NATIONAL RADIO NEWS

N.R.I. Men in Military Service Say:

Although I am not at liberty to discuss my work in the service, I do feel free to state that my NRI training has been of much help to me in the Navy, just as it was in Civil Life.

C.L.K., Chief Electrician's Mate
U.S. Naval Reserve, Indian Head, Md.

NEEDED NO FURTHER TRAINING. I GOT A RATING OF "RADIO SPECIALIST" ON MY QUALIFICATIONS ACQUIRED FROM NRI. I NOW AM "RADIO OPERATOR AND MECHANIC."

E.C., 3RD OBSERVATION SQDN.
ARMY AIR CORPS
CAMP COOKE, CALIF.

The N.R.I. Course rates pretty high in the Signal Corps.

N.M.P., Corporal
Signal Corps School
Fort Monmouth, N.J.

I was drafted into the Army June 11, 1941, and upon my knowledge of Radio due to my NRI training, I was put in the Signal Corps and sent to Ft. Monmouth. I completed a course in Radio repair here and upon my excellent progress with Signal Corps equipment, was recommended to study secret aircraft warning equipment. I completed the course Jan. 17, 1942 and have been an instructor since Jan. 1, 1942. I am now a Sergeant and am very grateful to my NRI training, to Mr. Smith and the entire NRI personnel.

A.W., Jr.
Signal Corps School
Ft. Monmouth, N. J.

LITTLE FACTS MENTIONED IN MY NRI TEXTBOOKS WHICH SEEMED OF LITTLE IMPORTANCE THEN, ARE NOW SHOWING UP TO BE VERY VALUABLE INDEED. I CARRY MY NRI COURSE EVERYWHERE I GO. AS A REFERENCE, TOO, THEY HELP ME OUT OF MANY TOUGH SPOTS. I WOULD NOT TAKE TEN TIMES THE PRICE I PAID FOR THE NRI TRAINING. IT'S PROVING MORE VALUABLE EACH DAY.

H.C.B.
SIGNAL CORPS, U.S. ARMY
PRESIDIO OF SAN FRANCISCO, CALIF.

When I was interviewed by the officer who was selecting instructors for the Air Corps Technical School in Communications, he said my grade was one of the highest of the men he was interviewing. I feel that NRI had a great deal to do with this. I am also using my NRI theory texts for daily reference. I find them much better for this purpose than any of the texts I have yet found.

G.A.G.
U.S. Army Air Force

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AUG.-SEPT.
1942

IN THIS ISSUE

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No. 4

Friendship

It may be old-fashioned to believe that success in business is dependent upon friendship but if it is, we plead guilty. For friendship is the watchword of the National Radio Institute.

I might amplify that a bit and say, friendly service is what has helped greatly to build the National Radio Institute into the largest institution of its kind in the world.

A friendly attitude toward those with whom we are associated and toward those with whom we do business brings handsome returns. I have new proof of this every day. The friendly tone of letters we receive from students and also from graduates of many years ago are a genuine inspiration to us.

In our relations with you we try, at all times, to do things in a friendly and cordial way. In turn you show the same attitude toward us. As a result we are brought closer together and there is better team work.

Friendship is one of the pillars upon which a business is built. Keep that in mind. Never forget it.

E. R. HAAS
Executive Vice President

HOW TO CARE FOR TRANSMITTERS AND LENGTHEN TUBE LIFE

By CHARLES H. SINGER

Technical Supervisor, WOR-W71NY, New York

In view of wartime shortages of critical materials needed in broadcast transmitters, this outstanding article by Mr. Singer contains particularly valuable and timely advice for N. R. I. men who are now employed in radio stations of any kind, or who plan to enter the communications field. The article was originally published in the March 30, 1942 issue of Broadcasting Magazine. We extend here our appreciation and thanks, both to Mr. Martin Codel, the publisher of Broadcasting and to Mr. Charles H. Singer, for permission to reprint the article.

TO operate and maintain a transmitter is a man-sized job.

During these times when materials are scarce, we must do some very careful planning on how we can keep our station protected and running efficiently to prolong longevity during the material shortage period. We must study our station and try to foresee difficulties and do what we can to substitute for each part.

What To Do

How to go about it?

Economize as you never did before. Get the longest possible service out of every *tube* as well as every *nut* and *bolt*.

At WOR, spare parts are classified and kept in ordinary cardboard transfiles, costing $1.29 each. The contents of the transfiles are clearly marked on index cards attached to each transfile.

Tube lockers, used to store spare tubes, are ordinary standard office lockers made of metal and painted to a suitable color. Tube racks, which hold each individual tube in an upright position, are made of plywood or any suitable material handy and drilled to accommodate different size tubes. The lockers may also be used for storage of logs, forms and other data.

For fewer carrier breaks and less program loss, two factors become of prime importance:

1. The dependability of the transmitter.
2. A systematized plan of operating and maintenance practices which are followed hour by hour, day and night, year in and year out.

These plans may be set down in book form, such as are used at WOR. They list every routine duty to be performed, as well as the handling of any emergency which may arise. Every procedure is described in the minutest detail and we feel that these manuals tend to tell a man *why* he is doing a job as well as *how*.

A permanent record is kept of each tube's current reading, so that comparisons can be made from week to week.

From past records, the approximate end of the tube's useful life can be predicted. Thus, instead of risking tube failures on the air, the tube may be removed from service before complete failure can occur. X-rays taken of tubes help the operators to understand more clearly just what happens when a tube fails.

A 10 kw. station can maintain its transmitter in 10 hours per week.
A 5 kw. station in 8 hours per week.
A 1 kw. station in 6 hours per week.

Stations of lesser power can effectively do their maintenance in 4 hours per week.

Always keep in mind that continuous inspection, proper attention to circuit changes, as evidenced on your logs, and passing information to your fellow co-workers is absolutely essential.

Trouble anticipation takes a good routine, together with careful operation. For example: Warm and hot spots may be evidenced in condensers. This condition may take from months to years to become evident and if you find this to be the case, remove the condenser and put it in a circuit where its requirements are not so stringent.

Relays are another prominent source of trouble. They should be cleaned monthly, using a very careful and well planned routine.

Four Main Points

Resistors are the most difficult place to anticipate trouble, but experience has shown that aside from overload, the first indication is discoloration, the second faulty connections. Resistors should be measured three times per year, in some cases more often. They should receive nightly inspection. It is in such failures in the transmitting circuit that your master operating log will help to indicate circuit changes which facilitate the maintenance crew to help find the faulty part.

Our experience has shown us that the four most vital and vulnerable points of transmitter maintenance are, in this order: (1) tubes; (2) condensers; (3) relays; (4) resistors.

These vital points should be checked *regularly* and a permanent record of current, capacity and resistance measurements kept in the appropriate section of maintenance books.

Naturally, successful operation ultimately rests in the hands of the technicians. Ability, neatness, consideration and cooperation are the essential qualifications. Originality, too, rates high, for the station lends an eager ear to new ideas. The technician who takes his watch seriously, digging into the job for all he is worth, is the one best fitted to shoulder greater responsibilities later.

In practically all types of radio transmitters, through the ingenuity of the radio engineer, it is possible to make repairs and replacements of all vulnerable parts except the vacuum tube which, as we all know, is the very heart of a radio broadcast station.

Some manufacturers of radio tubes have indicated that materials are becoming more scarce and the quality of the elements is tapering off.

It is obvious that, regardless of the high standards previously maintained by the makers, the poorer quality of tube elements will have an effect on the performance and life of tubes.

Gassy Tubes

Regardless of the rigid inspection a manufacturer puts in all parts to see that they are free of checks, blisters, surface scales, and high voltage treatment of the tube at potentials far in excess of that used in transmitters in the field, etc., some tubes at the station will become gassy.

It has been said that no material or progress known today can provide a tube entirely free of air or gas.

There are many factors that enter into the life of tubes. The main ones are as follows: Filament voltage, plate voltage, operating temperature, amount and nature of residual gas in tubes, etc.

Tungsten Filament Tubes

The source of emission is quite evident and operates at fairly high currents as compared to other types. If direct current is used on the filaments, the plate and grid circuit returns are usually connected to the positive filament terminal. It is because of this connection that you strongly consider reversing the polarity each week, since it is the additional current of these two circuits that flow through one side of the filament. If left in one position, the result will be the gradual thinning of one side of the filament, which ultimately will result in premature failure of the tube.

The filament and bias voltages should be checked weekly, using a standard calibrated meter. The filaments should be checked at the terminals. In this way, a precision check is made on the transmitter voltmeter and it may be set to read the proper value.

Zero adjustment of this vital tube filament voltmeter should be checked each day that the transmitter is off the air.

By decreasing the filament voltage 5%, the life of the tube is doubled. This can easily be done in transmitters with slight effect on peak powers, distortion or carrier shift. In fact, peak currents amounting in value to the total emission available may be drawn continuously without damage to the filaments. Reference to the tube manufacturer's chart will reveal data on filament saturation versus peak grid and plate currents reaching total emission value.

Voltage vs. Hours

A quick glance at some figures will show the effects of filament voltage versus total hours of useful life.

Fil. Volt.	*Useful Hours*
90%	400%
95%	195%
100%	100%
105%	50%
110%	26%

In many transmitters, because of the excess amount of emission designed into tubes of this type, it is possible to insert dropping resistors in series with the filament leads and achieve many hundreds of additional hours.

In transmitters of the WE 306-A type, it is strongly urged that you drop the filament voltage of the 2nd P.A. stage from 20 to 19 volts, since all the emission is definitely not needed and tube life is extended to possibly 30,000 hours, with little or no effect upon the positive peaks or distortion.

Much discussion may come about by the increase of transmitter distortion versus decrease of filament voltage. This factor should be given individual consideration dependent upon the spare tubes you have on hand or are in a position to get.

Thoriated Tungsten Filament

The source of emission is a layer of thorium on the filament surface which, during operation, is constantly being removed by evaporation and attraction towards the plate. The thorium is constantly being replenished from within the wire during operation. To effect a proper balance between the loss and replacement of active material, very careful consideration should be given its filament temperature.

The filament voltage should be maintained at its rated voltage and, in many cases, may be permitted to be low by 1%, dependent on the peak currents drawn which, in most cases, is recommended by the manufacturer not to exceed more than one-half of the maximum of which the filament is capable of emitting. The manufacturers, in most cases, provide at least double the emission in these tubes that would normally be needed in any class of operation.

Use a precision voltmeter and check the voltage at the tube socket each week for long-life expectancy.

It is this type tube that is being used by the armed forces, resulting in a real shortage.

If the thoriated tungsten filament tube is in any way gassy, the thorium is carried off much faster and tube life shortened.

Proper bias and plate voltages must be maintained and the latter should be applied with care and consideration of its output capabilities.

In cases where a severe and prolonged overload has temporarily impaired the electronic emission of the filament, the activity may be restored by operating the filament (with plate and grid voltages off) 30% above normal voltage for 10 minutes followed by a one or two-hour period at normal voltages.

Thermionic Mercury Vapor Tubes

This type tube usually operates at a low voltage, high currents using an oxide-coated filament. This is the source from which electrons are emitted, but once the coating is removed the tube is rendered useless. The filament is usually operated on a voltage from a.c. source.

Oxide-coated filaments must operate at specific temperatures. Therefore, sufficient time *must* be allowed for the filament temperature to reach its normal operating value, and for the mercury vapor pressure to become normal before the plate voltage is applied.

If you have good filament voltage regulation, a five-minute preheat period will suffice. Filament voltage on these tubes should remain at the rated voltage. Never go low. In fact, it is good practice to operate 1% above rated voltage.

Use a precision voltmeter to check the voltages each week to insure longer life.

Operating Value

If a tube is operated at ambient temperatures of 20° C. or below, a larger period of time is required for the mercury pressure to reach a satisfactory operating value.

For 10° C. preheat 5 minutes
For 5° C. preheat 10 minutes
For 0° C. preheat 15 minutes etc.

It is urgent that mercury vapor tubes remaining on the shelf be given a preheat period for one or two hours, every three months, to insure their operation when the time arises. It has been found that these tubes, if allowed to remain on the shelf for a longer period of time, will become useless due to the mercury vapor eating into the pores of the anode and cathode.

Tubes of this type must remain in an upright position, otherwise mercury will splash on anode and cathode and must be preheated to vaporize this mercury from the elements and be permitted to condense on bottom of tube. You should have free circulation of air either through forced circulation or any other means so that lower end of tube is cool to achieve this condensing of the mercury.

Keep all drafts and cold blasts of air from the rectifier tubes.

Keep all objects from touching glass.

Keep tubes in a vertical position at all times. This also prevents filament sag, and mercury will not be deposited on active elements of the tube.

Discontinue the practice of preheating these type tubes at half voltage. It has been proven in practice that this poisons the tube.

Because of the day-in-and-day-out operation of radio transmitters, along with the starting and stopping of the units, the filaments of the tubes are constantly going through a hot and cold cycle which causes an extreme strain on the elements and supports.

Provision should be made to limit the initial filament current when the tube is cold—prior to starting.

