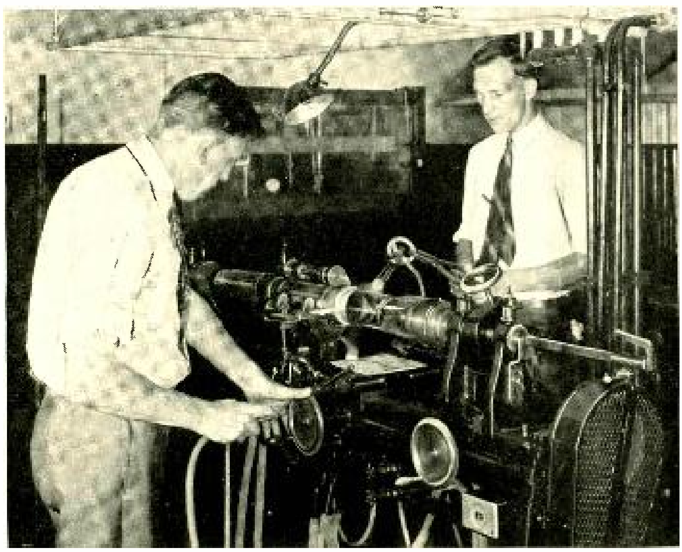
Bell Laboratories Record



J. J. Heil and H. W. Ericsson making copper-glass seals in high-power vacuum tubes (see page 63)

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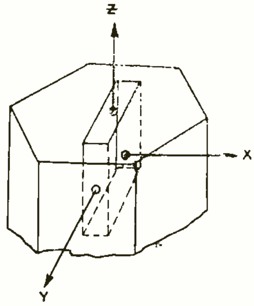
High-Frequency Quartz-Crystal Oscillators

By F. R. LACK
Radio Research

IN common with many communication systems that have come into extended use in the past few years, radio channels have need for a source of frequency whose absolute value is known to a high degree of accuracy and whose relative variations are held to within very narrow limits. Such a source of frequency is used in connection with appropriate amplifiers and in some cases frequency multipliers to supply the carrier wave for the radio system.

The reasons for this rigid frequency specification are obvious to everyone who has used a radio receiver whether for broadcast reception or otherwise. Absolute accuracy and freedom from slow variations of large magnitude are necessary to keep the station at the assigned position in the frequency spectrum and thus avoid interference. Rapid variations must be eliminated if good quality is to be maintained at the receiver.



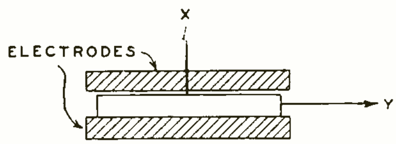


Fig. 1-*A* (*above*)—*Relation of typical quartz plate, used as vibrating crystal for frequency control in radio transmitters, to natural crystal from which it is cut. Fig.* 1-*B* (*below*)—*Relation of quartz plate to electrodes*

The usual means employed for frequency generation in the telephone art consist of a vacuum-tube oscillator in which the electric oscillations set up in a tuned electric circuit are sustained through the medium of a vacuum tube. The frequency of such an oscillator is affected by a number of factors, such as supply voltages to the tube, the load impedance, the temperature of the circuit elements, and the like. The frequency change of this oscillator as ordinarily set up is greater than a tenth of one per cent for a one per cent change in plate battery voltage. The modern operating requirements for a radio station require a constancy of five thousandths of one per cent or better, taking into account all the factors that affect the frequency. This oscillator is thus unsuitable for carrier frequency generation without some radical improvement in stability.

A large amount of experimental and theoretical work has centered about the stabilization of vacuum-tube oscillators for supply-voltage and load-impedance changes and a number of circuit arrangements have been devised which result in a material improvement. Some of these schemes involve the balancing of one disturbing factor against another, while others make use of phase-correcting networks. The most desirable scheme from the standpoint of simplicity uses a circuit whose reactance and resistance change very rapidly with frequency. This implies a sharply resonant circuit—that is, one with very low damping. Such a system can accommodate itself to a new set of conditions, such as changes in tube-supply voltages or load impedance, with a small frequency change, to an extent depending upon how much the damping has been reduced.

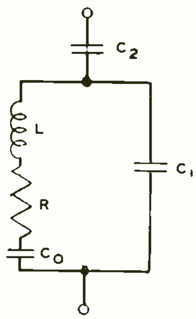


Fig. 2—Circuit electrically equivalent to quartz crystal vibrating in a normal mode

A good measure of the reduction of damping is the ratio of the inductive reactance of the circuit element to its resistance. For well-designed coils this ratio may be as high as three hundred, but mechanical vibrators can be constructed whose equivalent ratio of reactance to resistance is of the order of 30,000. If, then, a mechanical system can be used for the oscillator circuit, a hundred-fold improvement in damping is to be expected with a corresponding increase in frequency stability.

The use of mechanical vibrating systems in frequency generation is not new. The classical example is, of course, the clock pendulum; the clock is a frequency generator whether it delivers electrical impulses or not. There are also numerous applications of tuning forks, driven by vacuum tubes, as frequency standards.

With these mechanical vibrators some means must be provided for transforming the mechanical vibrations into electric oscillations and vice versa. With the tuning fork the transfer is usually accomplished magnetically. This form of coupling is satisfactory for low frequencies, but for frequencies much above ten kilocycles the hysteresis and eddy-current losses tend to defeat the very purpose of using a mechanical system. Moreover at higher frequencies the physical size of the vibrator becomes so small that it is difficult to couple to it.

The use of mechanical vibrators was confined to the low frequencies in the audible range until Professor Cady of Wesleyan University pointed out that the piezo-electric effect in crystals could be used to furnish the necessary coupling mechanism at the higher frequencies. The term "piezo-electric effect" describes that property of a certain group of crystals by which electric charges are generated on particular surfaces when the crys-

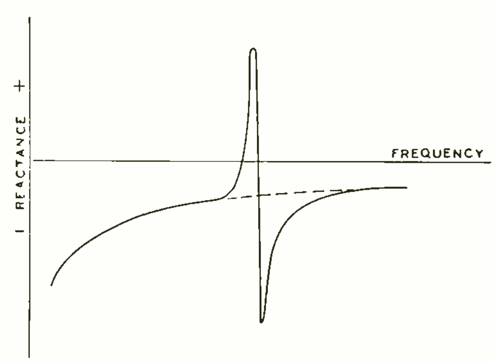


Fig. 3—Reactance-frequency characteristic of a quartz vibrator. The dotted line, for a simple capacity, coincides with the vibrator characteristic except in the region of the vibrator's normal mode

tal is stressed mechanically. Of this group of crystals there are only a few which possess the mechanical qualities necessary for a standard of frequency. Quartz is the most suitable of these because it is easy to obtain at a reasonable cost, offers no serious difficulties in preparation and has very low electrical losses.

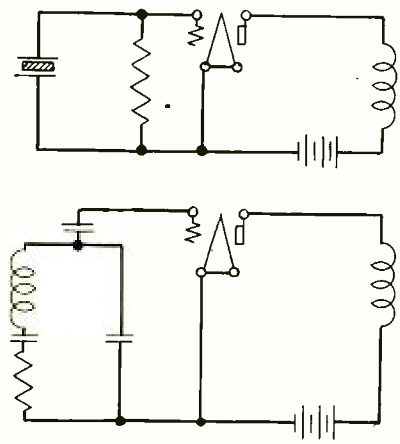


Fig. 4-A (above)—Typical electromechanical oscillating circuit incorporating a quartz crystal. Fig. 4-B (below)—Circuit electrically equivalent to 4-A

Quartz-crystal vibrators can be constructed for any frequency from a few kilocycles to ten megacycles but the ordinary useful commercial limits are from fifty kilocycles to six megacycles. As usually prepared, the vibrator consists of a plate or bar cut from the quartz crystal. Coupling to the element is secured by means of metallic electrodes placed in light contact or in close proximity to the major faces of the quartz. Figure 1-a shows one of the typical methods of cutting a plate with respect to the original axes of the crystal structure, and Figure 1-b illustrates the relative position of quartz plate and electrodes.

The process by which the plate is set in vibration can be described briefly as follows. When a potential is applied to the electrodes, the crystal plate, by reason of the piezo-electric effect, expands in the direction Y and contracts along the direction X. Along the third direction Z of the plate, which corresponds to the direction of the optic axis of the crystal, there is no motion. When the potential is removed, the crystal contracts and develops a voltage of opposite sign on the electrodes. For a steady potential, the magnitude of this effect is small; of the order of 6×10^{-7} centimeters for a potential of 3000 volts. But when an alternating potential having a frequency corresponding to one of the mechanical vibration frequencies of the plate is applied, the familiar phenomenon of resonance builds up the amplitude of vibration to a level at which the forces acting are very considerable. The motion of the surface is sometimes so violent that the crystal "walks" around between the electrodes, and it is not uncommon for a crystal to shatter when vibrating.

The equivalent circuit of a quartz vibrator in the region of one of its mechanical vibration frequencies, or "normal modes" of vibration, is shown in Figure 2. The elements L, R and C_0 represent the electrical equivalent of the mechanical vibrating system. C_1 is the capacity of the plate itself—of a condenser with the quartz plate as the dielectric. C_2 is the capacity of the air-gap between the quartz plate and the electrodes. For a million cycle vibrator, L may be of the order of a half a henry; R, 100 ohms; and C_0, C_1 and C_2, 0.06, 1.0 and 5.0 micromicrofarads respectively. The reactance curve of such a system is shown in Figure 3; except in the region of a mode of vibration, the crystal acts as a simple capacity.

High-frequency crystals are usually used in a circuit similar to that shown in Figure 4-a. The equivalent electrical circuit of this arrangement is shown in Figure 4-b. This type of circuit will only oscillate when the equivalent circuit element on the grid side is an inductive reactance, and, as the crystal is only an inductance in the region of its mechanical period, oscillations can only take place at the natural frequency of the crystal.

Assuming that the low damping of the crystal system is sufficient to reduce the frequency change with change of supply voltages and load impedance to a negligible amount, there are other factors which affect the frequency which have to be considered. Among these are the temperature of the quartz plate and possible change of position of the plate with respect to the coupling electrodes. To take care of these factors the crystal has to be held at a fixed temperature and so supported in the holder that it is free to vibrate but cannot change its position relative to the holder.

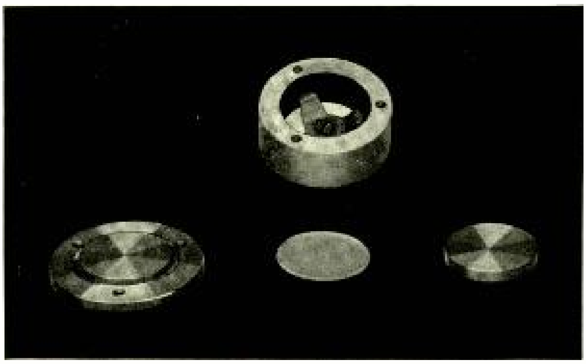


Fig. 5—Quartz crystal and its holder, of the type used at Lawrenceville, disassembled

The designer of a frequency generating system involving a quartz plate, therefore, must know: the relation between the dimensions of the plate and the frequency at which it will vibrate; the decrement of that vibration; its temperature coefficient of frequency; the type of vibration; and finally the fact that the voltage developed by the plate while vibrating will be adequate to insure sufficient coupling between the mechanical and the electrical systems. If a crystal plate could be so cut as to respond to only a single frequency, it would be simple to determine this information for this mode of vibration and write the complete specification. Unfortunately specification is not as straightforward as this.

