NATIONAL RADIO NEWS

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The Dangers of Haste

The fable of the hare and the tortoise is more than an interesting childhood story—it carries an important message we sometimes forget in this age of speed.

The hare, you will recall, started off in great haste. Soon he was so far ahead of the slow-plodding tortoise that be became overconfident and took a nap. The tortoise kept going steadily and won the race.

Haste does not always mean progress. Too often it leads instead to errors, to actual waste of time and energy, and even to complete failure as in the case of the hare.

We must learn to work and wait. Take time for all things, because time often achieves results which are obtainable in no other way. Shakespeare expresses it thusly: *"Wisely and slow; they stumble who run fast."* More emphatic still was Benjamin Franklin, who said: *"Great haste makes great waste."*

Don't risk the dangers of haste. Keep going steadily like the tortoise, and you'll approach your goal in Radio steadily, inevitably.

J. E. SMITH,
President.

How Recordings Are Made

No. 1—Principles of Disc Recording

By CLINTON B. DE SOTO
Executive Editor, QST

The Editor is very grateful to QST, the publication devoted to Amateur Radio, for permission to reprint this interesting article which originally appeared in QST, July, 1942.

AN interest in radio implies an interest in many allied fields—in fact, in the whole subject of electronics and electricity. One of these corollary fields that has long been of interest to the kind of amateur who likes to build gear and explore new techniques is that of recording. This interest has been demonstrated by the volume of correspondence on the subject received by QST's technical staff over a period of years.

Now that it is a matter of necessity rather than choice that many of us turn to these allied fields to satisfy the urge to work with radio apparatus, this interest has increased even above its previous level. Nor is it all a matter of finding something to do with one's spare time, either. There are plenty of new commercial and even military uses for recording these days, and the ARRL Personnel Bureau has already been called on to supply qualified amateurs experienced in recording to fill various specialized jobs—some of them thrilling assignments that any adventurous ham would give his right arm to get in on.

Of course, a comprehensive knowledge of recording is gained only by long study and experience. But the basic fundamentals, both of design and practice, can be summarized in sufficient detail to give the amateur adequate background information either to go into recording as an alternative hobby or to enter a job where such knowledge is essential.

Probably every amateur has done enough casual reading about recording to know the basic elements of the system. Every amateur knows that the process of recording involves the use of a cutter or stylus which engraves on a wax disc a groove corresponding to the frequency and amplitude variations of the sound being recorded, and that in playback the vibrations of a needle riding in this groove are reconverted into sound waves, either directly or through an amplifier.

Every amateur knows, too, that the cutting stylus is held by a cutter head, and that the needle is associated with something on the end of a long arm called the pickup. He knows that the record is placed on a turntable, driven by a constant-speed motor at a speed of 78 or 33 r.p.m., and that the 33 r.p.m. kind is called an electrical transcription.

He knows these things, and possibly even a little more—such as that the groove cut by the stylus may resemble either the meanderings of a winding stream in flat country (lateral) or an undulating journey over hill and dale (vertical). In the back of his mind is a recollection that in some recording the stylus follows a pre-cut groove on the record, while in other systems it cuts its own way following the explicit directions of a feed-screw.

But concerning the details behind all these general facts the typical amateur is probably more than a little hazy. Not that the technique is so difficult, you understand; it's just that he hasn't had occasion to learn about it before. And there's no better time to begin than right now.

Mechanics of Recording

The problems of recording divide into two general classes: electrical and mechanical. It is about the mechanical problems that the amateur needs most to learn; the electrical details are mostly equivalent to those he has already encountered and solved in his work with speech amplifiers and modulators and the general paraphernalia of radiotelephony.

In the mechanical end, however, he must learn new questions and their answers. He must understand the importance of purely mechanical considerations, of damping and vibration, of mountings and resonance, of the flywheel effect and the constancy of speed of turntables, of the principles of the lathe and the hardness and shape of cutting tools, of the hardness, resiliency, viscosity and homogeneity of recording blanks, of many other matters which, now recognized only as faintly-familiar terms, enter into the mechanics of recording.

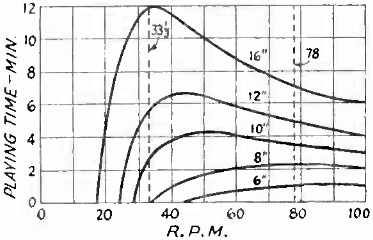

Fig. 1—Chart showing useful playing time for standard record sizes at various groove speeds. Small records (up to 10-inch) give longest playing time at 78 r.p.m., large records at 33-1/3 r.p.m. Latter speed was adopted originally because it gave longest playing time on 16-inch records used in talking-picture work. Chart is based on 96 lines per inch and minimum diameter required for sine-wave reproduction at 8000 cycles. With closer groove spacing and/or smaller minimum recording diameter, playing time can be extended up to 25%.

To get started on the right track, let us pause at the outset to establish the three major classes of recordings—commercial pressings, electrical transcriptions and instantaneous recordings.

The first two are strictly professional classifications. Commercial pressings are the ordinary 10- and 12-inch records you buy at the music store—fifty million or more of them annually. They are big-business, mass-production products turned out in a factory in the form of thousands of duplicates of a master recording.

These pressings are played on home phonographs and phono-radio combinations, and also to a surprising extent over broadcasting stations. But for high-quality reproduction, for "canned" programs and commercial announcements that are undistinguishable from direct pickups in quality of reproduction and freedom from noise, the broadcasters use electrical transcriptions.

Both pressings and transcriptions are made from a master recording on a soft wax blank, which is cut or engraved with an elaborate jewelled-bearing, precision-made cutting head. In the commercial recording studio this wax (metallic soap) blank, which is 17 inches in diameter and 1 to 2 inches thick, is engraved on a massive turntable which alone may weigh as much as 110 pounds, mounted on a concrete block foundation. After your favorite dance band has had its effects permanently preserved in the grooves on this blank, the wax is metalized by sputtering with gold or silver, or by chemical deposition of copper or silver. The master matrix which results is then used as one electrode in an electroplating bath and plated to a thickness of nearly 1/16th of an inch. By the electroplating process the markings on the wax are duplicated in the metal with a fineness as great as 0.00002 inch. This plating is carefully removed from the wax and reinforced with a solid metal plate.

Where only a limited number of duplicates are required, as in the case of electrical transcriptions, copies are made directly from this master matrix. In quantity production, however, additional duplicates called pressing plates or stampers are made from the master. The pressing plate is mounted on a hydraulic press, which is supplied with shellac blanks heated to perhaps 300° F. Every marking on the pressing plate—which is to say, everything recorded on the original wax—is then transferred to the blank under this heavy press. Thousands of exact duplicates of the original soft wax record can be made in this way.

Instantaneous Recording

The third classification—instantaneous recording—represents just what the name implies: single records that are played back immediately in the same form they are made. In other words, no masters and no copies. You make the one record and you play it. (Processes do exist for making pressings of certain forms of instantaneous recordings, but none are in common use.)

The instantaneous recording field ranges from the work done with high-quality equipment in broadcasting stations, which compares in quality with electrical transcriptions, to the simplest of home-recording equipment. In recent years even the latter has achieved surprising performance, as improved equipment and processes followed commercial popularization.

In fact, the better home recorders turn out records that surpass commercial phonograph records in quality and frequency range. This is because the instantaneous recordings start out in life with the understanding that they won't be required to play as long as the pressings. As a result they can be made of softer, and therefore more responsive, materials. The shellac pressings, on the other hand, must give many playings regardless of heavy pickups and cheap needles, and so the manufacturers add an abrasive to the shellac, which gives the disc greater resistance to wear by grinding the needle point to the shape of the record groove. It's a case of making the disc wear out the stylus rather than vice versa. Unfortunately, the action of this abrasive results in the familiar hiss noise or scratch when the record is played. Lacking the abrasive filler, the home recordings also lack the scratch.

The same is true of the electrical transcriptions, of course. In this case the abrasive is left out and materials with a high degree of homogeneity such as cellulose acetate or vinylite are used. The playing life is short, but that is of little or no consequence in the broadcasting studios to which the use of such transcriptions is confined.

Somewhat longer life is usually expected of the instantaneous records, and therefore harder, although still abrasive-free, materials are used. The exact nature of the blank used depends on the application, of which a wide range have come into being in recent years. Schools and colleges, industrial concerns, hospitals, theatres, scientific laboratories—there are a large variety of users of instantaneous recordings, apart from the home recordists and the amateur sound-movie makers. And each has his own requirements.

With modern equipment, however, the requirements of each can well be satisfied at reasonable cost. There has been a vast improvement in instantaneous recording technique in the past five years or so, the period during which the field has seen its great impetus. Five years ago the best systems available cut off only a little above 5,000 cycles—and were by no means flat below that. Now the technique will permit flat response out to 12,000 or even 15,000 cycles. Even the simpler home recording outfits are good up to 7,000 or 8,000 cycles. The amplitude range, too, has been extended from perhaps 35 db. to 40 or 45 db. for the home recorders and 55 or even 60 db. for the professional outfits.

Blanks

This improvement has resulted from development in all elements of the system, but particularly in the blanks. Those used now are a great step forward from the obsolete pre-grooved metal or acetate blanks which characterized the early days of home recording.

Present-day blanks are lacquer-coated discs with an aluminum, glass or cardboard base. It is in the lacquer, which is dipped, sprayed, flowed or spun on the surface of the disc to a thickness of 0.006 to 0.010 inches, that the groove is cut. The function of the base itself is to provide a flat, rigid, non-warping support for the lacquer. The principal requirement of the base is that it be flat and stay flat to record and play back without distortion or "wows." NAB standards stipulate that the maximum permissible warping of the disc from a true plane for satisfactory reproduction is 1/16th inch. In high-fidelity work even the slight variation in thickness produced by coating swirl is objectionable. The lacquer must therefore be applied in such a way as to give a smooth, even surface.

Because it is obviously the cheapest material, cardboard is used for thin, inexpensive blanks; but it suffers by comparison with other materials in that it is never truly smooth, bends under tension and tends to warp. Cardboard blanks usually show greater surface noise than other types, too. Yet with proper care in cutting and the correct playback needle fair results can be obtained with them.

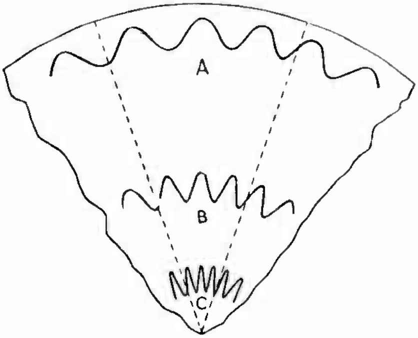

Fig. 2—Illustrating effect of recording diameter on reproduction quality. Because of the physical dimensions and inertia of the tip of the recording stylus, it cannot make groove configurations having too sharp a radius of curvature. Thus in the illustration shown the stylus is given the same time to execute the smooth gradual curves of A as it is the sharp curves of C. In practice it cannot execute the sharp-radiused curves of C and distortion results. The typical minimum diameter at which distortionless recording is practical is indicated at B. This minimum diameter can only be reduced by restricting the high-frequency range, which is equivalent to enlarging the minimum radius of curvature required.

From the standpoint of playback, even if the stylus would record a compressed groove as shown at C, the playback needle would be unable to follow it.

Up to the time the use of aluminum was restricted as a critical war material it was almost universally used as the base for high-quality blanks. Its characteristics were practically ideal—flatness, non-porosity, freedom from warping, stiffness against bending as well as thermal and hygroscopic changes. Aluminum blanks are used in both thin (flexible), medium and heavy weights.

In the search for a suitable substitute for aluminum, glass has been generally chosen. Apart from its inherent brittleness, glass has almost equally good characteristics, and some engineers claim that it produces even better recordings than aluminum. Breakage has not been a significant problem: even when a recorded blank has cracked the lacquer covering usually holds the pieces in place well enough to permit re-recording when that is considered necessary. The glass blanks in use range in thickness from 0.060 to 0.075 inches, with 0.065 about standard.

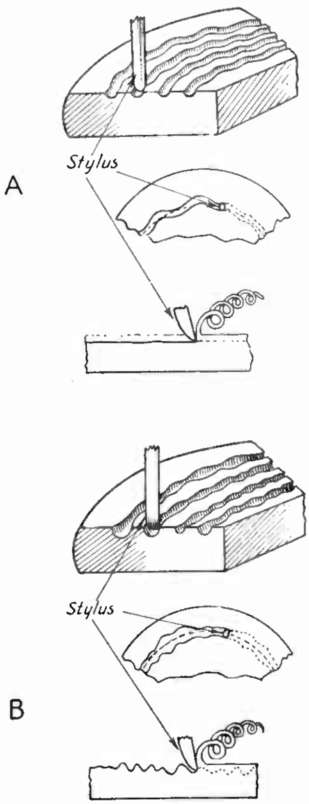

Fig. 3—(A) Lateral recording, as used in phonographic and most instantaneous recordings. The stylus cuts a groove of constant width and depth but moves from side to side in accordance with the frequency and amplitude of the signal being recorded. (B) Vertical recording, as used in electrical transcriptions for broadcasting. Stylus follows a constant-pitch lateral contour but moves up and down with modulation, cutting a groove of variable depth (and, since the stylus tip is spade-shaped, variable width).

Even more important than the base, of course, is the lacquer coating. As applied, this resembles the Duco finish on an automobile more than anything else. Although modern instantaneous blanks are still called "acetate" the term is a misnomer, because cellulose acetate is now seldom used for the purpose. Several bases are used, including nitrocellulose, acetyl cellulose, ethyl cellulose or one of several resins. Each of these substances is brittle in the pure state, and therefore plasticizers are added which serve to keep the coating soft and homogeneous. The kind and amount of the plasticizer determine the hardness of the coating in shear, and thereby control the noise level as well as the cutting characteristics and playing life. Soft records have lower surface noise, but the high-frequency response as well as the durability improve with hardness. The degree of hardness also has an effect on the manner in which the chip or thread behaves, as will be discussed in a later article. Coatings that are too soft, or that are cut before the solvent (used to dissolve the lacquer for the purpose of application) has thoroughly evaporated, will develop distortion later due to changes in the groove caused by surface strains during drying. On the other hand, a hard surface must be cut with care, using a sharp stylus at the correct angle, or the lacquer will tend to tear rather than cut cleanly.