This may be done by inserting additional resistance in the filament circuit when voltage is first applied, or by using a transformer having sufficiently high enough reactance.

It is considered good practice that, prior to turning on the filaments, the voltages be reduced to as low a value as possible. Allow to operate this way for five minutes, then increase to its rated voltage, or to a value you found desirable to operate at.

Retarded Voltage

In closing down, the retarding of filament voltage after plate voltage has been removed is also recommended. Five minutes in this retarded position will greatly aid, and possibly prevent the thermal shock the tube gets when shutting down. The currents and thermal temperature of the elements are high, and a quick shutdown in many cases has caused the filament tension springs to snap back too quickly and jam, causing the filament to wrench out of shape. The gradual low voltage preheating start and stop method rectifies this.

In air-cooled tubes it is recommended that the same procedure be used, but at shutdown include the following: Retard filament to minimum for five minutes after plate voltage is removed. Turn off filament. Leave blower on for one minute. Then completely shut down transmitter.

Metal parts in tubes, through their lengthy use, tend to evaporate, become brittle and are subject to severe shock.

All tubes should be mounted and stored vertically and in a manner to prevent mechanical shock or electrical vibration. This type of vibration may cause breakage of the filament and in some low-power tubes, cause misalignment of the elements.

In cases of water-cooled rectifiers and power amplifiers, the filaments and grid elements become brittle and if subjected to vibration may cause elements to distort or break. It is therefore recommended that tungsten filament tubes remain in the socket until they burn out, since practice has shown that removal of these tubes has caused shock to the elements and aggravate the condition, the result being continuous flash arcs.

The glass should be protected from scratches caused either from abrasives or diamond rings worn by the personnel during maintenance or cleaning periods.

Some tubes have filament leads attached. Care should be exercised not to drop them against the glass and possibly cause a crack.

Cooling of smaller type tubes is a known factor, but the cooling of larger type water-cooled and air-cooled units shall be treated here.

It has been suggested that water-cooled tubes remain in their sockets until they burn out. This brings up the problem of removal of scale from the tube. The water used in cooling of tubes should be of sufficient purity to retard the tendency toward the formation of scale in the anode and at the same time keep leakage current as low as possible. The important point is not to operate tube plates at high temperatures.

This tends to radiate heat inward as well as outward, and although the plate itself will be able to withstand excessive temperature without damage or gas evolution, the heat radiates to the grid or causes the filament to run at a temperature outside of its designed operating range.

It follows that any scale formation on the anode itself will reduce its ability to dissipate heat resulting from the scale, which is a poor conductor. Its comparatively rough surface tends to break up the smooth sheet of water flowing over the tube plate, and creates localized boiling which may cause a blister in the tube plate and possibly injure the tube, plus leading to difficulty in removing it.

Removing Scale

This scale may be removed by putting two pounds of tri-sodium phosphate or a commercial product known as Oakite into one socket. Replace the tube that permitted the Oakite to be poured into the system and flush throughout the water system for an hour with the filaments on and the *water* about 140° F.

This will remove an amazing amount of sludge and residue. It will require that you flush out the system with pure distilled water before the final filling of the system. This will suffice for at least 8,500 hours of operation before it will need reflushing.

In air-cooled type tubes, it is important to keep fins clean and blower operating at its maximum efficiency.

Free air circulation around other type tubes is recommended, plus the avoidance of using cold, damp rags on tubes while they are hot.

Adequate cooling of the glass during operation is a factor since the source of heat is within the tube. The heat is applied to the inside surfaces by radiation and conduction along the lead wires.

Keep water and air temperatures as low as possible.

How to Go About It

Should you find it necessary to remove the tube from the socket, the following procedure may be used for removing the scale from the tube:

For this condition, the plate may be cleaned with a 20% solution of muriatic acid. This is easily mixed in a stone crock by pouring 8 glasses of water into the crock *first*. Then *slowly* pour two glasses of the acid *into the water*. Never pour water into acid, as this will cause boiling and splattering of acid and may cause serious bodily injuries. Do not inhale fumes while the solution is mixing. Stir with a wooden stick. Fold up a small piece of rag into a square three inches. Wet with solution and gently rub over scale. Wait a moment and repeat.

The bottom of the tube plate may be rested on the bottom of the crock, but hold the tube so that it does not lay against the top rim of the crock, as this will damage the *glass seal* of the tube.

Caution: Do not clean above clamping ring on the tube plate, and be careful *not* to drip acid on glass seal.

Hands may be dipped into the solution, which is not of sufficient strength to cause damage or injury.

After cleaning the tube plate, be sure to wash hands in warm water and soap.

In higher-power tubes, more latitude is allowed for peak operation, but in thoriated tungsten type tubes the picture is entirely different and voltages must not exceed their manufacturers' rating.

Relay Adjustments

Tube life may increase by careful attention to efficiency of the various r.f. stages. It is recommended to get as high efficiency as possible which will lead to prolonged life of tubes and associated equipment.

Water-flow relays should be carefully adjusted and frequently observed for performance. All over-load d.c. relays should be operating at their required currents and frequently observed and maintained. Keep d.c. leakage at minimum with pure water in transmitter water circuit.

Tubes operating at plate voltages between 500 and 2000 volts are not generally affected by gas nor by time on the shelf.

The larger high voltage-high power types have a tendency to become gassy if allowed to remain idle for too long a time, which we find to be a period of three months.

This gassy condition is not necessarily brought about by air leaking into the tube but by the liberation of gas from the pores of the elements inside of the tube, long after the tube is sealed and conditioned for operation at high plate voltages. The gas gradually seeps into the vacuum during this idle period and this manifests itself in excessive plate current, pings or flash arcs.

The manufacturer makes it a practice to degas tubes prior to shipment to the customer, and if used immediately when received, it is very unlikely tube flashes would result. Due to the achieved long life of these tubes, the spares remain on the shelf for possibly too long a time before being used, and too long a period before tests are made.

Salvaging Tubes

Gas condition of tubes not only show up because of inactivity on the shelf, but also occur when the tube has been operating in the transmitter for many thousands of hours. This gaseous condition and its causes can enter into much controversy as to its origin. But the point of interest is: How can we salvage a tube that is gaseous and in its present condition all that is left is to discard it because of its continuous flash arcs when operating at its rated and applied plate potential and power? If placed in a circuit of lower plate potential, it is definitely possible to get continued long life from it. Therefore, considerable thought should be given this point before discarding it.

Since we have concluded by saying that gas in a tube influences the life in many ways, there are but three of the most important, namely, chemically, physically, electrically. Electrically is our problem.

The tube conditioner in use at WOR has, in several cases, dislodged this conducting gas and increased tube life by several thousands of hours and saved many hundreds of dollars.

n r i

Dependability

The story is told of certain officers on Napoleon's Staff, who came to him one day to recommend promotion for a young Captain. The great General asked, "Why do you suggest this man?"

It was explained that the candidate, by unusual courage and strategy, had won an important engagement a few days back.

"Good!" said Napoleon, "but what did he do the next day?"

There are TWO kinds of people in this world . . . those capable of an occasional burst of brilliance . . . and those who can be depended upon to do their best every day of the year. The brilliant boys have a place . . . but when the call goes out for men of responsibility and trust, someone is going to ask, "But what did he do the next day?"

Electronic Intrusion Alarms

and

Fire Detection Systems

THERE are three principal detection ideas used in all "burglar alarms" of an electronic type. These may be termed photoelectric, capacity control and audio control.

The first variety of detection is based on the idea that the intensity of light will vary when a beam of light is fully or partially interrupted. The second form of burglar alarm, the capacity control, is based on the idea that an oscillator will change its frequency when a foreign body—the burglar in our case—is in the vicinity of the oscillator. The third form takes advantage of the noise produced by the intruder—whether the sound is caused by the burglar's footsteps or the explosion of nitroglycerin, the working of a drill, or any other sound productive apparatus.

In all of these systems, a detector is used in conjunction with some form of amplifier that in turn works into a relay. It is the purpose of the relay to close an electrical circuit which will send a signal along a wire to a central headquarters, turn on a powerful siren or floodlights, or otherwise give an alarm.

The man who understands electronic control is in a good position to make high wages and to work under pleasant conditions, and in the future it may well be that this infant industry will grow to huge proportions. So, let us examine these new devices in detail.

Photoelectric Systems

Taking the photocell system first, we refer to Fig. 1 on page 10 which illustrates the method of hooking up a simple intrusion detector. The photo-tube d.c. output is amplified by the 25L6, the condenser C and potentiometer R_c providing the sensitivity adjustment. In this simple circuit, no rectifier is used, but self-rectification of the a.c. voltage from the power line is employed. The relay in the plate circuit is a rugged unit and in some cases will have contacts permitting the handling of power as high as 100 watts.

The transformer T supplies a 40-volt a.c. potential to provide bias on the 25L6 through the photocell p.e. Condenser C_P is a 200-volt condenser having a capacity of .25 microfarads, and by-passes a.c. current around the relay.

Contacts A, B and C on the relay are used for controlling an external circuit. When light falls on the photocell, its resistance drops and it forms a low-resistance shunt across condenser C, varying the grid potential and causing the relay to open contacts A and B and close B and C.

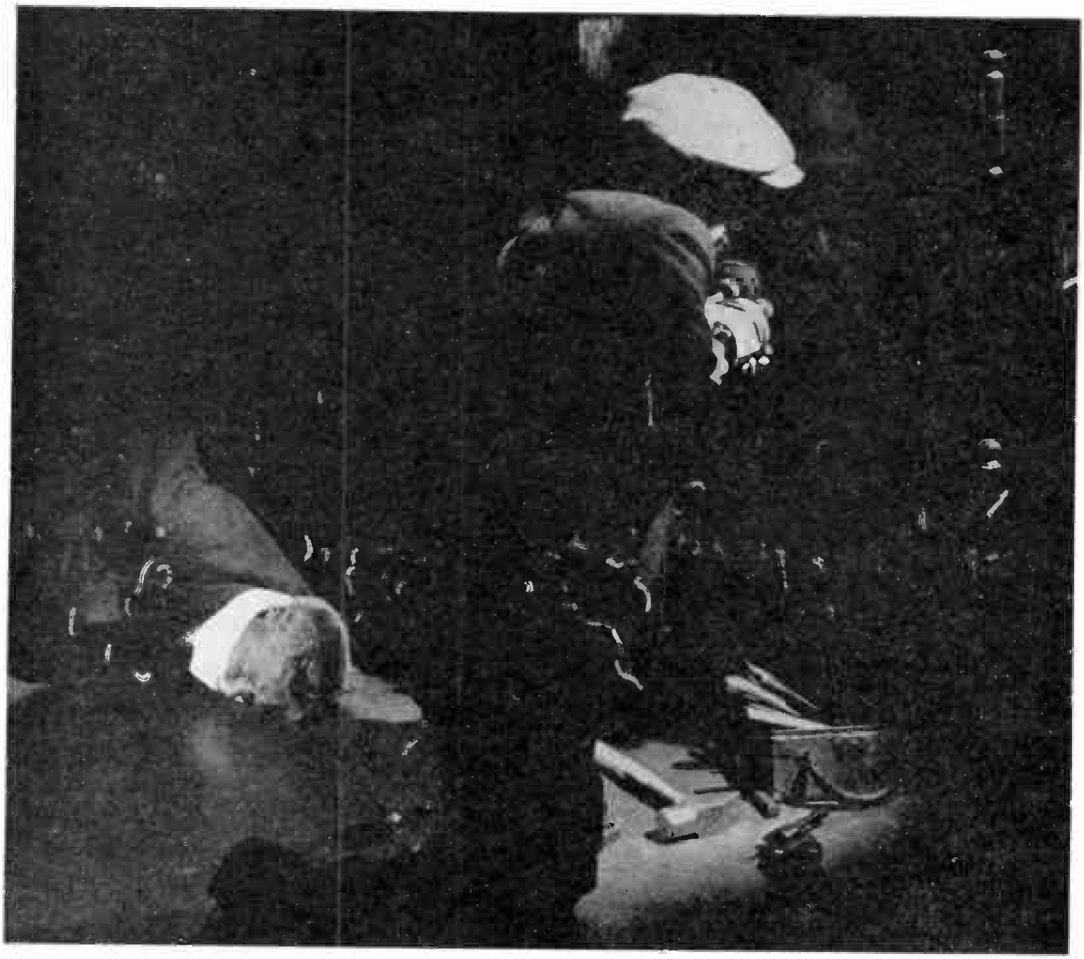
In order to keep down the number of false alarms, special sharply-focused lenses are used and hoods or visors are put over the photocell that receives the light beam. Light from sources other than the correct source is therefore excluded. This lends a "selectivity" to the system, and makes the photocell alarm installation more reliable and foolproof.

An ordinary beam of light can be seen by an intruder and betrays the presence of an alarm system. An infra-red filter is placed over the lens at the light source. Infra-red light, being invisible to the eye, lends itself to secrecy and effective protection of life and property. Also, in the case of a baby lying asleep in its crib and being protected from kidnappers by invisible light, the child is not kept awake by a beam of visible light. This illustrates but a single useful application. The principle may be applied, however, to many other situations and purposes.

