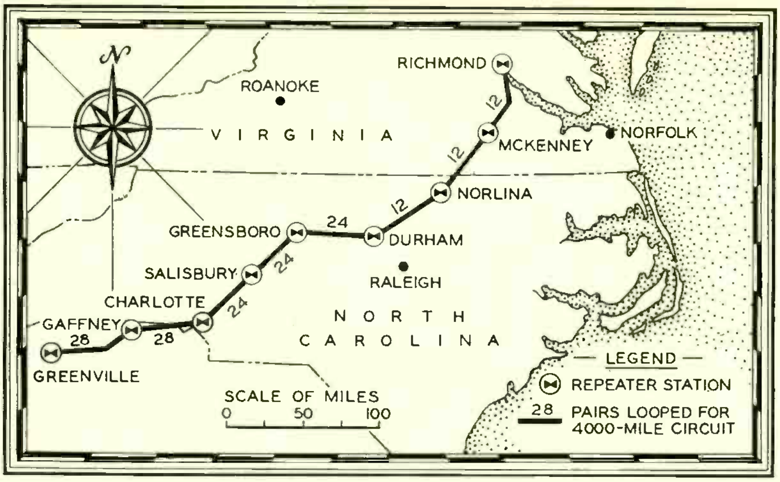


Lentinus Lepideus, a wood-destroying fungus, growing on a sample of untreated pole timber in the chemical laboratory at Summit



Amplitude Compression in Long Telephone Circuits

By S. B. WRIGHT
Transmission Development

MOST telephone connections are made over fine wires, many pairs of which are packed together in a lead sheath to form a cable. These fine wires have such a high electrical resistance that they could not be used to transmit telephone currents satisfactorily over long distances without the aid of electrical devices to conserve and strengthen the attenuated voice currents. The devices most commonly used are of two kinds: inductances, called loading coils, which are inserted at intervals of approximately six thousand feet, and vacuum-tube telephone repeaters which are located at stations about fifty miles apart along the cables.

Loading coils and repeaters have been developed to a high degree of perfection. However, when they are used in the large numbers required on telephone lines thousands of miles long their small residual imperfections may add up sufficiently to cause certain peculiar distortions of the speech waves. This possibility may be better appreciated when it is realized that in a 2000-mile cable circuit there are approximately 1760 loading coils and forty repeaters.

One type of distortion which the waves may suffer is known technically as "non-linear" distortion. This means simply that the received current is not proportional to the applied voltage. A "non-linear" telephone circuit usually causes more loss to strong waves than to weak ones, and in addition causes the formation of new, though weaker, waves of frequencies not in the original; also the presence of waves of different frequencies simultaneously may cause other effects due to their inter-action. The present paper deals only with the first mentioned aspect of non-linear distortion, which may be called "amplitude compression" to distinguish it from the other two, which may be called "intermodulation" and "mutual crowding," respectively.

Amplitude compression was one of the effects studied in the course of an experimental program on a system of unusually long lines which was built up by looping cable circuits back and forth between Richmond, Virginia, and Greenville, South Carolina. The cable route with the location of repeater stations is shown on the headpiece. It was possible to set up, by this procedure, a two-path, or four-wire circuit, approximately four thousand miles long. By connecting the two paths together, an extreme length of eight thousand miles could be arranged for test.

The steady-state "compression" was tested on these circuits by measuring the output or received power for different values of input, at different frequencies. The results of this type of test on a single repeater and on a circuit about two thousand miles long are shown in Figure 1. If there were no compression, the measurements would lie on straight lines, with 45-degree slopes, as shown in this figure. The single repeater departs from this ideal only very slightly at high inputs. For the two thousand-mile circuit, however, the compression is seen to be appreciable even in the range where the curve for a single repeater is practically linear. It also increases with frequency, and at different frequencies varies differently with input. To understand the reasons for such behavior it is necessary to know more of the sources of compression.

One source of compression is the vacuum tube used in the repeaters. In standard repeater circuits the grid is provided with a negative bias of nine volts, which permits an input of plus or minus nine volts without causing the grid to become positive and thus overload the tube. When we examine the behavior of a typical tube in a repeater circuit, as shown in Figure 2, we find that the output of a vacuum tube does not vary directly as the grid voltage but changes in a more complicated manner which involves higher order terms.

This indicates the possibility of distortion but not necessarily of compression. If compression is present straight lines drawn to show the average ratio of output to input for dif-

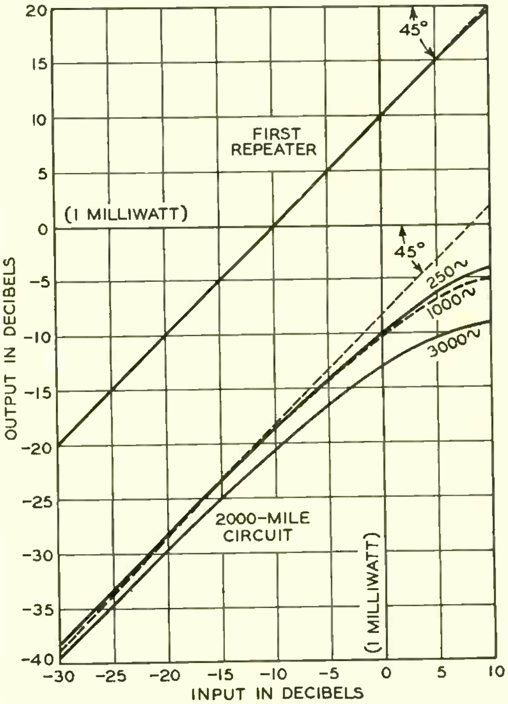


Fig. 1—The compression in a 2000-mile cable circuit is compared with that in the first repeater. The high frequencies are compressed more than the low frequencies because of slight residual non-linearities caused by the magnetic materials in the loading coils associated with the circuit

ferent applied voltages will not be parallel. Two such lines are shown in Figure 2, one for an input which varies from −9 to +9 volts (B′B) and another for a smaller applied voltage (A′A). The amplification of waves covering the whole working range is about ⅛ db less than that for very small waves. Such compression as occurs in the first repeater in a circuit slightly reduces the strong waves which reach the next repeater, so the effect of two repeaters is not necessarily ¼ db, but is generally less. That is, the added effect of additional repeaters is less and less, due to the effects that have occurred in the previous repeaters, and to other losses.

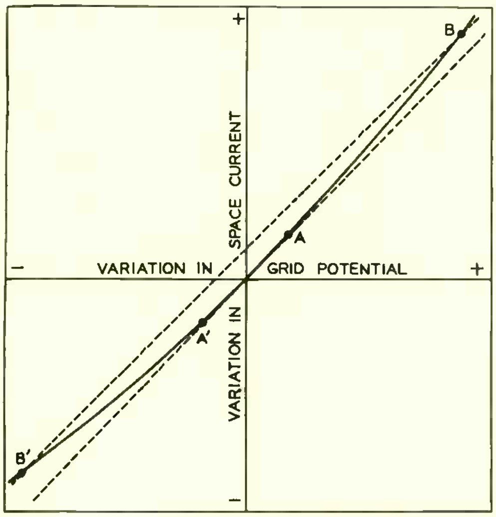


Fig. 2—Compression in a vacuum tube is indicated by a change in slope of the dynamic grid voltage-space current characteristic as the input is increased

The other principal source of compression in this long circuit was the core material of the many transformers and loading coils which were used. Due to magnetic effects in the core, the impedance of a loading coil—which, for a given frequency, is sometimes thought of as an immutable property of the coil—actually varies slightly, depending upon the strength of the current carried by the coil. When strong waves are transmitted, these slight variations are sufficient to cause an added compression in the first loading coil following a repeater of about 1/100 db at three thousand cycles. For the succeeding coils, the compression is less and less due to the line attenuation. At lower frequencies the effects are even smaller.