In the first place, any mechanical system of three dimensions possesses a large number of degrees of freedom. The crystalline nature of quartz further complicates its vibration, for the various elastic constants in a given direction vary as that direction changes with respect to the axes of the crystal structure. As a result, a quartz plate has a large number of possible modes of vibration, some of them within a few hundred cycles of each other. The frequencies of these modes depend upon the orientation of the plate with respect to the crystal axes and the shape and ratio of dimensions of the plate. The decrement, temperature coefficient, voltage developed, and the like, are all functions of the particular mode of vibration set up in the crystal and sometimes have values that are widely different for modes of vibration that are of very nearly the same frequency. Moreover, a slight change in temperature or a variation in the circuit to which the crystal is attached will sometimes cause the crystal to hop from one of these modes of vibration to another.

There has been a large amount of work done, both in these Laboratories and by other investigators, on the factors that determine the relative frequency spacing, activity, and other constants of these modes of vibration. The scope of this article does not permit any comprehensive summary of the result of these studies; hence it will be only noted in passing that it is possible so to cut a plate with respect to the crystal axis, and so to adjust the ratios of the dimensions of the plate in cutting, that certain definite modes of vibration have enhanced activity and thus predominate. These modes of vibration will have a predictable temperature coefficient of frequency.

Such crystals are now being produced on a commercial basis. Figure 5 shows one of these crystals designed for frequencies above two megacycles, with its associated holder. This is the type of crystal now in use in the Lawrenceville short wave radio transmitter. In these crystals the vibration utilized is that which takes place along the direction of the thickness of the plate. This vibration has a temperature coefficient of approximately ninety cycles in a million per degree centigrade, and will develop sufficient voltage to drive a 211-type tube.

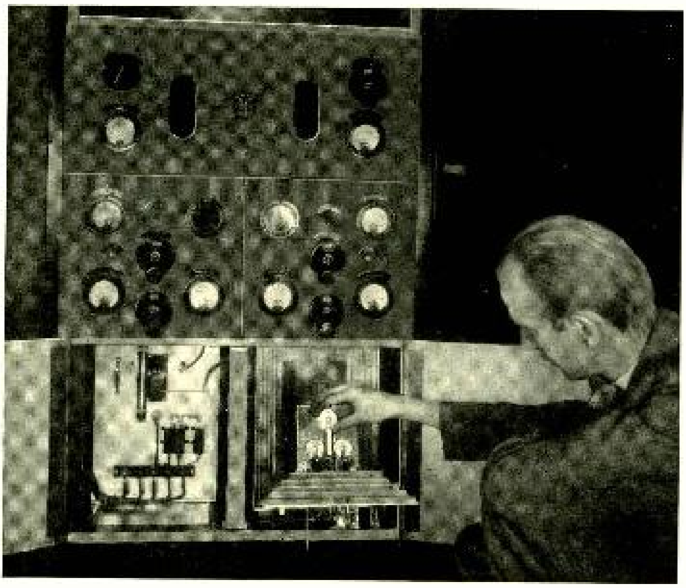


Fig. 6—A. Oxehufwud examining one of the Lawrenceville crystal-installations

At Lawrenceville, three of these crystals are mounted in one oven unit. These three crystals provide the three base frequencies, all in the neighborhood of three megacycles, which are stepped up by succeeding circuits to the three operating frequencies of the station. The crystal holders are fastened to a copper block mounted in a heat insulated container (Figure 6).

The temperature of the block is regulated by means of a heater and resistance thermometer buried in the block. The thermal inertia of the copper acts as a filter and prevents the temperature cycles at the heater from reaching the crystals. The resistance thermometer forms one element of the Wheatstone bridge of a Leeds & Northrup recording thermometer. Contacts provided on this recorder are so adjusted that current to the heater in the block is turned off when the temperature goes beyond fifty degrees Centigrade. By this means the temperature is held at this level to within one-tenth degree Centigrade. This Leeds & Northrup recorder not only controls the temperature but makes a printed record of variation.

In changing frequency, the desired crystal is connected to the grid of the crystal-oscillator tube by a switch on the front of the oven. Since it takes an appreciable time to warm a crystal to fifty degrees C., the complete crystal oscillator including oven and crystals is provided in duplicate, to avoid a shut-down in case of crystal failure.

This crystal oscillator installation is typical of the modern application of these mechanical vibrators. Of the means now known for securing accurate frequency control, the quartz crystal appears to be the best. As telephone and radio requirements become more rigorous, the application of crystals will doubtless be extended. By resort to harmonic and sub-harmonic generation, the frequency range to which crystal control can be applied becomes virtually unlimited.

Short-Wave Vacuum Tubes for Transoceanic Service

By H. E. MENDENHALL
Vacuum Tube Research

WHEN transmission studies showed that carrier frequencies of the order of thirty thousand kilocycles would play a part in transatlantic communication, investigations were immediately undertaken to determine the type of vacuum tubes most suited for transmission systems operating at such high frequencies. It was found that the vacuum tubes which had met the requirements of the transmission systems of the long-wave service, using a carrier frequency of the order of seventy-five kilocycles, were unsuited for short-wave systems. Such tubes could not be operated in parallel at the high frequencies; and, even when used singly, they were extremely short lived unless operated at considerably reduced plate voltages and output powers. There are several reasons why tubes that were structurally satisfactory for the low-frequency range were inadequate for the high-frequency range.

In the first place, at the high frequencies the inter-electrode capacity of the elements of the tube becomes very important from the circuital standpoint. The "charging" or displacement currents which flow through every dielectric in an alternating electric field increase with the frequency of the alternations. These displacement currents heat the various dielectrics whose power factors are not zero, used in and around the tube, thereby causing the ultimate failure of the tube. A "high" vacuum is the only perfect dielectric, for heat is not developed in it through dielectric losses. It can fail only when leaks or a slow evolution of gas from the parts

Fig. 1—Western Electric 240-A tube, to handle ten kilowatts of high-frequency power. The grid lead is at the left; the filament leads are at the right; the plate is the copper cylinder in the center surrounded by the jacket for cooling water

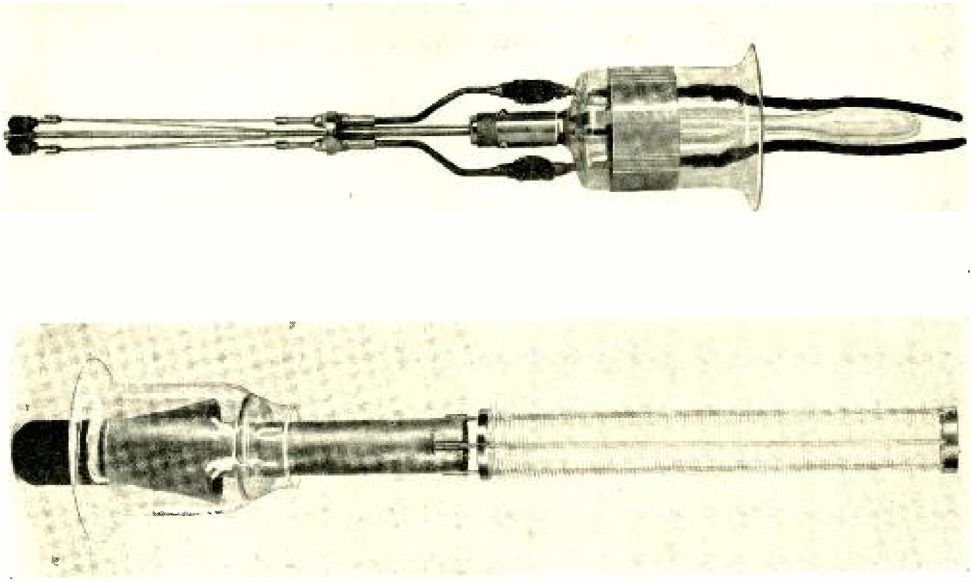


Fig. 2—Filament (above) and grid (below) structures of the 240-A tube

of the tube change both its status as a vacuum and its insulating properties. The air separating the elements on the outside of the tube will be only about one tenth as effective an insulator when the tube is oscillating at thirty thousand kilocycles as compared with the non-oscillating condition, when the same plate potential is applied to the terminals. The same air gap will be disrupted, moreover, by one-twelfth of the applied voltage if it be alternating at thirty thousand kilocycles instead of at sixty cycles.

Another reason for the failure of earlier types of vacuum tubes when used in short-wave circuits is to be found in the "skin effect." A high-frequency current passing through a conductor is forced to travel through a very thin layer at the outside of the conductor. The effective size of the conductor is thus reduced, its resistance correspondingly increased, and overheating engendered.

In view of such facts as these, new tubes had to be developed and old types modified to work with the new circuits. M. J. Kelly suggested several years ago that water-cooled power-amplifiers for short-waves be made double-ended: with the filament structure and leads supported on glass at one end, a water-cooled anode in the middle, and an oversize grid lead supporting the grid structure from the glass on the other end. In this construction a maximum of insulating glass and air separate the leads to the tube elements, and the leads can be made large in "skin" area.

Preliminary models of water-cooled tubes embodying these features were made in the laboratory and these models were supplied for transmission development work at Deal Beach. While this work was in progress, development activities were directed toward the final commercial design of water-cooled tubes so constructed. Such tubes were standardized and made available for the transoceanic short-wave service.

One of these tubes is shown in

Figure 1, and its filament and grid structures in Figure 2. It is the Western Electric 240-A vacuum tube, with an output rating of ten kilowatts in the high-frequency transmission range. Its present form has been reached after many cycles of change in the development process.

This tube was designed to meet short-wave circuit requirements, and then adopted after experimental tubes had weathered a long series of severe tests conducted by C. E. Fay. The circuit used for these tests consists of a shielded push-pull oscillator. A heavy straight lead, tapped in the center with a grid leak, connects the grid terminals of two 240-A tubes under test, which are mounted vertically on Pyrex insulators. The anodes are connected by means of a water-cooled coil, about eight inches in diameter, of three turns of copper tubing. The capacities of the tubes between grid and plate complete the oscillating circuit. The load is applied by shunting a small section of the inductance coil with hollow water-cooled carbon rods. The temperature rise and the volume of the cooling water supplied to the rods give a measure of the total power output. By means of these tests, the power limits of the tube are determined.

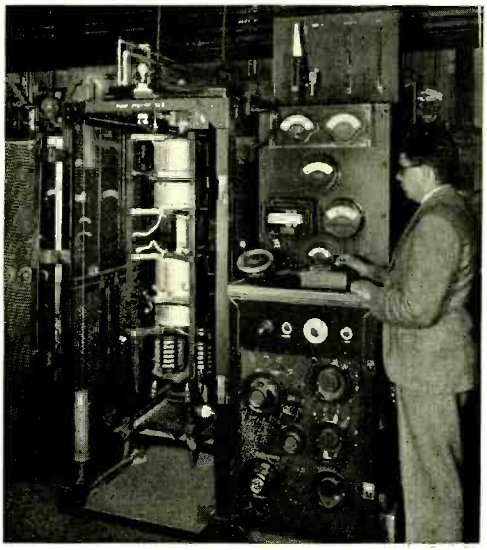


Fig. 3—Pumping station for outgassing and evacuating 240-A tubes, attended by C. W. Koons

Minute as are the capacitances between the test circuit and other unrelated circuits in adjacent rooms, the frequency of the testing currents is so high that considerable amounts of power can be transferred across the intervening space. In spite of radio-frequency chokes in the high voltage lines of the test set, and the shielding afforded by enclosing the whole circuit in a large aluminum case, enough high-frequency energy passes by displacement currents through the holes in the shielding for electric and water-supply lines, to upset galvanometer readings, reverse manometer microammeters and burn out thermocouples in adjoining laboratories. The tests are, therefore, conducted out of hours.

Another interesting phase of the development has been the technique used by C. W. Koons for evacuating tubes of this style. He appears in Figure 3, standing beside a high-voltage pump station and pumping a 240-A tube. The tube is supported on insulators at the middle, and has special ovens fitted over both glass ends. The grid, filament, anode and glass parts are outgassed simultaneously by heating each of these parts to the highest temperature which it will stand and still keep its form. The evacuation process consequently becomes a relatively short one, as compared with that for other water-cooled tubes whose various parts must be outgassed separately. The water jacket becomes an integral part of the tube after it has been pumped.