The nitrocellulose base used in the majority of home recording blanks is highly inflammable, and care must therefore be used in handling the chip or thread that results from cutting. The size of the blank used for a given purpose is regulated by the playing time required and the recording speed used. There are two standard speeds now in use: 33⅓ and 78 r.p.m. The 78 r.p.m. speed (to be precise, 78.26) is used for all commercial pressings and practically all instantaneous recordings except those for broadcast purposes, while 33⅓ r.p.m. is used for electrical transcriptions and long-playing instantaneous recording for broadcasting.

From the technical standpoint, the use of higher groove speeds makes it easier to record higher frequencies as well as to avoid waver. Because of the increased wave steepness resulting from the difference in velocity, records cannot be cut at as high a volume level at 33⅓ r.p.m. as at 78. Careful design and operation is required throughout with 33⅓ r.p.m. equipment, but it is used because of the increased playing time, making it possible to record as much as a 15-minute program on a 16-inch record.

The playing time afforded by records of different sizes at various speeds is shown in Fig. 1. It will be seen that the smaller records are not suitable for recording at 33⅓ r.p.m. The reason for this is that the velocity of stylus travel is proportional to the radius as well as the turntable speed. Because the stylus travels slowly when the radius is small, the groove waveform becomes so greatly compressed at the higher frequencies that distortion results. While not as severe, this effect is also present at 78 r.p.m., and consequently there is a recommended minimum inside diameter for recording at both speeds. To meet broadcast standards this minimum diameter must be 3¾ inches for 78 r.p.m. and 7½ for 33⅓. In home recording work the inside diameter can be reduced to about 2½ and 4 inches respectively without too serious distortion provided the high-frequency range is restricted.

Lateral vs. Vertical Recording

The groove cut in the blank by the stylus in recording is two-dimensional. That is to say, as shown in Fig. 2, it may go from side to side with modulation, or up and down—but never both. With lateral—side-to-side—recording, the groove depth should stay constant, while with vertical—up-and-down, or hill-and-dale—recording the groove should trace a steady line of constant pitch over the face of the blank. When the cutter starts to move in two planes simultaneously, through vibration or other mechanical fault, that means trouble.

As to which is the best method—vertical or lateral—well, that's where even the experts disagree. The lateral method has been used almost exclusively for phonographic and home recordings, but during the past decade or so one school of thought has urged the vertical method for highest-quality transcriptions for broadcasting, talking pictures and the like. Two advantages are urged: one, that the vertical method gives longer playing time, since the space required for one groove is less because it follows a straight line, and therefore more grooves can be engraved on a single blank without crossovers (the stylus breaking through the wall of one groove into another): and two, that distortion is reduced because of the lessened danger of crossovers, and also because the playback needle is held more firmly in the groove and follows the up and down convolutions more closely, while with the lateral type it tends to slide around in the groove.

To which the partisans of the lateral method reply that, by keeping the amplitude at a reasonable level, very nearly as many grooves can be made as is feasible with ordinary equipment using the vertical method; that the fault of playback needle movement can be overcome by using carefully-made needles whose contours closely fit the groove; and finally that the vertical method may, in fact, introduce even more distortion, owing to tracking error resulting from the manner in which the rounded playback needle point follows the groove. This arises from the difference in shapes of the sharp-faced cutting stylus and the round-pointed needle; the difference in the contours of the paths traversed causes harmonic distortion at certain frequencies when the radius of curvature of the needle point is of the order of the radius of curvature of the modulated sine wave in the groove. This problem does not arise with a horizontal groove. Another difficulty in the vertical system is that the stylus has more work to do on the down-stroke than on the up-stroke, while in the lateral system the resistance of the coating is equal in either direction.

Constant Amplitude vs. Constant Velocity

Another point of argument concerns the relationship between the movement of the stylus with modulation displacement and the amplitude of the modulating signal. There are two basic characteristics this relationship may have: constant amplitude and constant velocity. Constant amplitude means that, given a constant input to the recorder, the amplitude of the resulting cut is constant regardless of the frequency. With a constant-velocity characteristic, on the other hand, the amplitude of the cut is inversely proportional to the frequency; i.e., the product of amplitude and frequency is a constant.

Reduced to the simplest terms, this means that with the constant amplitude system the stylus always moves the same distance to right or left regardless of frequency, speeding up on the higher frequencies to travel the additional distance required to execute the increased number of cycles. Additional power must be supplied as the frequency increases to maintain the amplitude. With constant velocity the stylus maintains the same rate of speed, swinging out wide on the lower frequencies and shortening its travel on the higher frequencies so that it covers the same lineal distance. The power required is the same for all frequencies.

What difference does it make? Well, even though it sounds like an academic distinction, there are several practical aspects to the choice between the two systems. In the first place, it is not possible to record with one system and play back with the other without severe distortion. You've got to decide on one or the other.

The reason neither one nor the other has been finally decided upon is a matter of men and mechanics. One school of thought argues that all recording should be done on the constant amplitude principle. These are the modernists. Supporting them is the fact that a crystal cutter and pickup, operating without equalization, will cut and reproduce an essentially constant amplitude characteristic.

On the other hand, an uncompensated electromagnetic cutter will cut a constant velocity pattern, and since the magnetic pickup has a similar characteristic it gives a flat response from such a recording.

So it might be said to be a matter of whether you use magnetic or crystal equipment. (If you mix them up you've got to compensate one unit or the other.) In the case of instantaneous recording, using a crystal cutter and pickup, common practice is simply to cut the record constant amplitude without compensation and let it go at that.

Which is all right unless you've got a constant-velocity record to play—and all commercial pressings are modified constant velocity records. In that case you'll have to do some equalizing. There is still a further complication, in that even constant velocity cutters do not maintain that characteristic at the lower frequencies. All such cutters are down something like 15 db. at 50 cycles, to prevent the amplitude becoming so excessive as to cause crossover and echo effects.

In playing modern transcriptions or instantaneous recordings the problem seldom arises, since it is now standard practice to record with constant amplitude. If you play commercial phonograph records, however, you've still got to cope with it, because these are made with constant amplitude only up to a point variously called the transition frequency, turnover point or crossover point, when they change over to constant velocity.

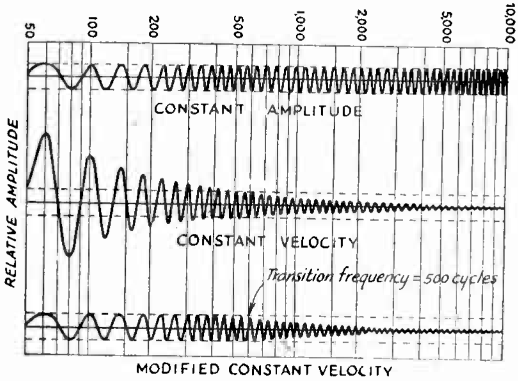

Fig. 4—Wave patterns characteristic of various recording systems. At top is illustrated the constant amplitude method, showing how the velocity of the stylus must increase with frequency to maintain the relative amplitude of stylus travel constant. In the constant-velocity system, the relative amplitude of stylus travel must be inversely proportional to frequency in order that the stylus velocity may remain constant.

The modified system used in commercial recordings is shown at bottom to have a constant-amplitude characteristic below 500 cycles (arbitrarily chosen as the transition or crossover frequency) and constant velocity above. Various manufacturers use different transition frequencies between 250 and 800 cycles.

The transition frequency may be anywhere from 250 to 800 cycles. Every time the frequency doubles above the transition point the output voltage drops to one-half. In other words, it goes down 6 db. per octave. This means, of course, that compensation is required when the record is played with a crystal pickup.

Just to confuse the situation still more, quite a number of recordings change over again somewhere above 1,000 cycles and from there on have a modified characteristic in between constant amplitude and constant velocity. This gives the highs an over all rising characteristic, which helps to mask the random background noise or hiss resulting from the grit contained in the shellac pressing. Of course, this must also be taken into consideration in equalizing. What it all adds up to is that no one amplifier or equalizer will serve to reproduce all kinds of records with true fidelity. And all you can do about it is play around until you get a pleasing result.

(This article is No. 1 of a series. Part II will discuss practical aspects of recording and the individual elements of the recorder in detail.—Editor.)

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Hygrade Sylvania Changes Name

The stockholders of Hygrade Sylvania Corporation acted to change the name of the Corporation to Sylvania Electric Products Incorporated, effective August 12, 1942.

It is planned to use the trade name Sylvania on all the company's products. This change will be made as rapidly as is consistent with economies of operation and the conservation of materials. The home address, of course, remains as before, Emporium, Pa.

n r i

Protecting the Home

"Why did you beat up this man?"

"Well, judge, I comes home and catches this guy in the parlor with my wife on his lap. He monkeyed with my radio and busted it. No guy is gonna bust up my radio and get away with it!"

n r i

Distantly Related

Kelly: Are yez related to Tim Reilly?

Reilly: Very distantly. I wuz me mither's first child and Tim wuz her tinth.

CIRCUIT ANALYSIS OF THORDARSON 15-WATT AMPLIFIER

By J. A. DOWIE
N.R.I. Chief Instructor

A TECHNICIAN'S work does not consist entirely of Radio receivers. In this issue of the NEWS we will analyze a typical audio amplifier which might be used in a p.a. system. This amplifier, whose circuit diagram is shown in Fig. 1, has sufficient power output to satisfy the requirements of many different public address installations. The versatility of the amplifier is evident when it is realized that it can be used for ordinary p.a. (public address) work, as a phonograph amplifier, for commercial or home recording, or to amplify the output of a photocell.

Starting with the output stage, we see that type 6V6-G beam power output tubes are used in a class A circuit. Distortion is kept below 5% even at full output by the use of inverse feed-back. This low level of distortion is quite good.

The high-impedance microphone and high-impedance phonograph channel, with independent gain controls, will allow use of any type of microphone and either a crystal or magnetic pick-up. The gain is sufficient to obtain full output either from the microphone or pick-up under normal operating conditions.

The circuit diagram shows two loudspeaker sockets, in which either electrodynamic or p.m. dynamic loudspeakers can be plugged. The power pack is designed to serve as field supply for one or two electrodynamic loudspeakers. More than two p.m. dynamic loudspeakers can be used, but naturally there would be no reason to use more than two with a relatively small p.a. system like this.

When a phono pick-up is used, the leads are plugged into the jacks provided on the *PHONO* terminal strip, and microphone volume control R-8 is set for zero volume (so its movable contact is grounded). The signal voltage from the pick-up is applied across phono volume control R-6, and the portion of this voltage between the movable contact and ground is applied to a voltage-dividing network consisting of R-7 and R-9. Only that portion of the signal across R-9 is applied to the input of the second 6J7 tube, the a.f. signal across R-7 being lost as far as the amplifier is concerned. This cuts the signal in half, but the gain built into the amplifier takes this into consideration.

The purpose of resistor R-7 is to isolate phono volume control R-6 from microphone volume control R-8 when the microphone input is used. Under this condition, R-6 is set to zero, and volume is controlled by R-8. If it were not for resistor R-7, control R-6 in its off position would connect the control grid of the second 6J7 tube directly to ground, thus cutting off the microphone signals. Resistor R-7 is 500,000 ohms which is enough to isolate R-6 from the microphone volume control.

Note the symbol for the microphone jack. The jack is of the telephone type, the outside shell going to ground and the hot (ungrounded) contact going to coupling condenser C-2. When a "mike" is plugged into this jack, one lead makes contact to the chassis through the jack shell, while the other connects to condenser C-2.

The mike signal is impressed through C-2 across the single bias cell and resistor R-3. In this way it is fed into the input of the first 6J7 tube. This tube is connected as a high-gain voltage amplifier. The weak a.f. signal applied to its input is amplified many times, so a strong a.f. signal is developed across plate load resistor R-5. Capacity coupling through condensers C-4 and C-10 allows the signal to be applied across volume control R-8, whose setting governs the amount of signal fed into the second 6J7 tube.

At the microphone input, you will notice the terminal strip marked POL-V. This means polarizing voltage. When a condenser-type microphone is used, a wire jumper is used to connect terminals 1 and 2 together, thus applying the necessary high d.c. voltage to the microphone plates. Here resistor R-2 and condenser C-1 serve as a decoupler filter, preventing any hum voltage from being applied to the condenser microphone and preventing the microphone signal from traveling through the power supply.

If a photoelectric cell of the gas-filled type is plugged into the mike jack, about 90 volts will be required to operate the cell. At terminal 1 we have about 270 volts, and when a photocell is used this is reduced to 90 volts across the mike jack by connecting a 5-megohm, 1-watt resistor between terminals 1 and 2.

If a condenser microphone or photoelectric cell is never to be used, R-1, R-2 and C-1 are eliminated during construction of the amplifier.

The shielding of wires and parts in the circuits of the two 6J7 tubes and the 6C5 tube is very important, if hum and noise are to be eliminated. Any hum or noise signals picked up at these points would receive great amplification. If they were as strong as the a.f. signals normally existing here, they would be just as loud at the loudspeakers, thus preventing use of the amplifier.

The microphone, photocell or phono signals applied to the input of the second 6J7 tube cause a large variation in the tube's plate current. The variation in current flowing through plate load resistor R-11 produces a strong a.f. output voltage across R-11.

Before we follow the signal to the next stage, note the electrode connections employed in the second 6J7 tube. With the screen grid, suppressor grid and plate tied together in this manner, the tube acts as a triode instead of a pentode. The gain as a triode is considerable, but far less than that obtained with the pentode connection used for the first 6J7 tube.

The triode connection was employed because a pentode tube fed with a strong signal will produce very strong harmonics, and these will cause severe distortion. Push-pull action and inverse feed-back permit the use of the 6V6 pentode-type output tubes, while the signal input of the first 6J7 is too low to produce much harmonic voltage. The signal fed the second 6J7 is, for either microphone or phonograph operation, too large to permit pentode operation of the tube.