In order to show how compression results from non-linearity in the coil characteristics, curves have been plotted in Figure 3, which show the relation of the current in the telephone line to that fraction of the voltage across the coil which is in phase with the current. At any point on these curves the ratio of the abscissa to the

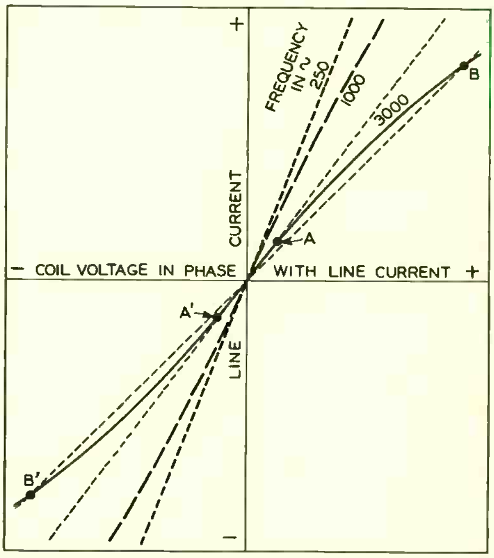


Fig. 3—Loading coil compression is much more complex, since the current varies from coil to coil, both in magnitude and in phase. This is an exaggerated picture of the "slope test" applied to the characteristic of the effective resistance component of a loading coil at three thousand cycles. At low frequencies the loading coil compression is less

ordinate gives the resistance component, or real part, of the impedance of the coil. The resistance component is chosen, rather than the total impedance, because the variations in the latter are too small to show on a graph. Since the line connecting the end points for large currents (B′B) has less slope than the line for small currents (A′A), an increase in the resistance component is indicated for strong currents; that is, the non-linearity which is present in coils is also of a type which causes compression.

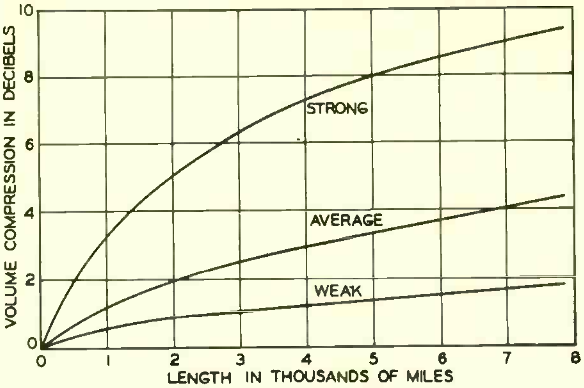


Fig. 4—Compression increases with circuit length as well as with speech intensity. The three curves show the effect for strong, average and weak voices. The distortion accompanying a volume compression of from 2 to 4 db is hardly noticeable in a telephone receiver but larger values can easily be detected

Although compression increases at the higher frequencies this is, in part, offset by the fact that in telephony the voice currents at high frequencies are generally weaker than those near one thousand cycles. These weak high-frequency currents may, nevertheless, be subjected to compression from the effects of stronger low frequencies which are transmitted with them even though the compression that is caused by their own intensity is relatively small.

That these effects are easily perceptible to the ear was established by listening to speech transmitted over various lengths of the circuit. The speech received over the line was compared with that received over an artificial circuit which had the same noise, the same overall loss, and the same transmission frequency characteristic as the real line had for weak inputs. In this comparison the additional gain needed at the receiving end of the real line to make speech received over it sound as loud as that over the artificial line was determined. These amounts of gain are shown in Figure 4.

In addition to causing volume loss and quality distortion, compression also causes the incidental weak currents of the circuit to increase relative to the stronger speech waves when the speech waves cease. These incidental currents consist of noise, cross-talk, transients, and echo. Transients, for example, are relatively stronger when the transmitted waves producing them are large than when they are small. To illustrate this, oscillograms, such as those shown in Figure 5, were taken of spurts of testing current transmitted over a 4000-mile circuit. The stronger current (a) was about 15 db greater than the weaker (b) all along the line. This difference in amplitude was made up at the end of the circuit by increasing the receiving gain for (b). In the case of the strong pulse shown in (a) the transient current starts out fairly strong at a frequency which is low compared with the fundamental (2690 cycles per second). After a time, t_1, the wave builds up to full amplitude. When the impulse ceases, there is a strong transient characterized by gradual reduction in amplitude and increase in frequency.

Now consider the weak current picture in (b). The initial transient starts at a lower amplitude than in (a), but the building-up time is about the same. The final transient, however, dies away faster and at the end of the time t_2 is obviously weaker than in (a). Such oscillograms indicate that the transients should sound worse when the transmitted currents are strong and the compression effect is great than when the currents are weak; and this was confirmed by listening tests.

Fortunately, there are adequate means for suppressing transients and echoes even though they are exaggerated by compression. The other effects of compression are kept at a minimum by careful attention to detail in the design of the coils and vacuum tubes, and by care in arranging the lines so that the repeater spacings and gains will not be excessive. In this connection it may be pointed out that it is not practicable to reduce compression by using low volumes on the lines. This is precluded by the presence of noise above which the transmitted waves must stand out to be intelligible.

At the present time, the effects of amplitude compression are of minor importance even on the longest cable circuits in service. This is due in part to the knowledge gained by tests in the field such as have been described, in part to laboratory work, and partly to the coördination of all the factors entering into such effects, from the raw materials to the completed call.

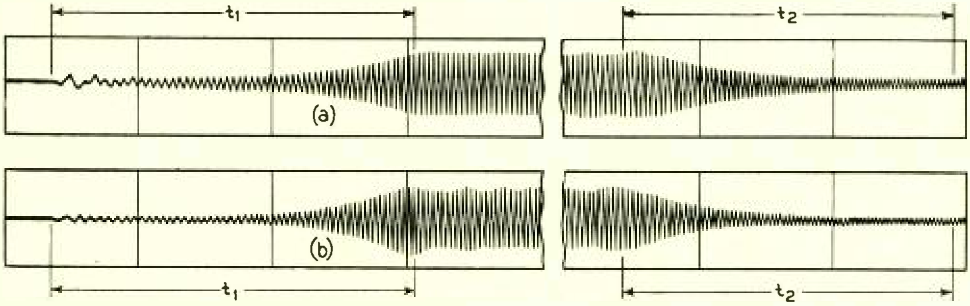


Fig. 5—One effect of compression is to make the transients relatively louder when the line current is strong (a) than when it is weak (b). This is shown by the relative amplitudes during the building-up and dying-away periods t_1 and t_2

New Telephone Booth

By F. A. KUNTZ

Telephone Apparatus Development

BECAUSE of the premium on space in many public places where telephone booths are needed, the present standard booth* has been designed to be economical of floor area. For some places, however, such as clubs and hotels, where it is desired to provide more space in the interest of the comfort and convenience of telephone patrons, a larger booth has recently been developed.

This new booth is the same in height as the standard type but is eight inches wider and six inches deeper, thereby affording sufficient room for a comfortable revolving chair which is of appropriate design to harmonize with the rest of the booth. The coin collector is located in the corner. The door is made in two parts, hinged together so as to fold back against the inside of the booth, as in the present type, and is provided with full-length bevelled glass panels. Two-thirds of the front area is occupied by the door and the remaining space by a fixed glass panel, thus giving the front of the booth a symmetrical appearance when the door is closed and providing increased illumination and visibility. The steel floor and the rubber floor covering, which extends six inches up the sides of the booth, are the same as in the standard booth. The smooth sheet steel lining which covers the side walls of the booth is finished in mottled brown and gold.