There is, however, a drawback to the infra-red method when long-distance operation is desired. The transmission of light between two points is dependent on the light intensity of the source; the opposition offered by the medium separating light source and light pick-up and, in the last analysis, the sensitivity of the light pick-up, is a governing factor.

Where a bend occurs in the "protection line," mirrors must be used. The mirror is set to reflect the light beam in the desired new direction. Since a mirror is ordinarily only about 80% efficient in reflecting light, there is an appreciable loss in beam intensity at each mirror. Dirt and dust on the reflecting surface will also cut down reflection of light. Brightly polished metal reflectors are sometimes used in place of ordinary glass mirrors.

Applications. The primary defense against sabotage is the prevention of entry to the protected plant by the saboteur. In general, protec-



This illustration, supplied us through the courtesy of the American District Telegraph Co., shows a typical location which can be protected by an acoustic intrusion detection alarm. Its sensitive concealed microphone or vibration pick-up would respond to noises made in breaking into the vault.

tive systems which have as their purpose *the prevention of entry* by burglers are best adapted to accomplishing this result. Prevention of destruction can only be accomplished by the presence of armed guards in sufficient numbers and so trained and equipped as to be capable of handling the emergency.

Conventional burglar alarm systems, utilizing screens, foil, contacts, traps, protective linings, and other devices of proven effectiveness, afford a degree of protection which depends solely upon the extent to which they are used in covering the boundaries of the protection. Thus, for example, it is theoretically possible to provide through conventional means a complete system of coverage of any structure. In practice, however, such complete coverage may be uneconomical, may interfere with the normal functioning of the plant or may not be sufficient to protect this structure against damage inflicted without the saboteur's crossing the boundaries of the premises. Many organizations, for example, have found it necessary to surround a production plant with a fenced space for some distance from the buildings themselves, in an effort to isolate the premises proper from adjacent areas used by the public.

The American District Telegraph Company has pioneered during the past five years with photoelectric protection, comprising receiving units operating in combination with suitable sources of semi-invisible light. From its original application as an indoor trap, supplementing conventional protection within premises, its use has been slowly and cautiously extended to outdoor applications, and a new method for the protection of open areas surrounding structures has been developed. The American District Telegraph Company has installed and operates approximately forty-one hundred photoelectric ray installations, of which approximately twenty-eight hundred are of the indoor type, and the remaining thirteen hundred are of the outdoor type. Almost without exception these units have been connected to, and register alarms in, one of the central stations of the company.

Photoelectric rays, by their very nature, are instruments of line protection. Because the protective medium is intangible and unobserved or, if observed, difficult to circumvent, it has very definite advantages. It can, for example, be extended across aisles, walkways, and open areas without requiring the construction of barriers, and it can be used outdoors under climatic conditions which would be destructive to conventional forms of protection.

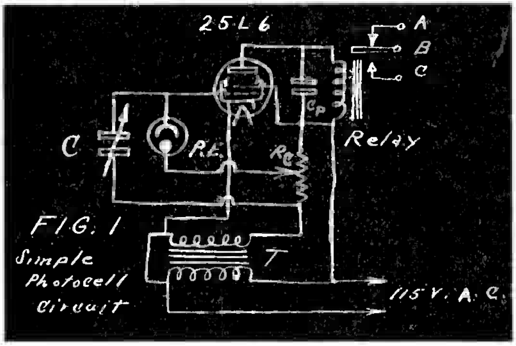


FIG. 1 Simple Photocell Circuit

The particular utility of photoelectric protection against sabotage lies in its capability of being used outdoors to detect entry to yards or fenced areas surrounding production or storage plants.

Equipment. In adapting photoelectric principles to protection problems, many unusual conditions have to be met. Equipment must be designed to function reliably in spite of all forms of weather. The light ray itself must be capable of penetrating the heaviest fog conditions apt to be encountered and, also, to work through heavy rain and snow storms without sending a false alarm. The devices must be so designed that they are adequately shielded against the effects of driving rain and snow, and if these latter elements fall upon the lenses through which the invisible ray leaves the light source and in turn enters the receiving unit, their effect must not be great enough to produce a false alarm. Protection by means of photoelectric devices is vastly different from the mere utilization of the normal run of photocell equipment designed for such purposes as opening doors, counting boxes or persons and turning on and off of lights. It must be designed specifically for protective services. By that is meant that it must possess a large "factor of safety" to permit it to operate reliably at reduced voltage, with equipment somewhat out of line, with the electronic elements or lamps in a certain state of depreciation, through a reasonable degree of indoor dust and haze, with the lens surfaces and mirror surfaces dirty, etc. Systems that do not operate with this margin of safety are prone to be unstable and to produce frequent false alarms.

Different types of equipment must be available for working over different distances and under varied conditions. To use equipment to protect a distance of 100 feet that is designed to operate reliably over a few thousand feet would be economically unsound. On the other hand, the attempt to stretch a light beam designed to give reliable operation over 100 feet to protect a distance of 300 or 400 feet would result in unstable operation and many false alarms. Three basic systems of photoelectric protection have therefore been developed: 1. Short-range indoor or outdoor; 2. Long-range outdoor; 3. Waterfront protection. Typical commercial versions of each type will be described briefly.

Short-Range Systems

Units in this group, as normally used, are capable of projecting an invisible light ray up to a distance of 200 feet. When designed for intrusion detection, the diameter of the beam originating at the light source is generally about 3 inches and, therefore, is capable of complete interception by an individual even when installed near the floor for a "trapping" purpose. The speed of operation is such that a man walking at a normal speed will create an alarm when his leg intercepts the beam.

The three applications for this equipment are: 1. As a floor trap to protect the floors of an area such as a stock room, or to detect entry through doorways, alleyways, etc.; 2. As a means of interlacing premises with invisible rays at an average height of 36 inches from the floor to detect the movements of intruders who may have entered through otherwise unprotected openings; 3. As an adjunct to a holdup alarm system to detect the passage of a bandit over the top of a bank counter, coping, or the like.

Where outdoor protection is required up to 150 feet, the system is usually equipped with 5" diameter lenses. The purpose of these is two fold. First, they increase the effective power of the beam three times and thus make it possible to penetrate fog and smoke which could not be handled if the 3-inch lenses were retained. Secondly, they make the beam diameter large enough so that it will not be completely intercepted by birds flying through it. Since the factor of safety is increased greatly by the use of the 5-inch lenses, a large part of the total area may be intercepted without causing an alarm. Because the beam diameter is 5 inches, it is customary to install the apparatus at least 36 inches from the ground so that complete interception of the beam will be insured as a person passes through it.

In applying outdoor protection, consideration must be given to the possibility of animals prowling around the premises during the protected period. If there is any possibility of this, to prevent interception, the beams should be raised high enough off the ground and be located away from platforms, window ledges, etc., that might serve as a logical place for animals to jump to or from.

Long-Range Outdoor Systems

Numerous applications for a super-powerful photoelectric system are suggested every day in this time of increasing national emergency, where the distances to be covered in a single span are greater than 200 feet. In the protection of public utility plants, prison walls, government buildings, arsenals, aircraft plants, national defense industries, etc., distances of 1,000 feet or more are frequently encountered where it would be undesirable to install a large number of rays. Moreover, at these great distances, there is need for equipment which will function in stormy weather, in fog, with dirty lenses, and with birds and paper flying through the beams.

The American District Telegraph Company has designed and now produces such protection equipment. The principal innovation it brings into the field of electric protection is its use of a modulated light beam, or, in other words, a source of interrupted light to whose frequency a receiver amplifier is tuned. By resorting to this principle of operation, the receiving system can be made very sensitive, with the result that the light source can be separated from it over long distances. Furthermore, the receiving unit will respond only to the light projected from the light source, and no other light that might be accidentally or maliciously applied with intent to defeat the system will prevent it from operating normally.

Daylight and artificial lights, thus, have no paralyzing effect that will prevent an alarm from being received should the beam be intercepted anywhere along its path. The system is so designed that a momentary power failure will not transmit an alarm.

The light source consists of two lamps, their optical equipment, and a motor-driven light interrupter. Each lens is 3″ in diameter, so that the height of the projected beam at the source is 6½″ and the width is 3″. Internal condensation is eliminated by sealing the motor, light interrupter, and lamps in a dehydrated compartment. Vane deflectors prevent snow and ice from coating the lenses, and birds from roosting or resting in front of the lenses.

The interrupter can be a circular disc having a number of drilled holes. In a typical system, the motor speed and number of disc holes are such as to interrupt the beam somewhere between 500 and 1500 times per second, thus giving to the beam a modulation frequency value somewhere between 500 and 1500 cycles. This is in the audio range, hence ordinary a.f. amplifier circuits can be used in the receiver unit.

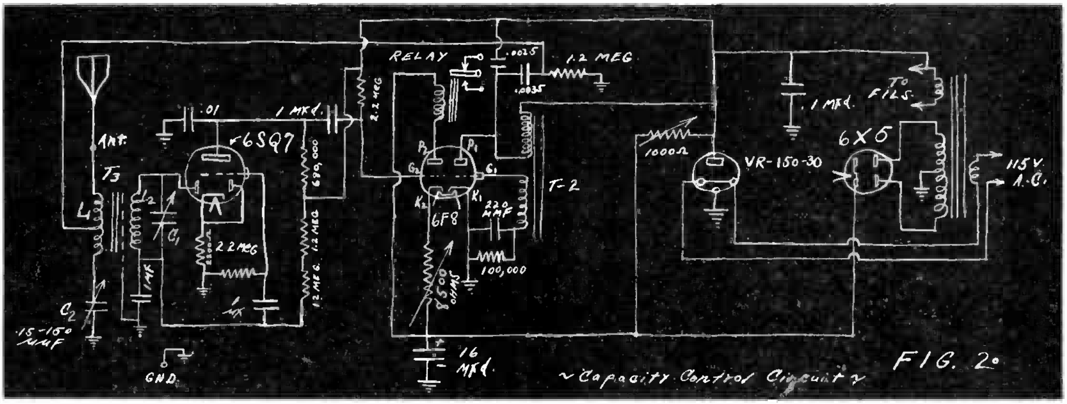
The receiver unit houses an ultra-sensitive photoelectric cell and an a.f. amplifier which amplifies the alternating current generated by the intermittent light falling on the photocell. The optical system used in the receiver involves a mirror, which permits a long focus lens of low-acceptance angle to be used in a relatively small housing. The diameter of the receiving lens is 6″. This, combined with the 6½″ height of the projected beam, insures freedom from false alarms due to birds and small pieces of paper. Provision has been made in circuit design to obviate the effect of strong unvarying light, such as sunlight, on the photocell, and a gain control has been provided to adjust the amplifier to the desired output.

The control unit contains the necessary switches, meters, and relays to annunciate each beam, and both the receiver and the light source units have been provided with jacks permitting the use of a meter in testing and alignment. A constant voltage transformer associated with the control unit assures uniform voltage on all units and thus, long life for the lamps, and permits calculation of a schedule for lamp change which will prevent alarms which might otherwise result from simultaneous burnout of lamps. Three wires only are needed to interconnect the light source, receiver and control unit.

Waterfront Protection

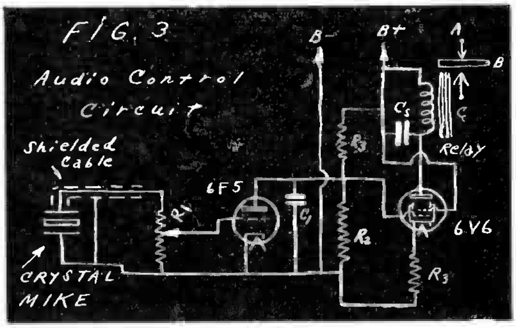
Beyond the range and scope of the two forms of apparatus described above, there is an application where still larger and more powerful equipment is necessary. This application is particularly pertinent today where protection of waterfront areas is required against sabotage.

A.D.T. photoelectric waterfront protection apparatus has been used successfully in an installation on the New York waterfront over the past five years. In this application, the beam span is approximately 3,000 feet and is installed to seal



the waterfront boundaries of the area just as the wire fence surrounds and protects the boundaries of the land side. The beam projects across the end of six docks and seven slips and, on floating supports, rises and falls with the tidal variation so that the beam is constantly located just above the water surface. Due to the size of the equipment at the installation and the power produced, it operates effectively through all kinds of weather, including dense fogs and heavy snow storms.

To make available a complete protection system for waterfront areas, or entrances to important channels, bays or basins, apparatus has been produced to include as a single unit the float and the beam equipment. Provision is made for adjusting the height of the beam with respect to the



float, and thus the water surface, but no automatic control is provided for this purpose, as it has been found that most applications requiring this class of equipment are located in relatively smooth water.

The light source and receiving unit themselves are, in principle, similar to those already described, with the single exception that 12-inch diameter lenses are used for greater reliability in operation. Inasmuch as this equipment is intended for the detection of harbor craft, or even small junk boats, there is no objection to increasing the beam diameter to this extent, and, by so doing, false alarms which might otherwise be caused by sea gulls are prevented.

This latter application of photoelectric equipment for sabotage protection is extremely specialized and each installation must be given special attention and study.