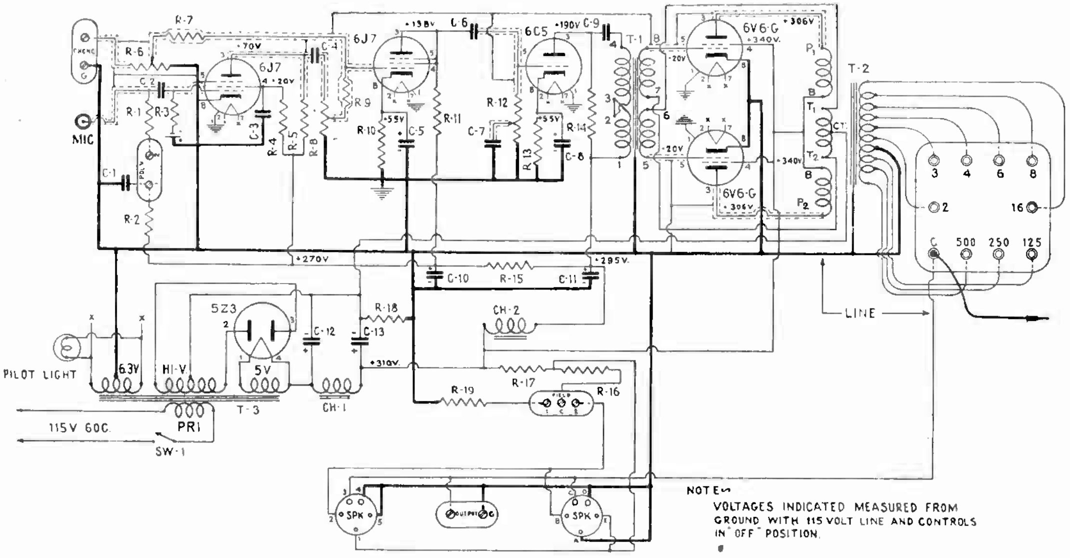
The second 6J7 is not replaced with a regular triode tube such as a 6C5, because even when connected as a triode the 6J7 can produce more gain than a 6C5. It is necessary to use a 6C5 in the next stage, for by now the signal is so strong that it would overload the 6J7 even when triode connections were used.

The a.f. signal voltage across R-11 is applied to grid resistor R-12 of the 6C5 tube through coupling condenser C-6 and filter condenser C-10. The signal current flowing through grid resistor R-12 produces a voltage drop which drives the grid of the tube. R-12 is a potentiometer, and the movable arm connects to ground through C-7, a .03-mfd. condenser. As the arm is moved up, more and more of the high frequencies are shorted or by-passed around R-12, and hence are not applied to the grid of the 6C5. In this way we achieve tone control, which permits attenuation of high audio frequencies as desired.

The a.f. signal voltage across R-12 alternately adds and subtracts from the d.c. bias developed across C-8 and R-13, making the grid first more negative and then less negative. This variation in control grid voltage causes a corresponding variation in plate current. As a result, we have a pulsating d.c. plate current flowing through plate load resistor R-14. Condenser C-9 and the primary of T-1 comprise a short path for the a.f. component, hence the effective plate load for signals is R-14 in parallel with C-9 and the primary of T-1. Since the resistance of R-14 is much greater than the impedance of the C-9, T-1 path at audio frequencies, practically all of the signal current passes through C-9 and the transformer.

This method of capacity coupling is a little out of the ordinary. If R-14 and C-9 were not used, the primary of T-1 would be placed right in the plate supply circuit of the 6C5. The circuit would function but the d.c. portion of the plate current would tend to saturate the transformer primary, and the mutual inductance of the transformer would decrease. This would decrease the voltage induced into the secondary, and would cause distortion since the change in flux linkage would be greater for a decrease in plate current than for an increase. For distortionless transfer of signal, the flux must follow current changes exactly. The loss in gain would be more serious at the low audio frequencies, because the primary inductance and hence the plate load impedance naturally decreases with frequency.

By keeping the d.c. portion of the plate current out of the primary, we avoid transformer saturation and thereby secure good low-frequency response from this stage. Resistor R-14 and condenser C-9 do this; the resistor supplies d.c. plate



NOTE—
VOLTAGES INDICATED MEASURED FROM
GROUND WITH 115 VOLT LINE AND CONTROLS
IN "OFF" POSITION.

Fig. 1. Circuit diagram of Thordarson-designed 15-watt a.f. amplifier. The parts values are as follows:

T-1	Input Transformer
T-2	Output Transformer
T-3	Power Transformer
CH-1	First Choke
CH-2	Second Choke
R-1	10 MEG., ½ w.
R-2	10 MEG., ½ w.
R-3	5 MEG., ½ w.
R-4	3 MEG., 1 w.
R-5	500,000 ohms, 1 w.
R-6	1 MEG. Volume Control
R-7	500,000 ohms, ½ w.
R-8	1 MEG. Volume Control
R-9	500,000 ohms, ½ w.
R-10	5,000 ohms, 1 w.
R-11	100,000 ohms, 1 w.
R-12	500,000 ohms Tone Control
R-13	1,000 ohms, 1 w.
R-14	20,000 ohms, 1 w.

R-15	20,000 ohms, 1 w.
R-16	2,500 ohms, 25 w.
R-17	1,500 ohms, 25 w.
R-18	125 ohms, 25 w.
R-19	2,500 ohms, 25 w.
C-1	.1 mfd., 400V Paper
C-2	.03 mfd., 400V Paper
C-3	.04 mfd., 400V Paper
C-4	.1 mfd., 400V Paper
C-5	10 mfd., 25V Elect.
C-6	.1 mfd., 400V Paper
C-7	.03 mfd., 400V Paper
C-8	10 mfd., 25V Elect.
C-9	.1 mfd., 400V Paper
C-10, C-11	8-8 mfd., 450 W.V. Elect.
C-12	8 mfd., 600V Elect.
C-13	8 mfd., 600V Elect.

voltage to the tube, and C-9 blocks d.c. while allowing a.c. to pass. By choosing a value of C-9 which will resonate with the primary of T-1 at a low audio frequency, a definite boost in gain at low audio frequencies can be obtained.

A.F. signal current flowing through the primary of T-1 sets up a flux linkage with the secondary, inducing an a.c. voltage in each half of the secondary. These secondary windings feed the two 6V6-G tubes in the push-pull output stage, with inverse feed-back being provided in the following manner by an extra center-tapped winding on output transformer T-2. Let us consider secondary 8-7 of T-1 first. Terminal 8 goes to the control grid of the upper 6V6-G output tube, while 7 goes to terminal T_2 on the special winding having a center tap marked CT. Resistor R-18 (a C bias resistor in the power pack) completes the path from CT to ground. The voltage between 8 and 7 thus acts in series with the a.f. voltage across the lower half of the "CT" winding and the d.c. voltage across resistor R-18. In a similar manner, the signal voltage between point 5 and point 6 acts in series with the a.f. voltage across the upper half of the "CT" winding and the d.c. voltage across R-18, all feeding the control grid of the other 6V6-G tube.

The 6V6-G tubes amplify the signals applied to their grids, and the resulting plate currents flow through primaries P_1-B and P_2-B of output transformer T-2. Due to the push-pull action, all even harmonics produced within the tubes are canceled out.

The odd harmonics, of which the third is the strongest and hence most troublesome, are not canceled out by the push-pull arrangement, but are taken care of by inverse feed-back (degeneration). The fundamentals and odd harmonics flowing through the primaries of output transformer T-2 induce voltages in the "CT" winding as well as in the regular secondary. These voltages, as you just learned, act in series with the a.f. voltages applied to the grids of the output tubes but are 180° out of phase due to the phase reversal provided by the output tubes.

The fundamental component which is fed back out of phase cancels out some of the fundamental at the grid input, thus reducing the gain. The designer took this into account, however, and there is gain to spare. The odd harmonics are also fed into the grid input of each 6V6-G, but since they were produced inside the 6V6-G tubes, they are not originally present in the input circuit. The fedback odd harmonics thus enter the tubes, are amplified and thus cancel out some of the odd harmonics being produced by the tubes. The amount of odd harmonic signal induced into T_1 and T_2 is hence very low. Complete cancelation is impossible, for we must have some signal induced into T_1-T_2 for feed-back purposes.

The output signal induced into the secondary of T-2 thus has only a very small amount of third harmonic distortion. The secondary has a number of taps, so that it can be connected to match most any load. The grounded secondary terminal goes to one load (loudspeaker) terminal by way of terminals 4 or 5 and A or D on the SPK. sockets, and the tap selected by probe lead C of the output transformer goes to the other load terminal through SPK. socket terminals 3 and C.

When the amplifier is to feed a device over a considerable distance, either the 125-, 250- or 500-ohm taps are used, and a special matching transformer is placed at the other end of the line. The lower-impedance taps are used for direct connections to voice coils, recorder cutting heads or other low impedance devices.

Most voice coils have an impedance of 8 ohms, so for a single voice coil we would plug probe lead C into the jack marked 8. If two speakers with 8-ohm voice coils were used, the coils could be connected in parallel; the combined impedance would then be 4 ohms, and the 4-ohm tap would be used. While voice coils are not ordinarily connected in series, we could do this and get a combined impedance of 16 ohms, which would be matched by using the 16-ohm tap.

If electrodynamic loudspeakers are employed, 10 watts of field excitation is available for one 5,000-ohm or one or two 2,500-ohm speaker fields. The following table indicates how speaker field connections are made to the SPKR. sockets. Note that in some cases a jumper wire is used between jacks on the terminal strip marked FIELD.

	Connect Jumper Between	Connect Field to Prongs
One 5000-ohm field	Not used	1 and 5
One 2500-ohm field	C and 2	2 and 5
Two 2500-ohm fields	Not used	B and E; 2 and 5
P.M. Loudspeaker	C and 1	no field

For practice, see if you can figure out the field supply circuits and the reasons for the connections given in the table. When doing this, take into consideration the ohmic values of the fields and of resistors R-16 and R-19. The ability to do this arises from a thorough understanding of radio fundamentals. Any student who can do this and has not finished more than the first twenty-three lessons in the course shows extraordinary ability.

The power supply circuit in this amplifier does not represent anything new to the experienced radio technician and is very similar to those shown in ordinary receiver diagrams. The rules for tracing circuit continuity apply to this amplifier just as to receiver circuits.

Most troubles which may be expected will take the form of distortion, hum and oscillation. The usual causes are to be suspected, but shielding is particularly important in the case of hum or oscillation. The reason for hum, if shielding is not employed, has already been pointed out. The thing to watch out for is poor ground contacts on the shielding.

The shields on the control grid and plate leads of the 6V6-G tubes prevent electromagnetic and electrostatic coupling between these points and others at a lower audio potential. Suppose, for example, the plate leads of the 6V6-G tubes were inductively coupled to the input of the 6J7 tube by being close to resistor R-3. Signal voltage would be induced into R-3, and being in phase with the input signal voltage, it would cause oscillation and a loud squeal.

Everything considered, the servicing of p.a. systems is no more difficult than servicing receivers and an experienced serviceman will have no trouble with p.a. systems if he has a good understanding of the fundamentals of radio.

ELECTRONICS PROMISES BRIGHT FUTURE

ELECTRONICS is the new science for the new world, and the bright promise for the future, the General Electric Company points out in its quarterly report to its stockholders. The report follows:

"Human beings, with a natural flair for the dramatic, like to dwell on the great 'accidents' of science which have served as humble foundation stones for tremendous achievement. Among others they list Newton's apple, Galvani's twitching frog legs, the destruction caused by lightning in Steinmetz' cabin on the Mohawk. Accidents? Not really. Rather call them legitimate by-products in the unending search for new knowledge, call them unsuspected doorways along the rich corridor of scientific study. The corridors, the whole research structure, and the trained men had to exist, of course, before the 'accidents' could happen.

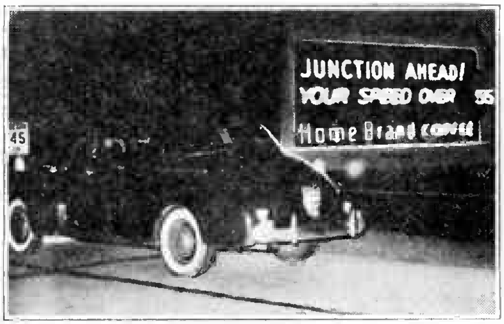
"Perhaps the greatest 'accident' of all was the Edison Effect. It came about in 1883, when Edison observed a bothersome phenomenon in some of his lamps when they were first lighted. It was a glow between the filament terminals, accompanied by a rapid disintegration of the filament. Investigating, he found the glow was due to current passing between the terminals, and that a better exhaust eliminated the glow. There Edison—and the rest of the world—paused for several years, unimpressed by the fact that the phenomena of electronics had been recorded for the first time. The 'glow' was actually an electronic gaseous discharge. It remained for Thomson, Fleming and DeForest, Langmuir, Richardson and Hull to build that accident into a whole new science. Today we say: 'Electronics is the new science for the new world, the bright promise for the future.' In that future General Electric is destined to play a major role.

"What is electronics? It is the science of the electron. The world of substance is built of molecules. Molecules, in turn, are various combinations of atoms, or elements. Continuing this simplified, but fundamentally accurate explanation of the structure of matter, it might be said that atoms consist of a nucleus of neutrons and protons, around which negatively charged electrons whirl as do the earth and other planets about the sun. Through the medium of the vacuum tube it is possible to separate these electrons from the atoms and put them to work.

"In Edison's lamp, negative electrons, rushing from the hot filament, had no place to go until he sealed a wire, or anode, inside the loop between the two legs of the filament, and sent the electron flow, or current, from filament to 'plate,' or—in electrical language from cathode to anode. The rest is one of those fascinating, painstaking scientific stories which rightly has no ending but only new chapters. In the first application of the Edison Effect, Professor Fleming developed a detector for wireless telegraphy, called the 'Fleming Valve.' Lee DeForest followed with the vacuum-tube grid, a small charged wire screen to control the flow of electrons through the valve. Armstrong found how to use DeForest's discovery to amplify radio-frequency waves, and thereby put an end to the earphone era. Lagmuir designed a high-vacuum tube which would handle watts and kilowatts, instead of merely fractions of a watt, and which could amplify the impulse of a microphone to tremendous power for radiation from an antenna. This was another key, to an even larger room—that of radiobroadcasting, and the work went on.

Radio engineers inspecting a new General Electric circular type radio antenna exhibited at the recent convention of the Institute of Radio Engineers at Cleveland. An outstanding feature of the antenna, simple in structure, is its ability to radiate substantially uniform energy in all directions without resorting to the complex and comparatively costly structures previously designed with phasing networks to secure this uniform pattern.