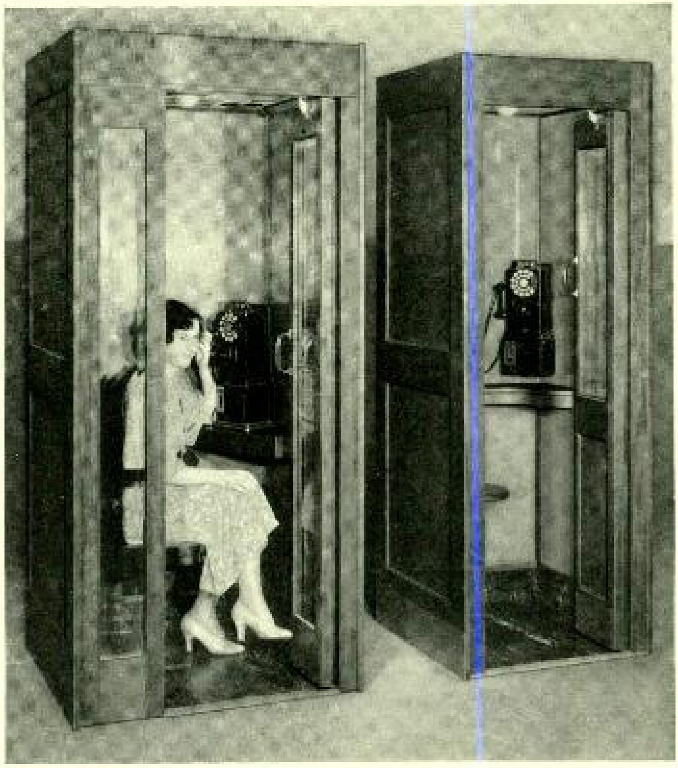


Fig. 1—The new telephone booth is larger than the standard type shown at the right. It is equipped with a revolving chair for added convenience. The door which would normally be closed when the booth is in use has been left open in order to show the arrangement of the interior equipment more clearly

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*Record, *May*, 1930, p. 421.

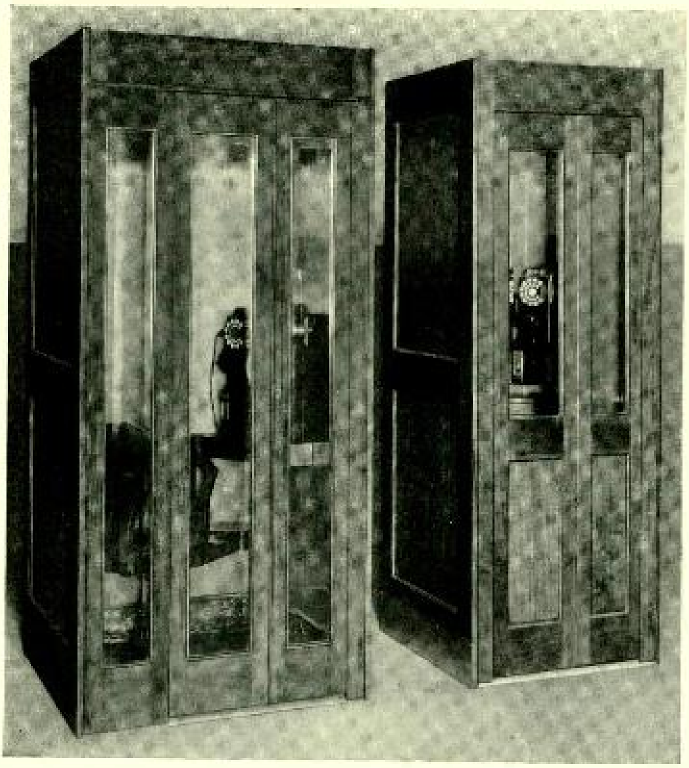


Fig. 2—The new booth is equipped with full-length glass panels for increased illumination and visibility

Another feature is the provision of a built-in ventilating fan. This is housed in a compartment above the ceiling and forces air downward into the booth through a grille. The intake in the top of the booth is covered with a screened cowl. The air escapes through the lighting fixture in the ceiling to a grille in the roof and also through a gap underneath the door. A continuous change of air is thus obtained. The fan, which has been specially designed and mounted to insure quiet operation, is normally controlled by the door switch which turns the fan off when the door is open. An additional switch is provided near the coin collector so that the patron may turn the fan off and on at will when the door is closed. Parts of the standard booth have been used in the new design wherever possible without sacrificing comfort, convenience or appearance. The light fixtures, hardware and switch operating mechanism for example are standard parts.

The new booth is available in walnut and light or dark mahogany and is arranged so that it can be used singly, in groups, or in conjunction with standard booths.

Testing for Air Contamination in Manholes

By A. P. JAHN
Outside Plant Development

THE air in any poorly ventilated underground place may become contaminated with gases which can be ignited or are injurious to breathe, or the air may become deficient in oxygen. Such contamination is not uncommon in mines and may sometimes occur in manholes as a result of accidental leaks in gas mains. Carbon dioxide or other gases which originate from sources other than gas mains may also occasionally accumulate in manholes and leave insufficient oxygen. To guard against these conditions simple and effective tests have been devised.

A natural way to judge whether the air in a manhole is contaminated is to note its odor. A person with a normal sense of smell can usually detect manufactured gas in this manner but sometimes this gas has very little odor because it has entered by infiltration through soil which has largely absorbed the odorous ingredient. Natural gas is odorless unless, as is sometimes the practice, an odorous constituent is deliberately added as a safety measure. Naturally the sense of smell cannot detect a deficiency of oxygen. This condition is found most often in the bottom of deep manholes where carbon dioxide, which is heavier than air, has collected. The deficiency of oxygen is most likely to occur at certain times of the year in manholes which contain stagnant water or are located near refuse dumps where the decaying of various organic substances has produced carbon dioxide.

Fig. 1—A. P. Jahn demonstrates the heater and heating element of the carbon monoxide detector for manholes

To provide a positive method for testing manholes for explosive or suffocating gases, safety lamps are used. These devices, which resemble lanterns in general appearance, operate on the principle of a miner's safety lamp, that is, a wick-fed flame burns inside a protective mantle of bronze gauzes. Air from the outside passes through the gauzes to support the combustion of the flame but the mantle remains cool enough because of heat radiation and conduction to prevent any inflammable gas, except hydrogen, in the air outside from being ignited. The lamps are provided with sparking devices for igniting the wick, and with screw adjustments to regulate the height of the flame.

Any alteration of the height of the flame after it has been adjusted in normal air is an indication of an abnormal atmosphere. A deficiency of oxygen will cause the flame to lower, flicker, or go out. If a combustible gas is present in amounts too small to change substantially the oxygen content, the flame may rise slightly. If there is considerable combustible gas present, the lamp may go out with an explosive puff.

One design of safety lamp--the Natural Gas Indicator—was standardized several years ago for use in the Bell System. To make a test for contaminated air, this lamp, with flame properly adjusted, is lowered into the manhole. A hinged mirror on the side of the lamp reflects the image of the flame to an observer at the street level. This indicator is employed in areas supplied only with natural gas to test manholes for such gas or for oxygen deficiency. It cannot be used safely for this purpose in areas which use manufactured gas or mixtures of this gas with natural gas because manufactured gas contains hydrogen which is apt to be ignited by a flame in spite of the protection afforded by gauze housings. Consequently, a modified form of safety lamp, called the Suction Gas Indicator, has recently been standardized for test work in areas which use manufactured gas.

The new design of indicator is not lowered into the manhole, but is equipped with an aspirator bulb to draw air from the manhole through a hose and pump it into the combustion chamber of the lamp positioned above ground. The apparatus contains a flame arrestor which prevents the flame from travelling back through the hose and igniting any explosive hydrogen in the manhole.

Poisonous gases are not positively indicated by any safety lamp test. Fortunately the only poisonous gas likely to be encountered in telephone manholes is carbon monoxide which is always a constituent of gas made from coal or coke. A chemical test, made with a device called the Carbon Monoxide Detector, is used in the Bell System to detect this gas. The detector consists essentially of an easily crushed glass ampoule which is encased in absorbent cotton and contains a chemical which darkens by reaction with carbon monoxide. The crushed ampoule is suspended in the manhole for ten minutes and its color is then compared with the scale on a special color chart.