All of the above protection systems may either be connected to an American District Telegraph Company Central Station, which is manned by skilled operators, technicians and armed guards who immediately take appropriate action with Police Department cooperation when necessary, or may form the nucleus of a Proprietary System where signals are transmitted to a point within the protected premises. The signals may be either bells, sirens, or floodlights with or without individual annunciation of each separate point of protection.

Capacity Control Systems

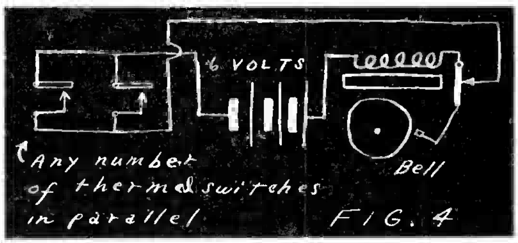
The electronic control by RCA, illustrated in Fig. 2, is of the momentary contact type. It will operate any desired electrical or mechanical system through changes in capacity when a person or other object approaches within several feet of the short antenna. It is useful for the operation of displays, control of electric motors, and opening of doors or similar automatic control applications.

Essentially, the device includes a capacity bridge fed by an oscillator, the signal being generated by the 6F8 tube (triode K_1, G_1 and P_1). Oscillating power from the plate circuit P_1 of this tube is sent through the .0035-mfd. condenser to the center tap of the primary winding L_1 of radio frequency transformer T_3. Note that T_3 has a special construction, using an electrostatic shield and iron core of special construction and is designed for r.f. operation.

The two halves of L_1, the capacity of the antenna to ground and the capacity of C_2, are both made equal, the latter by adjusting C_2 until balance results. Because of this balance, current flowing through either section of the primary winding of T_3 will produce no flux, and no voltage will be induced into the secondary winding of the transformer. However, if a person approaches the antenna, the bridge balance is destroyed and current through one-half of the winding will be greater than the other, inducing a voltage in the secondary of transformer T_3. By means of resonance, this induced voltage is stepped up before being rectified by the diode. C_1 is normally adjusted so the desired resonance rise is obtained when the desired unbalance is accomplished. As you will shortly see, a capacity unbalance changes the frequency of the circulating signal.

The diode cathode circuit, and the triode cathode circuit of the 6SQ7, are common and a change in the diode cathode current will produce a change in the grid potential applied to the 6SQ7 triode section. As a result, a plate current change will occur in the plate load for this tube, and only this change will be transferred to the grid G_2 of the 6F8 tube. As a result, the current in plate P_2 of the 6F8 tube will change and operate the relay shown just above the tube in the diagram.

The transformer T_2 is of the iron-core radio frequency type and is the basic oscillator coil system. The oscillator has a definite frequency initially set by the plate coil, L_1, condenser C_2, and the antenna capacity. Note that the oscillator portion of the 6F8, P_1, G_1 and K_1, is connected in such a way that the oscillator functions as a tuned-plate form of oscillator circuit. If either of these two elements, the antenna capacity, or C_2, is shifted in value, the frequency of the oscillator will also vary and the tank circuit L_2 and C_1 will react to this new frequency. If L_2-C_1 is tuned to the frequency resulting from an intrusion, the resonant voltage across C_1 will rise and there will be a current change in the 2200-ohm resistor in the cathode circuit of the 6SQ7. Consequently, the grid potential for this tube will shift and the plate current will change. This changing plate current will produce a grid potential pulse or change on G_2 of the 6F8 tube and cause a plate current shift in the circuit of P_2.



The relay would then be activated, and being of the latch-in type, will continue to sound an alarm or operate any desired mechanism until released.

The power supply includes a VR-150-30 voltage regulator tube. This control is designed so that it remains unaffected by even severe line voltage fluctuations.

Unlike other capacity operated devices, this control is responsive to sudden capacity increases. The device will not operate when slow changes in capacity are caused by temperature and humidity, or other circuit changes. This is basically due to the capacitor-grid resistor coupling between the plate circuit of the triode section of the 6SQ7 tube and the grid of the triode in double triode section (K_2, G_2 and P_2). The time constant of these two elements determine the speed and duration of the impulse required to get relay action.

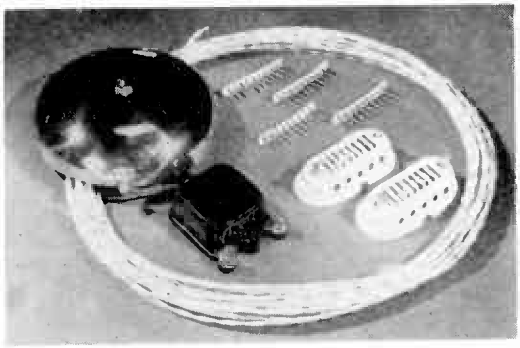


Fig. 5.

Capacity relays are being used a great deal for protection of indoor vaults. Safes, for example, are insulated from ground and connected to serve as the antenna for a capacity control device. The control device need not be especially sensitive as it has plenty of capacity-change on which to function. Adjustments hold over long periods because the capacity between safe and ground remains fairly constant.

Capacity-alarm systems designed to protect extensive areas or long boundaries encounter more difficult design problems. For one thing, the capacity to ground of a long antenna is certain to be high by comparison with the change produced when an intruder enters the antenna field. This requires much greater control sensitivity. Also, the capacity between antenna and ground is likely to vary materially where antenna systems are outdoors. Grass and weeds growing up beneath antennas produce week-to-week changes. More troublesome variations are caused by rain, snow and ice on the antenna itself, on the ground beneath it or on antenna insulators.

Audio Control Systems

Audio control systems commonly are used for protection of bank vaults, but may be used efficiently for many additional services of protection against theft, arson, or sabotage in other forms. The safe-drilling scene on page 9 is a typical situation to which an audio alarm will respond.

Required sensitivity varies according to installation needs, and depends greatly on whether vaults are reverberant or have goods in storage, as in a clothing factory equipped with a fur vault for the guarding of expensive and costly furs.

A typical circuit used in this kind of work is shown in Fig. 3. Sound vibrations picked up by the microphone are amplified, rectified and used to operate by virtue of plate current swing the relay connected to the output tube. The relay, in turn, controls an auxiliary circuit that turns on an alarm or sends a signal to the headquarters of a protective association which "rents" such units to firms or companies desiring burglar alarm protection.

Fire Detection Systems

Not the least important, though last to be mentioned in this discussion, is fire control. Fire, as a powerful tool of enemy saboteurs, must be held to a minimum by employment of detection apparatus as a supplement to armed men. Here, simplicity is of paramount importance and reliability imperative. Electronic methods find little application in this work. Instead, rugged, simple electrical arrangements are employed.

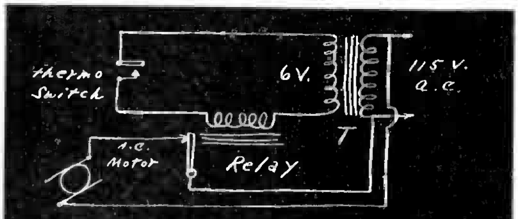


FIG. 6
Electric Motor Control Circuit

In Fig. 4 is shown one simple method by which temperature changes may be converted into electrical changes which can actuate an alarm bell. Each thermal switch contains a bi-metallic strip which curls and closes its contacts when temperature rises above a certain value. The detector heads are wired in parallel. Figure 5 shows a commercial version of this arrangement. The 6-volt d.c. or a.c. voltage required for operation of the alarm can be obtained from a battery or bell-ringing transformer. The detector heads should be located high on the wall of a kitchen, cellar, attic, or living room, wherever fire is a potential danger in home or business locations.

A similar arrangement, designed for 115-volt a.c. operation, is shown in Fig. 6. The principle of operation remains unchanged, the only difference being the type of power required and the use of a relay to control an electric motor. The motor could be used to close a sliding door by means of gears and a suitable mechanical system, or could be the motor of a high-power siren. The possibilities of such control circuits are almost unlimited.

Aero Automatic Fire Alarm System

An equally simple but entirely different principle of operation is employed in the "Aero" fire detection service provided by American District Telegraph Company. The basic scheme is shown in Fig. 7.

Metal tubing (A), 1/12 inch in diameter, is attached to ceilings or walls in continuous loops or circuits. This tubing contains air, normally at atmospheric temperature and pressure.

Each end of a tubing circuit terminates in an air chamber, the walls of which are flexible metal diaphragms (B). When fire starts, the rapid rise in temperature causes the air in the tubing to expand, exerting a pressure which causes the diaphragms to bulge, as shown by dotted lines (C), closing an electrical circuit at contacts (D).

This actuates the alarm transmitter (E), which automatically transmits the alarm by direct wire to the A.D.T. Central Station and at the same time sounds an alarm within the protected premises and registers the location of the fire on an annunciator on the outside of the building.

To allow for normal variations in temperature as caused by heating systems, etc., each air chamber is provided with a "breather" vent (F), which permits the slow seepage of air into and out of the tubing, keeping the pressure normal under all except fire conditions. When a fire condition occurs, the temperature rise is so rapid that the pressure cannot be normalized by the escape of air through the vents, and an alarm results as described above. The system is self-restoring, requiring no adjustment or replacement of the fire-detecting element after operation.

These systems take out of human hands the responsibility for detecting fires (and reporting them also, when the Aero system is connected to the A.D.T. Central Office).

In conclusion, the radio expert, whether serviceman, radio operator, or technician, should have a

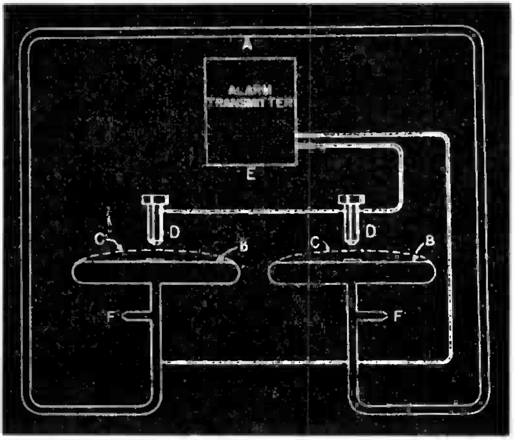


Fig. 7.

broad knowledge of radio as well as the specialized training his job requires. Today, additional emphasis on alarm systems and fire control is vital and is part of our war effort for which you must be prepared. Do your part now; resolve now to study a little harder, so you can better serve your country.

—n r i—

Emerson Sells Radio Parts

The Emerson Radio and Phonograph Corporation, 111 Eighth Ave., New York City, has recently announced a complete line of quality replacement radio parts for servicing all makes of sets on the market. To facilitate the merchandising of many of these parts, Emerson has designed various kits, such as a volume control kit, drive belt kit, resistor kit, condenser kit, etc. Each kit contains an assortment of popular values most generally used in servicing. Catalogs illustrating and listing prices are available to dealers and servicemen through Emerson distributors.

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Wartime Condenser Catalog

This is war. That is the keynote of the new 1942 Aerovox Catalog just off the press. Starting out with a cover that reflects the stern atmosphere of the huge plant working day and night on the radio fighting and home fronts, the catalog lists those essential condensers, resistors and test instruments in popular demand and therefore still produced, stocked and available for prompt delivery. A copy of this catalog may be had by addressing Aerovox Corporation, New Bedford, Mass., or through the local Aerovox jobber.

Operator Requirement Change

Since the war effort is removing a large number of experienced operators, broadcast stations are finding it rather difficult to get the necessary number of first-class radiotelephone licensed men which heretofore have been required.

As a result of this, the Federal Communications Commission has made a number of changes in the requirements. It is now possible for the holder of *any class* of Commercial Operator's License to operate a broadcast station, provided at least one first-class operator is hired by that station and is responsible for the adjustments made.

A holder of a restricted radiotelephone permit can become such an operator in either of two ways. By taking a special examination in radiotelephone theory, a restricted license holder can have an endorsement added to his license which will permit him to operate under a first-class radiotelephone operator until such time as he can get a higher class of license.

It is also possible for the holder of a restricted radiotelephone license to operate in stations classed as local stations if the station licensee will certify him as being familiar with their respective broadcasting equipment. Within six months, the holder of this class license must pass at least an endorsement examination, however.

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Avoid Careless Talk

All buses, street cars and taxi-cabs in Washington display signs warning passengers not to divulge war information. The placards declare, "Don't kill Americans by careless talk! Never discuss military or naval information in a public vehicle!"

This is good advice which we want to pass along to the many N. R. I. men who are serving Uncle Sam, in one capacity or another. It is hardly necessary to warn intelligent men against revealing military information of any kind, but please note the emphasis is put on "careless talk." No loyal American would intentionally reveal any information but we are all inclined to get careless at times. Let's tighten up our lips. Don't talk. What we might tell someone in strict confidence may be passed along to wrong ears through careless conversation.

We repeat, "Don't kill Americans by careless talk! Never discuss military or naval information in a public vehicle." And to improve on that we say, "Never discuss military or naval information in *any* public place." Look out for the fellow who tries to draw you into what may seem like an innocent argument. He may want to get you to talk.