In order that these tubes may be operated successfully in parallel, without singing at still higher frequency, their characteristics and thus their construction must be as nearly alike as possible. V. L. Ronci has been responsible for the mechanical design, and with A. I. Crawford for the manufacturing specifications, of these tubes. His group, in collaboration with the Development Shop, has built machines (one of which is shown in the frontispiece) resembling lathes but with fires for their tools. On these are made the glass-to-copper seals for the filament and grid leads and for the anodes. Glassblowers are still necessary for assembling the parts in their proper alignment—one of the most important steps in the manufacture. The skill and experience of such men as J. J. Heil and H. W. Ericsson make pioneering in large vacuum tubes possible.

Figure 4, a picture of the 241-A tube, shows how the 212-D 250-watt tube had to be redesigned as a double-ended tube to make it suitable as an amplifier in the earlier stages of short-wave radio-telephone development. The 243-A, another member of the vacuum-tube family, is exactly similar in appearance to the 240-A but has only one-half its filament capacity. It is rated at two kilowatts and has been used to drive the 240-A tubes.

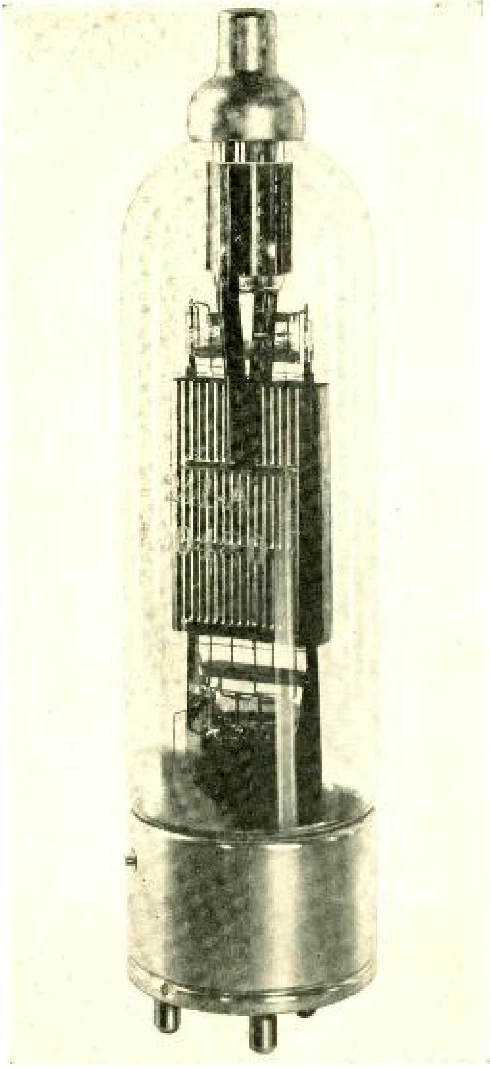


Fig. 4—250-*watt double-ended tube of the* 241-*A type*

Since April 1, the Tube Shop at Hudson Street has been making these double-ended tubes at a rate sufficient to supply the needs of the short-wave radio transmitters, and they are performing fully up to expectations.

Restoring Speech

By R. R. RIESZ
Acoustical Research

IN the United States there are several hundred people who, because of malignant disease, have had their larynx or "voice-box" removed by a surgical operation. After removal of the larynx, breathing no longer takes place through the nose: the windpipe is terminated directly in an opening in the front of the neck. The effects of this operation on the ability to speak, and the problem of minimizing them, can best be discussed by first surveying the nature of speech sounds and their normal production.

	Voiced Sounds		*Unvoiced Sounds*
Vowels	o͞o as in pool	a as in tap	
	u as in put	e as in ten	
	ō as in tone	a as in tape	
	au as in talk	i as in tip	
	o as in ton	ē as in team	
	ä as in father		
Semi-Vowels	l		
	r		
	m		
	n		
	ng		
Dipthongs	i as in high		
	ou as in house		
	oi as in boy		
	ew as in mute		
Transitionals	w as in win		
	y as in yes		
Fricative Consonants	v		f
	z		s
	th as in then		th as in thin
	zh		sh
Stop Consonants	b		p
	d		t
	j		ch
	g		k
Aspirant			h

Table 1—Common English speech sounds

The sounds composing our spoken language may be classified in a number of ways depending on the point of view; for the present purpose it is convenient to divide speech sounds into two groups (Table 1). In the first group are placed all the "voiced" sounds, in the production of which the generation of sound by the vocal cords plays an important part. Vowels, semi-vowels, diphthongs, transitionals and voiced consonants are members of this group. The second group comprises the "unvoiced" sounds, in the production of which no sound is generated by the vocal cords. In this group are placed the unvoiced consonants.

With a single exception all the unvoiced sounds are produced in the mouth. In producing the fricative consonants a current of air is blown through a narrow slit formed between the tongue and the roof of the mouth, between the teeth and the tongue, between the teeth, or between the teeth and the lower lip. In producing the stop consonants the current of air is suddenly started or stopped by any of the above combinations. The aspirant sound, h, is a particular way of beginning a vowel or diphthong by blowing a current of air with the mouth passage fairly wide open.

For the voiced sounds, on the other hand, the source of sound is no longer located in the mouth but in the larynx or voice-box. The larynx is situated at the top of the wind-pipe whereby it is connected with the lungs, a pair of bellows consisting of many small air sacs. In the larynx is a pair of exceedingly adjustable lips, the vocal cords, which during ordinary breathing are drawn out of the way allowing air to pass freely to and from the lungs. When a speaker desires to produce a sound, these remarkable vocal cords are drawn close together to leave a narrow slit between them. Then, as the lungs force a current of air through this slit, the vocal cords are thrown into vibration and change the steady current of air from the lungs into a pulsating sound wave. The action of the vocal cords is not unlike that of the lips of a trumpeter, when they are placed under tension against the mouthpiece and a stream of air is blown through the narrow slit formed between them.

The sound produced by the vocal cords would probably never be recognized as a vowel by a listener, if it were possible for him to hear it directly. It corresponds to the rough block of marble out of which the sculptor carves his statue. This basic sound passes from the larynx up into the cavities of the throat, mouth and nose where its quality is modified by the resonating action of these cavities. Thus modified, it is finally radiated into the air as a recognizable speech sound.

The removal of the larynx, therefore, destroys the power of speech, because it prevents the admission of the air stream to the mouth and because it removes the vibratory vocal cords. The power can be restored by providing a new passage for the air stream from lungs to mouth and interposing a vibratory element in it.

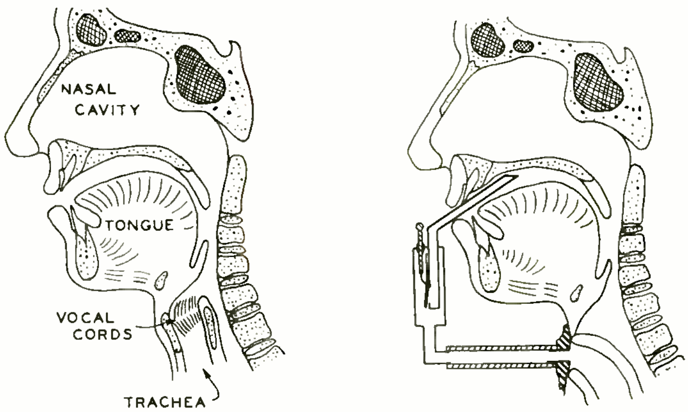


Fig. 1—Left: in normal speech production, air passes from the lungs through the trachea and vibratory vocal cords to the resonating cavities of the head. Right: when the trachea is terminated in the neck, it is extended by rubber tubing and the vocal cords are replaced by an artificial larynx containing a vibratory metal reed

Apparatus which fills these functions has been developed in these Laboratories and is available under the name, "artificial larynx." Stated thus in scientific language there is no connotation of the loneliness which settles around one who can no longer talk, nor of the joy which comes to him when the power of speech is restored.

Instead of a pair of vocal cords, the vibrating element in the artificial larynx is a thin metal reed, clamped at one end and free at the other. One of the metal tubes leading from the artificial larynx is connected by means of a rubber tube and coupling pad to the termination of the windpipe on the front of the neck. The user blows air from his lungs through the larynx and so sets the metal reed in vibration. This vibration alternately stops and starts the flow of air and gener-

Fig. 2—The author demonstrates how one with normal vocal equipment can use the artificial larynx with the aid of bellows

ates a train of sound waves similar to that generated by the vocal cords of a normal person. The sound, whose fundamental frequency must be about 125 vibrations per second for a man's voice and 250 vibrations per second for a woman's voice, and which must contain a large number of overtones, would not be recognizable as a speech sound. It is introduced into the mouth of the speaker by the outlet tube of the artificial larynx and the speaker goes through the ordinary motions of speaking with his tongue, lips, and the like. The resonating action of the mouth, throat and nasal cavities manufactures out of the basic sound produced by the artificial larynx the voiced speech sounds. The sounds of the unvoiced group are produced by blowing air through the larynx in such a manner that the metal reed is not thrown into vibration and modifying this air stream with the tongue, lips and teeth. A breathing hole placed in the side of the instrument enables the user to inhale air into his lungs. This he covers with the thumb when he desires to speak. An adjustment is provided for changing the pitch of the larynx so that it can be used by either men or women. By continual practice people can become very proficient at speaking with an artificial larynx and so be restored to the happiness and useful normal activities which attend the power of speech.

A normal person whose larynx has not been removed can, with a little practice, learn to speak with an artificial larynx. The air to operate the instrument cannot, of course, be supplied from the lungs; the larynx is connected to a small bellows operated by hand. Air is forced from the bellows through the artificial larynx, and the sound is thence introduced into the mouth. The speaker then goes through all the motions of talking, being careful not to produce a sound with his own vocal cords; and the artificial larynx, with the help of his mouth, throat and nasal cavities, talks for him. Aside from its value in studying the mechanism of speech production and as a means of demonstrating the artificial larynx, this method of using the instrument is of use in restoring the power of speech to mutes or to persons who, from some other cause than removal, have lost the use of their vocal cords.

Bearings in Power-Driven Telephone Apparatus

By J. T. BUTTERFIELD
General Apparatus Development

IN designing switchboards to be operated manually, telephone engineers have had little occasion to concern themselves with bearings and with provision for their lubrication. With equipment for completing dial calls, however, the subject of bearings is of major importance. In a panel-system office there are many thousands of bearings, some of them running constantly, and the remainder at frequent intervals; these should all have a long useful life consistent with the probable life of the equipment with which they are used, and should require a minimum of care. Furthermore many of the bearings, on account of their closeness to electric contacts or friction-driven clutches, should be so lubricated that no electrical or other operating trouble is introduced. Such demands mean that design of the bearings, and adoption of the best procedure for their maintenance, are comparable in importance to the mechanical design of other parts of the panel equipment.

The problems involved are of many sorts, with widely varying requirements of speed, bearing pressure, choice of lubricants available, and limiting cost. Many different constructions have of course been used, of which several are shown in the figures. Figure 1 shows a typical group of mechanically operated switches, presenting lubrication problems of several types, and giving a partial idea of the range of conditions to be met. At the bottom is a small motor coupled to a gear box or "drive." Through the drive, motion is imparted to a vertical shaft carrying a series of horizontal discs, and also to three horizontal shafts, covered with cork rolls, by which the selector rods of the adjoining panel are raised and lowered. Arranged along the vertical shaft are eight sequence switches, such as are shown in Figure 2; these are driven through steel friction discs which are controlled magnetically. Near the top of the rotating vertical shaft, and driven by gears attached thereto, are two bar-type interrupters; enlarged views of these are shown in Figures 3 and 4.