The ampoules are sealed glass tubes about one and one-quarter inches long and three-sixteenths inch in diameter which contain a solution made of palladium chloride, sodium chloride, acetone, and distilled water. The palladium chloride is the essential ingredient; it reacts with carbon monoxide to precipitate finely divided black palladium. The precipitate darkens the cotton covering on the ampoule to a shade of gray which depends on the quantity of monoxide gas present and on the duration of exposure. The sodium chloride increases the stability of palladium chloride against decomposing on aging. The acetone provides a medium in which the chemicals are more soluble than in water alone and it also prevents the solution from freezing in cold weather. Because the determination of the amount of carbon monoxide gas depends on a color chart comparison, the ampoule is encased in a glassine envelope to keep the cotton clean and prevent it from being soiled during the crushing operation.

The color chart is a card on which is printed a graduated strip of colors ranging from straw color to dark gray. These graduated colors correspond to those which the saturated cotton will assume after exposure for ten minutes in air which contains carbon monoxide

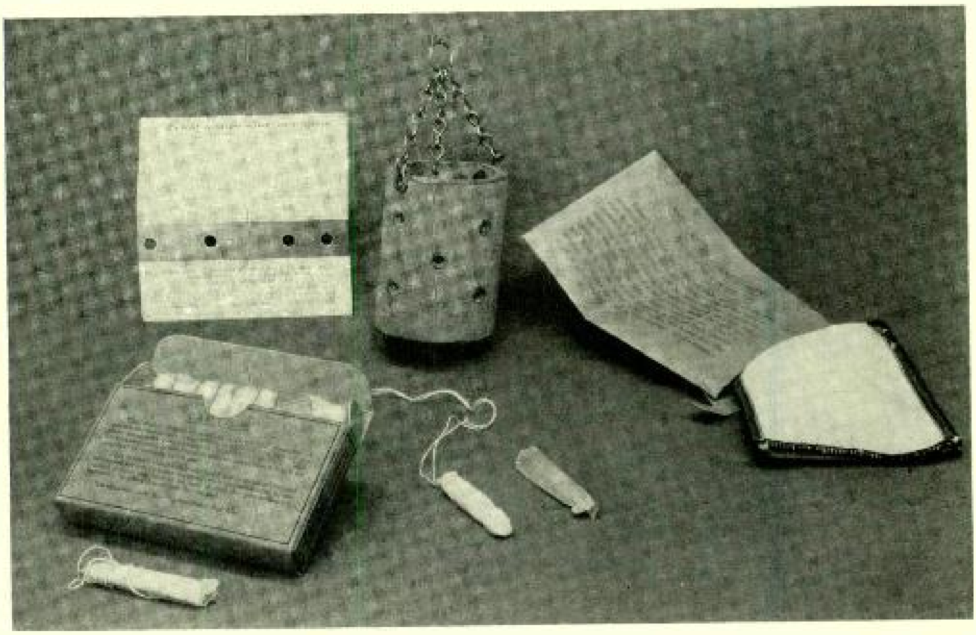


Fig. 2—Complete equipment for the carbon monoxide test—palladium chloride solution in glass ampoule covered with absorbent cotton, color chart, heater, and heating element

in amounts varying from one to ten parts of the gas in 10,000 parts of air. A concentration of carbon monoxide greater than six parts in 10,000 parts of air is unsafe and extreme caution must be exercised in its presence.

The reaction of the solution with carbon monoxide becomes slower at low temperatures, and to prevent a retarded action from giving a wrong indication, a heater has been provided for use whenever the temperature is below forty degrees Fahrenheit. The heating element consists of a small flat canvas bag which contains certain chemicals and a sealed glass vial of salt water. When this vial is crushed, the release of the water starts an electrochemical action which evolves considerable heat. In cold weather the detector is placed in a brass tube around which the heating element is wrapped, and this assembly is then placed in a short section of heat insulating hose, which is lowered into the manhole. The air which flows through the brass tube around the detector is kept warm by the heater for the time required for a test.

Gas masks have been considered for use in manholes, but they are too uncomfortable to wear at regular work. It is preferable to test for gas conditions first, and if gases are found to remove them by ventilating the manhole. In this way the men are assured of safe conditions and at the same time are not hampered in their work by awkward apparatus.

The effectiveness of the present tests is attested by the fact that their use has practically eliminated lost-time accidents attributable to contaminated air in manholes.

Studies of Single-Sideband Short-Wave Transmission

By N. F. SCHLAACK
Radio Research

WHEN a carrier frequency and a band of speech frequencies are combined in a non-linear device such as a vacuum tube modulator, there appear in the output circuit—in addition to the frequencies impressed—two groups of frequencies, one above and the other below the carrier. These groups of frequencies are normally referred to as sidebands. When the carrier frequency and both sidebands are radiated—as is the usual practice in radio transmission—and are impressed on a detector, the two sidebands add in phase so as to reproduce the frequencies of the original speech.

At complete modulation of the carrier in a double-sideband system, the combined voltage amplitude of the two sidebands is just equal to that of the carrier. Each sideband contains all the intelligence-bearing elements necessary to reproduce the original speech frequencies and the carrier performs no useful function except to simplify demodulation at the receiver. This is a very important function in broadcasting, since a large number of receivers are thus supplied with carrier in a simple manner. But for point-to-point telephony, where but a single receiver is involved, it is inefficient because one-half of the available amplitude capacity of the system is used up for sending carrier and only the remaining half is available for the intelligence-bearing frequencies. This inefficient method of transmission has nevertheless been almost universally employed because of its simplicity.

If the carrier and one sideband are suppressed after modulation, it is evident that the entire available voltage-amplitude capacity of the equipment may be utilized by the single remaining sideband. Besides this advantage, such a system requires only one-half the space in the frequency spectrum necessary for a double-sideband system. Both of these advantages contribute to a more effective received signal. Viewed from the point of reception, the effectiveness of a signal depends not alone on its amplitude but on the ratio of the amplitude of the signal to the amplitude of the noise. On the basis of equal voltage amplitudes at the transmitter, and complete modulation for double-sideband, a single-sideband suppressed-carrier system gives a four-fold increase in demodulated signal power over a carrier and double-sideband system. Furthermore the halving of the frequency range decreases the noise power by one-half. There is thus theoretically an eight-fold gain, or an improvement in signal-to-noise ratio of approximately nine db.

In the reception of single-sideband suppressed-carrier transmission it is necessary to supply a local carrier to the detector to demodulate the signal. If undue distortion is to be avoided, the applied carrier must be within about twenty cycles of the correct value. At carrier telephone frequencies this is not difficult, and the single-sideband suppressed-carrier method of transmission was successfully utilized very early in the design of carrier equipment. In the long-wave transatlantic telephone system, the necessary stability is more difficult to obtain on account of the higher frequency. At the frequencies employed for the short-wave transatlantic telephone systems—varying from 5000 to 20,000 kilocycles—the maintenance of the required degree of synchronization for any extended period of time places a very severe requirement on the frequency stability of both transmitting and receiving oscillators.

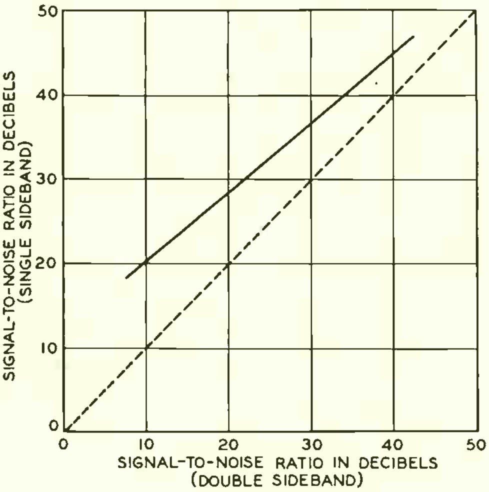


Fig. 1—*Measurements of signal-to-noise ratios for single- and double-sideband transmission. The dotted curve represents equal signal-to-noise ratio for both systems*

This was confirmed experimentally in some preliminary tests of a short-wave single-sideband system made between Deal, New Jersey, and New Southgate, England, in 1928. A specially constructed temperature-controlled crystal oscillator was used at the transmitter, and a local carrier frequency for the receiver was obtained by beating a low-frequency oscillator of the tuned circuit type with a crystal oscillator. During these tests it was found that the local oscillator at the receiver had to be adjusted continuously to maintain the oscillator frequency in proper relation to the incoming sideband. When the correct local carrier frequency was maintained, however, marked improvements in signal-to-noise ratio over normal carrier and double-sideband transmission were observed.