"For this generation radio is still an amazing and unbelievable thing, even though it has become as familiar and commonplace as plumbing and the automobile. In the wonderful mansion that is electronics, we have tarried longest in the room called radio because the experience has been pleasant and exciting. Electrons are as elemental and ubiquitious as fire. Fire made light and heat for centuries, as men rose in the scale of civilization, and that seemed to be wonder enough until they discovered stoves, and boilers for steam, and turbines for power, and saw that fire was not an end in itself but a tool of many uses and a new starting point. Something similar has been happening in electronics. Today we can have radio and television; tomorrow we can have much more, as new blessings are tumbled from that scientific cornucopia which is the vacuum tube. Even today these tubes range in size from tiny globes to cylinders several feet in length; they serve the doctor, the fireman, the artist, the fruit grower, the sea captain, the air pilot, the policeman, the manufacturer. Let us briefly see how.

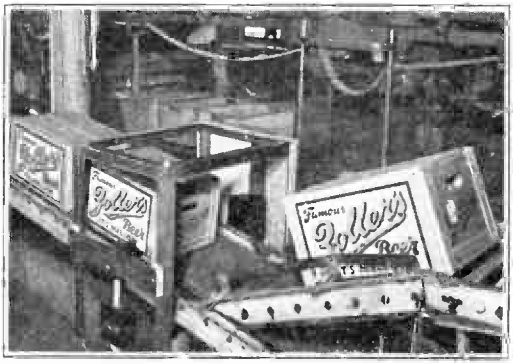


"Electronic Cop" "telling" motorist how fast he is going. The trick is done with G-E CR7505 photoelectric equipment and electronic timer. On highway near St. Paul and Minneapolis, Minn.

"A recording spectrophotometer, utilizing photoelectric cells, provides the most reliable method of analyzing color ever devised, defining accurately some 2,000,000 different shades, working for textile, paper, chemical and paint industries. Electronic devices automatically square the lengthwise and crosswise threads in weaving. Electric eyes guard sheets of metal on a conveyor, discarding those with defects. Vacuum tubes turn on the lights as the sky darkens, turn them off when it is light. Electronic devices, through carrier current, send messages and control distant apparatus linked only by power wires. Electronic rectifiers supply power to produce vital metals like aluminum. Electronic devices control the high-speed wrapping of packages, fill ginger-ale bottles to the proper level, remove slate from coal at the mines, sort the pure crystals of rock salt, level elevators, open doors, control punch presses, detect smoke and fumes, measure vibration and thickness. X-ray, priceless electronic tool of the doctor, now examines heavy steel castings for imperfections, detects porosities in welded seams, sees hidden defects in automobile tires, searches candy bars for foreign materials, picks good oranges from bad, analyzes metals and alloys in terms of diffraction patterns.

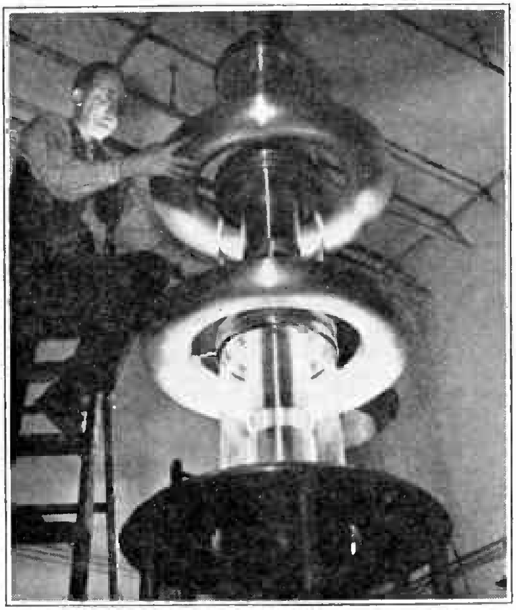
"The genetic effect of electronic X-rays has already produced new kinds of flowers, many well improved strains of fruits, vegetables, and grains as seeds are bombarded with millions of volts. The electronic microscope has revealed to biologists the character of the tobacco mosaic virus, a deadly crop disease that has cost growers millions of dollars a year. The electron will not long remain an abstraction for the farmer.

"In 1895 Roentgen observed—then named—the X-ray. Dr. W. D. Coolidge developed the Coolidge X-ray tube at Schenectady—and medicine had one of its most precious tools. Radiography today discloses when broken bones are mending, when teeth are decaying, how to treat a sinus condition; it shows the presence of tuberculosis and silicosis. Often on the heels of diagnosis comes therapy, as X-rays treat skin disorders and infections and wage war against cancer, gangrene and gas bacilli. By inducothermy, another electronic application, heat is safely generated in living tissues. The electrocardiograph amplifies the faint voltages of the heart muscle and records the action on photographic paper for the observation and guidance of the physician.



G-E photoelectric equipment used to count cases of beer passing along on conveyor belt, in plant of the Zoller Brewing Co. in Davenport, Iowa.

"Even radio is no longer just Bing Crosby, and baseball games and music while you shave. It is mobile police protection at all hours, weather observer, automatic pilot, instant communication for fireboat and fire truck, operator of remote power stations, fire fighter, cradle watcher. It



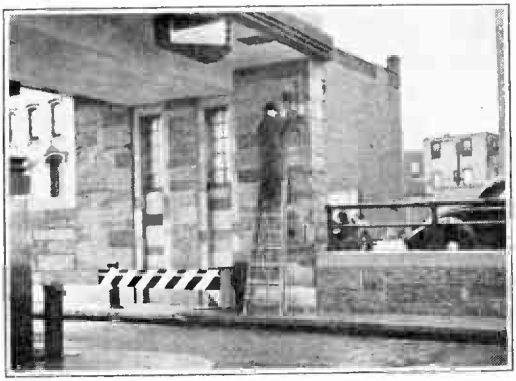
G-E X-Ray Tube, 1,400,000 volts, 10-section, 28.5 ft. Picture taken in G-E Research Laboratory at Schenectady, N. Y. Tube for National Bureau of Standards, Washington, D. C.

has learned to serve as well as to amuse and educate. Tomorrow, when the thunder and pain and preoccupation of war have passed, radio—released from the manacles of static by frequency modulation, or FM, and stripped of its blinders by television—will transport you to Carnegie Hall, to the White House, and to the ball game, bringing you the clear high note of the violin, the timbre of the voice, and even the color of the umpire's tie. Electronics has in store for millions of homes of the future a radio performance that as yet has not been a part of their experience.

"Only a short time ago the engineers of General Electric constructed a 20-million-volt induction electron accelerator. This is a research tool that whirls electrons at the highest speed ever produced, only a fraction of a percent less than the speed of light. General Electric has already begun work on a 100-million-volt accelerator.

"To the men in laboratories, and to the men in the factories and the offices of the electrical industry, it seems natural to speak of electronics as a science of the future because it gives such promise of great things to come. Yet that promise is based solidly on the present, as the electronic tasks and achievements sketched so hastily here will indicate. Of electronics' part in the war little has been said, but much will one day be written. While war with one hand withholds and obstructs our peaceful progress, commanding the energies of science for its own purposes, with the other it actually pushes forward research and application. Under the lash of necessity, developments which might have taken years are compressed into months. The world will reap these fruits of war, and they will not be bitter. A single example, in the field of ultra-short-wave radio, helps to make the point. Air transport pilots will have constantly before them, on the screen of a cathode-ray tube, clear warning of any obstacles ahead, so that mountains will lose their terror in darkness, and thick weather, and blind landings will be facilitated. At sea the ship's pilot will detect nearby shipping or icebergs through fog and darkness as plainly as in clear weather by day.

"The inspiration which electronics gives to the engineer springs from its fundamental nature. Before the invention of electronic tubes, electrical engineering was largely a science of wires and circuits. We were concerned with the jars and bottles and pipes in which electricity was stored, through which it was distributed. Now, with that magical Aladdin's lamp, the electron tube, the engineer can command electrons so that they will do his bidding. For the first time he has hold of electricity itself—not just its manifestations. All that has gone before, important as it has been to our lives and fortunes, may well be only a preparation for a new and greater adventure in living. And that is why we say: 'Electronics—a new science for a new world'."



G-E photoelectric installation at entrance of vehicular tunnel as height indicator. When truck is high enough to interrupt beam, loud horn is sounded, warning traffic officers to halt truck. At Queens-Midtown Tunnel, New York.

INTERCHANGEABILITY CHART FOR DISCONTINUED TUBES

The following 349 different types of tubes are no longer being manufactured for civilian use. The order banning production of these duplicate, obsolete and little-used types of tubes was issued by the War Production Board to conserve essential materials, machines and man hours for long production runs of the approximately 360 types of tubes still being made for civilian use.

Since adequate stocks of these discontinued tubes will be available in most localities for at least two years, and since many of the discontinued tubes can be directly replaced by tubes still in production, Radiotricians need not be particularly concerned by this WPB ruling on tubes.

Note that many special Majestic (Maj.) tubes have been dropped. The specified equivalent replacements should be shielded if trouble is experienced with them. In a few other instances, the equivalent replacement may necessitate using an external tube shield and realigning the set.

The greater part of this list is taken from the Technical Section of "Sylvania News," through the courtesy of Sylvania Electric Products, Incorporated. In many cases, however, recommended equivalent replacement tubes have been added to the original Sylvania list.

Type	Comment
00A	Obsolete type
0Z3	Obsolete type
01A	Slow moving type
01AA	Slow moving type
1A1	Slow moving type
1A1/5E1	Slow moving type
1A5G	1A5GT/G replaces
1A7G	1A7GT replaces
1B1	Slow moving type
1B4	Obsolete, use 1B4T
1B4P	Slow moving, use 1B4T
1B4P/951	Slow moving, use 1B4T
1B7G	1B7GT replaces
1B8GT	Slow moving type
1C1	Slow moving type
1C4	Australian type
1C5G	1C5GT/G replaces
1D1	Slow moving type
1D2	Obsolete type
1D4	Australian type
1D7G	Slow moving type
1E1	Slow moving type
1E2	Obsolete type
1E4G	Slow moving type
1E5G	Obsolete type
1E5GP	Slow moving type
1E5GT	Slow moving type
1E7G	Slow moving type
1F1	Slow moving type
1F7GH	1F7G replaces
1F7GV	1F7G replaces
1G1	Slow moving type
1G4G	1G4GT/G replaces
1G5GT/G	Slow moving, use 1G5G
1G6G	1G6GT/G replaces
1G6GT	1G6GT/G replaces
1G7GT/G	Never released
1H5G	1H5GT replaces
1J1	Slow moving type
1J5G	Slow moving type
1K1	Slow moving type
1K4	Australian type
1K5G	Australian type
1K6	Australian type
1K7G	Australian type
1L1	Obsolete type
1L5G	Australian type
1L5GT	Never released
1LB6	Slow moving type
1LC5	Slow moving type
1M5G	Australian type
1N1	Obsolete type
1N5G	1N5GT replaces
1N6G	Slow moving type
1N6GT	Slow moving type
1P1	Obsolete type
1P5G	1P5GT replaces
1Q1	Obsolete type
1Q5G	1Q5GT/G replaces
1R1G	Slow moving type
1R4	Never released
1S1G	Obsolete type
1T1G	Slow moving type
1T4GT	Never released
1T5G	Never released
1U1	Obsolete type
1W1	Obsolete type
1Y1	Slow moving type
1Z1	Slow moving type
2	Slow moving type
2A3H	Obsolete, use 2A3
2A7S	Maj.; use 2A7
2B6	Obsolete type
2B7	Slow moving type
2B7S	Maj.—Slow moving
2E5	Slow moving type
2G5	Obsolete type
2S/4S	Maj.—Slow moving
2W3	Slow moving type
2W3GT	Slow moving type
2X3G	Never released
2Y2	Obsolete; use 2X2/879
2Y3	Canadian type
2Y4	Canadian type
2Z2	Obsolete type
2Z2/G84	Maj.—Slow moving
3	Slow moving type
3B8GT	Never released
3C5GT	Slow moving type
3LE4	Withdrawn type
3Q5G	3Q5GT/G replaces
3S5	Never released
4	Slow moving type
4A1	Slow moving type
4A6G	Slow moving type
5	Slow moving type
5T4	Withdrawn, use 5U4G
5V3G	Never released
5W4	5W4GT/G replaces
5W4G	5W4GT/G replaces
5X3	Special—Obsolete
5Y3G	5Y3GT/G replaces
5Z4G	Obsolete; use 5Z4
5Z4MG	Obsolete; use 5Z4
6	Slow moving type
6A4	Obsolete type
6A4/LA	Slow moving type
6A5G	Slow moving type
6A6X	Ceramic based; use 6A6
6A7S	Maj.—use 6A7
6A8MG	Obsolete; use 6A8G
6AB5	6AB5/6N5 replaces
6AB6G	Slow moving; use 6N6G
6AC5G	6AC5GT/G replaces
6AC6G	Slow moving; use 6N6G
6AC6GT	Slow moving; use 6N6G
6AD5G	Obsolete type
6AD5GT	Never released
6AD6G	Slow moving; use 6AF6G
6AE5G	6AE5GT/G replaces
6AE5GT	6AE5GT/G replaces
6AE6G	Slow moving type
6AE7GT	Slow moving type
6AF5G	Slow moving type
6AF6GT	Slow moving; use 6AF6G
6AF7G	French type
6AG5GT	Never released
6AG6G	Never released
6AH5G	Never released
6AL6G	Slow moving type
6B6	Obsolete; use 6B6G
6B7S	Maj.—use 6B7
6B8GT	Slow moving; use 6B8G
6C5G	6C5GT/G replaces
6C5MG	Obsolete; use 6C5GT/G
6C7	Maj.—Slow moving
6C8GT	Never released
6D5G	Obsolete type
6D5MG	Obsolete type
6D6G	Never released
6D7	Maj.—Slow moving
6D8	Never released
6E4GT	Never released
6E6	Slow moving type
6E7	Maj.—Slow moving
6E8G	French type
6F5MG	Obsolete; use 6F5G
6F7S	Maj.—use 6F7
6G5	6U5/6G5 replaces
6G7	Canadian type
6G7S	Canadian type
6H4G	Never released