Sample Questions and Answers for Radio Operator License Examinations

By WM. FRANKLIN COOK

N. R. I. Technical Consultant

THE following questions are taken from the book "Study Guide and Reference Material for Commercial Radio Operator Examinations," published by the Federal Communications Commission. This Study Guide gives a general idea of the questions which may be asked in the commercial radio operator examinations.

Although the following material answers particular questions found in the above-mentioned Study Guide, all students and graduates should study these questions and answers. The scope of this material is such that a very thorough review of radio will be obtained by such study.

Of course, it is not expected that the beginner will understand all of the points brought out. Much of the material is advanced, so that only a student sufficiently far along in the Course would fully understand it.

More of these questions and answers are scheduled for future issues of NATIONAL RADIO NEWS. You should study them as received, and save the sections. The questions are grouped into Elements, just as they appear in the Study Guide and in the commercial license examinations.

Element I, covering Radio Laws and Regulations, is omitted here because it is covered in a single lesson of the Advanced Communications Course. We therefore start with Element II, on Basic Theory and Practice. This will be followed in order by questions and answers for Element III on Radiotelephone, Element IV on Advanced Radiotelephone, Element V on Radiotelegraph and Element VI on Advanced Radiotelegraph. The radio theory pertaining to these questions is found throughout the entire N. R. I. Course. If some of the material requires further study, be sure to review your N. R. I. lessons covering that subject.

The questions are numbered in a definite manner. The first numeral is the Element number, and the numerals after the dash give the Study Guide number for the question. Thus, question 3-12 is question 12 of Element III.

As a point for those intending to take the examination for an operator's license—remember that the following questions are *not* the questions you will find in your examination. These merely represent the scope of the examination. The questions asked in actual examinations will probably be worded in a different manner from the following, and may be different questions altogether, though based on the same general subject. For this reason, the answers given here are far longer than necessary. We have attempted to develop some of the basic theory, and give you a general understanding of the subjects, because this will be quite helpful should you get a differently worded question.

Therefore, don't try to memorize the answers to these questions. Try to *understand* the answers instead.

Of course, you won't be asked all these questions. The examining officer will choose a number of questions from all those he has available. You will be asked questions out of the Elements which apply to the particular class of license for which you are being examined.

The number of questions asked on each Element may be anywhere from ten to fifty questions. The amount of writing necessary has been cut down considerably. This has been accomplished partly through the use of multiple choice questions, similar to those you answered in filling out the experimental report sheets. In other words, several possibilities will be put down, and you will check off or fill in the correct possibility.

For example, they may state: *In a particular circuit the voltage is 10 volts and the current is 2 amperes, which means that the resistance must be 20 ohms, 5 ohms, 1 ohm or 8 ohms.* You are to choose the correct one out of the four resistance values. From your knowledge of Ohm's Law, you know that voltage is divided by current to find resistance. Dividing 10 by 2 gives 5, so 5 ohms must be the resistance value.

Element II
Basic Theory and Practice

(2-1) By what other expression may a "difference of potential" be described?

Ans. The difference of potential between two points is also known as a voltage, an IR drop, or a voltage drop.

(2-2) By what other expression may an electric current flow be described?

Ans. The flow of electric current in a circuit is actually a movement of electrons. Therefore, we could describe an electric current flow as an electron flow or electron movement. The rate of flow is measured in amperes, so sometimes you may find current flow described as "amperage."

(2-3) Which factors determine the amplitude of the e.m.f. induced in a conductor which is cutting magnetic lines of force?

Ans. The e.m.f. induced in a conductor is dependent upon the rate of change in flux linkage. Considering a single conductor, this rate is determined by the density of the flux, the speed of the conductor, the length of the conductor, and the angle at which the conductor passes through the magnetic field. The greatest number of lines will be cut when the conductor moves at right angles with respect to the direction of the lines of force.

(2-4) Name four methods by which an electrical potential may be generated.

Ans. An electrical potential or voltage may be generated in a number of different ways. Some of these are:

1. By chemical means, as in a battery.

2. By mechanical means, as in a generator or dynamo.

3. By means of heat, as in a thermocouple.

4. By light energy, as in a photovoltaic cell.

5. By pressure, as in a crystal.

6. By friction, as in a static generator.

(2-5) If the diameter of a conductor of given length is doubled, how will the resistance be affected?

Ans. Assuming that d.c. resistance is being referred to here, we can immediately see that increasing the diameter is the same as adding other wires in parallel. From your knowledge of parallel resistance circuits, you know that the total of resistances in parallel are always less than the smallest, so increasing the diameter is going to decrease the resistance.

Actually, the resistance of a wire varies inversely as the *area* of the cross-section. This means the resistance goes down as the cross-section area is increased. Since the area of a circle varies as the square of the diameter, doubling the diameter would mean that the area has increased four times. Since the resistance varies inversely as the area, doubling the diameter of a given wire will reduce the resistance to one-fourth its original value.

(2-6) If the value of a resistance, to which a constant e.m.f. is applied, is halved, what will be the resultant proportional power dissipation?

Ans. When the resistance is cut in half and voltage is constant, the current is doubled (from Ohm's Law: $I = E \div R$). Now, since the power dissipation is equal to $E \times I$, doubling the current means the power is doubled. This may also be found from another formula for power, $P = E^2 \div R$. Cutting R in half doubles the power P.

(2-7) What method of connection should be used to obtain the maximum no-load output voltage from a group of similar cells in a storage battery?

Ans. Maximum voltage will be obtained when the cells are connected together in series, because battery voltages add when in series.

(2-8) What is the sum of all voltage drops

around a simple d.c. series circuit, including the source?

Ans. From Kirchhoff's voltage law, the voltage rises in a circuit are always equal to the voltage drops. The source is considered a rise, while all voltages developed across parts are drops. If the voltage drops are subtracted from the voltage rises, the result will be zero. Hence, we say that the sum of all the voltages around the circuit is zero.

For those interested in algebra, this is known as algebraic addition. In other words the voltage rises are considered as positive, while voltage drops are considered as negative. This consideration is from the fact that a meter being moved around the circuit must have its terminals reversed when you shift from measuring rises to drops. Adding equal positive and negative values algebraically gives zero. This is the same thing as just subtracting one from the other.

(2-9) What method of connection should be used to obtain the maximum short-circuit current from a group of similar cells in a storage battery?

Ans. From Ohm's Law, the maximum current which can flow in any circuit is determined by the voltage and resistance in the circuit. If we short-circuit a battery, we have practically no external resistance. However, the battery itself has some resistance. Normally, we disregard the battery resistance because it is so small compared to the usual external circuit resistance. With a short-circuit, however, this internal resistance is the only resistance in the circuit. Therefore, the amount of current which can be obtained from a single cell is dependent on the voltage of the cell and on its internal resistance.

If we connect batteries in series, the voltages add, but the internal resistances also are in series and add. Hence, under a short-circuit, batteries in series can deliver no more current than a single battery.

On the other hand, if we connect batteries in parallel, the voltage is the same as that for a single cell but we are now connecting the internal resistances in parallel. As you know, this reduces the total resistance. Therefore, by connecting batteries in parallel we can get a greater short-circuit current flow.

Of course, we do not ordinarily short-circuit batteries, but the short-circuit current theorem is helpful in certain advanced problems and also gives an indication of the current capacity available from batteries. Hence, this brings out the important fact that connecting batteries in parallel gives a greater current capacity.

(2-10) If the value of a resistance, across which a constant e.m.f. is applied, is doubled, what will be the resultant proportional power dissipation?

Ans. This question is just the reverse of question 2-6, so we simply use reversed reasoning. Doubling the resistance cuts the current in half, so the power is likewise cut in half.

(2-11) Name four materials which are good insulators at radio frequencies. Name four materials which are not good insulators at radio frequencies, but which are satisfactory for use at commercial power frequencies.

Ans. Polystyrene, quartz, isolantite, Pyrex, steatite, porcelain, pure bakelite, rubber, and clear mica are good insulators at radio frequencies. (The first five materials named are good insulators at ultra-high frequencies also.)

Materials which are good insulators at commercial power frequencies (25 cycles, 60 cycles, 133 cycles, etc.) but which are poor at radio frequencies include oil, slate, asbestos, paraffin, fiber, wood, and insulating cloth (called empire cloth or varnished cambric).

(2-12) Explain the factors which influence the resistance of a conductor.

Ans. The resistance of a conductor depends on the resistivity of the material, the temperature, and the dimensions (length and cross-sectional area). Resistance varies directly with the length (it increases as the length is increased). Resistance varies inversely with the cross-sectional area (it decreases as the area is increased). Resistance varies directly with resistivity (it increases as resistivity is increased). Resistance varies with temperature (it may either increase or decrease with rises in temperature, depending on the material). The temperature of the conductor is the temperature in which it is working, determined not only by the surrounding temperature but also by heating effects in the conductor, due to the dissipation of power in the conductor.

(2-13) What effect does the cross-section area of a conductor have upon its resistance per unit length?

Ans. This question is very similar to 2-5, and you will find an explanation there of the fundamentals. Resistance varies inversely with the cross-sectional area, so increasing the cross-sectional area reduces the resistance.

(2-14) Name four conducting materials in the order of their conductivity.

Ans. This question requires that we list materials so that the best conductor is first, the next best second, etc. Referring to materials used as wire commercially, we have silver, copper, aluminum, and iron, in that order. Copper is considered the standard of comparison, although silver is a slightly better conductor. The price of silver wire restricts its use.

(2-15) What effect does a change in the dielectric constant of a condenser dielectric material have upon the capacitance of a condenser?

Ans. The capacitance (capacity) of a condenser depends on the number, size and spacing of the plates, and on the dielectric constant of the material between the plates. A pure vacuum between the plates gives the lowest capacitance for a given arrangement of plates; this capacitance in a vacuum is used for reference purposes, and the dielectric constant of a vacuum is said to be exactly 1. Any insulating (dielectric) material between the plates increases the capacitance. The number of times the capacitance of a condenser is increased by using a dielectric material instead of a vacuum between the plates is called the dielectric constant of the material. Therefore, the larger the dielectric constant, the greater the capacity of the condenser.

(2-16) Explain the effect of increasing the number of plates upon the capacitance of the condenser.

Ans. By definition, a condenser consists of any two conductors separated by a non-conducting medium. The capacitance of a condenser varies directly with the area of the opposing surfaces of the two plates. If more plates are used, this is the same as using a pair of larger plates, so the area is increased. Hence, the capacitance of a condenser varies directly with the number of plates. Flat plates, parallel to each other, are most generally used. The outside plates each have one side (the outer one) which is not effective because it does not have an opposite plate next to it. Therefore, we can say that the total capacitance is equal to the capacity of two plates multiplied by N-1, where N is the total number of plates.

(2-17) State the formula to determine the capacitive reactance of a condenser.

Ans. $$X_C = \frac{1}{2\pi fC}$$

where f = frequency in cycles
C = capacitance in farads
X_C = reactance in ohms
π = 3.14

(2-18) If the specific inductive capacity of a condenser dielectric material between the condenser plates were changed from one to two, what would be the resultant change in capacity?

Ans. The specific inductive capacity is just another name for the dielectric constant. It is a ratio number, indicating how any certain material may increase the capacitance of a condenser. The capacitance varies directly with this ratio. If the specific inductive capacity is increased from one to two, the capacitance would be multiplied by two or would be doubled.

(2-19) State the formula for determining the quantity or charge of a condenser. The energy stored in a condenser.

Ans. The quantity or charge in a condenser depends upon the number of electrons collected in the condenser when a voltage is applied to the condenser. The number of electrons that can be stored in a condenser therefore depends on the amount of voltage and upon the capacity of the condenser for holding these electrons. The formula is $Q = C \times E$, where Q is in coulombs, C is in farads and E is in volts.

The energy stored in a condenser represents the amount of work involved in putting the electrons in the condenser. Its formula is $W = \frac{1}{2} CE^2$, where W is in joules, E is in volts and C is in farads.

(2-20) Neglecting temperature co-efficient of resistance and using the same gauge of wire and the same applied voltage in each case, what would be the effect upon the field strength of a single layer solenoid, of a small increase in the number of turns?

Ans. The strength of the magnetic field of a coil is dependent upon the magnetomotive force developed by the coil. Magnetomotive force is directly dependent upon the number of turns and on the amount of current. Increasing the number of turns would, therefore, apparently increase the strength of the magnetic field. However, when we increase the number of turns, we are adding more wire of the same resistance in series, so the total resistance increases.

Therefore, if the voltage is constant as given in the question, increasing the length of the wire will decrease the current. The decrease in current would exactly cancel the increase in turns in this case, and there would be no effect whatever on the field strength.

On the other hand, if the voltage is not a constant, or if the current can be kept as a constant, increasing the number of turns will increase the strength of the field, providing the number of turns are kept within reasonable physical limits.

(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. This magnetic field will affect the position of the compass needle, according to the laws of magnetism. Like poles repel and unlike poles attract, so the compass needle, which is magnetized, will move to such a position, along the lines of force, that the North pole of the compass will point toward the South pole of the coil. The needle will then be lined up with (parallel to) the magnetic lines of force.