In these various members, some of the bearings used are of types commercially standard and others were designed specifically for telephone use. The armature of the motor is supported on ball bearings which, in this particular case, are lubricated with grease. Inside the drive, the gearing and shafting are mounted on ball bearings and sleeve bearings, all flooded with a suitable mineral oil with which the case is partly filled. The vertical shaft projecting upward revolves continuously at a speed of approximately 35 r.p.m. It is supported vertically upon the coupling just above the gear case, and radially by ball bearings about two feet apart, lubricated with a heavy mineral oil. In the sequence switch of Figure 2, the main spindle is mounted in plain sleeve bearings, lubricated with grease. The simpler of the two interrupters, that of Figure 3, is made with a cam shaft rotating on oilless bearings. The roller operated by the cam, which drives the reciprocating bar to operate the contacts, is of hardened steel and is mounted on a hardened steel bushing; these are lubricated with a heavy petroleum oil.

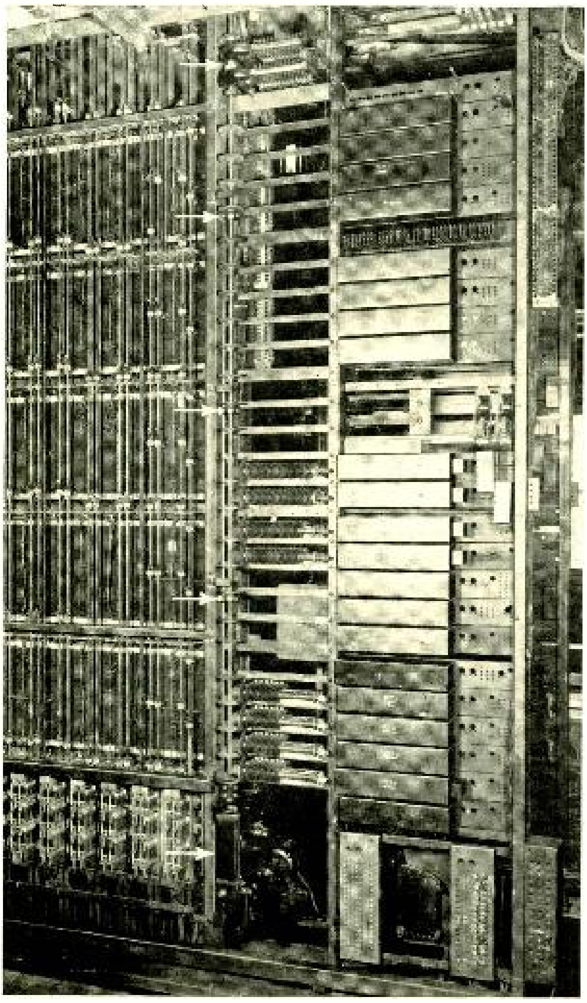


Fig. 1—Typical group of mechanically operated switches; arrows indicate some of the bearings to be lubricated

From even such an incomplete description, it is apparent that a wide variety of bearings and a corresponding variety of lubricants are used in the power-driven equipment. These bearings, and others throughout the telephone plant, may properly be divided into two groups—those that may be lubricated freely, and those so close to electrical contacts and frictional devices that special means must be used to prevent lubricant from spreading to surfaces where it would be injurious. Bearings of the former class, including those for motors, generators, and enclosed gear boxes, present the same problem as would similar bearings in other fields: that of applying the best current engineering usage. Their story need not be given here. With the second group, however, the problem is that of developing solutions to certain problems peculiar to dial equipment. These problems demand bearings either without oil or with very little oily lubricant and special means for keeping it within bounds. Fitting this classification are ball bearings, semi-oilless bearings, and completely oilless bearings, with their several fields of application.

Where comparatively few bearings are required in a mechanism so expensive that their cost is of minor importance, ball bearings are likely to be the most satisfactory and, ultimately, the most economical. These bearings inherently require only such lubrication as is necessary to protect the highly polished surfaces from corrosion and to provide a slight film between the balls and the races. Fortunately there are a number of lubricants which meet these requirements and also are comparatively easy to control by a suitable housing. For low maintenance the lubricant should be chemically stable, in order to retain its lubricating properties for long periods. One of the most satisfactory lubricants for use with ball bearings in telephone apparatus is a heavy petroleum distillate or cylinder stock oil containing a large percentage of the tarry matter naturally occurring in the petroleum. When it is used in a properly designed bearing, lubricant need be added only at long intervals; in fact ball bearings have been operating satisfactorily for several years on vertical drive shafts after an initial lubrication with a few drops of this heavy oil.

When large numbers of bearings are needed in apparatus which must be very inexpensive both in first cost and maintenance, semi-oilless or oilless sleeve bearings are likely to be preferable to ball bearings, provided the operating requirements are not too severe. Semi-oilless bearings of several different types are obtainable commercially at very reasonable cost. Several well-known makes consist of porous bushings moulded from finely divided alloys of copper, tin, lead and other suitable metals mixed with various ratios of finely divided graphite. The powdered constituents are formed under high pressure into a solid but porous body which is subsequently impregnated with a light mineral oil. Such bearings have been found satisfactory when used with steel shafting, but ordinarily they are too hard for use with shafting of brass or bronze, adopted when a non-magnetic material is needed. A brass or bronze shaft rotating in one of these bearings may wear excessively, even when an adequate supply of lubricant is present. Also there is a tendency for the bearing to seize the shaft as soon as the quantity of lubricant falls below a certain critical amount.

Semi-oilless bearings of another type, consisting of hard wood impregnated with oil or wax, operate satisfactorily for periods of many years with very little wear. They are unsuitable however in apparatus exposed to wide variations in humidity, or where very small and substantially constant bearing play must be maintained, since both friction and high humidity tend to cause the wood to expand. To prevent seizing therefore these bearings must be made with ample clearance when the shaft is at rest and the assembly is exposed to air of moderate humidity, and for certain applications such clearance can-

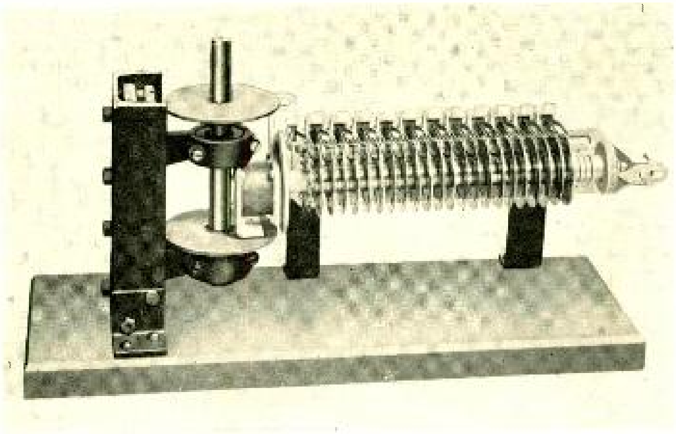


Fig. 2—Sequence switch with friction disc drive

not be permitted. Furthermore impregnated wood bearings have a tendency to score shafts of brass or bronze, even when an excess of lubricant is provided. Although for these reasons wooden bearings have not been used extensively in telephone equipment, there are certain applications where they have been used successfully. For example, drive shafts of sequence switches in some of the early panel-type offices are still functioning in wooden bearings, after more than ten years of continuous operation.

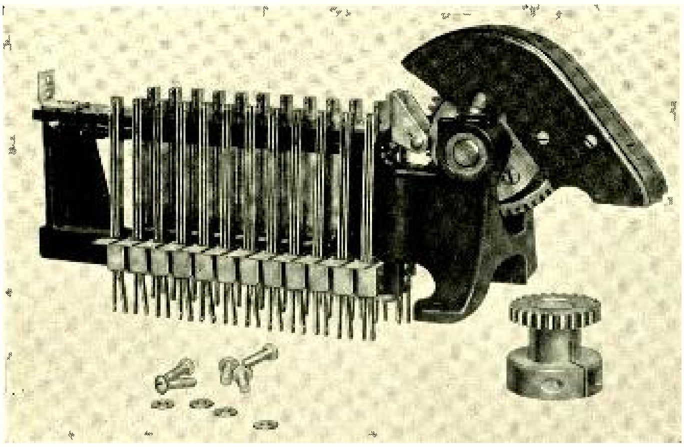


Fig. 3—Interrupter with spur gear drive

Among bearing materials which may properly be classed as oilless are several in which the lubrication is provided chiefly by graphite. One of these has been found satisfactory with brass or bronze shafting; it consists of moulded and baked graphite rods, impregnated with a suitably soft Babbitt metal. With this material the necessary lubrication is provided entirely by the graphite, which rubs off from the bearing and forms a shiny skin on the journal. After a few hours of operation the sliding action takes place almost entirely between layers of graphite, presenting a situation somewhat similar to that at the surface of the commutator of a motor or generator operating with carbon brushes. On account of the softness of the Babbitt-graphite mixture, wear is rapid compared with that of the harder bearing materials previously mentioned, but since the unit pressures which must be withstood are quite low in many cases, the graphite bearings will last as long as the assemblies in which they are used. A noteworthy advantage is that replacement of a wornout bearing is quick and inexpensive, and in many cases can be accomplished without stopping the shaft affected. After loosening the housing, it is necessary merely to break the old bearing and remove the parts, split the new bearing and place the halves around the rotating shaft, and replace the housing. Specifically, there is no need for removing clutch discs or other projections from a shaft, as is the case when a ball bearing is to be replaced. At present, sleeves of this graphite material are used for bearings in clutch rollers and bar-type interrupters, and certain of their properties recommend them for use elsewhere in place of ball bearings.

Wherever steel shafting is used there are available not only the materials mentioned, but also a number of patented alloys which are cast and then moulded or ground to final form. Experiments are now in progress with a number of different alloys of this class, which at light loads and low speeds require no oil. For their intended use with steel shafting, however, these bearings must compete with those made of the various commonly used bearing metals and lubricated by means of a wick which supplies oil at a suitable rate.

In certain other bearings, the limitations of space require unit pressures too high for any of the oilless or semi-oilless materials. For such cases, it is necessary to use journals of hardened steel operating in bushings of steel or phosphor bronze. An example is the cam roller of the bar-type interrupter shown in Figure 3. Here it is important that bearing play shall be kept at a minimum and that the roller shall always rotate, else there will be severe wear between the cam and the roller, and the adjustment of the interrupter will be disturbed. Also the roller is so close to the electrical contacts that a wick-oiled bearing cannot safely be used. In such a case, as in the case of ball bearings located close to contacts, choice of a lubricant is of great importance. It should be stable chemically, light enough to work its way into the recesses of the bearing, yet heavy enough not to evaporate, creep rapidly, or permit rust, and also of a nature to resist absorption and dissipation by dust. Those requirements are all met with a heavy petroleum oil similar to that used in the ball bearings of the vertical shafts.

Protection from the effects of dust is one of the most important problems relating to ordinary sleeve bearings as used in telephone equipment. If the question be asked, "what becomes of all the oil that is supplied to these sleeve bearings?", the answer must be that it is largely absorbed and dissipated by dust. Finely divided solid matter is always present in the air to a greater or less extent, especially in large cities and in the neighborhood of certain industrial plants. In telephone offices dust is kept at a minimum by careful housekeeping methods, including regular use of vacuum cleaners and frequent waxing of the floors. Even so, normal wear of the thousands of contacts and other moving parts is continuously producing finely divided metal dust which is deposited on the apparatus along with the normal dust from other sources. The thin layers of dust resulting on all surfaces, particularly on horizontal surfaces, provides a capillary path from bearings and oiling points, tending to spread the oil and absorb it. When the oily dust is wiped off in the course of maintenance routine, the oil is lost to the apparatus.