Type	Comment
6H5	Withdrawn, 6U5/6G5 replaces
6H6G	6H6GT/G replaces
6H6MG	Obsolete; use 6H6GT/G
6H7S	Canadian type
6H8G	French type
6J5G	6J5GT/G replaces
6J5GX	Ceramic based; use 6J5GT/G
6J6GT	Never released
6J7MG	Obsolete; use 6J7G
6K6G	6K6GT/G replaces
6K6MG	Obsolete; use 6K6GT/G
6K7MG	Obsolete type
6L6GT	Never released
6L6GX	Ceramic based; use 6L6G
6M6G	French type
6M7G	French type
6M8GT	Slow moving type
6N5	6AB5/6N5 replaces
6N5G	Never released
6N6	Slow moving; use 6N6G
6N6GT	Never released
6N6MG	Obsolete; use 6N6G
6N7G	Slow moving; use 6N7
6N7GT	Never released
6P5G	6P5GT/G replaces
6P6	Australian type
6P7G	Slow moving; use 6P7
6P8G	English type
6Q6	Never released
6Q6G	Withdrawn, 6T7G replaces
6Q7MG	Obsolete; use 6Q7G
6R6G	Slow moving type
6S5	Canadian type
6S6GT	Slow moving type
6SE7GT	Slow moving type
6T5	Withdrawn, 6U5/6G5 replaces
6T6	Canadian type
6T7G/6Q6G	6T7G replaces
6U5	Withdrawn, 6U5/6G5 replaces
6V4G	Never released
6V5G	Never released
6V6G	6V6GT/G replaces
6V6GX	Ceramic based 6V6G
6V7G	Slow moving type
6W5G	Slow moving; use 6X5GT/G
6W6GT	Slow moving type
6X5	6X5GT/G replaces
6X5G	6X5GT/G replaces
6X6G	Canadian type
6Y3G	Special slow moving
6Y5	Maj.—Slow moving
6Y5G	Never released
6Y5GT	Slow moving type
6Y5S	Obsolete type
6Y5V	Obsolete type
6Y6	Never released
6Y6GT	Never released
6Y7G	Slow moving type
6Z3	Withdrawn; 11 replaces
6Z4	84/6Z4 replaces
6Z5	Maj.—Slow moving
6Z5/12Z5	Obsolete type
6Z6MG	Obsolete type
6Z7G	Slow moving type
7	Slow moving type
7A7LM	7A7 replaces
7B5LT	7B5 replaces
7B6LM	7B6 replaces
7B8LM	7B8 replaces
7C5LT	7C5 replaces
7D7	Slow moving type
7G7	7G7/1232 replaces
7N5	Never released
7R7	Slow moving type
8	Slow moving type
9	Slow moving type
WD11	Obsolete type
WD12	Obsolete type
WX12	Obsolete type
12A	Slow moving type
12A5	Slow moving type
12A8G	12A8GT replaces
12B6	Canadian type
12B7	14A7/12B7 replaces
12C8GT	Never released
12E5GT	Slow moving type
12J5G	Never released
12J7G	12J7GT replaces
12K7G	12K7GT replaces
12K8GT	Slow moving; use 12K8
12Q7G	12Q7GT replaces
12S7GT	Never released
12SA7G	12SA7GT/G replaces
12SC7GT	Never released
12SK7G	12SK7GT/G replaces
12Z5	Obsolete—6Z5 replaces
14	Slow moving type
14A4	Slow moving type
14A7	14A7/12B7 replaces
1486	Slow moving type
14B8	Slow moving type
14C5	Slow moving type
14E6	Slow moving type
14E7	Slow moving type
14F7	Slow moving type
14N7	Slow moving type
14Y4	Slow moving type
15	Slow moving type
17	Slow moving type
18	Slow moving type
20	Slow moving type
22	Slow moving type
24	Obsolete—24A replaces
24S	Maj.—use 24A
25A6	25A6GT/G replaces
25A6G	25A6GT/G replaces
25A7G	25A7GT/G replaces
25AC5G	25AC5GT/G replaces
25B5	Slow moving type
25B6G	Slow moving type
25B8GT	Slow moving type
25D8GT	Slow moving type
25L6	25L6GT/G replaces
25L6G	25L6GT/G replaces
25N6G	Slow moving type
25RE	Export type
25S	Obsolete, 1B5/25S replaces
25X6GT	Slow moving; use 25Z6GT/G
25Y4GT	Slow moving type
25Y5	Heavy duty 25Z5 for Export
25Z3	Never released
25Z4	Slow moving type
25Z4GT	Slow moving type
25Z5MG	Obsolete; use 25Z5
25Z6G	25Z6GT/G replaces
27S	Maj.—use Z7
29	Obsolete type
31	Slow moving type
35A5LT	35A5 replaces
35L6G	35L6GT/G replaces
35RE	Export type
35S/51S	Maj.—use 35-51
35Z3LT	35Z3 replaces
35Z5G	35Z5GT/G replaces
35Z6GT	Slow moving; use 35Z6G
40	Slow moving type
45A	Obsolete—45 replaces
46A1	Slow moving type
46B1	Slow moving type
48	Slow moving type
49	Slow moving type
50C6G	Slow moving type
50L6G	Never released
50Y6G	50Y6GT/G replaces
50Z6G	Slow moving type
50Z6GT	Never released
50Z7G	Slow moving; use 50Y6GT/G
51	Obsolete—35/51 replaces
52	Slow moving type
55	Slow moving type
55S	Maj.—Slow moving
56AS	Maj.—use 76
56S	Maj.—Slow moving
57AS	Maj.—use 77-6C6
57S	Maj.—use 57
58AS	Maj.—use 78-6D6
58S	Maj.—use 58
64	Obsolete; use 36
65	Obsolete; use 39/44
68	Obsolete type
69	Obsolete type
70	Obsolete type
70A7GT	Slow moving; use 70A7G
70L6GT	Slow moving type
75S	Maj.—use 75
79	Slow moving type
82V	Never released
85AS	Maj.—Slow moving
87S	Canadian type
88S	Canadian type
89	Slow moving type
95	Obsolete; use 2A5
V99	Slow moving type
X99	Slow moving type
117E4GT	Never released
117L7GT	117L7/M7GT replaces
117M7GT	117L7/M7GT replaces
117Z6G	117Z6GT/G replaces
117Z6GC	117Z6GT/G replaces
182B/482B	Slow moving type
183/483	Slow moving type
401	Obsolete type
485	Slow moving type
950	Slow moving type
1232	7G7/1232 replaces
1852	6AC7/1852 replaces
1853	6AB7/1853 replaces

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Sample Questions and Answers for Radio Operator License Examinations

By WM. FRANKLIN COOK

N. R. I. Technical Consultant

THIS is the second installment of the answers to questions taken from the *Study Guide for Commercial Radio Operators.**

As pointed out before, the following material answers particular questions found in the Study Guide, but all students and graduates should study these questions and answers. Of course, it is not expected that the beginner will understand all of the points brought out, as much of the material is advanced.

There is apparently some misunderstanding about the Study Guide. This is just a booklet full of questions, *with no answers.* It is published by the Federal Communications Commission for the purpose of indicating the scope of the operators' examinations. In other words, the questions are given as review topics to those interested in obtaining a license. If satisfactory answers can be given to most of the questions, then one has an excellent chance of passing the license examination.

Remember, the following answers are far more detailed than would be required for an operator's license examination. The questions are theoretical, so the answers go more thoroughly into basic theory in order to permit similar questions to be answered.

A mistake was made in the previous installment in answering Question 2-21. The answer given is correct for a magnetic compass placed in the field of a coil. However, the question asks about a compass placed within a coil *itself.* This changes matters. Substitute the following for that question and answer.

(2-21) How may a magnetic compass be affected when placed within a coil carrying an electric current?

Ans. A current-carrying coil has a magnetic field about it and passing through it. As a compass is a magnetized object, this field will affect the compass if it is placed anywhere near the coil. The compass needle will line itself up in the magnetic field in such a manner that the pole marked North on the compass will point in the direction in which the magnetic lines of force act.

That end of a coil which magnetic lines of force leave is called the North pole of the coil, and that end of the coil which lines of force enter is called the South pole.

Therefore, if the compass is placed outside the coil, but in the coil field, it will line up so that the North Pole on the compass will point toward the South pole on the coil.

If the compass is now moved within the coil, the North pole of the compass will still point in the direction in which the lines of force act. It happens that this will then be pointing toward the North pole of the coil.

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*The full title of the book is "*Study Guide and Reference Material for Commercial Radio Operator Examinations.*" Copies of this Study Guide can be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C., for a price of fifteen cents. This must be in coins or money order, as stamps are not acceptable.

In other words, when the compass is placed *within the coil*, the pole marked North on the compass will point toward the North pole of the coil. Outside the coil, in the coil *field*, the North pole on the compass points toward the South pole of the coil. I am, of course, assuming that the compass is held in a position so that the needle will be parallel to the direction of the lines of force.

ELEMENT II
Basic Theory and Practice

(2-42) Define the term "decibel."

Ans. The decibel is a measure of the amount by which a pure sine wave sound must be increased before the change in sound level can be distinguished by the average human ear. The human ear does not react in proportion to sound pressure or sound power, so doubling of the sound intensity as indicated by a meter will not make the sound twice as loud to our ears. In fact, the human ear is known to have a logarithmic characteristic, which means that its ability to distinguish changes in audio power varies as a logarithm of the power ratio.

For reference, the formula is

$$\text{db} = 10 \log \frac{P_1}{P_2}$$

As a practical example, if we increase the electrical power from three watts to six watts, we have a power ratio of six divided by three, or two. Obtaining the logarithm of this number and multiplying it by ten, we find we have had a three-decibel increase in sound. This means that the ear would be capable of distinguishing three definite steps in sound if we increase the power from three to six watts.

On the other hand, if we increase the power from thirty watts to sixty watts, we have sixty divided by thirty, or a power ratio of 2, and again only a three-decibel increase in power. Note that as the power level increases, it requires tremendous further power increases before the ear can distinguish the fact that the power is changed.

It is important to note that the decibel by itself does not represent any certain amount of sound. It is entirely a ratio item, expressing the ratio between two power or energy levels.

In common practice, we assume a certain level as the starting point or reference level, so that we can get some absolute decibel value. For example, in radio work (public address), it has been normal practice to assign .006 watt as the reference level. Then, by comparing any wattage output of an amplifier to this reference level, we can determine the decibel increase of the amplifier, above the reference level. As an example, a 10-watt amplifier has a decibel output of slightly more than 32 decibels when compared to the .006-watt reference level.

(2-43) What is meant by "ampere-turn"?

Ans. The ampere-turns of a coil is the product obtained by multiplying the coil current in amperes by the number of turns in the coil. The magnetic field or flux density produced by a coil is proportional to the current and also proportional to the number of turns. Increasing either will increase the flux. Hence, the magnetomotive force which forces flux around the magnetic circuit of a coil is expressed in ampere-turns.

(2-44) Define the term "inductance."

Ans. The ability to produce flux linkages is called *inductance*. The flux linkage of a coil is equal to the number of lines of flux multiplied by the number of turns the flux links or passes through. The number of flux linkages per ampere of current is a measure of inductance. When 1 ampere produces 100,000,000 flux linkages, we have one henry of inductance.

If the current through a one-henry inductance changes at the rate of one ampere per second, a voltage of one volt will be induced in the coil. Therefore, we have an inductance of one henry when a current change of one ampere per second induces one volt.

Inductance, therefore, can also be defined as the factor which, when multiplied by the rate of change in current, will give the induced voltage.

An inductance stores energy in magnetic form when current is increasing, and releases this energy when the current decreases, using this stored energy to oppose any change in current flow. It thus is similar to inertia, and has been called *electrical inertia*.

Inductance in the same circuit, as in a single coil, is referred to as *self-inductance*. Where the inductance is the common property between two associated circuits, it is referred to as *mutual inductance*. Where mutual inductance exists, a change in current in one circuit induces a voltage in the other, as in a transformer.

(2-45) Define the term "coulomb."

Ans. The coulomb is a unit of quantity of electric current. It is usually defined as the amount of electricity which will pass a point in one second, when the rate of flow is one ampere.

Since the coulomb is a unit of quantity, it is a measure of the number of electrons flowing. It takes about 6,300,000,000,000,000,000 electrons to make one coulomb.

Notice that this is a measure of quantity, just as the gallon is the measure of a quantity of water. If we were to talk about the rate of flow of water, we would refer to the gallons flowing past a point in a second. Coulombs per second is the rate of current, which is measured in amperes. In other words, dividing the coulombs by the time gives amperes. Similarly, multiplying the current in amperes by time gives coulombs.

(2-46) Define the term "power factor."

Ans. Refer to Question 2-38, as this is essentially the same question.

(2-47) What is the unit of magnetomotive force?

Ans. The unit of magnetomotive force is the gilbert.

When we speak of coils, we use the ampere-turn as a practical unit for magnetomotive force. However, we could not use such a term when referring to magnets, so the gilbert is the standard unit. To change ampere-turns into gilberts, multiply the number of ampere-turns by 1.26.

(2-48) Express one horsepower in watts.

Ans. One horsepower is equal to 746 watts. In other words, this amount of electric power is capable of doing the same work as the horsepower unit used in mechanical systems.

(2-49) State the three ordinary mathematical forms of Ohm's Law.

Ans. $I = \frac{E}{R}$ $E = I \times R$ $R = \frac{E}{I}$

(2-50) State Ohm's Law.

Ans. Ohm's Law states that the current in an electric circuit is directly proportional to the electromotive force and inversely proportional to the resistance.

This just means that as the voltage is increased for a fixed resistance, the current will be increased. If the resistance is increased while the voltage is fixed, the current will be decreased.

Strictly speaking, this applies only to a d.c. circuit or to a circuit containing only resistance. It can be made to apply to an alternating current circuit having a reactance if full account is taken of phase, through the proper use of reactance and impedance factors. At radio frequencies, the a.c. resistance may be different from the d.c. resistance, particularly due to skin effect, where the current may tend to flow more on the surface of the wire than in the middle of the wire.

(2-51) If a vacuum tube having a filament rated at one-quarter ampere and five volts is to be operated from a six-volt battery, what is the value of the necessary series resistor?