(2-22) What materials may be used for shielding an r.f. magnetic field?

Ans. Materials such as copper and aluminum are ordinarily used as shields around radio frequency coils. The shield material must be a good electrical conductor. It should completely enclose the coil or object being shielded and be sufficiently far away from it so as not to seriously distort the field about the coil in question.

Materials of good conductivity are used, because the r.f. shielding action arises from eddy currents. In other words, the magnetic field of the coil causes eddy currents to flow in the shielding material by induction. These eddy currents flow over circular paths, establishing their own magetic fields which oppose the original field. This serves to bend the coil field away from the shield. The material must be a good electrical conductor so that the eddy currents will be high enough to be effective.

(2-23) What is the advantage to be gained by "bank winding" an inductance?

Ans. In an ordinary layer-wound coil, a number of turns are wound one right after the other, on the coil form. Then, if more than one layer is desired, succeeding layers are wound right on top of the last one. From the definition of a condenser (two conductors separated by an insulator), you can see that small capacities exist between adjacent turns on a coil and also between layers on a coil.

This distributed capacity, as it is called, can be rather troublesome in audio or radio frequency coils, because it has the effect of adding capacity across the coil in the circuit, and this is usually undesirable.

Bank winding consists of winding two or three turns of the layer, winding the succeeding turn over these, then dropping back to the original level to wind another turn.

For example, turns one and two may be wound, then turn three wound on top, in the groove between these two. Turn four is wound next to turn two, with turn five on top of windings two and four, etc. The capacity between pairs of turns is still the same as before, but the new arrangement is such that the capacity between layers is far less effective. This is because the capacities are arranged so that they are more in series, which decreases capacity. Hence, a bank-wound coil will have less distributed capacity than a straight layer-wound coil.

(2-24) What factors influence the direction of magnetic lines of force generated by an electromagnet?

Ans. We must assume here that they are referring to the direction in which the magnetic poles act, rather than the path over which the flux may pass. In this case, the direction is determined by the direction of current flow through the coil. Reversing the direction of current will cause the North and South poles to reverse.

(2-25) Explain the meaning of and factors which determine the "Q" or "figure of merit" of an inductance.

Ans. The "Q" factor, also called the "figure of merit," is a measure of the efficiency of a coil. It is the ratio of coil reactance to the a.c. resistance ($Q = X_L \div R$).

The Q factor is particularly important in resonant circuits, as it gives directly the amount of resonant step-up obtainable. In a series-resonant circuit, the applied voltage multiplied by Q gives the voltage available across either the coil or condenser. In a parallel-resonant circuit, the line current multiplied by Q gives the tank current; also, Q times the coil reactance gives the resonant resistance in a parallel-resonant circuit.

The larger the Q factor, the better the coil in most applications. Hence, if we can decrease R for a fixed X_L, or can increase X_L for a fixed R, we can have a higher Q factor.

The inductive reactance (X_L) is determined by the frequency and the coil inductance in henrys. Of course, the value of the inductance is determined by many factors, such as the number of turns, size of the coil, type of core material, and method of winding the coil.

The a.c. resistance, sometimes called the r.f. resistance, is affected by the d.c. resistance, the skin effect. dielectric losses in the coil form, shield losses. and in the case of a coil having an iron core, by losses in the core itself.

(2-26) Define the term "permeability."

Ans. The amount of flux produced in a magnetic circuit is dependent on the magnetomotive force and the reluctance. The reluctance depends on the length and area of the flux path and also on the material in the path. Some materials, such as iron, are much better magnetic conductors than others.

The ratio between the ability of a material to carry flux and the ability of air to carry flux is called its *permeability*. Permeability is thus a measure of the ability of the material to be permeated or filled with magnetic flux. The higher the permeability, the greater the amount of flux we can get for a given flux path and given amount of magnetomotive force.

Permeability (μ) is also defined as the ratio of magnetic flux density (B) to the magnetic force intensity (H), where $\mu = B \div H$. The flux density is a measure of the number of lines per unit of area, such as per square inch or square centimeter. (The total flux is flux density multiplied by the total cross-sectional area.) The force intensity is the strength of the magnetic force within a unit length. (The total force is the intensity multiplied by the total length of the magnetic circuit.)

So far, we have considered flux density for definite values of force intensity. In radio, we are also concerned with the change in flux density for definite changes in force intensity. This is known as incremental, a.c., or differential permeability. Near saturation. a.c. permeability becomes small. Thus, the a.c. permeability of iron can drop down to a low value when the core is filled with flux (saturated).

(2-27) What unit is used in expressing the alternating current impedance of a circuit?

Ans. Impedance is the total opposition to the flow of alternating current in a circuit. This term combines both resistances and reactances, and is measured or expressed in ohms.

(2-28) What is the unit of resistance?

Ans. Resistance is the opposition to a flow of electric current. The unit of measurement of resistance is the ohm.

(2-29) Explain the meaning of "micromicrofarad."

Ans. The unit of capacitance is the farad. However, this is a very large unit for practical radio work, so we must make use of small fractions of this value. The prefix "micro" means one-millionth. A microfarad is therefore one-millionth of a farad. The prefix "micromicro" means a millionth of a millionth, so one micromicrofarad is a millionth of a microfarad. Also, it is one-millionth of a millionth of a farad.

If you wish to express this as a decimal, a micromicrofarad is equal to .000000000001 farad. You will also sometimes find this written as 1×10^{-12} farad.

(2-30) What is the unit of capacitance?

Ans. As explained in question 2-29, the unit of capacitance is the farad. As this is a rather large unit, the microfarad and the micromicrofarad are found more commonly in radio work.

(2-31) What single instrument may be used to measure electrical resistance? Electrical power? Electrical current? Electromotive force?

Ans. Resistance may be measured with an ohmmeter. Power may be measured with a wattmeter. Current may be measured with an ammeter. Electromotive force is voltage, and may be measured with a voltmeter.

(2-32) Define the term "residual magnetism."

Ans. When iron is magnetized by being placed in a magnetic field, and the field is turned off or removed, a certain amount of magnetism remains in the iron. The magnetism remaining in the material after the magnetizing force has been removed is called "residual magnetism."

(2-33) What is the unit of electrical power?

Ans. The unit of electrical power is the watt.

(2-34) What is the unit of conductance?

Ans. Conductance is the ability of a circuit to conduct or carry current. It is therefore the opposite of resistance. Resistance is measured in ohms, so the unit of conductance was named the "mho" (pronounced "mo"). This is the word ohm, spelled backwards.

(2-35) What is the unit of inductance?

Ans. The unit of inductance is the henry.

(2-36) What is the meaning of the prefix "kilo"?

Ans. Kilo means one thousand. Hence, one kilocycle means one thousand cycles.

(2-37) What is the meaning of the prefix "micro"?

Ans. Micro means one-millionth. As an example, one microfarad is one-millionth of a farad.

(2-38) What is the meaning of "power factor"?

Ans. When we attempt to measure power in an a.c. circuit, we run into the problem of phase relationships. Ordinarily, we think of power as the product of voltage multiplied by current. This is strictly true in any d.c. circuit or a.c. resistive circuit. However, if we use an ammeter and voltmeter to determine the power in an a.c. circuit having inductive or capacitive reactances, we would not obtain the true power.

This is due to the fact that the voltage and current in such a circuit may not be in phase, which means that peak values are not reached at the same instant of time. As a result, one of the reactive devices may be taking power from the circuit, which it returns on the next half cycle. The meters do not indicate this.

Due to this phase relationship, we must multiply the product of voltage and current by another factor, called the *power factor*. This is a correction figure to change this apparent power into true power.

The power factor is the ratio of resistance to impedance in the circuit. In other words, dividing the resistance by the impedance will give the power factor number.

It is interesting to know that a wattmeter always indicates true power. A wattmeter is a meter with a double coil system, there being one voltage coil and one current coil. The movement obtained in a wattmeter is dependent upon the relative strengths of the magnetic fields of the two coils, which automatically takes phase into consideration. Therefore, if we measure power with a wattmeter, we always get the true power.

From this, it is apparent that the power factor in any particular circuit can be determined by making a measurement of the true power with a wattmeter, then obtaining the apparent power through the use of a separate voltmeter and separate ammeter. Dividing the true power by the product of the voltage multiplied by the current gives the power factor.

(2-39) What is the meaning of the prefix "meg."?

Ans. This prefix means one million. Hence, one megohm is one million ohms.

(2-40) Define the term "conductance."

Ans. Refer to the answer to 2-34. Conductance is a measure of the ability of a circuit to conduct or carry current. It is the opposite of resistance. Mathematically, conductance is called the reciprocal of resistance because the number 1 divided by the resistance will give the conductance of the circuit. Obviously, if the resistance is decreased, the conductance is increased.

(2-41) What instrument is used to measure current flow?

Ans. The practical unit of current measurement is the ampere. Hence, the meter used to measure this flow is an ampere meter or an ammeter.

In radio work, we frequently deal with milliamperes and microamperes, which are normally measured by milliammeters and microammeters, respectively. A milliampere is one-thousandth of an ampere. A microampere is one-millionth of an ampere.

n r i

Testing

The electrician was puzzled. "Hi!" he called to his assistant, "put your hand on one of these wires."

The assistant did as he was told.

"Feel anything?"

"No."

"Good!" said the electrician. "I wasn't sure which wire was which. Don't touch the other or you'll drop dead."

—*Williams Words*—

CIRCUIT ANALYSIS OF A EMERSON MODEL DU-379 AND DU-380 BATTERY PORTABLE

By J. B. STRAUGHN

N. R. I. Service Consultant

General Description. Although the diagram of this battery portable bears two model numbers, both models are essentially the same. The only difference lies in the degree of portability. The model DU-379 is an outdoor portable and may be carried by the special strap which fits over the user's shoulder. Since the loop is placed in this strap, there is a slight difference in the design of this loop and the one used in the model DU-380. Other than this, the two chassis are identical and are both known as the DU chassis.

J. B. Straughn

To achieve real portability, special small-size, low current drain tubes are used and two flash-light cells connected in parallel serve as the A supply. A special light-weight 67½-volt B battery is used. The tubes and their functions are: A 1R5 pentagrid converter tube as the first detector - mixer - oscillator; a 1T4 super control grid tube as the i.f. amplifier; a 1S5 diode pentode as the second detector, a.v.c. and first a.f. amplifier; and a 1S4 power output pentode to feed the loudspeaker.

Signal Circuits. There are a number of small but important variations from normal in the circuits of this receiver which make it of interest. Each item will be explained as we come to it.

Signals picked up by the loop may be tuned in by adjusting the tuning condenser dial which controls ganged condensers C1 and C2. Condenser C1 tunes the loop and the chosen signal receives a boost in strength due to resonance step-up. In the shoulder strap model 379, the inductance tuned by C1 consists of loop L2 and an extra inductance L1, which is not used in the house model, number 380. In the model 380, all of the inductance is concentrated in the loop, which is rigidly fastened in place. In the model 379, the loop shape will change as the wearer breathes and moves around. This results in some inductance change and to avoid serious detuning, most of the circuit inductance is concentrated in L1. Then even large changes in the loop inductance have only a small effect on the total circuit inductance and hence on the tuning. The shoulder strap loop is primarily a pick-up device rather than a tuning coil. In either model the resonant circuit is completed through C5 which, as far as r.f. is concerned, acts like a short circuit.

The modulated carrier of the selected station appears across C1 and is applied to the input of the first detector. The filament connection is made through the chassis and the lower half of oscillator tank coil T1. At the same time, the oscillator signal is injected into the first detector. The two signals are mixed inside the tube and the i.f. beat voltage, bearing the original carrier modulation, is applied to the primary of i.f. transformer T2.

An examination shows the oscillator circuit to be different from that found with the usual pentagrid tube, and this will bear investigation. First you will note that we have been speaking of the 1R5 as a pentagrid converter, when only four grids (the screen grid is counted as two grids) are shown. The facts of the case are that the manufacturer's draftsman took a little poetic license and left out the suppressor grid, figuring perhaps that the tube drawing was going to be spread out enough as it was and that the omission didn't matter as far as service work was concerned. In this he was right, for the extra grid, placed between the screen and plate, connects inside the tube envelope to the negative side of the filament, simply to prevent secondary emission from the plate to the screen. A serviceman can't get at this grid or do anything about it, so it doesn't enter as a service problem. If the grid shorts to the plate, a tube tester will show this up in the usual manner, and in the set the short, if it occurred, would appear to be between the plate and filament.

The oscillator is an ordinary Hartley with the plate grounded. Here the screen grid acts as the plate and the screen is kept at r.f. ground potential by means of by-pass condenser C9. The screen also acts as the virtual cathode, as far as the detector section is concerned, and the third grid which is the detector control grid controls the stream of electrons coming through the screen grid. This electron stream is varying at the oscillator frequency, so the i.f. beat is produced in the detector (mixer) section of the tube.

Feed-back in the oscillator is obtained by causing the plate current to flow through the tapped portion of T1, and the voltage induced into the rest of T1 causes the circuit consisting of T1-C2 to oscillate at its resonant frequency. The oscillator voltage is applied to the oscillator control grid through C6. R1 is the oscillator grid resistor. L3 is used to prevent the 1R5 filament and the A battery from shorting the tapped section of T1. Such a short would prevent the oscillator from working.