It was realized at the time that a highly stable carrier oscillator at the receiver would be unnecessary if a pilot frequency were transmitted over the channel. For this purpose the carrier itself reduced in amplitude, would serve as well as, if not better than, any other frequency, since it is easily obtained at the transmitter and readily utilized at the receiver. The development of a single-sideband system incorporating the reduced carrier feature was temporarily postponed, however, so that the completion of the short-wave transatlantic circuits, then under construction, might proceed as rapidly as possible.

The study of the virtues of single-sideband transmission was continued later along another line. Receivers were built that could separate the sidebands and carrier of ordinary double-sideband transmission so that single-sideband and other types of transmission could be simulated. This work was begun at Holmdel. After some of the fundamental features had been worked out, a receiver more suitable for commercial tests was installed at Netcong, where additional observations were made on the performance of transatlantic signals. These tests revealed no insurmountable difficulties in the reception of single-sideband transmission.

To obtain more quantitative information on the improvement to be realized from single-sideband reduced-carrier operation, and a better understanding of the requirements of commercial single-sideband equipment, apparatus was constructed during 1933 for an extensive trial of a short-wave single-sideband system over a transatlantic channel. Transmitter input equipment was constructed which was capable of delivering a single-sideband signal to the input of the water-cooled amplifiers ordinarily used for double-sideband transmission. This equipment was sent to Rubgy, England, and with the coöperation of the British Post Office was installed for use with one of their transatlantic transmitters. For comparison purposes the normal double-sideband output of this same transmitter was used. A single-sideband receiver, having a number of novel features, was constructed and installed at the transatlantic receiving station at Netcong, New Jersey. During the latter part of 1933 and the early part of 1934 comparative tests of double- and single-sideband transmission were conducted between the British Post Office headquarters in London and the Laboratories at West Street.

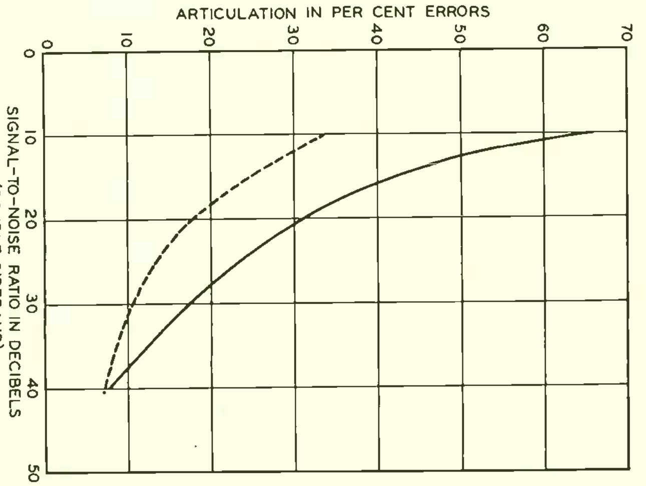


Fig. 2—Comparative results of articulation test made on single- and double-sideband transmission systems

Short-wave radio conditions are seldom constant and to determine quantitatively the relative merits of two radio systems, such as those employing single- and double-sideband transmission, is not a simple matter. Three types of tests have been used for rapidly obtaining information on the performance of radio circuits. They are a determination of the signal-to-noise ratio, articulation tests, and observations of circuit merit. In determining signal-to-noise ratio the transmitter is modulated a given amount and the tone at the receiving point measured. The tone is then removed and the noise measured with the same equipment. The difference in db between the two is the signal-to-noise ratio. Articulation tests involve reading over the circuit meaningless syllables, carefully chosen words inserted in a variety of sentences, or a simple list of words chosen at random from the dictionary and inserted in an unvarying phrase. A record is made at the receiving end of the words or syllables as understood by a group of observers. The correctness of the result is a measure of the circuit performance. "Circuit merit" measurements are composite figures on an arbitrary scale representing the operator's judgment of the commercial value of the circuit, and are made as a matter of operating routine on the transatlantic channels.

All observations were made while transmitting on 9790 kilocycles, the system having an audio-frequency band from 250 to 2800 cycles. Successive observations were made on single- and double-sideband transmission for nine-minute intervals.

The results of the signal-to-noise measurements are shown in Figure 1, where the ordinate scale is the signal-to-noise ratio for single-sideband, and the abscissa scale that for the double-sideband system. The curve shown is a representative line through the large number of points obtained, each point being the signal-to-noise ratio observed on the single-sideband system at a particular period plotted against the average of the preceding and succeeding values of signal-to-noise ratio measured on the double-sideband system. When the signal-to-noise ratio on double-sideband was ten db, that for the single-sideband was ten db higher. When the signal-to-noise ratio on double-sideband was forty db, however, that on single-sideband was only five db higher. The cause of the lesser improvement for the higher signal-to-noise ratios has not been entirely explained, but was probably due to limitations of the signal-to-noise ratio of the transmitting equipment.

Upon occasions, the advantage of the single-sideband system was considerably higher than the average shown by the curves. It is known that at times the two sidebands of a double-sideband system may be shifted in phase relative to each other and the carrier so that the audio-frequency components add at random rather than directly in phase. Under such circumstances the received signal-to-noise ratio of the double-sideband system would be reduced by three db relative to the single-sideband system. Further, under bad fading conditions the double-sideband system may suffer because of the lack of an adequate carrier at the receiver. The single-sideband receiver used in these tests had provision for an adequate carrier while the double-sideband receiver did not. These facts may account for the occasions of exceptional improvement in reception.

The articulation of the two systems was compared by using words of three syllables taken at random from the dictionary. They were inserted in the phrase "Write down . . ." The observations were made by trained crews in the usual manner under the supervision of the Laboratories groups engaged in articulation testing. Results for the two systems are shown in Figure 2, where the solid line is the average for the double-sideband system, and the dashed line, for the single. Here the percentage error in articulation is plotted against the signal-to-noise ratio on the double-sideband system. The improvement due to the use of single-sideband is the difference in the abscissas of the two curves for the same percentage articulation. This is seen to average about eight db for intermediate values of signal-to-noise ratio.

Circuit merit observations were in substantial agreement with the results of the signal-to-noise ratio and articulation tests.

A higher signal-to-noise ratio and a higher percentage articulation mean that a radio circuit not only is easier to communicate over but has increased reliability and more margin against adverse transmission conditions. It is evident from these tests that single-sideband offers a possible way of making important improvements in short-wave circuits.

A Broadcast Frequency Measuring Set

By W. M. KELLOGG
Radio Development Department

RADIO broadcast stations of this country operate on frequencies assigned by the Federal Communications Commission, and to stabilize the whole system of frequency assignments, each station is required to maintain its nominal frequency within ±50 cycles. In the production of crystals for broadcast stations, and in testing their frequency control equipment, it is necessary to make use of frequency measuring apparatus. To provide such apparatus in a more convenient and easily operated form than has been available before, the Radio Department has developed improved frequency-measuring equipment for use in the Laboratories for the precise measurement of broadcast frequencies. The appearance of the completed apparatus is shown in Figure 1.

This equipment measures the deviation of local or distant transmitters and crystal-controlled oscillators from their assigned frequencies. The measuring method employed is one of indirect comparison between the assigned frequency, which is derived from a local standard, and the unknown frequency. The assigned frequency and the unknown frequency are in turn reduced to an audio frequency by means of a beating oscillator and modulator, and the frequency deviation is measured by means of an audio-frequency oscillator that has been calibrated.