Ans. Here we have a series circuit, consisting of a tube filament and a resistor, connected to a six-volt battery. We can assume that the battery voltage is exactly six volts for this example.

From Kirchhoff's voltage law, the voltage rise must equal the voltage drops, and we have a voltage drop of five volts in the tube filament. Since the drops must equal the rises, we must have a total of six volts as drops, and one volt must be dropped in the resistor.

From Ohm's Law, the resistance is equal to the voltage across the resistor divided by the current through it. This is a series circuit and the tube requires .25 ampere. Therefore, the resistance will be equal to one volt divided by .25 ampere. This gives a value of four ohms for the series resistor.

(2-52) If the voltage applied to a circuit is doubled and the resistance of the circuit is increased to three times its former value, what will be the final current value?

Ans. From Ohm's Law, the current varies directly with voltage. Hence, doubling the voltage will double the current. However, current also varies inversely with resistance, so multiplying the resistance by three will reduce the current to one-third its former value. In other words, we have multiplied the current by two and divided it by three, so it is two divided by three or two-thirds its former value.

(2-53) If a relay is designed to operate properly from a six-volt d.c. source, and if

the resistance of the winding is 120 ohms, what value of resistance should be connected in series with the winding if the relay is to be used with a 120-volt d.c. source?

Ans. This question is very similar to Question 2-51. Again from Kirchhoff's voltage law, we know the voltage rises equal the voltage drops. Therefore, the voltage across the resistor must be 114 volts, so that when added to the 6 volts required by the relay, we get the 120 volts which is the new source voltage.

The current flow which is to pass through the relay must now be determined. From Ohm's Law, dividing the relay voltage by the relay resistance will give the current. Six volts divided by the given resistance of 120 ohms gives a current of .05 ampere. This current must also flow through the resistor when used to adapt the relay to a 120-volt source. Hence, the value of the resistor will be its voltage drop divided by the current, which gives 114 divided by .05, or 2280 ohms.

(2-54) What should be the minimum power dissipation rating of a resistor of 20,000 ohms to be connected across a potential of 500 volts?

Ans. The power dissipation in a resistor can be obtained from any of the three forms of the power formula. These are $P = E \times I$, $P = I^2 \times R$, or $P = E^2 \div R$. If we use either of the first two, we will have to determine the current flow from Ohm's Law. We can use the last form directly, however. The voltage is given as 500 volts. The square of this is 500 × 500, or 250,000. Dividing this value by the resistance value of 20,000 ohms, we will obtain an answer of 12.5 watts.

This is the actual dissipation of the resistor itself. In usual practice, a safety factor is necessary. The next commercial size above a 10-watt resistor would be a 20 or 25-watt size. Allowing a double safety factor, a 25-watt resistor would probably be used. Furthermore, if the resistor is to be enclosed, such as underneath a crowded chassis, it cannot radiate heat so well and an even larger size might be desirable for safety.

(2-55) If resistors of 5, 3, and 15 ohms are connected in parallel, what is the total resistance?

Ans. There are two ways of figuring out a problem of this kind. We know that when resistors are connected in parallel, the resistance is less than the smallest resistance.

The basic formula for use, regardless of the number of resistors, is:

$$R = \cfrac{1}{\cfrac{1}{R_1} + \cfrac{1}{R_2} + \cfrac{1}{R_3} \text{ etc.}}$$

Using this formula, and inserting the values given in the question, we have:

$$R = \cfrac{1}{\cfrac{1}{5} + \cfrac{1}{3} + \cfrac{1}{15}}$$

$$R = \frac{1}{.2 + .333 + .066}$$

$$R = \frac{1}{.599}$$

$$R = 1.67 \text{ ohms}$$

Another method which is sometimes used for three resistors is to combine two of them in parallel first, then combine the resulting answer with the third one. To use this method, we start with the formula for two resistors in parallel, which is:

$$R_A = \frac{R_1 \times R_2}{R_1 + R_2}$$

$$= \frac{15 \times 5}{15 + 5}$$

$$= \frac{75}{20}$$

$$= 3.75 \text{ ohms}$$

$$R = \frac{R_A \times R_3}{R_A + R_3}$$

$$= \frac{3.75 \times 3}{3.75 + 3}$$

$$= \frac{11.25}{6.75}$$

$$= 1.67 \text{ ohms}$$

(2-56) What is the maximum rated current-carrying capacity of a resistor marked "5000 ohms, 200 watts"?

Ans. We are given the resistance and wattage rating of this resistor, and are asked to find the current. We must find some formula involving these three factors. You will remember that the basic power formula indicates that the power in watts is equal to the square of the current, multiplied by the resistance. By solving this formula for current, we will have the necessary three factors. in other words:

$$P = I^2R$$

$$I^2 = \frac{P}{R}$$

$$I = \sqrt{\frac{P}{R}}$$

Now, to find the current, insert the values given for the power and resistance; divide the power value by the resistance value and extract the square root of the result. This gives:

$$I = \sqrt{\frac{200}{5000}}$$

$$I = \sqrt{.04}$$

$$I = .2 \text{ amp.}$$

(2-57) Show how you would use a wave trap to exclude an undesired radio signal from a receiver.

Ans. There are several ways in which wave traps can be connected to a receiver. Incidentally, a wave trap is just a coil and condenser combination tuned to the undesired signal. It is used in such a manner that the undesired signal input is cut down.

We can put the coil and condenser in parallel. then connect the combination in series with the antenna lead-in of the radio, as shown at the left in *Fig. 2-57*. When tuned to the interfering station, the result is a high impedance to that signal. Other frequencies are passed by the coil or condenser with little opposition.

It is also possible to arrange a coil and condenser in series, and connect the combination across the antenna and ground terminals of the radio, as shown in *Fig. 2-57*. In this case, the series-resonant circuit offers a very low-impedance path to the *undesired* signal, thus tending to by-pass it around the input of the receiver. Other frequencies encounter high opposition in this wave-trap path, and are thus forced to follow the desired path through the input of the receiver.

The best connection depends on the design of the input circuit of the receiver. It is usually desirable to shield the coil and condenser.

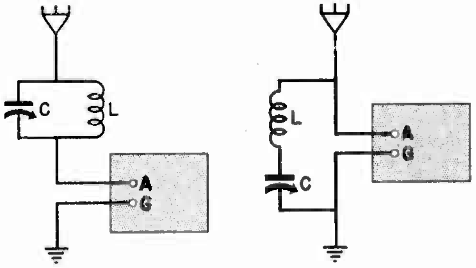

Fig. 2-57

(2-58) A milliammeter with a full-scale deflection of 1 ma., and having a resistance of 25 ohms, was used to measure an unknown current by shunting the meter with a 4-ohm resistor. It then reads .4 ma. What was the unknown current value?

Ans. The meter is indicating the current which is actually passing through it, so we must find the current flow through the shunt resistor to find the total. As the meter indicates .4 ma. (.0004 ampere) and the meter resistance is 25 ohms, we can find the voltage across the meter and parallel resistor by Ohm's Law, $E = I \times R$. Multiplying .0004 by 25 gives .01 volt. Divide this voltage by the shunt resistance (4 ohms) and you will get the shunt current, which is .0025 ampere or 2.5 ma. Hence the unknown current is the meter current plus the shunt current, or .4 + 2.5, which gives 2.9 ma.

Another way to figure this is to find the new full-scale current and work backwards. The meter current at full scale is 1 ma. and the resistance is 25 ohms. The voltage for full-scale is then $.001 \times 25 = .025$ volt. When a 4-ohm shunt resistor is used, the shunt current for the full-scale condition would be $.025 \div 4 = .00625$ ampere or 6.25 ma.

Hence, the new maximum current range of the combination will be this current plus the meter current, or a total of 7.25 ma. The addition of the shunt has increased the range of the meter from 1 ma. to 7.25 ma. By dividing the new current maximum by the old, we get a multiplier number ($7.25 \div 1 = 7.25$ in this case).

Now, all we need to do is multiply the meter deflection by this multiplier number to find just what current is flowing. We are told that the meter indicated .4 ma. Multiplying this by 7.25 gives an answer of 2.9 ma.

(2-59) What will be the heat dissipation, in watts, of a resistor of 20 ohms having a current of ¼ ampere passing through it?

Ans. The formula to use here is the one which says the power in watts is equal to the square of the current, multiplied by the resistance. The current of ¼ ampere is the same as .25 ampere. Multiplying this by itself, we will get an answer of .0625. Multiplying this, in turn, by the 20 ohms will give an answer of 1.25 as the heat dissipation in watts of the resistor.

$W = I^2R = .25 \times .25 \times 20 = .0625 \times 20 = 1.25$ watts.

(2-60) If two 10-watt, 500-ohm resistors are connected in parallel, what is the power dissipation capabilities of the combination?

Ans. Since the resistances and wattages are exactly equal, we can add the wattage dissipation factors, which means that these two resistors can dissipate 20 watts.

If they are not equal in resistance, it is not possible to add the wattages in this manner. For example, suppose we have a 500-ohm, 10-watt resistor and a 1000-ohm, 10-watt resistor in parallel. The two resistances in parallel give us an effective resistance of about 333 ohms. If we add the wattage ratings to obtain 20 watts, and then use our 333-ohm value to find the voltage across the combination, we will find that we will have about 82 volts. Eighty-two volts across a 500-ohm resistor would result in a wattage dissipation of more than 13 watts, instead of 10 watts. Therefore, the smallest resistor is being overloaded.

In a case of this kind, to determine just what the new wattage dissipation will be, you will have to find the voltage which will give the required wattage dissipation in each resistor. Then take the smaller of the two voltages and use the combined resistance value to determine the new wattage rating.

If the resistances are equal, but the wattage is unequal, again we can not add directly. For example, suppose we have two 500 ohm resistors, one rated at 10 watts and the other at 5 watts. If placed in parallel, the same amount of current will pass through each resistor. (In parallel the same voltage is across both and their resistances were assumed equal.) Hence, when the 5-watt resistor is dissipating its rated power, the 10-watt resistor is also dissipating 5 watts, so the total is only 10 watts dissipation. Therefore, we have only twice the lowest wattage dissipation when resistances are equal but wattages are unequal.

(2-61) What is the formula used to determine the total capacitance of three or more capacitors connected in series?

Ans. This formula is the same as the one for resistors in parallel, except that capacity values are used.

The formula is given below. All of the capacities must be in the same unit, farads, microfarads, or micro-microfarads, in which case the answer will be in the same kind of unit.

$$C = \cfrac{1}{\cfrac{1}{C_1} + \cfrac{1}{C_2} + \cfrac{1}{C_3} \text{ etc.}}$$

(2-62) What is the formula for determining the capacitive reactance of a condenser?

Ans. The capacitive reactance is the opposition a condenser offers to the flow of alternating current. It varies inversely as the capacity, which means that it goes down as the capacity goes up. It also varies inversely as the frequency. The formula is:

$$X_C = \frac{1}{2\pi f C}$$

where X_C is in ohms, 2π is equal to 6.28, f is in cycles per second and C is in farads.

Since the farad is such a large unit of capacity, this formula is sometimes simplified to:

$$X_C = \frac{159{,}000}{fC}$$

where X_C is in ohms, f is in cycles, and C is in microfarads.

(2-63) If condensers of 1, 3 and 5 microfarads are connected in parallel, what is the total capacitance?

Ans. Note that the condensers are in parallel. When condensers are placed in parallel, the resulting capacity is the sum of all the capacities. Hence, the capacity in this case is 1 + 3 + 5, or 9 mfd.

(2-64) What is the formula used to determine the total capacitance of three or more condensers connected in parallel?

Ans. This is answered in Question 2-63. When condensers are connected in parallel, you just add them up. Hence, the formula is $C_1 + C_2 + C_3$. etc.

(2-65) If condensers of 5, 3 and 7 mfds. are connected in series, what is the total capacitance?

Ans. We must go back to our formula for series condensers, given in Question 2-63. Insert the proper values and solve for the answer as shown below:

$$C = \cfrac{1}{\cfrac{1}{C_1} + \cfrac{1}{C_2} + \cfrac{1}{C_3}} = \cfrac{1}{\cfrac{1}{5} + \cfrac{1}{3} + \cfrac{1}{7}} = \frac{1}{.2 + .333 + .142} = \frac{1}{.675} = 1.48 \text{ mfd.}$$

(2-66) The charge in a condenser is stored in what portion of the condenser?

Ans. A condenser is primarily two conductors separated by an insulator or dielectric. Ordinarily, we think of the conductors as plates, because this is a common form.

The charge in a condenser is stored in the dielectric. In other words, when we apply a voltage to a condenser, it results in an electrical stress in the dielecrric. We say that an electrostatic field exists between the condenser plates and hence in the dielectric.

The ability to store energy in this manner is a measure of the capacity. Hence, a proof that this energy is stored in the dielectric arises from the fact that a change in the dielectric will change the capacity of the condenser. For example, if we have a condenser with an air space between the plates and charge it to a certain voltage, we will store a definite amount of energy in the condenser. Then, if we put some material between the plates, and measure the voltage, we will find the voltage has decreased. Since the quantity of electricity stored in the condenser has remained the same, this decrease in voltage means that the capacity has increased. This arises from the formula $Q = C \times V$.

(2-67) Having available a number of condensers rated at 400 volts and 2 mfds. each, how many of these condensers would be necessary to obtain a combination rated at 1600 volts, 1.5 mfds.?

Ans. We have to make an assumption here. Either we must assume that the condensers are perfect, or else we must assume that they all have the same leakage resistance, or that each condenser is shunted by an equalizing resistor.

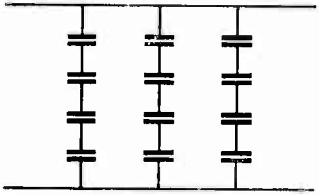

Fig. 2-67

After making any one of these assumptions, we can then go ahead and consider the connections. The condensers are rated at 400 volts and must withstand 1600 volts. We must therefore connect condensers in series until we get a voltage rating of 1600 volts. This would take four condensers rated at 400 volts, connected in series.

When condensers of equal capacity are placed in series, the resulting capacity is equal to that of one condenser divided by the number in the series connection. Hence, 2 mfd. divided by 4 will give us a capacity of .5 mfd. for our four condensers in series.