Now that the oscillator has been investigated, we return to our i.f. signal delivered by the 1R5 to the primary of T2. The resonant circuit is formed by the coil winding and C7 which shunts it. However, the circuit is adjusted to the i.f. value (455 kc.) not by varying the capacity of C7 but by adjusting the inductance of the primary. A pulverized iron core can be screwed in or out of the coil. The inductance is increased and the resonant frequency made lower as more of the core is inserted into the coil.

By mutual induction a voltage is induced into the secondary shunted by C8, and again the circuit is tuned to 455 kc. by adjusting the coil inductance.

The i.f. signal across the secondary of T2 is fed to the input of the 1T4 i.f. tube, the filament connection being through C5 and the chassis.

The 1T4 causes a large i.f. signal current to flow through the primary of T3. A voltage is induced into the secondary where it undergoes resonant step-up. The primary of T3 is untuned and hence the coupling in this transformer may be close enough to give high gain. This is typical of any i.f. transformer where only one winding is tuned.

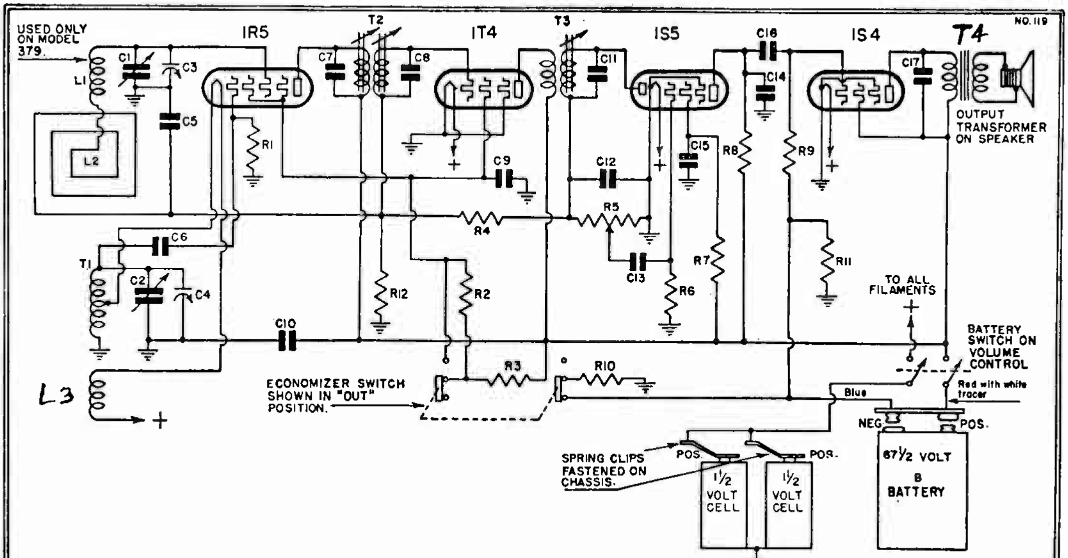
The large i.f. voltage across C11 is applied to the diode and filament of the 1S5, the filament connection being through C12. As a result, rectification occurs and we have the audio modulation plus a d.c. component across the volume control, which is also the diode load resistor. As previously stated, C12 prevents any i.f. voltage from being dropped across the diode load, all of the signal being applied to the diode plate and tube filament.

The d.c. voltage across R5 is used for a.v.c. purposes, since it will vary directly with the strength of the carrier applied to the second detector. The ungrounded end of the resistor is negative with respect to the filament of the 1R5, which is at d.c. ground potential. Tracing the circuit from the negative side of R5, we see that part of this voltage is applied to the first detector control grid (third grid of the 1R5) through resistor R4. This resistor, together with C5, serves to remove the audio signal voltage and only pure d.c. is available across C5 for a.v.c. bias purposes. The full d.c. voltage across R5 is not used, for you will note that R12 and R4 are across R5 and hence act as a voltage divider. The voltage across R12, which is in parallel with C5, is the a.v.c. voltage fed the 1R5 tube. Since R4 and R12 are both 500,000 ohms (the same size), both have equal voltage drops and only half of the voltage across the diode load R5 is used for a.v.c. purposes. Thus, while a.v.c. action is reduced, danger of cutting off the plate current of the 1R5 tube, with consequent blocking or motorboating on strong signals, is eliminated. The i.f. tube receives the same a.v.c. voltage as the 1R5.

Returning to our audio signal, which we left across the volume control, we see that this signal is applied across resistor R6 through coupling condenser C13. Since C13 connects to the slider arm of the control, the setting of this slider arm will determine the amount of signal voltage fed to R6. As R6 is directly in the grid input circuit of the pentode portion of the 1S5, the tube amplifies the audio signal fed it and we have the amplified signal voltage across its plate load resistor R8.

Condenser C14 serves to by-pass any stray i.f. signal which may have been amplified by the tube, along with the audio signal.

The audio signal across R8 is transferred across R9 and R11 through C16, and through C10 and the chassis. The signal voltage across R9 and R11 is amplified by the 1S4 and delivered by the impedance-matching output transformer T4 to the loudspeaker voice coil, movement of which



SCHEMATIC DIAGRAM
4 TUBE BATTERY RECEIVER

Item No.	Description	Item No.	Description
L1	Iron core loading coil (379)	R6	10 megohm ¼ watt carbon resistor
L2	Shoulder strap loop assembly (379)	R7, R9	3 megohm ¼ watt carbon resistor
L2	Loop antenna (380)	R8	1 megohm ¼ watt carbon resistor
T1	Oscillator coil	R10	2200 ohm ¼ watt carbon resistor
T2	Iron core double-tuned 455 kc first i-f transformer	R11	1800 ohm ¼ watt carbon resistor
T3	Iron core single-tuned 455 kc second i-f transformer	C1, C2	Two-gang variable condenser
R1	100,000 ohm ¼ watt carbon resistor	C3, C4	Trimmers, part of variable condenser
R2	5,000 ohm ¼ watt carbon resistor	C5, C9, C15	0.02 mf. 200 volt tubular condenser
R3	10,000 ohm ¼ watt carbon resistor	C6, C12, C14	0.00011 mf mica condenser
R4, R12	5 megohm ¼ watt carbon resistor (see production change No. 1)	C7, C8, C11	Fixed trimming condensers, contained inside i-f cans
R5	Volume control 1.5 megohm with double pole battery switch	C10	10 mf. 100 volt dry electrolytic condenser
		C13	0.002 mf. 600 volt tubular condenser
		C16, C17	0.001 mf. 600 volt tubular condenser

and its attached cone produces the audio signal as audible sounds.

Biasing Methods. As you already know, the grid bias of a battery-operated filament type tube is measured between the control grid and the negative side of the tube filament. The effective bias, however, is the difference in voltage between the center of the filament and the grid. Therefore, any voltage between the center of the filament and the negative filament terminal is added to the voltage between the negative filament terminal and the control grid. In these special low voltage tubes which handle only small amounts of signal voltage, the bias is quite small. The a.v.c. voltage across R12 is added to the voltage drop in one-half the tube filament to form the bias for the i.f. 1T4 tube and the first detector 1R5 tube. Since these tube filaments are supplied with approximately 1.4 volts, half of this or .7 volt is used as the initial bias, and when signals are received the a.v.c. bias voltage is added to this. The oscillator grid of the 1R5 receives half the filament voltage, plus the voltage created across R1 by grid current through this grid resistor.

The voltage drop across R6, due to convection current through it, plus one-half of the filament voltage biases the pentode section of the 1S5 first audio tube.

The 1S4 power output tube requires considerable bias, more than can be readily furnished by convection current through the grid resistor or by the filament voltage drop. Bleeder bias is employed by causing the plate currents of all tubes to flow through R11. The voltage drop across this resistor makes the 1S4 control grid, which connects to the negative end of the resistor, negative with respect to its filament, which connects to the grounded positive end of R11.

Battery Economizer. We have now considered the bias arrangement of all the tubes, but the discussion of the 1S4 bias brings up another related object. As you will note, the receiver is equipped with a two-position switch called an *economizer*. By throwing this switch to the "out" position, maximum power output is obtained from the 1S4 tube and the total B current drain, according to the factory manual, is 7.5 milliamperes. With the switch thrown "in," the B drain is reduced to only 5 milliamperes, a considerable saving.

This is accomplished by increasing the bias on the 1S4 tube. When the switch is in, resistor R10 is no longer in parallel with R11 and the total resistance between B— and the chassis is increased. Therefore, the voltage drop across R11 increases and this increase in grid bias cuts down on the 1S4 plate current.

As in any battery set, the d.c. plate and screen voltages are applied between these electrodes and the tube filaments. The filaments are grounded to the chassis as shown. Therefore, since the voltage between —B and the chassis is increased with the economizer switch in, the voltage between the filaments and screens, and filaments and plates has decreased. This is unimportant save in the case of the 1R5 and 1T4 screen voltages. A decrease at this point results in a loss in sensitivity. To keep the sensitivity constant, the economizer switch in the "in" position shorts out R2 in the screen supply circuits of these tubes, thus keeping the screen voltage constant and preventing a loss in sensitivity.

Voltage Measurements. The operating voltages for each tube are measured with a d.c. voltmeter. The negative probe of the voltmeter goes to the negative filament terminal (grounded terminal) in each measurement save for control grid voltage, where the positive meter probe goes to ground and the negative probe to the control grid.

A definite control grid voltage will only be measured on the 1S4 tube and, due to the high resistance of R9, the exact voltage will not be measured. However, it can be checked by placing the meter probes directly across R11 (positive probe to chassis).

Miscellaneous. The alignment of the receiver is standard for a superheterodyne. Note that there are only three i.f. adjustments, since only the secondary of T3 may be tuned, and that a low-frequency oscillator padder condenser is not provided.

No unusual difficulties are to be expected, although the oscillator will stop when the A batteries begin to run down.

Electronic Tubes Reveal Wing Strain In Air Corps Test Flights

If you have ever seen a fighter streak across the sky, diving, twisting, and turning with the seeming speed of lightning, you may have wondered how it is possible to build planes that can withstand such terrific strains as those in power dives at speeds greater than 500 miles an hour.

Did you ever put your hand out the window of a car going 50 miles an hour? Well, at 500 miles an hour, the wind pressure will not be ten times but a hundred times as great, which means that those gleaming American "wings of victory" must have tremendous strength. And the U. S. Army Air Forces must be dead sure they have that strength.

"Electronic tubes and strain gages give that assurance," according to Frazier Hunt, General Electric newscaster. "By attaching strain gages to the proper parts of a wing, and by putting recording instruments in the plane, a few little electronic tubes will write a complete record of the strains during a test flight," he explains. "From these records, the designer knows whether he can reduce weight and thus give more speed to our bombers and fighters. But most important, he knows that American boys can fly American planes with greater safety. And he knows that the science of electronics can provide him with the facts to build planes that really can take it."

Stresses in the plane structure are detected by the strain gages, which are mounted on various parts of the plane. These stresses are converted into tiny electrical impulses which are amplified sufficiently by electronic tubes to drive highly sensitive oscillograph galvanometers. By deflecting light beams of an optical system, the galvanometers record the strain gage impulses on a photographic film. Having calibrated this equipment before flight tests, the trace on the film can be converted to either pounds per square inch of load on the plane structure, or by thousands of an inch deflection.

n r i

Squirrel Food

An inmate of a state institution was trying to drive a nail into a wall, but he had the head of the nail against the wood and was hammering the point.

After a while he threw down the nail in disgust and said. "Bah! Idiots! They gave me a nail with the head at the wrong end!"

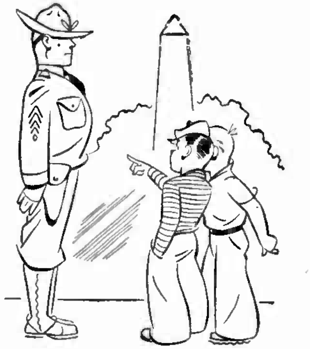
Another inmate, who had been watching, began to laugh. "It's you that's the idiot," he said as he jerked his thumb toward the opposite wall. "That nail was made for the other side of the room!"

N.R.I. ALUMNI NEWS

CHICAGO CHAPTER HOLDS WARTIME PARTY

The members of Chicago Chapter had a big time at a recent party held for the benefit of all members of the family. To promote the spirit of conservation the dress was informal. A number of those present came garbed in "hard time" fashion. The entertainment, supplied by talented members of the chapter, was excellent. Plenty of good music—good dancers—eat—drink. What more is needed for a good time.

Here and There Among Alumni Members



Visitors formerly came to Washington to admire our great federal buildings and memorials. Now they are more intrigued with the vast number of soldiers who guard these buildings. Finely trained, stately, with military poise, they stand in hundreds of places throughout the Capital. It is comforting to see these soldierly young men guarding our institutions—yours and mine. Yes, Washington is prepared for any emergency.