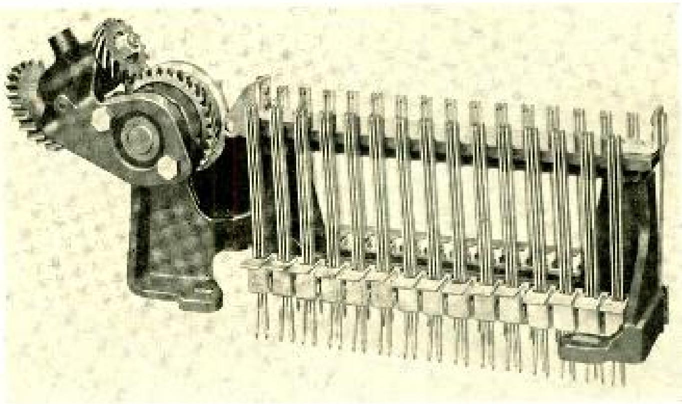


Fig. 4—Interrupter with helical gear drive

Keeping dust away from sleeve bearings lubricated with oil is largely a problem of design. Wherever possible, bearings requiring oil lubrication should be so designed that one end is sealed against the escape of oil. The regions where oil is needed for lubrication should be separated from the open air by a space as long and as restricted as possible, or by a suitable barrier such as a felt washer. The rubbing parts of the bearing should be so designed that oil will tend to remain where it is needed, rather than to escape. For example, narrow capillary spaces may be provided adjacent to the rubbing surfaces, for retaining oil closely. Also wherever possible, the exposed end of the bearing should be so located as to be protected from falling dust. The problem of protecting bearings of telephone apparatus from the effects of dust somewhat resembles the problem of protecting the bearings of a watch, but one of the chief protections of the watch bearings, that of entirely enclosing them in a dustproof case, often can not be adopted. Instead, the course is to make the bearings of a form giving the greatest protection from dust commensurate with their requirements of operation.

It is evident from the several constructions mentioned and their comparative advantages and limitations that usage in designing and lubricating bearings for the telephone plant is in a state of active development. A wide range of bearing materials is already at hand, and new materials are put on the market from time to time. These are investigated, and their possibilities explored, so that advantage may be taken promptly of any improvements in materials or design, as they become available.

Methods of Handling Toll Calls

By R. S. WILBUR
Toll Systems Development

TWO steps are required in handling a toll call: first, the necessary information for identifying the calling and called subscribers is recorded on a ticket; and second, the necessary switching operations are performed to complete the connection. The search for the most effective and satisfactory manner of performing these two functions has resulted in several methods of handling toll calls.

From the standpoint of simplicity, the ideal method would be one that enabled the "A" or subscribers' operator to plug directly into the toll line. This method, known as "A-B", is employed for calls between subscribers' lines served by offices which in general are not more than about fifty miles apart. Toll calls, covering greater distances or characterized by intermediate switching or for which a particular person is to be reached, require methods not compatible with the regular work of the "A" operators, and are handled, therefore, by specially trained toll operators.

The "A-B" method, shown on Figure 1, is so called because calls are completed by the local "A" operator who answers the calling subscriber's line, and an operator in the office in which the called subscriber's line appears. This method is thus the same as that used for completing local connections between subscribers' lines that appear in different offices of the same exchange area except that the "A" operator makes out a "ticket." Handling this class of calls reduces somewhat the number of local calls that the "A" operator can handle, but it is the most desirable method to use for

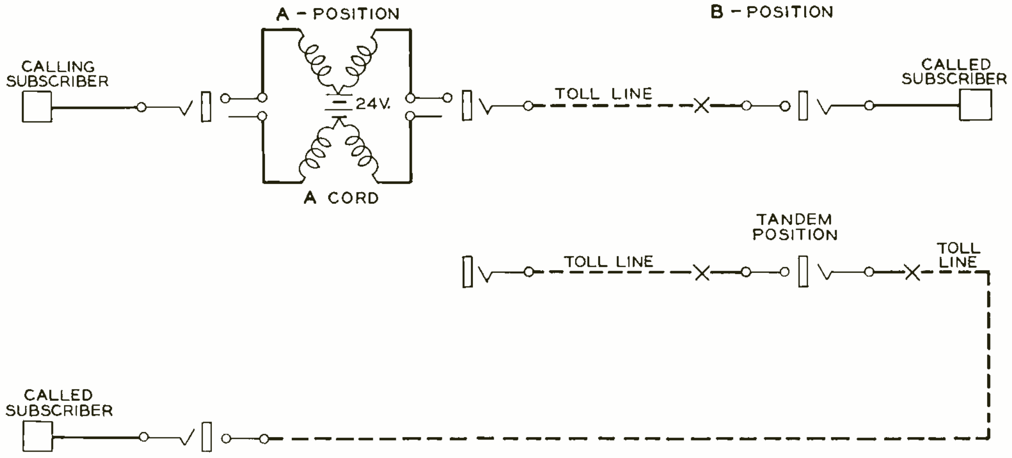


Fig. 1—Toll calls between subscribers within moderate distance of each other are sometimes completed directly by the original "A" operator

short-haul toll business from the standpoint of economy and satisfaction to the subscriber.

The long-distance method, used until recently for completing calls when the toll switchboard is not a part of the local board, is indicated by Figure 2. Here the subscriber calls his local "A" operator in the regular way, and asks for "Long Distance." The "A" operator connects the subscriber's line, through an "A" cord-circuit, to a recording trunk which appears at the distant end in a recording switchboard. The operator at this position records the information required on a ticket and then tells the subscriber that he will be called.

Since the subscriber does not always know the telephone number of the person he is calling, it is often necessary to obtain additional information by routing the ticket to a directory operator, who is provided with directories listing the subscribers in the more important towns and cities. The ticket is then sent through a distributing system or by messenger to the line operator handling the toll line that will be used for completing the call. This "line" or "outward" operator proceeds to get the called number in the distant office, and as soon as this has been done the calling subscriber, who is being held on a toll switching trunk, is rung.

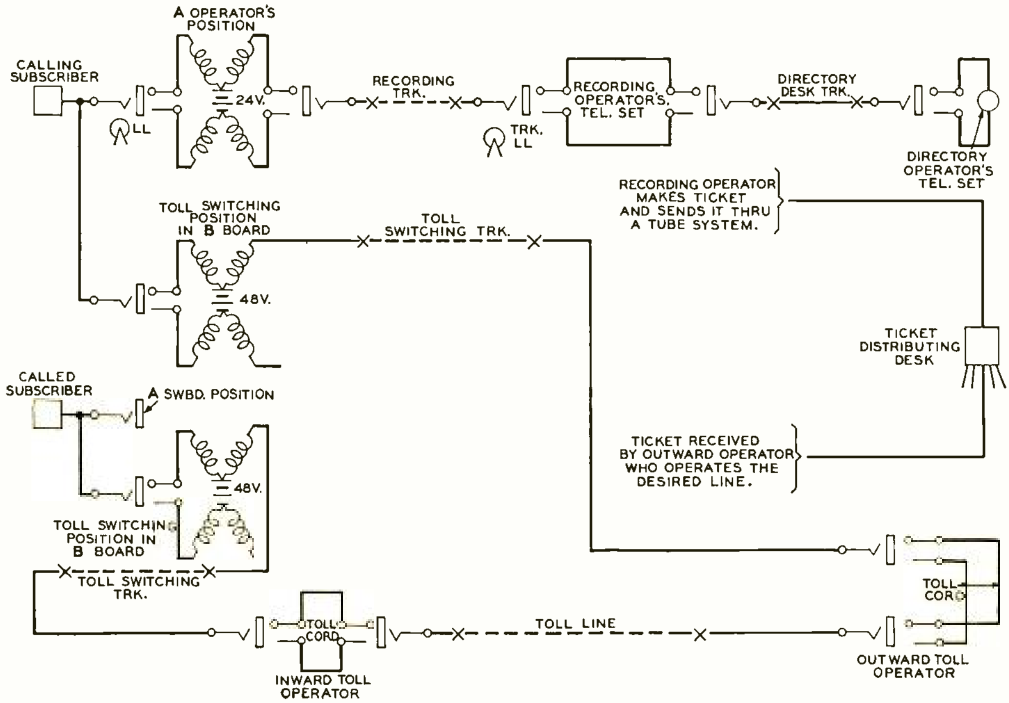


Fig. 2—Until recently all long distance calls went first to a recording operator and later were completed by a line operator

This "single-ticket" method of recording and completing a toll call is not entirely satisfactory for it would be desirable to complete the calls so promptly that the subscriber could remain at his telephone. This improved type of service has been made possible on a large percentage of the toll calls by introducing the CLR method of operation, which combines the functions of the recording and line operators of the older method—CLR being merely the initials of "combined line and recording."

The CLR method of operation for manual systems is indicated by Figure 3. The subscriber calls his local "A" operator who completes the connection to the outward, instead of the recording, switchboard. The outward operator answers the call, records the information on a ticket, and proceeds immediately to get the called subscriber in the distant office while the calling subscriber remains on the line. While waiting for the called station to answer, the outward operator, without telling the subscriber to hang up, obtains another connection to his line. This is over a trunk arranged to provide switchhook supervision to the toll operator and forty-eight volts for the operation of the subscriber's transmitter. As soon as the toll switching or "B" operator completes the connection to the subscriber's line, the toll operator takes down the connection to the CLR trunk, and this gives an indication to the "A" operator that the connection may be taken down at her position also. If for some reason the call can not be completed immediately, the subscriber is told that he will be called as soon as the called party is available and the ticket is then sent to a delayed-outward operator's position where the call is handled as it would have been by the old method. Reports are given the subscriber periodically of the progress of his call.

If a calling subscriber has a dial telephone, he dials a code that ordinarily connects his line over a CLR completing trunk to the outward toll operator. This method of operation is shown on Figure 4. The CLR com-

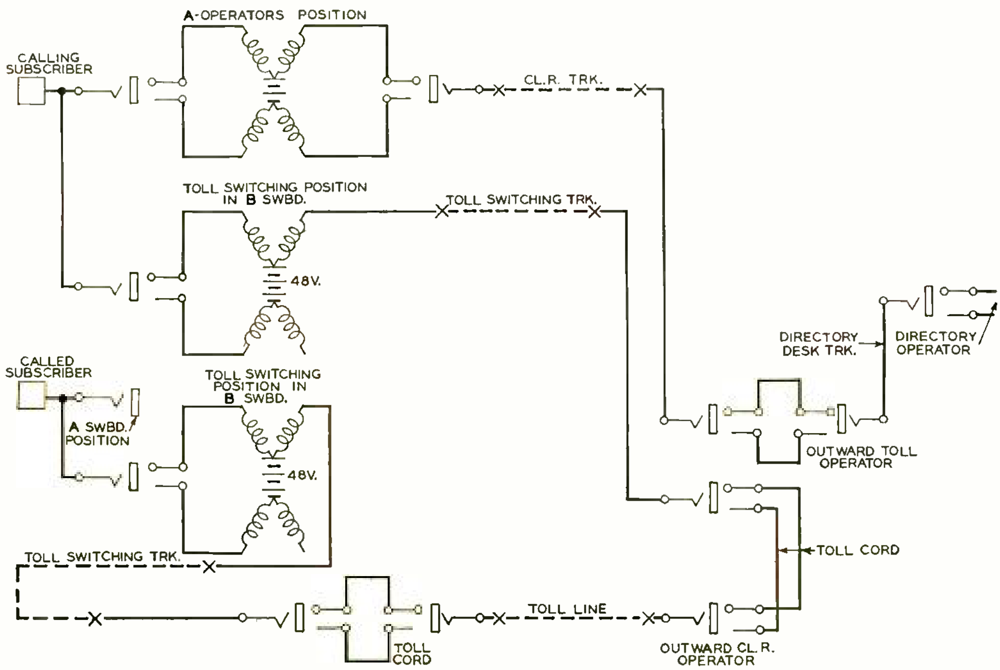


Fig. 3—CLR operation combines the "recording" and the "line" operators and so cuts out one step in the completion of a toll call

pleting trunk is arranged to provide forty-eight volts for supplying talking battery to the subscriber's telephone so that it is not necessary for the outward operator to obtain connection to the calling subscriber's line over another trunk, as it was in the manual system. The line operator then proceeds to complete the connection in the same way as for manual systems.