A block schematic of the system, showing the major pieces of equipment, is given in Figure 2. A 10,000-cycle frequency, employed as the measuring standard, is obtained from the Laboratories' high precision source, and is accurate to better than one part in a million. This frequency is supplied to a harmonic generator, which produces all harmonics up through the broadcast range, extending from 550 to 1500 kilocycles. This

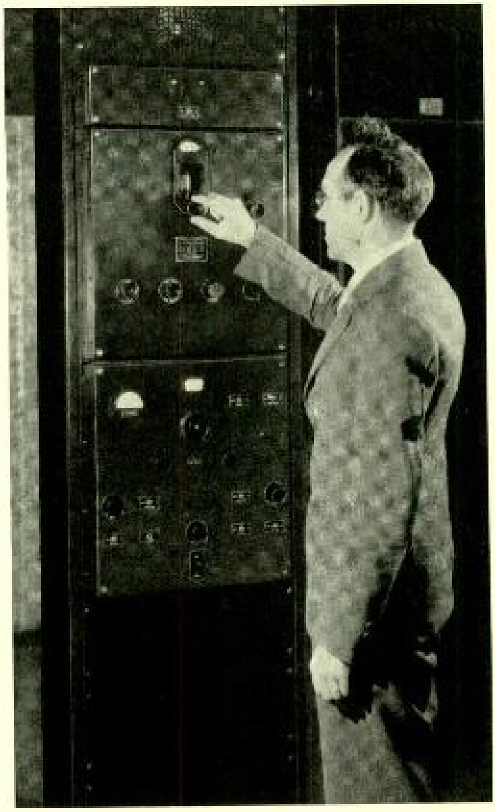


Fig. 1—Setting the radio-frequency tuning dial at the frequency to be measured prior to making a frequency measurement

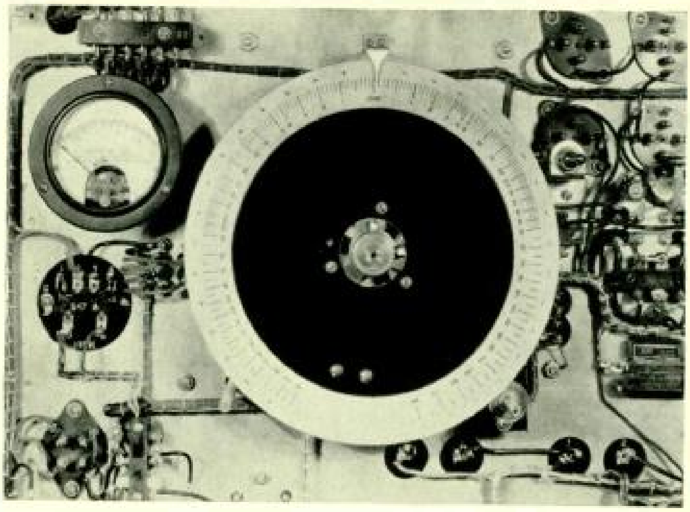


Fig. 3—A dial, only the top central portion of which is visible from the front of the panel, indicates the error to at least one cycle over the important range of variation

provides a reference frequency, better than one part in a million, for each broadcast assignment. The particular reference frequency desired is selected by a tuned radio-frequency amplifier. The tuning of this amplifier is "ganged" with that of a radio-frequency oscillator covering the broadcast range. This gang-tuning is arranged, however, so that the oscillator frequency is always approximately 1000 cycles below the broadcast frequency selected. Thus, when the tuning dial is set for 600 kilocycles, the output of the oscillator will be approximately 599 kilocycles.

The output of the amplifier and oscillator is supplied to the modulator, which yields a difference frequency of approximately 1000 cycles. This is combined with the output of the 1000-cycle measuring oscillator, and after passage through an audio amplifier, the resulting beat frequency is indicated both by a loud speaker and by a beat indicator. The loud speaker is the best indicator when the beat frequency is relatively high, but as it approaches zero, the beat indicator gives the most accurate indication, and is employed for the final setting to "zero beat."

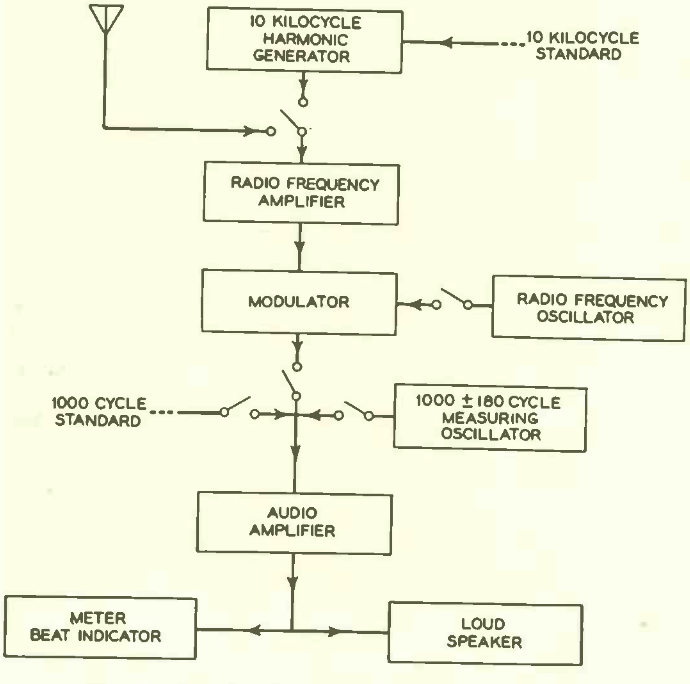


Fig. 2—Block schematic of measuring apparatus

When making a measurement, the radio-frequency tuning dial is set for the assigned broadcast frequency, and connection is made to the harmonic generator. The frequency of the radio-frequency oscillator is then adjusted until the output of the modulator is exactly 1000 cycles, indicated by a zero beat on the beat indicator with the measuring oscillator set at 1000. Under these conditions the frequency of the RF oscillator is exactly 1000 cycles below the reference frequency obtained from the harmonic generator.

The RF amplifier is then switched from the harmonic generator to an antenna, which is used to pick up the frequency to be measured. The output of the modulator will now be 1000 cycles plus or minus the amount by which the frequency being measured differs from the correct, or reference, frequency. When this output is combined with that of the measuring oscillator, the beat frequency will be an exact measure of the frequency deviation, which may therefore be read directly from the tuning dial of the measuring oscillator after the latter has been adjusted to bring the beat frequency to zero. The tuning dial of the measuring oscillator, shown in Figure 3, is calibrated to read from 180 cycles below to 180 cycles above 1000 cycles. The scale of the dial is expanded in the mid-scale range, thus providing for greater precision in the measurement of slight deviations. Deviations of 4 cycles or less can be read to 0.1 cycle, and deviations of 50 cycles or less can be read to 0.5 cycle.

The only high-precision standard frequency required is that supplied to the 10-kilocycle harmonic-generator. While as at present set up a standard of approximately the same accuracy is employed to check the measuring oscillator, this is not essential, since the frequency of this oscillator may differ somewhat from 1000 cycles without causing any appreciable error in the measurement. It is essential only that the frequency of this oscillator remain constant during a measurement, and since it has a frequency of only 1000 cycles and a precision of only slightly better than one cycle is desired, the necessary constancy of frequency for measurement purposes is easily obtainable.