—n r i—

J. H. Anderson, Atlanta, Ga., who graduated sixteen years ago, still writes to us at regular intervals. He operates his own Radio shop and does very well indeed.

—n r i—

Notice the picture on page 27, left hand side, where a sign says "step down." Earl Bennett stepped down and fell to the basement. When Jimmy Cada went to see what happened, Earl said, "If you are coming down here, look out for that first step—it's a sonofagun!"

—n r i—

G. R. Gallager of Savannah, Ga., delayed taking the examination for a Radiotelephone license in order to get acquainted with his new son, but has since secured a second class Radiotelephone ticket and is in line for a first class telephone and amateur A, very soon.

—n r i—

Mike Tresh, catcher for the Chicago White Sox, was in to see us recently when his team was playing a series with our Washington Senators. Tresh is studying Radio with us to use his spare time to good advantage. As every baseball fan knows, he is one of the star catchers in the American League.

—n r i—

Haven Kessel of West Virginia sends us a nice note. He is a First Lieutenant, Signal Corps, U. S. Army.

—n r i—

Another fellow who recently got a commission in the Army is Richard W. Anderson, who was promoted to Second Lieutenant in the Signal Corps. Frederick D. Ritter is Commanding Officer of a Signal Platoon with rank of First Lieutenant.

—n r i—

W. R. Nichols, chief operator at KINY, Juneau, Alaska, recently returned to his post after devoting about four months full time in supervising the construction of a new 5,000-watt transmitter in Seattle.

—n r i—

At the recent Chicago hard time party, Cecil Morehead cut a hole in the seat of his pants and sewed a gaudy patch over it. All was swell until the fellows tore the patch off.

—n r i—

John G. MacDougall, Jr., of Skowhegan, Maine, is employed by Maze Stores. His boss was so impressed with his Radio technique he also has enrolled with NRI.

—n r i—

Gordon Angwin, who has a good Radio business in Richmond, California, has gone with the Army Air Corps as a Junior Radio Repairman.

—n r i—

J. F. Huff of Austin, Texas, has been President of the Texas Radio Service Association since 1939, and also is President of the Austin Radio Service Association for the third year.

—n r i—

We are very proud of Albert A. Arnhym, who is Chief Engineer for the Airmax Corporation in San Diego, California. He is the inventor of numerous electronic devices, among them the first device for the electronic transmission of natural colors, a photo-tube for the conversion of heat—and infrared pictures into directly visible images for penetration of haze and mist in high altitude flights.

—n r i—

Mr. L. L. Hughes of Erick, Okla., was in Washington on business and dropped in to see us. We prize a picture Mr. Hughes gave us showing his fine store. His secretary, Miss Opal Hammons, who is also in the picture, has since lost her life in an automobile accident. Our deepest sympathies are with her mother, Mrs. W. O. Hammons.

—n r i—

Eladio Fonseca was selected by the director of a government school in Costa Rica to design an orthophonic system consisting of amplifier, phonograph, microphone, phone, attenuators, and the corresponding hook-up to be used in a class room to help deaf and dumb children to develop and regain their sense of hearing and speech by listening to themselves, the teachers and music. The system is giving very good results.

—n r i—

J. A. Cordero of South Chicago, Ill., has a full time defense job, but he continues his spare time Radio business in his well-equipped shop. He is a highly regarded member of Chicago Chapter and manages to attend meetings now and then.

—n r i—

Melvin F. Berstler is Engineer with Radio Station WJJD, Chicago. About two years ago, at our recommendation, he accepted a job with a small station in Wisconsin. He has been steadily moving upward.

Chicago Chapter

At our meeting of the 13th Mr. Jimeson of Walker Jimeson Co., was the speaker for the evening. He spoke on present day emergency conditions due to the War and offered some excellent suggestions on how to meet them. A soldering iron, donated by Mr. Milton Coleman of Radolek was won by Richard Pierz. Refreshments were served after the meeting.

On the 23rd we held one of our very popular social affairs which was well attended by members, their wives and children. Mr. Menne, our Executive Secretary from National Headquarters, also was present. The food was tasty—the drinks were cool and refreshing. There was excellent entertainment and good music. We wish to express our thanks to the entertainment committee and the ladies for their fine cooperation in making this party a very successful one.

Our next regular business meeting was held at Kaplan's Hall with a good attendance. Mr. L. Warner of Warner Products Corporation, spoke to us on Electronics and their many uses. A condenser kit which was donated by our very loyal friend, Mr. Milt Coleman, of Radolek Co., was won by Art Miller.

In spite of the warm weather our attendance has been very good. All N. R. I. men are invited. Information regarding meetings may be had by communicating with Chairman James Cada, 2511 So. Highland Ave., Berwyn, Ill., or Secretary Harry Andresen, 3317 No. Albany Ave., Chicago.

HARRY ANDRESEN, Secretary.

n r i

Philadelphia-Camden Chapter

We have been meeting regularly on the first and third Thursday of the month with Harvey Morris at the controls. Most of our meetings are informal discussions of Radio problems. Any member has the privilege to present his problem and the solution is supplied by Harvey Morris or others of our thoroughly experienced members.

On July 2nd Mr. L. L. Menne, Executive Secretary and Mr. J. B. Straughn, N. R. I. Servicing Consultant, visited our Chapter. Mr. Straughn gave us a fine talk on Circuit Analysis of Modern Radio Receivers, after which he held open forum. It was a very fine meeting.

Mr. Charles Fehn, National Vice President, is extremely anxious to do everything he possibly can to help fellow N. R. I. graduates in this area, and he extends a special invitation to visit with us. Meetings are held at Freas Shop, northeast corner Atlantic and Emerald Sts., Philadelphia.

HAROLD S. STRAWN, Secretary.

New York Chapter

We have been spending considerable time in the study of code, which seems to be very interesting to the members. A licensed operator, Mr. Alfred R. Weismantel, has acted as our instructor. He is an excellent teacher and we have all profited greatly through his work. Part of each meeting is devoted to our Service Forum which is conducted by Ralph Baer. This is always an extremely popular part of our sessions.

Since our Chairman has taken a position out of the city, National Vice President Louis J. Kunert has been acting as supervisor of the affairs of our Chapter. This arrangement will continue until a new Chairman is elected. We meet on the first and third Thursday of the month at Damanzek's Manor, 12 St. Marks Pl., N. Y. (between 2nd and 3rd Aves.).

LOUIS J. KUNERT, Secretary.

n r i

Baltimore Chapter

Through the inspiration of Chairman E. W. Gosnell, ably supported by National Vice President Pete Dunn, our meetings are usually very interesting and productive.

All of the officers are doing splendid work which accounts for our good attendance. Our publicity director, Mr. L. J. Arthur, has pepped up our members considerably by his regular and lively notices of meetings.

We shall continue to hold our meetings regularly right through the summer on the second and fourth Tuesday of the month at Redmen's Hall, 745 W. Baltimore St. Drop in on us.

B. G. ULRICH, Secretary.

n r i

Detroit Chapter

Mr. L. L. Menne from Headquarters visited our Chapter. The members turned out strong for this meeting and after a very lively session we had the usual refreshments.

Chairman John Stanish was called out of the city, and Vice Chairman Harold Chase took over. He did a fine job of pinch-hitting. A novelty was a long distance call from Chairman Stanish to extend his greetings to Mr. Menne and a brief message to the members.

At each of our most recent meetings some member led the discussion. Among these were Fred Clow, H. R. Stevens, and Harold Chase.

No meetings will be held during July and August but we will open again, in the usual way, on the second Friday in September.

F. EARL OLIVER, Secretary.

Novel Radio Items

—BY L. J. MARKUS—

Individual soldering units sold under the trade name of "Jiggers" are now obtainable for making soldered connections without any tools or source of heat other than a match. The wires to be soldered are twisted together and inserted in one of these soldering units. A lighted match is applied to the other end of the "Jigger," which ignites and burns much like a Fourth of July sparkler. The resulting heat melts solder and rosin inside the unit, and this in turn gives a perfect soldered joint. The units are particularly useful when making outdoor antenna connections or working in any other location where a soldering iron would be inconvenient. They are sold by Jiggers, Inc., 215 West Illinois Street, Chicago, Ill.

n r i

Automatic control of street and store lighting during air raid alarms has received considerable attention by radio inventors this year. A number of different units are on the market at present. Some are relay units or relay attachments for receivers, so arranged that the relay operates and turns out connected lights when the carrier of a local 24-hour broadcast station goes off the air by order of defense authorities during a raid alarm. In another type of alarm unit being considered for municipal use, it is proposed that the frequency of the city's power plant be changed for a few moments from 60 cycles to 58 cycles. Frequency-sensitive devices with relays would open street lighting circuits when frequency dropped in this way. At the end of the raid, the power line frequency would be boosted momentarily to 62 cycles, thereby causing these radio remote control switches to turn on lights again automatically all over the city.

n r i

The fact that modern naval vessels have complete public address systems with loudspeakers located in every part of the vessel made it possible for all men on one aircraft carrier to hear a shot-by-shot description of one of the most thrilling aerial battles of the war. During the encounter in which Lieutenant O'Hare shot down five Japanese planes one after another, an officer at an observation post on this aircraft carrier grabbed a microphone and described the action to those whose duties kept them below decks.

n r i

A radio operator in the American bomber formation which recently carried out the surprise bombing of Tokio was tuned to a Japanese radio station being used to guide the bombers. As the planes approached Tokio, the station suddenly went off the air, then came back as an excited voice cut in suddenly in Japanese. The monitor operator, who understood Japanese, heard a detailed, almost panicky bomb-by-bomb description of the approach of the bombers and the effects of each bomb. Long after the formation had passed over Japan, reports of casualties and damage were heard. It was not until 24 hours later that radio censorship began, with resultant playing down of the effects of the raid.

n r i

All diathermy apparatus capable of generating radio frequency energy was registered this year in accordance with an order of the Federal Communications Commission. The purpose of this order is to regulate the use of equipment capable of being transformed into long-range short-wave transmitters. It is estimated that there are more than 100,000 diathermy machines in this country capable of being adapted for subversive purposes.

n r i

Manufacture of almost half of the 710 types of radio tubes now on the market was discontinued this spring by order of the War Production Board. The 349 discontinued types of tubes represent chiefly near-duplicate tubes, obsolete tubes and those in small demand.

n r i

All classes of commercial operator licenses are now valid for the operation of broadcast stations, provided that one or more first-class radiotelephone operators are employed at the station and are responsible for the technical operation.

n r i

An air raid alarm unit which can be attached to any radio receiver by making four simple connections is now being marketed by National Union Radio Corporation, 57 State St., Newark, N. J. When the receiver is tuned to any local station, the unit automatically goes off with a loud siren-like tone when the station carrier disappears. Normal operation of the receiver is not affected by connections to the alarm unit. A toggle switch is provided for turning off the alarm after it has accomplished its purpose or when the alarm feature is not desired, as when tuning to a different station. The alarm is recommended only for localities having 24-hour broadcast stations which must go off the air during an air raid alarm, such as along the West Coast.

"Radio has an increasing obligation to keep the public fully informed. A free Radio is just as essential as a free press."

Franklin Delano Roosevelt
President of the United States

"Radio constitutes an important factor in defense. Besides serving as a source of news and of entertainment vital to morale, it furnishes the principal channel through which civilian defense authorities are enabled to disseminate directions and intelligence necessary to public safety."

Leon Henderson, ADMINISTRATOR
Office of Price Administration

JAMES L. FLY
Chairman, Federal Communications Comm.

"I AM gratified with the splendid way American Radio has gone to war. The industry is united in the national march to Victory. Such patriotic cooperation is reflected in every type of Radio service, extending from manufacture to maintenance. This should be a matter of pride and satisfaction to every Radio man, whether operating a broadcast station or providing day-to-day repairs keeping Radio sets on the alert in 30 million American homes."

ALFRED J. McCOSKER
President, WOR,
Chairman of the Board,
Mutual Broadcasting System

"TODAY we are engaged in winning a War. The words 'National Defense' have resolved themselves into all-out offense to maintain the life we value so dearly. At a time such as this the function of Broadcasting becomes daily more important in maintaining national morale and broadcasting information and instruction.

"It is of vital importance today that the Radio sets of the American public be cared for at a point of peak efficiency and that such a service be prompt and efficient."

★ N. R. I. Service Stars ★

Sergeant Chas. Mezger, N. R. I. Inventorian, meaning, a fellow who keeps tab of the stock room, is now a member of the Chemical Warfare Department, U. S. Army. Sergeant Mezger, always a clean-cut young man, makes a fine soldier.

Staff Sergeant Irving Wort of the N. R. I. Accounting Department, is serving in the Air Corps, U. S. Army. Sergeant Wort, at last report, expected to enter an Officers Training School. He may soon have a Commission. These two hard-hitting soldiers will do plenty alright for our Uncle Sam.

n r i

Prosperous Spare Time Business

Wm. Sullivan, 2460 W. Center St., Milwaukee, Wis., has good reasons to be proud of his shop. Mr. Sullivan holds his regular job and does only a spare time Radio business yet his shop and orderly equipment would do credit to any full time business. He has all the Radio work he can possibly find time for.

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