With the CLR method of operation, the service to the subscriber is improved if the called number is furnished by the calling subscriber at the time the call is filed. On calls to the larger cities, where the number is not furnished by the calling subscriber, the CLR operator attempts to obtain the number over trunks to the directory operator in her own office before working out on the toll line. Information is posted at the CLR position giving the routing instructions to frequently called points, and this list is supplemented by complete information at a routing desk where the additional routing information may be had over trunks provided for this purpose.

The combined line and recording method of completing toll calls is used at the present time in practically every Bell System office. Its use has greatly improved the service from a subscriber's point of view; the average System circuit build-up time, which was 7 minutes in 1925, had been reduced to 2.4 minutes in 1928. This improved service has been made possible without incurring additional costs for facilities or operating time.

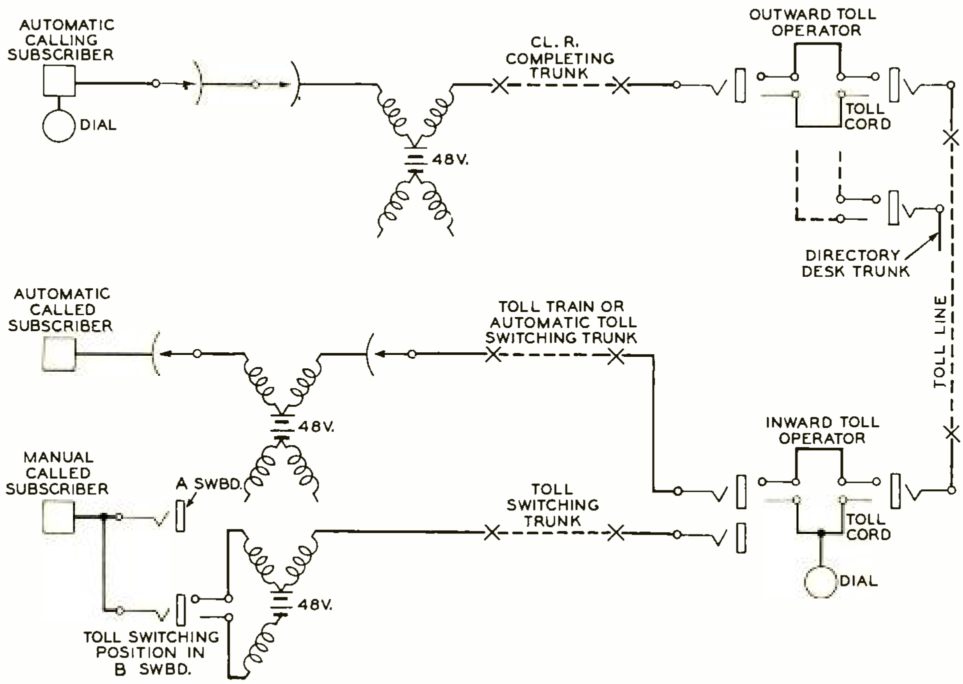


Fig. 4—When applied to dial areas the CLR method makes a further simplification possible as it is not necessary to obtain a new connection with the calling subscriber to secure toll facilities

Season-Cracking of Metals

By I. V. WILLIAMS
General Apparatus Development

MOST of us have seen badly cracked brass parts which formerly seemed perfectly sound. They may have been ornamental or complicated pieces such as light fixtures, or simple pieces such as flower bowls. This failure is often described by saying that the metal has "crystallized." Actually all metal is crystalline; the failure is not caused by crystallization but occurs between the crystals, thereby revealing the structure and giving rise to this false term. Such failures are now generally attributed to "season cracking."

This is a phenomenon characterized by cracking after manufacture, and often before the application of any external stress, of parts of seemingly sound metals which show good mechanical properties when tested in the ordinary manner. The name "season cracking" is probably applied due to the similarity of this form of failure to the cracking of timber when undergoing seasoning. The name is not truly descriptive and the terms, "corrosion cracking" and "stress cracking," have both been suggested to replace it. Neither of these terms is fully descriptive of the failure, however, and so the change of terms has never been accepted. Nickel silver, high nickel steel (20% nickel), aluminum bronze, and some other alloys are all subject to season cracking but the alloys principally affected are the brasses containing more than 20% zinc. The limits of composition for the other alloys have never been determined.

Season cracking has been encountered in several instances in telephone apparatus. One was the development of radial cracks in the aluminum-bronze ratchet wheel of the 200-type selector. The ratchet, cut transversely from hard drawn stock, was assembled by forcing the knurled head of the shaft into the ratchet blank. It was found that many of these ratchet wheels cracked, either during handling or after installation. Figure 1 shows one of the ratchets with three radial cracks and illustrates the likeness to the cracking of timber, and Figure 2 is a photomicrograph of one of these cracks showing its intercrystalline path. It was found that the cracking could be avoided by heating the ratchets after assembly at 450° F. for four hours.

There are two factors which together cause this failure: a stress in tension in the outer surface of the material and an accompanying corrosion. The stress in the outer surface is usually that left by the manufacturing process though it may be due to externally applied forces. No particular shape of material seems free from this effect. Cracking has been found to occur in parts produced by spinning, drawing, pressing, or rolling. There seems to be a minimum stress limit below which cracking will not occur, and although this limit has not been very well defined for any of the alloys, it has been accepted as lying between 10,000 and 15,000 pounds per square inch for brasses. It has also been conceded that hard materials will stand a greater stress

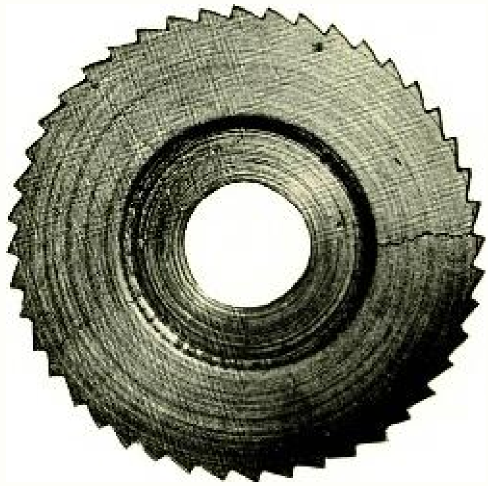


Fig. 1—The cracks in this ratchet wheel of a 200-type selector show a strong resemblance to "season cracking" of wood

than will soft materials, probably because of the greater strength of the material. This is offset to some extent, however, by the fact that the same amount of deformation of a hard material will produce a greater stress in the finished part.

The corrosion which is a contributing cause of season cracking is not the type with which we are all familiar but is of a peculiar nature. The failure in almost every instance follows an intercrystalline path as shown in Figure 2, though it will occasionally cut across crystals which are at right angles to its path. A similar failure has been produced in stressed material by a combination of mercury and ammonia, or their salts, and high humidity. It has been found that in general other reagents are not active in this way. Parts which readily cracked when placed in solutions of mercurous or ammonium salts, did not crack when subjected to the action of acids although they were deeply pitted and eaten through in many places when removed from the reagent. Mercurous salts, especially mercurous nitrate, have been found to be the most active in producing this type of failure. It is probably ammonia and atmospheric humidity which cause season cracking in materials in storage and in service since small amounts of ammonia are always present in the atmosphere, especially in industrial centers.

It has been found that this type of failure cannot be prevented by covering the parts with lacquers or varnishes since these materials are permeable to the corrosive gases of the atmosphere, and although they will slow up the action, they will not prevent it. It has been found that polishing a surface, probably due to a flowing of the material over the intercrystalline boundaries, will retard the

Fig. 2—In this photomicrograph of part of the wheel of Figure 1, it may be seen how the crack (AB) follows the crystal boundaries

corrosion and greatly reduce the tendency to crack. It is also true that plating the surface will prevent cracking providing a continuous plate is produced. This, however, is very difficult to obtain in practice and as a result is not often used.

Several methods of prevention have been found to be effective. Two of these involve the removal of the stress from the surface layers of the material. The first is known as "springing" and consists of bending the material and straightening it several times, which results in a more even distribution of the stress and removes the concentration of stress in the outer layers. The second method, and the one which has been found to be most effective, is a low temperature annealing at a temperature varying from 300° F. to 600° F. for from two to six hours depending upon the alloy and the work it has received. This is the method that was applied in the example cited. This low temperature heating, which is below the recrystallizing temperature of the material, is high enough to remove the localized stresses left in the material by the cold working without softening it. Plating or polishing, as stated above, will delay corrosion and thus sometimes prevent season cracking for a considerable time.

A fairly well recognized test for season cracking has been adopted. This consists of placing the part to be tested for fifteen minutes in a solution of mercurous nitrate and nitric acid. It is generally conceded that parts which will not crack after this test will give a satisfactory life, and it is also generally held that any part which will crack in this solution will eventually crack in use. Parts such as bolts which will be subjected to external stress should have this stress applied to them while under test as the two factors, stress and corrosion, must always be present to produce season cracking.

Telephone voices from America were carried across the Alps for the first time on August 28 when the transatlantic service to Milan, Italy, was formally opened. With the extension of this service to Italy, twenty-one countries are now linked to this country by transoceanic circuits. Calls to Milan are being routed from New York to the radio transmitting station at Lawrenceville, to the receiving station in Great Britain, thence by wire to London where the messages are transmitted through cables running under the English Channel, and then overland by wire to Italy.

Imaginative Engineering

The untimely death of Dr. E. B. Craft removes a man whose career has been peculiarly American. It was his luck to have had little or no technical training of conventional varieties. Yet he became, while still on the sunny side of middle age, an outstanding figure in what is perhaps the most strictly scientific engineering organization in America. Until his recent illness he was not merely by title the executive vice-president of the Bell Telephone Laboratories; he was the active director of the manifold technical enterprises of that institution, foremost in his own right as an expert in the new science of electro-acoustics, an inventor of both practical and theoretical distinction and a scientist whose opinions were sought by men whose lives, longer even than his own, had been spent in laboratory studies and in the mastery of what other scientific men had done. When a boy with no springboard to take off from except a high school education can make himself master of such a science and the peer of well-trained academicians, American opportunity is not dead.

By the public Dr. Craft's career—his degree was an honorary one, well earned by achievement but indicating no academic help to his advancement—will be best remembered, perhaps, for the achievement of the talking motion picture. Many inventors have contributed to that development, and many more must do so before it is complete. But it is probably to the inspiration and enthusiasm of Dr. Craft that the new art must trace its rise. First trials were anything but encouraging. Few experts were hopeful. Fortunately, Dr. Craft combined the imagination, the optimism and the official position which saw the idea through. Three years ago, when in a lecture delivered on the vitaphone he described that instrument itself before the New York Electrical Society, he put a period to perhaps the most heart-breaking bit of technical labor accomplished since the war.

The story of that effort is typical not only of Dr. Craft but, it may be permitted us to hope, of a type of engineer becoming slowly more numerous. To follow in the paths laid down by academic fathers is easy but relatively profitless. Technology needs continually the efforts of imaginative engineers, able to think of new applications for old ideas, as Dr. Craft saw new possibilities for devices perfected in the telephone art. Without that quality the completest academic training means something short of perfection; with it the absence of conventional education, Dr. Craft's career proves, is no fatal handicap.

—*An Editorial in New York Herald-Tribune of August* 25, 1929.