A similar requirement applies to the radio-frequency oscillator, which must also maintain its frequency constant to better than one cycle during the two or three minutes required for a measurement. Greater care must be taken with this oscillator than with the measuring oscillator, however, be-

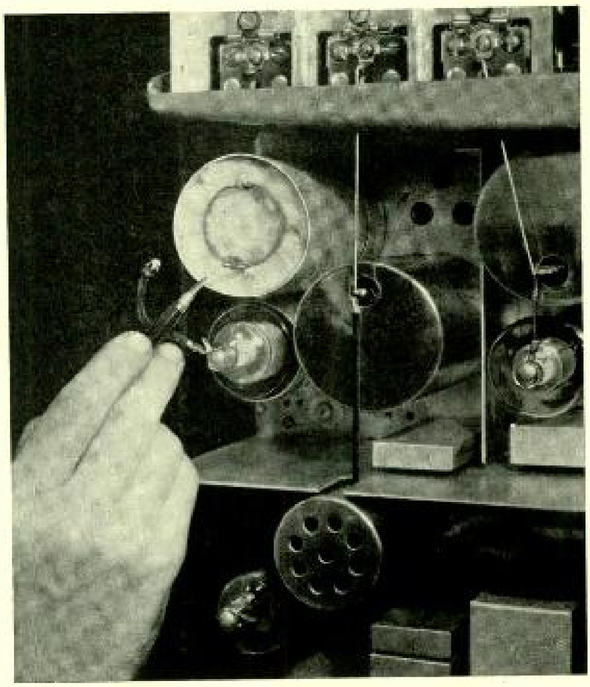


Fig. 4—Rock Wool thermal insulation is employed to stabilize the temperature of the tuning coil of the radio-frequency oscillator in the measuring equipment

cause its frequency is much higher and hence the required precision is also greater. The voltage supplies for this oscillator are kept constant by special regulatory devices, and the tuning coil is completely surrounded by Rock Wool insulation to prevent rapid temperature variations, as shown in Figure 4. In this way the oscillator is stabilized so that it fully meets the desired requirements.

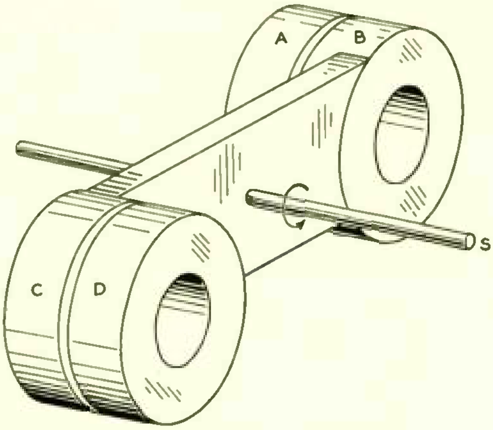


Fig. 5—Schematic representation of variometer employed to adjust the frequency of the measuring oscillator

The frequency of the measuring oscillator must be capable of being varied appreciably above and below its nominal frequency. This is accomplished by a special variometer which is used as the inductance of the tuned circuit of the oscillator. The arrangement of this variometer is indicated in Figure 5. Coils A and D are stationary while the coils B and C are mounted on a common yoke, which may be rotated with the shaft, S. This shaft, in turn, is geared to the tuning dial shown in Figure 3. Coils A and B are connected in series aiding and are in parallel with the series aiding combination of coils C and D. The wiring directions are such, however, that when the shaft is rotated 180 degrees, coils A and C, and B and D will be in opposition. The inductance is a maximum with the coils in the position shown in the illustration, and a minimum when rotated 180 degrees, and is at intermediate values for intermediate positions.

Halfway between the two extreme positions corresponds to the position on the dial marked 1000, with minus deviations marked to the right, and plus to the left. The dial is set to this mid-position when the calibration is made against the standard at the beginning of a measurement. The variation of inductance per degree of rotation is small in this position, thus spreading out the graduations on the scale at the small deviations, but the variation becomes greater as the coils approach the extreme positions.

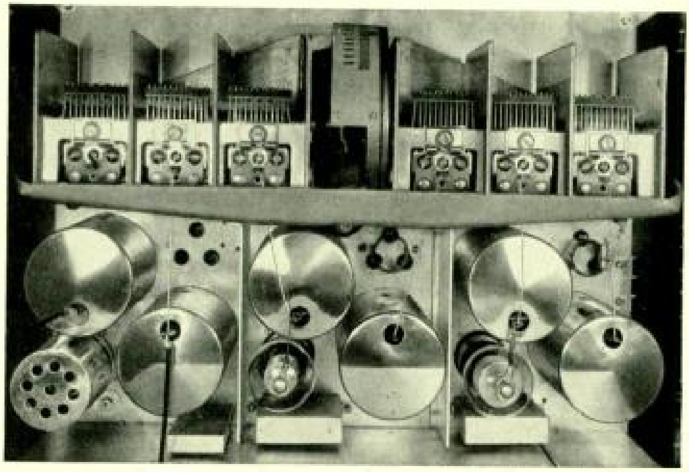
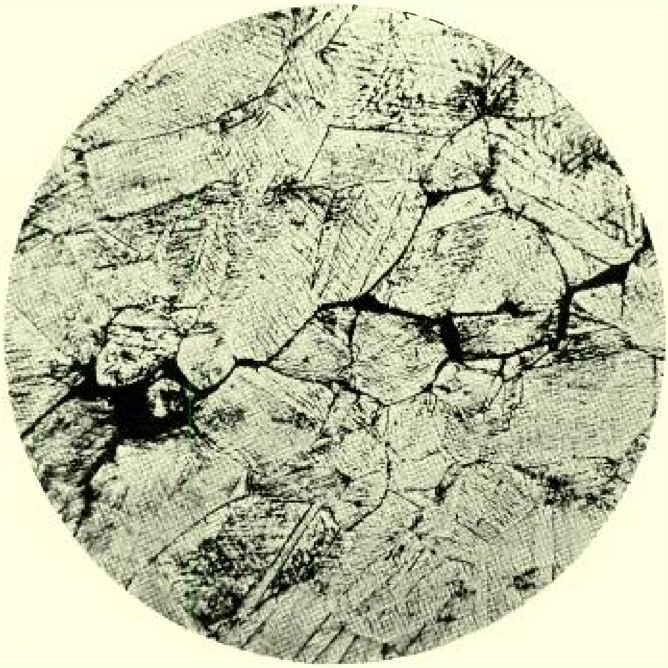


Fig. 6—A rear view of the gang tuning unit of the radio-frequency oscillator shows, in the upper center, a part of the dial used in selecting the required frequency of the harmonic generator

The change in inductance required to change the frequency a given number of cycles above the nominal value is less than that required to produce an equal change below the nominal. To compensate for this difference, and thus to have the same amount of rotation produce the same change of frequency on each side of the nominal value, the coils B and C are not mounted symmetrically on the supporting yoke. This yoke is, in effect, mounted to the right of the center of coil B and to the left of the center of coil C. This arrangement brings the coil B close to A and C close to D in the maximum inductance position shown, but when the yoke is rotated 180 degrees there will be an appreciable gap between each of the two pairs of coils. This arrangement of apparatus permits a symmetrical frequency calibration above and below the mid-frequency point.

The set is operated directly from a 60-cycle, 110-volt power supply, and requires in addition only the 10-kilocycle standard frequency and a calibrating frequency for the measuring oscillator. The sensitivity of the receiving equipment is such that received signals as low as four microvolts can be measured. While developed primarily for work in connection with crystal production, this set is suitable for measuring the frequency of broadcast stations, and its sensitivity gives it a wide range.



Photomicrograph of a section of a telephone gong that has suffered corrosion cracking. The failure is intercrystalline, and the surrounding structure is plastically strained

The Telephone As a Conference Aid

By J. F. D. HOGE
Special Products Development

THE rapid progress made by scientific and business effort in modern times is, to a large extent, the result of the subdivision of tasks and the specialization of activities. Many minds are brought to bear on the problems of the moment, and each contributes his share from his particular point of view. When those who are thus related in business activity are separated, the telephone becomes a very important factor, and its advantages constantly contribute to the speed of the work. It has become increasingly evident, furthermore, that the possibility of having a telephone conversation simultaneously with several people at one or both ends of the line adds materially to the speed and effectiveness with which important conclusions can be reached.