Now, remembering that the capacities in parallel add together, you can see that we will have to have three parallel groups of four condensers to give us the required capacity of 1.5 mfd. This gives us a total of 12 condensers, connected as shown in *Fig. 2-67*.

n r i

George and the Dragon

A tramp knocked on the door of the inn known as "George and the Dragon." The landlady opened the door and the tramp beseeched: "Could you spare a poor, hungry man a bite to eat?"

"No!"—and she slammed the door.

A few minutes later the tramp knocked again. The landlady again came to the door. He asked: "Could I have a few words with George?"

CAPTAIN GEORGE J. ROHRICH

U. S. Signal Corps

★ ★ ★

GEORGE J. Rohrich is one of Radio's real old timers. He built his first radio receiver and transmitter way back in 1911, and in 1912 was issued Amateur License Number 5. His station was 3GB. At that time, which was some 30 years ago, young Mr. Rohrich was a student at McKinley High School in Washington, D. C. He was tremendously interested in "Wireless," as radio was then called. His Science teacher at McKinley High, who had a far reaching vision of Wireless, or Radio, at every opportunity encouraged Rohrich in his experiments. The name of this teacher was J. E. Smith.

One evening, young Mr. Rohrich invited his instructor to inspect his "ham" outfit. Mr. Smith was very much impressed—so much so he started picturing Mr. Rohrich in a project which was fast taking shape in the mind of Mr. Smith. In 1914 then, when Mr. Smith started the National Radio Institute, it was a natural turn of events that he should enlist Mr. Rohrich as one of his instructors.

He had his first taste of Army life in 1916 on the Mexican Border. When the United States entered the first World War, Mr. Rohrich packed his kit bag and proceeded to France as one of Uncle Sam's boys. He served 13 months as radio instructor for the Army Signal Corps at Langres, France.

Came the Armistice, and Mr. Rohrich began to long for that desk at N.R.I. Back he came none the worse physically for his experience and rich in newly gained knowledge in the subject nearest his heart—Radio. Returning to civilian life as radio engineer in charge of the Laboratory at N.R.I. Mr. Rohrich found time to continue his studies in electrical engineering at George Washington University.

Like most veterans of the first World War, Mr. Rohrich joined the American Legion. He soon became one of the most active members in his Post. He rose from one office to another until he was elected Commander of Post No. 27 in the Department, District of Columbia. One of Mr. Rohrich's proudest possessions is the diamond-studded American Legion ring which was presented to him by his buddies when he completed his term as Commander.

History repeats itself. When the United States entered the second World War, Mr. Rohrich began to get restless. He wanted to get into action. His first opportunity was to serve as a member of Local Draft Board Number 6, Washington, D. C. That was a job big enough to satisfy most men but every day Mr. Rohrich heard the call for men—radio men—thousands needed in the United States Signal Corps. It was a call Mr. Rohrich felt he had to answer. And answer he did. Again he asked Mr. Smith and Mr. Haas for a leave of absence for the duration of the war—a request which was gladly granted. In quick time Mr. Rohrich went through the usual routine required by the Army and in a few days he was in uniform—the uniform of a Captain in the Signal Corps of the United States Army.

Just before Captain Rohrich left to assume his new duties in the Army, Mr. Smith telephoned him to ask him to drop in at N.R.I. for a final visit. Actually, Mr. Smith and Mr. Haas had prepared a surprise for Captain Rohrich. All the employees gathered together for the purpose of witnessing the presentation of a beautiful wrist watch, as a gift from his associates at N.R.I. The tributes which Mr. Smith, Mr. Haas and other co-workers paid Captain Rohrich came from their hearts and deeply touched his, he admitted.

We are sure the thousands of friends Captain Rohrich has made among N.R.I. students and graduates join us in wishing him the best of good fortune. Captain Rohrich wanted to serve his country again. His loyalty—his devotion to the United States of America is a splendid example of practical patriotism. We are proud to put another service star in our flag at N.R.I.

N.R.I. ALUMNI NEWS

Edward Sorg	President
John Stanish	Vice-Pres.
Peter J. Dunn	Vice-Pres.
Louis J. Kunert	Vice-Pres.
Chas. J. Fehn	Vice-Pres.
Earl Merryman	Secretary
Louis L. Menne	Executive-Secretary

NOMINATIONS FOR 1943

IN accordance with our constitution the members of the National Radio Institute Alumni Association are called upon to nominate candidates for the various offices in our organization, to serve during 1943. This section of our constitution requires that the nominations be made 60 days before January 1st.

Our constitution further provides that one month prior to January 1st of each ensuing year the names of the two nominees for each office shall be submitted to the entire membership. The membership shall in return submit the ballots properly marked, voting for one nominee for each office.

It is our custom to call for nominees for the approaching year in the issue of NATIONAL RADIO NEWS corresponding to this one, then present the names of the two nominees for each office in the next issue of the NEWS, for the election of one, to take office on January 1st.

Most of our members know the procedure but for the benefit of those who have joined during the current year we wish to point out that all officers, except the President, may be nominated to succeed themselves. Several years ago the membership voted to amend our constitution to limit the term of office of the President to one year. The purpose of this amendment was to allow a greater number of our members to fill office in our organization.

The term of Edward Sorg of Chicago, therefore, will terminate on December 31st. Mr. Sorg has truly been honored by our Alumni Association having also been elected a Vice-President in 1941. In 1939 Mr. Sorg served as Chairman of Chicago Chapter. For faithful service to our Alumni Association his name will, on January 1st, go on our honor roll to join Past-Presidents, John E. Fetzer, K. W. Griffiths, T. J. Telaak, Peter J. Dunn, Earl R. Bennett, Clarence Stokes, and Dr. George B. Thompson. In the meantime, of course, Mr. Sorg still has several months to serve.

All present Vice-Presidents may be re-nominated to succeed themselves. Eight candidates for Vice-President will be nominated from which number, four will be elected.

A strong candidate for President in 1943 is F. Earl Oliver of Detroit. Mr. Oliver served as Vice-President in 1940 and 1941. In 1942 he was nominated for President only to run second to Mr. Sorg. Mr. Oliver is a very hard worker for our Alumni Association. He is Past-Chairman of Detroit Chapter and at present Secretary of that Chapter. He is tremendously interested in our Alumni Association, and our members individually. He is always glad to extend a helping hand to any member whenever he is called upon. Mr. Oliver would make an ideal President of our Alumni Association.

In order that our members may have a wide list of candidates to choose from we are submitting a list of names of members located in various parts of the country. These are submitted merely to be of assistance to you. Any member of the Alumni Association may be a candidate for office. Vote for anyone you like. Use ballot on pages 29 and 30.

Allen McCluskey, Birmingham, Ala.
Don Smelley, Cottondale, Ala.
Julius L. Billy, Mobile, Ala.
H. E. Nichols, Lowell, Ariz.

Albert Damerest, Phoenix, Ariz.
Edgar E. Joiner, El Dorado, Ark.
Roy Bryan, Ft. Smith, Ark.
P. Rochelle, Little Rock, Ark.
Oliver B. Hill, Burbank, Calif.
C. F. West, San Francisco, Calif.
R. H. Rood, Los Angeles, Calif.
Dr. Geo. B. Thompson, Los Angeles, Calif.
P. A. Abelt, Denver, Colo.
John Jerry, Denver, Colo.
A. H. Wilson, Leadville, Colo.
W. R. Haberlin, Bridgeport, Conn.
M. E. Perkins, Bristol, Conn.
Joseph Snyder, Danbury, Conn.
Leonard A. Dugan, Wilmington, Del.
George W. Howell, Wilmington, Del.
Charles W. Hoffman, Washington, D. C.
J. J. Jenkins, Washington, D. C.
Clyde D. Kiebach, Washington, D. C.
Robert E. Maney, Washington, D. C.
J. W. Nally, Washington, D. C.
Ben McGehee, Arcadia, Fla.
Austin L. Hatch, Ft. Lauderdale, Fla.
Stephen J. Petruff, Miami, Fla.
W. C. Hill, II, St. Petersburg, Fla.
Gene Atkinson, Atlanta, Ga.
R. R. Wallace, Ben Hill, Ga.
L. E. McAllister, Mt. Berry, Ga.
John C. Bills, Boise, Idaho
Arvil H. King, Montpelier, Idaho
Jerry C. Miller, Chicago, Ill.
Earl R. Bennett, Evanston, Ill.
James Cada, Berwyn, Ill.
Harry Andresen, Chicago, Ill.
Harold Bailey, Peoria, Ill.
Lowell Long, Geneva, Ind.
G. H. Millspaugh, Anderson, Ind.
Chase E. Brown, Indianapolis, Ind.
George Palmer, Kokoma, Ind.
Raymond L. Drake, Cedar Falls, Iowa
E. C. Hirschler, Clarinda, Iowa
O. L. Kirkpatrick, Augusta, Kans.
Louis A. Harrison, Ellis, Kans.
William B. Martin, Kansas City, Kans.
Ernest Horton, Pittsburgh, Kans.
Hazelton M. Yober, Topeka, Kans.
Robert Steidle, Covington, Ky.
Wm. S. Nichols, Cynthiana, Ky.
S. E. Banta, Gonzales, La.
James H. Foster, New Orleans, La.
Lawrence Merz, New Orleans, La.
Peter J. Dunn, Baltimore, Md.
E. W. Gosnell, Baltimore, Md.
J. B. Gough, Baltimore, Md.
Samuel Robinson, Hagerstown, Md.
G. O. Spicer, Hyattsville, Md.
Austin Vachon, Bath, Maine
Joseph Dubois, Biddeford, Maine
Ralph E. Locke, Calais, Maine
Laurence E. Grant, Belmont, Mass.
Louis Crestin, Boston, Mass.
A. Singleton, Chicopee, Mass.
Omer Lapointe, Salem, Mass.
O. A. Grindahl, Duluth, Minn.
Francis P. Hoffman, Minneapolis, Minn.
Lloyd R. Olson, Minneapolis, Minn.
F. Earl Oliver, Detroit, Mich.
J. Stanish, Detroit, Mich.
Frederick Gaul, Freeland, Mich.
Winfred V. Watts, Winona, Miss.
Ralph Blank, Grayridge, Mo.
C. S. Burkhart, Kansas City, Mo.
A. Campbell, St. Louis, Mo.
C. W. Wichmann, Inverness, Mont.
Carl M. Darner, Sweet Grass, Mont.
U. S. Capes, Fairmont, Nebr.
Melvin C. Ashbaugh, Merna, Nebr.
C. D. Parker, Lovelock, Nev.
R. E. Sawyer, Silver City, Nev.
Clement Morrissette, Cascade, N. H.
Arthur Cornellier, Dover, N. H.
E. Everett Darby, Woodsville, N. H.
J. A. Stegmaier, Arlington, N. J.
John Stein, Union City, N. J.
Delbert Delanoy, Weehawken, N. J.
Claude W. Longstreet, Westfield, N. J.
Gus W. Fisher, Alamogordo, N. Mex.
James E. Graham, Carlsbad, N. Mex.
Clarence D. Morrison, Gallup, N. Mex.
John E. Kreitner, Buffalo, N. Y.
Alfred R. Guiles, Corinth, N. Y.
L. J. Kunert, Middle Village, L. I., N. Y.
Charles W. Dussing, Syracuse, N. Y.
C. C. Cobb, Winston Salem, N. C.
Irvin Gardner, Saratoga, N. C.
Arvid Bye, Spring Brook, N. Dak.
Frank Moore, Portsmouth, Ohio
Jacob J. Knaak, Cleveland, Ohio.
F. L. Kirschner, Tulsa, Okla.
R. E. Fullhart, Bartlesville, Okla.
Emil Domas, Dale, Oreg.
George H. Newton, Eugene, Oreg.
Elmer E. Hartzell, Allentown, Penna.
Charles J. Fehn, Philadelphia, Penna.
William Dyson, Pawtucket, R. I.
James F. Barton, Greer, S. C.
Noel J. Lawson, Aberdeen, S. Dak.
Chester Warren, Lead, S. Dak.
W. P. Brownlow, Johnson City, Tenn.
J. E. Collins, Paris, Tenn.
H. A. Gilmore, Amarillo, Texas
B. A. McLendon, Dallas, Texas
L. H. Watkins, Ogden, Utah
Walter Leland, Orleans, Vt.
J. W. Gladden, Alexandria, Va.
A. P. Caldwell, Buchanan, Va.
T. E. Ellis, Richmond, Va.
R. F. Keil, Seattle, Wash.
J. V. Williams, Winslow, Wash.
R. A. Heise, Wheeling, W. Va.
Wm. Wiesmann, Fort Atkinson, Wisc.
J. C. Duncan, Duncan, Wyo.
Robert Kirkham, Calgary, Alta., Canada
M. Martin, New Westminster, B.C., Canada
Henry H. Sutton, Flin Flon, Man., Canada
H. V. Baxter, St. John, N.B., Canada
Donald Swan, Springhill, N.S., Canada
G. C. Gunning, Smiths Falls, Ont., Canada
E. Bergeron, Sherbrooke, P.Q., Canada
J. W. Meadwell, Saskatoon, Sask., Canada

Here And There Among Alumni Members . . . .

B. S. Lavins, N.R.I. Comptroller, is a Sergeant in the Auxiliary Police Force in Washington, D. C. Darned if the guy isn't beginning to look and act like a copper. He is liable to arrest himself, most any day now, for overtime parking in front of his house.

n r i

David S. Blackwell, former Chairman of Phila-Camden chapter, is employed by the War Department as an Inspector of Signal Corps equipment.

n r i

J. L. Billy of Mobile, Ala., writes that he has just finished paying for his home and radio shop. Thanks for the pictures.

n r i

Arlington Baldeck is employed with Eastman Kodak Company, Rochester, N. Y., in their Electronics Department.

n r i

N.R.I. graduates who are qualified will find a list of Job Opportunities on page 30 of this issue. If interested, write a neat letter of application, giving age, education, experience, citizenship and draft classification, if known. Send your application direct to the prospective employer, not N.R.I.

n r i

Roy D. Brownson is now engaged in the Electrical Research Department of Douglas Aircraft Company. Gives credit to his N.R.I. training.

n r i

Tom S. Baker is employed by the War Department, Air Corps Materiel Division.

n r i

Fidele Comtois has a radio business in the gold mining section of Canada. Doing fine too. There's a radio business that is a gold mine, no fooling.

n r i

Henry T. Hungerpiller was a grocery clerk when he enrolled with us three years ago. Now he is Radio Operator in the Merchant Marine, on a tanker. A game young man who is giving his all to serve our country in the face of great danger.

n r i

Herbert Caswill, Province of Ontario, Canada, is a member of the R.C.A.F., now on duty across the water. Nice to hear from you, Herb, and good luck to you and your buddies.