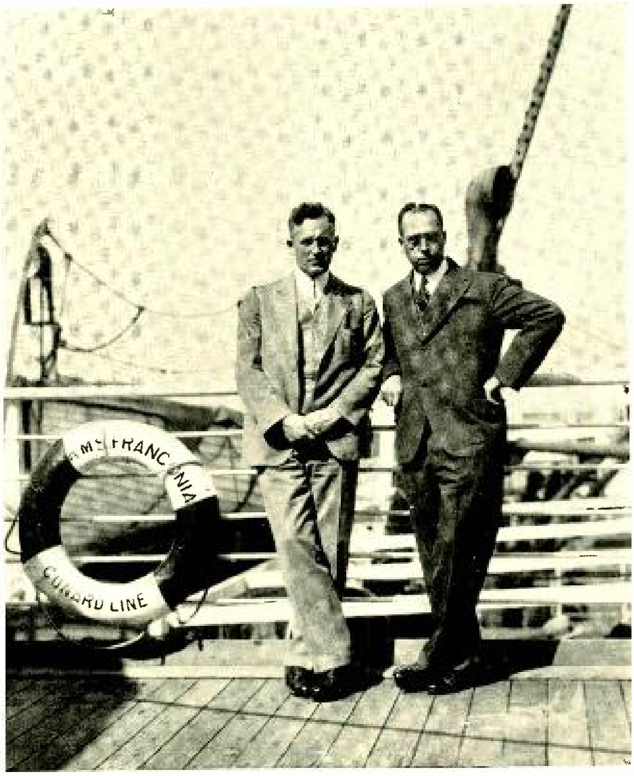
The Month's News

IN

STORIES AND PICTURES

INCLUDING

NOTES OF THE CLUB



W. Wilson, and Lloyd Espenschied of A. T. & T., sail for Europe on the "Franconia"

News Notes

F. B. Jewett headed the Round Table discussion at the Williamstown Institute of Politics on August 28. The subject was *Influence of Science and Engineering on Communications and the Effect of Improved Communication on World Affairs.*

A book entitled *Transmission Networks and Wave Filters* by T. E. Shea is scheduled for publication this month by the D. Van Nostrand Company. This book, the sixth of Bell Telephone Laboratories series, explains the principles and uses of transmission networks in telephone systems, and applies these elements to the art of electric-wave filter design.

For the past two months members of R. A. Heising's group have been stationed on the *S.S. Leviathan* installing transmitting and receiving apparatus in preparation for ship-to-shore tests. On September 23, F. R. Lack, G. Thurston, W. L. Lawrence and G. L. Morris returned on the *Leviathan* after being engaged in this work while the ship was under way on its trip to and from Europe. On the liner's previous trip, Messrs. Lack, Thurston, Lawrence, H. J. Scott, J. G. Chaffee and F. B. Llewellyn were occupied in making the apparatus ready. While the *Leviathan* was recently in drydock at Boston, a small steel structure was built on one of the upper decks to house the equipment.

Inspection Engineering

W. A. Boyd and L. G. Hoyt attended a Special Products survey conference at Hawthorne during the week of August 20. They also visited the new Electrical Research Products Company warehouse at Chicago.

R. J. Nossaman visited Denver and St. Louis in connection with investigations of central office equipment.

W. A. Shewhart spent the last week in August at Boulder, Colorado, where he attended the summer meeting of the American Mathematical Society.

H. W. Nylund visited Dallas, Fort Worth, Tulsa and Oklahoma City, during the week of August 5 to conduct investigations on step-by-step apparatus.

Apparatus Development

Francis F. Lucas leaves on October 2 to attend the World Engineering Congress at Tokio, Japan, where he will deliver a paper entitled *On the Structure and Nature of Troostite.* Mr. Lucas is the official delegate of the American Society for Steel Treating to the World Congress.

On request of the National Engineering Society of Czechoslovakia, Mr. Lucas has prepared a paper on recent metallurgical developments and illustrated by high power photomicrographs for the Society's anniversary number.

H. N. Van Deusen, J. M. Wilson, J. R. Townsend and H. A. Anderson attended the National Metal Congress and Exposition in Cleveland during the week of September 9. Mr.

Anderson presided at a meeting of the A. S. T. M. Die Casting Committee held at the Hotel Cleveland on September 11.

J. R. TOWNSEND visited the Bureau of Standards at Washington on September 3 in connection with standardization of Rockwell hardness test blocks.

D. H. GLEASON and V. F. BOHMAN have been in Hawthorne in connection with the revision of testing requirements for step-by-step switches.

J. R. FRY visited Hawthorne for conferences on relay developments.

H. A. BREDEHOFT spent a month at Hawthorne for engineering training.

H. O. SIEGMUND visited Hawthorne in connection with recent developments on contacts and resistances.

R. L. TAMBLING visited Newcastle, Pa., and Wheeling, W. Va., in regard to investigations of contacts in pilot wire regulators.

O. L. WALTER spent a week in Hawthorne working on the projector head for the 202-B Reproducer Sets.

J. F. HEARN has been admitted to membership in the Edward J. Hall Chapter of the Telephone Pioneers of America.

MESSRS. PULLER and WALTER were in Hawthorne for an extended period in connection with the manufacture of sound picture equipment.

H. WAGNER has been elected to membership in the Edward J. Hall Chapter of the Telephone Pioneers of America.

PAUL C. HOERNEL, a member of the technical staff, died August 29. He was graduated by Polytechnic Institute of Brooklyn in 1920, with the degree of E.E. Then entering the Laboratories, he was associated with carrier-current development, with personnel and publication work, and most recently with radio broadcasting where he was in charge of a group engaged in transmitter development.

C. A. WEBBER was at Hawthorne with A. N. Gray of the Research Department in connection with new developments on rubber covered tinsel.

H. H. GLENN, together with H. E. Marting and E. J. Kane of the Systems Development Department, visited Stamford, Conn., to inspect wire and cable in dial offices.

Paul C. Hoernel

N. INSLEY was at Hawthorne to confer on the establishment of new standards for amber lamp caps.

D. R. BROBST visited five central offices in northern New Jersey with E. W. Olcott of the Systems Department and G. H. Downes of the American Telephone and Telegraph Company, to inspect the insulation on wire and cable in manual boards.

Systems Development

S. B. Williams spent some time in Wilmington, Delaware, where new step-by-step equipment was cut into service to replace the manual switchboard. This manual board was arranged for automatically distributing originating calls to idle operators.

L. D. Plotner is on the Pacific Coast checking the operation of the dial system PBX's recently installed on the *U.S.S. Lexington* and *Saratoga*. Tests are being made while the vessels are at sea and while heavy guns are being fired.

R. P. Jutson visited Greensboro and Durham, N. C., during the month to observe the trial installation of the recently developed pilot wire regulator and 5-20 ampere automatic plate battery supply.

J. M. Duguid went to Wilmington, Delaware, to remedy trouble which developed in connection with the ringing machine in an unattended office. He later visited Chicago in connection with the testing of the master group busy tone on toll lines.

D. E. Trucksess visited the Acme Apparatus Corporation at Boston where he conferred on matters concerning automatic voltage regulators.

F. T. Forster visited Wilmington, Delaware, to observe the operation of cam type voltage regulators.

F. G. Colbath inspected the new 740 type PBX installed in the Dupont Plant at Wilmington, Delaware.

M. E. Maloney went to Hawthorne to inspect the final design of metal casings for dial PBX's.

J. E. Cassidy sailed August 17 for Buenos Aires, where he will act as the Laboratories' representative in connection with the installation of the South American terminal of the New York-Buenos Aires radio telephone channel.

D. S. Myers spent several days at Chicago to introduce changes in methods of strapping.

C. H. Achenbach was at Detroit and Pittsburgh to inspect the first shipments of battery on cut-off relay panel equipment.

S. F. Butler and H. H. Lowry went to Philadelphia, to confer with the Installation Department representatives of the Western Electric Company and to inspect new methods of clipping cables.

J. E. Greene visited Stamford, Conn., in connection with the new design of distributing ring for step-by-step selector frames.

A. G. Lang spent some time during August at the Chicago toll office to investigate the possibility of applying group busy tone to sleeves of toll trunk circuits.

C. C. Munro and E. M. Squire were at Kearny most of the month testing out the wire line terminating equipment to be shipped to Buenos Aires for the New York-Buenos Aires radio telephone channel.

J. A. Krecek was at Scranton, Elmira, Harrisburg and Pittsburgh in connection with the trial of improved 44-A 1 repeaters for program transmission over open-wire telephone lines.

John V. Kurtinaitis, of C. W. Green's group, was drowned on September 1, 1929, while on his vacation at Hudson, New York. Mr. Kurtinaitis, who was a graduate of the University of Illinois, had been with the Laboratories since September 4, 1928.

Research

A paper *Differential Equations as*

a Foundation for Electrical Circuit Theory was presented by T. C. Fry at the meeting of the American Mathematical Society at Boulder, Colorado.

W. C. JONES has been at Hawthorne to arrange with the Manufacturing Department for the production of a limited number of special desk stand transmitters.

J. R. ERICKSON was at Hawthorne to make an inspection trip of the plant and to observe the manufacturing progress on click reduction receivers.

F. S. MAYER was in Hawthorne in connection with the tests of granular carbon for transmitters.

L. H. CAMPBELL and A. E. SCHUH visited New Haven to make field tests on loading coil cases.

L. H. CAMPBELL visited Netcong in connection with field trial of paint sealers for telephone creosoted poles.

J. E. HARRIS and E. E. SCHUMACHER visited Hawthorne to investigate lead cable sheath development.

W. MCMAHON and C. O. WELLS, together with members of the Outside Plant Department, are in Texas making studies on preservative treatments for southern yellow pine poles.

A NEW ERA of accurate clock making was cited as a possibility in an article appearing in the supplement section of *Science* and widely quoted as a news item in the daily papers. The article refers to the experiments of W. A. Marrison on quartz crystal oscillators, used to give a high precision laboratory standard and later adapted to perform the work of a pendulum in a newly devised clock. The quartz crystals, similar to those used in radio stations to keep the wave length constant, vibrate at 100,000 cycles a second and give the clock an accuracy within a hundredth of a second a day.

W. WILSON, Assistant Director of Research, and Lloyd Espenschied of the Development and Research Department of the American Telephone and Telegraph Company, sailed on the *S.S. Franconia* for Europe to attend the technical consulting conference on radio at the Hague. This conference which is held under the auspices of the C. C. I. R. had its first meeting on September 19. The American delegation, headed by General C. McK. Saltzman, consists of representatives from the army, navy, and the several government departments and also representatives of the foremost communication companies of the country. Mr. Wilson and Mr. Espenschied are attending as delegates of the American Telephone and Telegraph Company. They will be gone two months.

OUTSIDE PLANT

C. H. AMADON visited St. Louis, Dallas, Houston, and New Orleans in connection with the inspection of experimental pole lines. While at Houston, Mr. Amadon worked on the experimental treatment of creosoted southern pine poles.

C. R. MOORE made a trip with members of the Inspection Department to the Reliable Manufacturing Company at New Haven in order to give final approval to methods of procedure in the manufacture of strand dynamometers.

J. G. BREARLEY was at Hawthorne during the early part of August to observe handling tests on lead covered cable. During the latter part of the month Mr. Brearley visited Washington, N. J., to observe the installation of cables in connection with studies of the composition of insulating paper.

Publication

L. S. O'Roark gave a talk entitled *Electrical Eyes* at the ninth annual convention of the Telephone Association of Maine at Portland on September 5. The talk was illustrated with sound pictures.

A talk on the same subject with a similar demonstration of sound pictures was given by W. C. F. Farnell at the convention of the New Hampshire Telephone Association at Manchester on September 10.

Patent

The following members of the Patent Department visited Washington between August 7 and September 6, 1929, in connection with the prosecution of patents: H. A. Burgess, J. A. Hall and G. F. Heuerman.

Praying Mantis, denizen of the South, on a flying visit to E. R. Morton and E. L. Ericson, avails himself of the Laboratories' hospitality to dial the operator

Changes in A. T. & T. Stock Plan

ANNOUNCEMENT has been made of several important changes, effective September 1, in the provisions of the Employee's Stock Subscription Plan.

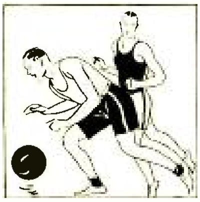
As was anticipated owing to the steadily advancing price of A.T.& T. stock, the subscription price has been increased, the price being fixed at $150 per share.

