RADIO NEWS

APRIL
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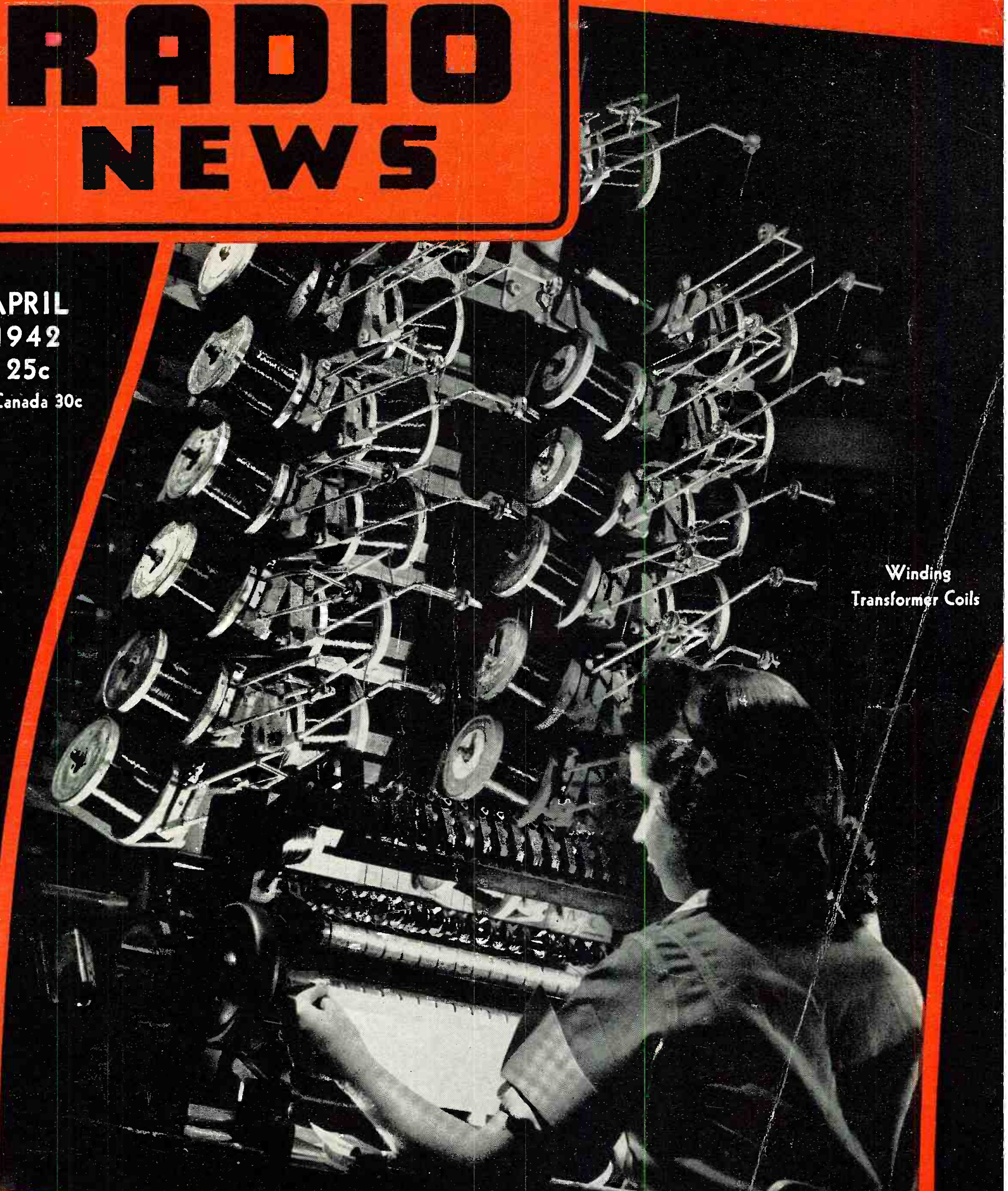

Winding
Transformer Coils

AL -PURPOSE
PA AMPLIFIER

★ RADIO-EQUIPPED
SMOKE JUMPERS

★ BEGINNERS DYNAMIC
DEMONSTRATOR

by THE EDITOR

What of FM and Television?

WE stated recently that *Television* was shelved "for the duration" as far as the public was concerned. The recent order to the radio manufacturers to "go military" has left the country with a limited number of video sets. Most of these are in the hands of John Q. Public. There is a demand for receivers to be used in giving instructions to official air raid wardens. This applies in particular to large metropolitan areas like New York City or Chicago. It might be a good idea for the authorities to purchase these sets and to turn them over to those who would gain the greatest amount of value from their use. We feel that the owners would cooperate with the authorities by giving up those sets which would be placed into proper hands "for the duration."

There has been much ballyhoo about FM radio entertainment in recent weeks. We cannot agree that this is the proper time to stress the "fidelity" angle. It would be far better to face the facts and stress the importance of FM in defense and offense! For example—many areas which are served by conventional AM transmissions are in real need for FM transmitters and receivers in order that the dead spots will not interfere with the reception of important messages in times of emergencies.