F. C. Underwood, Jr., is Supervisor of the 3rd Air Force Communications School in Savannah, Ga. Has a staff of 12 instructors including George R. Gallager, also N.R.I.

n r i

Alfred J. Raper is teaching radio code to a group of Army and Navy fliers at an airport in Nebraska. This is part time work. Mr. Raper regularly is Ass't Engineer in a Broadcast Station.

n r i

John J. Cleaver has been appointed General Manager of the Public Utilities Commission, Almonte, Ontario, Canada. He has had wide experience in Public Utility work and is an ideal man for the new job.

n r i

Chas. A. Kuhns, until recently Vice-Chairman of Phila-Camden Chapter has gone to Johnson City, Tennessee, where he has taken a job as Radio Serviceman for W. T. Brownlow, a great N.R.I. booster.

n r i

When Donald Lewis of Brownsville, Texas enrolled with N.R.I. he was a Service Station Attendant making $50.00 a month. He started his Radio career doing spare time work while studying the Course, then took a job as Serviceman for Montgomery Wards—took additional Code training—got a first class phone and second class telegraph license—now is Flight Radio Operator for Braniff Airways, Inc., and gets well over $300 a month, with expenses paid. There's a short success story for you.

n r i

Michael Burns, Jr., is a Warden in the C.P.C. Patrol, District 19, Montreal, Quebec, Canada.

n r i

C. E. Davidson, who held positions as Chief Engineer at several Radio Stations, most recently WNOE, New Orleans, is now a Staff Sergeant in the U. S. Marines. Watch that fellow go up in the Service.

n r i

Anthony T. Puscizna of New York State, is a member of the Signal Service Department in a Florida Army camp. Is getting some fine Radio Engineering training, for which his N.R.I. Course prepared him. John F. Prajka of Pennsylvania, also N.R.I., is a member of the same Company.

n r i

Leon D. Markham of St. Louis, Michigan (not Missouri) is making plans to take a position in a Broadcasting Station. He has been doing very well in his Radio Servicing work.

n r i

Lige Crumbley is Instructor of Radio, Jackson Lake Vocational School, Covington, Georgia.

Directory of Officers

(To Serve Until January, 1943)

President—Edward Sorg, Chicago, Ill.
Vice Presidents—
L. J. Kunert, Middle Village, L. I., N. Y.
Peter J. Dunn, Baltimore, Md.
John Stanish, Detroit, Mich.
Chas. J. Fehn, Philadelphia, Penna.
Secretary—Earl Merryman, Washington, D. C.
Executive Secretary — L. L. Menne, National Headquarters, Washington, D. C.

n r i

Our Cover Photograph

Our cover, this issue, shows Stanley Lukes at work at his bench.

Stan, as he is affectionately known by Chicago Alumni members, owns and operates National Radio Lab., 2634 W. Cermak, Chicago, Ill. He has one of the nicest shops on the south side of the Windy City and is doing remarkably well.

Starting out to do Radio servicing on a full-time basis shortly after completing the N.R.I. Course, Stan found just the location he had long dreamed about on one of Chicago's busy thoroughfares. Stan is very proud of his establishment, particularly because all of the counters, as well as his work bench, were built by himself.

During 1941 Stan Lukes served as Chairman of Chicago Chapter of the N. R. I. Alumni Association. Although very busy, Stan continues to keep in contact with his N. R. I. buddies. His wife, Rose-Mary, always lends her charming presence to all social affairs conducted by the Chapter.

Your editor, on a recent trip to Chicago, had an opportunity to visit Stan in his place of business. We were much impressed with the splendid arrangement of things in the Lukes establishment.

Stan Lukes is definitely on the way up.

n r i

Local Chapter Meetings

While some local chapters suspended meetings during July and August, others continued to meet right through the summer. Space limitations, this issue, do not permit us to make the usual detailed reports.

Now that the summer is over chapter members are reminded that all local chapters are again meeting on regular schedule. Full reports of chapter activities will be given in the next and succeeding issues of NATIONAL RADIO NEWS.

Tear carefully along this line

Nomination Ballot

All Alumni Association Members are requested to fill in this Ballot and return it promptly to National Headquarters. This is your opportunity to select the men who you want to run your Association. Turn this page over—the other side is arranged for your selections.

After the ballots are returned to National Headquarters they will be checked carefully and *the two men having the highest number of votes* for each office will be nominated as candidates for the 1943 election. This election will be conducted in the next issue of NATIONAL RADIO NEWS.

The President cannot be a candidate to succeed himself but you may nominate him for any other office, if you wish. You may, however, nominate all other officers who are now serving, for President or any office, or select entirely new ones. It's up to you—select any men you wish as long as they are MEMBERS IN GOOD STANDING OF THE N. R. I. ALUMNI ASSOCIATION. Be sure to give the city and state of your selections to prevent any misunderstanding. A list of the 1942 officers is given in the opposite column.

Detach this slip carefully from your NATIONAL RADIO NEWS so as not to damage the book. Tear off the slip at the dotted line, fill it out carefully, and return it immediately to L. L. Menne, Executive Secretary, N. R. I. Alumni Association, 16th and U Sts., N. W., Washington, D. C.

Your signature ....

City .... *State* ....

(Over)

The 1943 nomination is a very important one. Choose carefully the men you desire to handle the reins of the Alumni Association for the coming year. Let's all do our part to help the staff handling the elections, by submitting ballots on or before October 15, 1942.

Nomination Ballot

L. L. MENNE, *Executive Secretary*,
N. R. I. Alumni Association,
16th and You Sts., N. W.
Washington, D. C.

I am submitting this Nomination Ballot for my choice of candidates for the coming election. The men below are those whom I would like to see elected as officers for the year 1943.

MY CHOICE FOR PRESIDENT IS

. . . .

City. . . . . State. . . . .

MY CHOICE FOR FOUR VICE-PRESIDENTS IS

1. . . . .

City. . . . . State. . . . .

2. . . . .

City. . . . . State. . . . .

3. . . . .

City. . . . . State. . . . .

4. . . . .

City. . . . . State. . . . .

MY CHOICE FOR SECRETARY IS

. . . .

City. . . . . State. . . . .

MY CHOICE FOR EXECUTIVE SECRETARY IS

. . . .

City. . . . . State. . . . .

Job Opportunities

Spokane Radio Company, Inc., W. 1130 Sprague Avenue, Spokane, Wash., builders of radio communication equipment, needs additional employees. Applications are desired from men living in Oregon, Washington, Idaho, Montana, Utah, Wyoming, No. and So. Dakota. Address Mr. Morris H. Willis, President.

Bliley Electric Company, Erie, Penna., manufacturers of Quartz Crystals, needs young men to do radio construction wiring and test work. Write to Mr. J. M. Wolfskill, Chief Engineer.

The 7th U. S. Civil Service District, Room 1115, New Post Office Building, Chicago, Ill., is urgently in need of civilian radio instructors in Illinois, No. Dakota, Wisconsin and Florida. Qualifications for these positions are either one year of technical radio work (amateur radio operators acceptable) or two or three years of college study which has included a certain amount of mathematics and physics. Men chosen as instructors will be given special training during which they will receive compensation. If you can qualify, write promptly to Mr. S. H. Kaplan, c/o the above address.

The Crosley Corporation, Cincinnati, Ohio, is in need of men qualified for test work in radio line. Address your letter c/o Mr. H. D. Beutlich, Personnel Director.

Raytheon Manufacturing Company, 190 Willow Street, Waltham, Mass., can use testers, mechanics and junior engineers. Mrs. Elizabeth Currier is Personnel Manager.

Pan-American Airways, New York Municipal Airport, Jackson Hgts., L. I., N. Y., needs radio operators. Write Mr. W. T. Garbo, Jr., Supervisor.

Goodyear Tire and Rubber Company, Akron, Ohio, is interested in applications from radio technicians. Address Mr. W. R. Dubois.

National Defense Training Program, San Antonio Aircraft School, 430 West Poplar, San Antonio, Texas, is in need of radio instructors. Address Mr. G. L. Fling, Assistant Director.

Army Air Force Headquarters Technical Training Command, Knollwood Field, N. Carolina, wants applications from men qualified to serve as civilian radio instructors. Graduates who have had one year in radio work or who have outstanding qualifications which may make them eligible for these positions, address Major General Walter R. Weaver.

National Union Radio Corporation, Newark, N. J., recently opened a new plant at Lansdale, N. J. Employment applications from both skilled and unskilled persons should be addressed to Miss Jewell C. Foley, Personnel Director. Write to the Newark, N. J. office.

Novel Radio Items

-BY L.J. MARKUS-

Two electric eyes and one man now do the work of two men in calibrating precision meters. Formerly one man watched a voltmeter and adjusted a rheostat to keep the voltage absolutely constant while the other calibrated the meter. Now a tiny mirror fastened to the end of the voltmeter pointer reflects a beam of light between two photoelectric tubes when the voltage is correct. If the voltage varies, the beam hits one tube or the other, causing an electronic amplifier to make the necessary correction automatically. One man can now do the whole calibrating job.

—*n r i*—

Recordings are being used to cut toll charges when long messages or speeches are sent over long-distance telephone lines. The message is recorded at 16 r.p.m., and the record is speeded up four times, to 64 r.p.m., for the telephone. At the receiving end, the resulting unintelligible gibberish is recorded at 64 r.p.m. and played at 16 r.p.m. to get the message clear and distinct. The process takes only 25 per cent of the normal toll line time.

—*n r i*—

When an explosion in an ordnance plant jammed factory telephone lines due to families of employees calling up, a local radio station cleared the lines in a few minutes for doctors and emergency crews by promising to make a full report of injuries as soon as possible.

—*n r i*—

When Navy planes caught in a night fog were compelled to use an emergency field, the local radio station was contacted. It broadcast a request for cars to outline the field with their headlights. In 30 minutes all planes had landed safely.

—*n r i*—

A 500-pound bomb hitting within 200 or 300 yards of a radio transmitter will smash all tubes by concussion, according to W. P. Mitchell of Station WJR in Detroit. His station has set up two additional racks of spare tubes in the basement, mounted on springs capable of floating with each concussion.

—*n r i*—

Bus bars and large conductors in newly-constructed aluminum and magnesium plants are made from solid silver. The U. S. Treasury Department has loaned 40,000 tons of silver from its reserves for this purpose, to offset the shortage of copper. Silver is a better conductor of electricity than copper, but its higher cost prevents the use of silver wiring under ordinary conditions. The silver will be returned to the Treasury after the war.

—*n r i*—

Game fish are kept out of irrigation ditches, power plant input pipes and other dangerous waters by the Burkey Electric Fish Screen. This device generates a voltage which gives a harmless but definitely unpleasant shock to all fish coming within the electrified zone, causing the fish to stop and turn away.

—*n r i*—

Silver solder gives a joint which in many cases is actually stronger than the original metal. Silver bearings in airplanes make possible increased speed. Silver is doing many other valuable services today, even in the radio industry, as a substitute for other metals made scarce by the war program.

—*n r i*—

"Canned" air raid alarm signals are to announce air raid alarms to the people of Annapolis, Md., and its vicinity. Phonograph recordings of the warning whistles at the United States Naval Academy will be broadcast over loudspeaker systems located at the three fire department houses in Annapolis when alarms are to be given.

—*n r i*—

An interesting technical oddity revealed in an advertisement of Radio Station WMAL in Washington is the fact that 44 times as much power is required by a 1500-kc. broadcast transmitter as by a 630-kc. broadcast transmitter to develop a given signal strength at a given distance. For example, 5000 watts at 630 kc. develops a signal strength of 2 millivolts at a distance of 31 miles. At 1500 kc., 220,000 watts would be needed for the same job.

—*n r i*—

Attempts have been made by German and Japanese broadcast stations to jam many of the short-wave radio pick-ups from remote army posts such as from Chungking, China, and Curacao, Dutch Guiana. In the latter instance, the German controlled station somewhere along the east coast of Europe released a 7-minute blast of piano music on the frequency of the Curacao station. This did not completely jam the broadcast, though it made it difficult for NBC listeners to understand some of the army and navy officials speaking from a U. S. Army post in the Dutch West Indies.

The Corbett Family Goes to War

Reading from left to right the boys are: Richard Martin Corbett, age 21, Communications, now employed in a Defense plant, Cleveland, Ohio, as maintenance operator, automatic telephones, due to be inducted within the next few weeks, single; William Howard Corbett, Father and Grandfather, age 52 (8 children, 4 boys, one married, 4 girls, three married), amateur radio man W-8DVP, since 1908, formerly CRM U.S.N.R., employed as telegrapher for the Nickel Plate railroad, N.R.I. student; Sgt. Harold Marty Corbett, Radioman, service and maintenance, formerly attached to 751st Tank Battalion, now attached to Air Corps, married, one son, lives in Cleveland, Ohio, age 23, W8HKV; Sgt. Howard Edward, age 26, single, Radioman attached to 123rd Sig. Radio Intelligence Co.; Donald Lee, school student, age 14, radio operator, signalman. All use the International and Morse codes.

These boys were trained by their Father who gives credit for their theoretical knowledge to N.R.I., which Mr. Corbett, Sr., says, "has the finest radio training this old timer knows anything about. No boy can go wrong if he wants to learn radio and is willing to study the N.R.I. Course."

n r i

★ Another N.R.I. Service Star ★

George R. Mays, Jr., formerly employed in the stock room at N.R.I. and now on duty at a U. S. Naval Training Station, represents another star in our Service Flag at N.R.I. George recently sent us a fine letter which he closed in this fashion, "Keep pitching for good old N.R.I. while I keep pitching for good old U.S.A." And pitch he will for George has plenty on the ball.

NATIONAL RADIO NEWS

FROM N.R.I. TRAINING HEADQUARTERS

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Washington, D. C.

L. L. MENNE, EDITOR
L. J. MARKUS, TECHNICAL EDITOR

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