Changes were also effected in the rates of interest credited to the subscriber's account. On all amounts deducted, from the date of initial payment until the time when dividends accrue on paid-up stock, the interest rate, compounded quarterly, has been changed from 7% to 6%. Subscription payments incompleted owing to death are likewise affected. On incompleted accounts wherein an employee withdraws from his subscription agreement, or his service is terminated for causes other than death, the rate of interest has been changed from 6% to 5%.

An optional plan has been offered which permits an employee to subscribe for one share for each $400.00, or fraction thereof, of his annual rate of pay and pay for these shares at the rate of $4.00 per share per month. The original subscription basis — one share for each $300.00, or fraction thereof, of the employee's annual salary deducted at the rate of $3.00 per share per month — still remains intact. Or if he should so choose, an employee may subscribe for stock under both plans. For example, an employee receiving $3,600 annually may be already paying for 8 shares under the original $300 — $3 per share per month plan. He would thereby have allocated for subscription purposes $2400 of his salary. There still remains $1200 on which he may subscribe for the stock. If he wished he could either subscribe to 3 shares more upon the $400 — $4 per share per month basis, or to 4 shares on the $300 — $3 basis. Or if his annual salary were $3800 leaving $1400 unallocated he could subscribe to 4 additional shares on the $400 — $4 basis or 5 shares on the $300 — $3 plan. The right to subscribe to the extra share in this instance arises from the fact that a fraction remains when the unallocated $1400 is divided by either $400 or $300. Subscriptions filed after September 1 are to be made out on white cards if on the $300 — $3 per share per month basis, or upon green cards if taken out on the $400 — $4 basis.

Club Notes

THE Bell Laboratories Club Interdepartmental Basketball League will start on Tuesday, October 29, at Labor Temple, 14th Street and 2nd Avenue, N. Y. C. Two games will be played every Tuesday and Thursday evenings with the first game starting promptly at 5:30 o'clock. Eight teams representing the various major departments will take part in the 1929-30 tournament. The departments to be represented in the League are: Research, Equipment, Toll and Circuit, Apparatus Development, Tube Shop and Junior Assistant.



The Labor Temple court will be available on Tuesday and Thursday evenings starting October 1, thereby, providing eight evenings for practice by the teams participating in the league. For further information regarding basketball activities call D. D. Haggerty, extension 542.

Club Elections

The nomination committee of the Bell Laboratories Club will meet on Wednesday, October 23, to nominate candidates for the club elections to be held on Monday, December 16. The offices to be filled for 1930 are as follows: president, first vice-president, second vice-president and departmental representatives for two-year terms from the Plant and Shops Departments, Patent and Inspection Departments, and Apparatus Development Department. At least two, but not more than three candidates, are to be nominated for each office.

The nomination committee consists of the following members: O. M. Glunt, president; H. F. Dodge, first vice-president; Marion F. Kane, second vice-president; D. D. Haggerty, secretary-treasurer; departmental representatives: S. J. Stranahan, Apparatus Development; G. Rupp, Plant and Shops; A. C. Thoesen, Tube Shop; T. C. Rice, Patent-Inspection; P. B. Fairlamb, Systems Development; J. C. Kennelty, Commercial and F. W. Hultqvist, Research Department.

Club members desiring to submit candidates' names to departmental representatives should do so before the meeting.

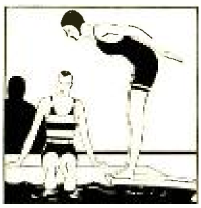
Men's Bridge

The men's bridge club will begin its season on Monday, October 14, meeting in Rooms 275 and 277 at 6:00 P.M. After the brief preliminaries of organizing, the players will hold their first contest and will continue weekly in the same place until December. There will be two tournaments lasting ten weeks each, of which the second will start in January, and in addition a match with the players from 195 Broadway and a series of mixed games with players of the

women's bridge club, to be scheduled definitely later. In all there will be about twenty-five meetings. Membership in the bridge club does not involve any pledge of attendance but to be eligible for prizes the players must take part in at least eight of the ten meetings.

Indoor Swimming

The Bell Laboratories Club has available tickets for the pools at the Shelton Hotel, 49th Street and Lexington Avenue, Park Central Hotel, 55th Street and 7th Avenue, and Pierrepont Hotel, 55 Pierrepont Street, Brooklyn.



These tickets, which may be procured from D. D. Haggerty, Room 164, for 75c which is half the regular rate charged at the pools and entitles the holder to all facilities of the pool including suit, towel and locker.

Women's Bowling

Beginning September 29th, that best known bowler of all times, Rip Van Winkle, was again awakened by such activity as he never dreamed existed, when the "bowlerettes" got together again at Dwyer's, 53rd Street and Broadway. They are known as the Bell Laboratories Club Women's Bowling League. Such interest has been shown in this gentle art that two extra alleys have been hired so that those who are not fortunate enough to "make" one of the four teams can come and practice.

Incidentally, this season's slogan is "the more the merrier," so you really must come up some night. To let you in on a big secret—you do *not* slide down the bowling alley with the ball!

The officers for the season are: Antoinette Kelly, chairman; Ann Muller, secretary-treasurer; Marion Kane, chairman of substitute committee.

Women's Swimming Classes

Have you a secret longing to be able to out-swim that handsome life guard you met this summer? Then take heart, all you embryo water-nymphs, your wish can be granted if you just sign on the dotted line, pay two dollars and fifty cents, and put yourself under the care of Miss K. Spranger, assisted by Miss A. Wyckoff at the Carroll Club, Madison Avenue and 30th Street.

Incidentally, it's best to throw away your water wings because after taking your eight lessons you'll know how it feels to be a fish. It's just the thing for the Tired Business Woman!

Just get in touch with Katherine Tully and tell her you want to join the Fall Swimming Class.

Women's Bridge

If you have learned to smile sweetly when your partner, after raising you twice, has only one and a half quick tricks in her hand, then you are wanted in the Rest Room on Thursday, October 3rd. The occasion will be the first Women's Bridge Tournament of the season. Even though you haven't that nonchalance mentioned above, your presence is needed also to make the tournament a success—surely you won't begrudge us that!

By calling extension 1146 and asking for Miss M. Lynch, you can get all particulars.

The Laboratories Orchestra

Fall rehearsals for the Bell Telephone Laboratories orchestra began on September 24 in the women's rest room on the 11th floor. The rehearsals this year are being conducted in the same general way as last—beginning at 5:00 P.M., a recess at 6:15 for lunch, and continuing to 7:30.

The Laboratories Orchestra is now under the leadership of Mr. L. E. Melhuish who succeeded Mr. Ebert last January. The attendance for the last eleven rehearsals has ranged from between twenty to twenty-five persons at each meeting.

The organization of the orchestra has changed slightly since a year ago. At that time the administration and work was all on the shoulders of one man, Mr. D. D. Miller, who then was elected president. This year ballots were sent out during the summer and an election held in which two members were chosen to act on an executive committee. The third member of the committee is to be the conductor. Mr. L. E. Melhuish has agreed to continue his work as long as everybody is satisfied and Messrs. R. J. Podeyn and E. K. Van Tassel were elected as the remaining members.

Last season several members of the orchestra worked with the Research Department in the study of music and musical instruments. At the close of the season the orchestra as a unit presented a demonstration in cooperation with the Research Department. The success of this work has made it likely that more of it will be carried on this year. It is also probable that similar work will be undertaken in the new sound picture studio.

Everything is looking exceedingly good for a big season this year with over forty people now actively interested in the orchestra. For further information get in touch with Mr. L. E. Melhuish in room 973, Mr. R. J. Podeyn in 6-H or Mr. E. K. Van Tassel in 263.

Hiking

The Fall Hiking schedule may be obtained from Phyllis Barton, room 749-B, extension 857.

Hallowe'en Bridge and Dance

There will be no apple-ducking at the Hallowe'en Party, but the Committee can promise just as much fun. Dance music served up by a smart little band is to be the main dish of the evening with an hors d'oeuvres of bridge. All this takes place at the Telephone Club at 140 West Street, famous for its food, lounge, billiard and card tables. Refreshments will be served during the evening and are included in the subscription price of one dollar. Use of the billiard tables will be at small additional charge. Those who attend in formal wear will be distinctly uncomfortable. It is not considered in keeping with the spirit of Hallowe'en. Due to the size of the club rooms, the attendance will be limited. With bridge starting at 7 and dancing at 8 o'clock it is expected that those fortunate members who thought to apply for tickets in advance will move en masse to the New York Telephone building directly from the Laboratories on October 31.

Contributors to this Issue

I. V. WILLIAMS received the B.S. degree in electro-chemical engineering from Pennsylvania State College in 1926. He had been employed by the Bell Telephone Company of Pennsylvania during the summer of 1925, and after graduation he was transferred to the Apparatus Development Department of these Laboratories. Mr. Williams has been concerned with metallic materials and their testing.

F. R. LACK began a varied career when he entered the Western Electric Company in 1911. After shop and laboratory experience he was enrolled for a year in a student course given by Western Electric. In 1917 he went to France as a member of the research and inspection unit headed by Colonel Shreeve, where he attained the rank of First Lieutenant. Soon after his return he was sent to China to install a radio-telephone system between Peking and Tientsin, and to Japan where he installed printing-telegraphs. Back in the United States he attended Harvard University from which he was graduated in 1925 with the degree of B.S. Since then he has been with the radio research group, specializing recently on crystal oscillators.

R. S. WILBUR began his telephone experience in the independent field in 1899. After eleven years in telephone operating and manufacturing companies, he joined the Circuit Laboratory at West Street. In the Systems Development organization he has participated in both manual and toll developments and is at the present time Toll Circuit Engineer.

H. E. MENDENHALL received the B.S. degree from Whitman College in 1921, then went to California Institute of Technology to receive the Ph.D. degree in 1927. After a year as instructor in physics and electrical engineering at the University of Utah, he came to the vacuum-tube research

R. S. Wilbur

I. V. Williams

F. R. Lack

laboratory at West Street. He has been especially concerned with the development of vacuum tubes for transmission at high frequencies and powers.

R. R. Riesz entered Ripon College in 1920, after two years with the Engineering Department of the Western Electric Company. Receiving the A.B. degree in 1924, he spent a year at the University of Wisconsin as an assistant in physics, receiving the M.A. degree. Since 1925 he has been with the Research Department studying the mechanics of vibrating systems.

J. T. Butterfield

J. T. Butterfield received the B.S. degree from Worcester Polytechnic Institute in 1907 and the E.E. degree from Purdue University in 1910. Coming at once to these Laboratories, he has been associated with the old Physical Laboratory and its successor, the General Apparatus Development Department, ever since. Among the advances to which he has contributed are the iron-dust core for loading coils, vacuum thermocouples and fuses, and the electrolytic condenser. At present he is studying bearings and lubrication.

The rapid growth of development and research work required for the Bell System as a part of its efforts to give the American public more and better telephone service is indicated by the fact that Bell Telephone Laboratories has found it necessary to lease 35,000 *square feet of space in the old Collier Building at* 314 *West* 13*th Street and* 60,000 *square feet in the Davis Building at* 250 *Hudson Street.*

The Laboratories now have nearly 4700 *employees exclusive of those engaged in the manufacture of vacuum tubes for the Western Electric Co., and occupy nearly all the space in the block bounded by West, Bethune, Washington, and Bank Streets, in addition to two floors at Canal and Hudson Streets.*

The space acquired in the Collier Building will be used for general clerical purposes, while the Patent Department and certain large groups of draftsmen will be located in the Davis Building. Telephones in the Collier Building will be connected with the Chelsea 1000 *switchboard. Those in the Davis Building will be connected with an independent switchboard, the number of which is not yet assigned. Occupancy of the Collier Building will begin about October* 1 *and the Davis Building a month later.*