To provide for this service, a small compact unit, known as the 100-type loud speaker set, was developed in 1933. This set is housed in a small wood cabinet, weighing approximately eleven pounds. It has sufficient sound output to serve a group of from seventy-five to one hundred people under favorable room conditions, and is provided with a volume control and a power switch. The set operates on ordinary 110-volt direct or 25- to 60-cycle alternating current, and may be connected to any lighting fixture or outlet. Heater tubes are used in the amplifier and require about forty-five seconds to obtain maximum efficiency after the power is turned on. The power switch provided has three positions. In the first position, the power is turned off. In the intermediate position a reduced amount of power is drawn from the line, which keeps the heater elements sufficiently hot to insure a quick response when the loud speaker is needed. When the power switch is in this position, however, the set is inoperative. When the power switch is turned to the third position, the set is immediately ready to operate, maximum gain being reached in a few seconds. When it is desired to have the loud speaker ready for operation on short notice, the power switch is placed in the intermediate position. A small pilot lamp is provided to indicate the position of the power switch, the lamp being dark for the "Off" position, dim for the intermediate position, and bright for the "On" position.

Two forms of service are available. In the first, the telephone line is terminated in a two-position key so designed that the line can be connected to either the telephone set or the loud speaker. This key, arranged for mounting on the side of the desk, has two sets of transfer contacts so adjusted as to give a make-before-break sequence to prevent opening of the line circuit during the switching operation. This service is applicable where an address of some length is to be received over the line during which time it is not desired to use the line for talking in the other direction.

In the second type of service the line is terminated in a three-position key. Two positions of the key provide the same facilities as described above. In the third key position the subscriber set is connected to the line with the loud speaker set bridged across the receiver. The third key position is employed with ordinary telephone conversations where rapid alternations in the conversation occur, and with more than one listener at one or both ends of the line, under which conditions it would be inconvenient to the user to switch the key rapidly from the talking to the listening position. With the key in position three, however, there is an electrical path from the transmitter to the loud speaking receiver and an acoustic path from the latter to the transmitter. If the gain in these two paths in series exceeds the losses, a sustained tone or howling results. This imposes a limitation on the gain possible, and on the proximity of the transmitter and loud speaker. A material advance has been made, however, by the design of several networks, which are included in the subscriber set furnished for this service. They are designed to equalize the transmission characteristics between the transmitter and the loud speaker, and also to minimize disturbances of large magnitude but of short duration which would tend to build up to a continuous singing condition. As a result of these two networks, it is possible to employ about fifteen db more net gain in the amplifier than without their use. Upon installation of the apparatus a variable potentiometer in the subscriber's set is adjusted to give the best performance safe from howling for the particular location and subscriber's loop.

The procedure employed in using this equipment is simple. The power switch of the 100-type loud speaker set is turned to the intermediate position in advance of the time its use is required. With the key thrown to connect the telephone set to the line, the call is answered or originated in the regular way with the standard hand telephone set or desk stand. To receive the incoming conversation on the loud speaker, the power switch on the loud speaker is thrown to the operate position and the key is thrown to the desired position. When the conversation is completed, the key is restored to the telephone-set position and the handset or receiver returned to the mounting so as to operate the switchhook. The loud speaker power switch is then turned either to the intermediate or to the "Off" position, depending on whether or not it is expected that its use will again be required in the near future.

The 100-type loud speaker set and associated equipment may be installed on a permanent basis, or as occasion demands, on a temporary basis to serve a particular subscriber group for the time the service is required. The loud speaker sets and their associated equipment are installed and maintained by the telephone company, like the normal telephone installation.

The effect of the addition of the loud speakers to the telephone when used for conference purposes is to broaden its usefulness substantially. It permits those already present in the office, and others who may be called in, to hear the distant person's conversation and if desired, to participate in the discussion as their questions are repeated by the person using the transmitter. The use of the loud speaker saves time and money, expedites decisions, stimulates action, and reduces misunderstandings and errors. In addition, conference telephone service with loud speakers has a particular appeal to business executives since it enables them to get their message over to a group of employees in their own words without change in meaning or emphasis. Employees hear the executive's voice directly as though he were speaking to them personally so that his personality and enthusiasm are carried to them also. This is particularly desirable in selling campaigns, since in practically all lines of business today, better salesmanship and better supervision of sales forces are becoming increasingly important.

Contributors to This Issue

N. F. SCHLAACK received the B. S. degree in electrical engineering from the University of Michigan in 1925 and immediately joined the technical staff of the Laboratories. Here as a member of the Research Department he has been engaged primarily in development of short and ultra-short-wave transmitting equipment for various applications.

F. A. KUNTZ came to the Laboratories in 1919 after having had eleven years of practical experience elsewhere. He has since been engaged in station apparatus development problems and has specialized on telephone booths and accessories. In connection with this work he has been in touch with the manufacturing aspects involved through contact with the Western Electric Company's Queensboro Works. He received the degrees of B.A., B.Sc. and E.E. from the Catholic University of Washington, D. C.

A. P. JAHN received a B.S. degree from Cornell University in 1923. After two years with the U. S. Forest Service he joined the Department of Development and Research of the A. T. and T. Company where he was engaged in studies concerning the design and preservative treatment of timber products used in the outside plant. In 1934 he came to the Outside Plant Development group of the Bell Telephone Laboratories. His duties here have been principally in connection with problems dealing with miscellaneous materials and such items as body belts and

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safety straps for linemen, rubber gloves and other clothing for protection from electric shock, first aid materials, and the development of devices and methods for detecting such hazards to health as contaminated manhole atmospheres.

J. H. Bell spent over two years in South Africa with the Signal Corps of the British army during the Boer War and in 1902 went with the Engineering Department of the British Post Office. He left to join the Western Electric Company at West Street in 1911. Since that time he has been with the Laboratories continuously, engaged in telegraph development work and such allied systems as picture transmission. At the present time he is in charge of telegraph development.

G. C. Southworth came to the Bell System in 1923 after spending a year as assistant physicist at the Bureau of Standards and five years as instructor at Yale University. A year was spent with the American Telephone and Telegraph Company on the newly established *Technical Journal*. This was followed by ten years with the Department of Development and Research, coördinating various short-wave radio telephone activities. Since 1934 he has been in the Research Department of the Laboratories. While with the American Telephone and Telegraph Company, he published papers on wave propagation, antenna arrays, and the nature and behavior of earth currents. He was DeForest lecturer (radio) at Yale in 1927 and 1930, and was a member of the Washington International Radio Telegraph Conference in 1927. While an instructor at Yale he did some of the earliest work with continuous waves at ultra-radio frequencies. This subsequently led to the results described in this issue of the Record. He

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J. F. D. HOGE joined the Engineering Department of the Western Electric Company in 1918. His recent work has included the design of amplifiers and accessory apparatus for public address sound picture and U. S. Navy service. Prior to his work in the Special Products Group, he designed a series of telephone repeaters and mounting structures for telephone apparatus. Before coming to us, he was Chief Engineer of the Maintenance Company, New York City, during which time he was in charge of designing and testing various mechanical and electrical units manufactured by this company and the allied Wheeler-McDowell Elevator Company. For over eight years previous, he had been Development Engineer for the American District Telegraph Company in charge of the Company's Research Laboratory and its Development Shop. A still earlier engagement was with the Westinghouse Church Kerr and Company, consulting engineers. Mr. Hoge received the degree of M.E. from Cornell University in 1906.

S. B. WRIGHT entered the Engineering Department of the A. T. and T. Company in 1919 after graduating from Cornell University with the degree of M.E. in Electrical Engineering. His subsequent association with the Department of Development and Research and the Laboratories has been accompanied by a variety of experiences in connection with telephone transmission over long distances. These have included field studies on long land cables, transcontinental circuits, the first Cuban cables and transoceanic circuits. His present work involves studies of the transmission limitations of wire-radio and other long-distance two-way systems and the application of methods for overcoming or controlling these.