Now that production will cease on the manufacture of FM as well as AM sets we should take steps to place the advantages of FM where it can be of greatest service to our war efforts.

The listener won't be able to purchase FM receivers for long—but the military will! 'Nuff said!

It seems to us that manufacturers who have been in key positions in the radio industry should be allowed to complete receivers and other equipment for which parts are already fabricated and on hand. Parts left on the shelf cannot help our efforts to meet the huge demand for radio units that are vitally needed at this time.

Feature Material

THE present emergency has resulted in a considerable increase of outstanding technical articles coming into this office. Several of them appear in this issue. One of the least understood subjects in everyday radio is the *Phase-Inverter,* especially when used

(*Continued on page* 48)

RADIO NEWS

Vol. 27 No. 4

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for April, 1942

FEATURES

Cover Picture: Coil Winding Machine at Standard Transformer Corp.

DEPARTMENTS

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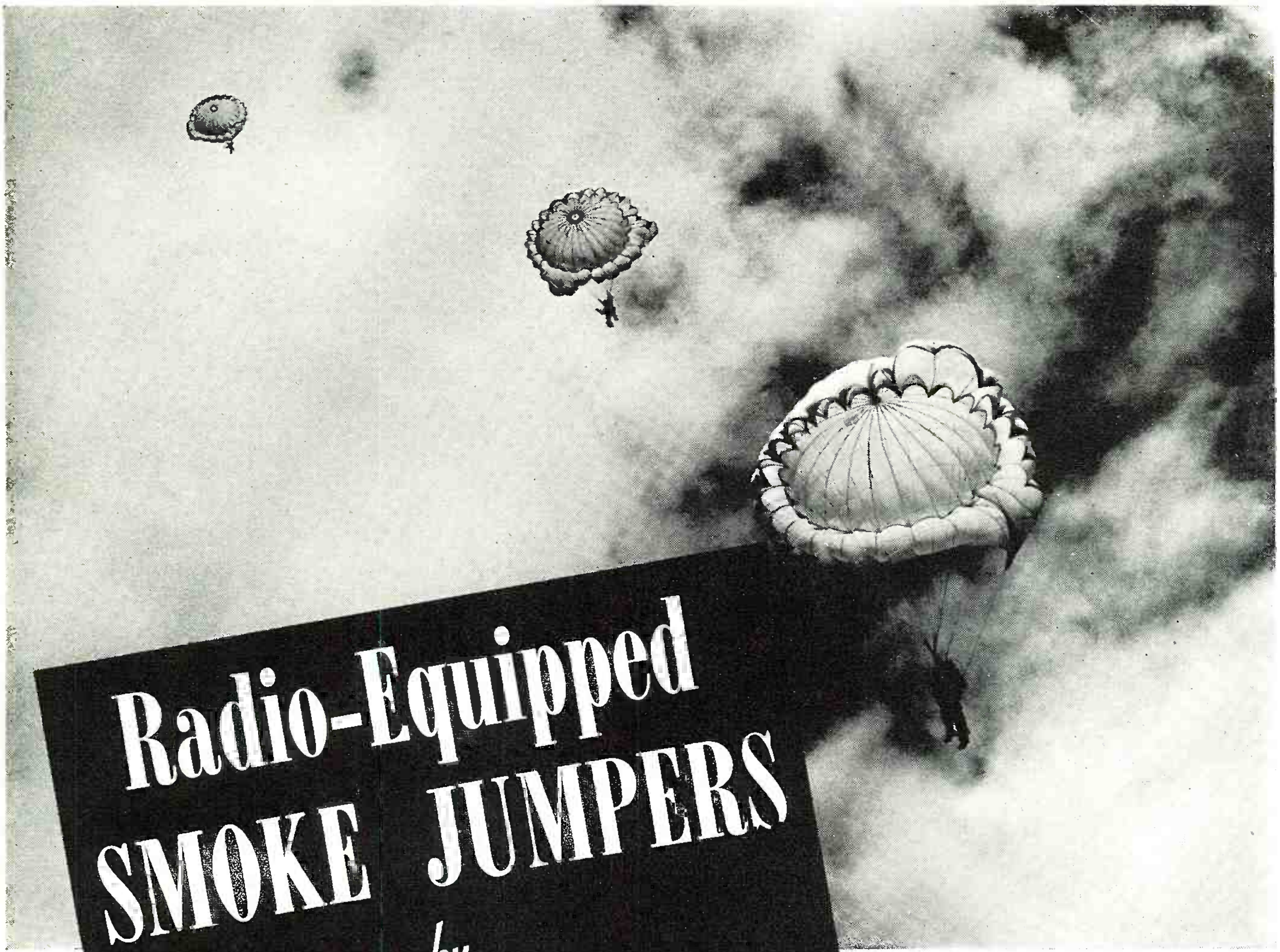


Radio-Equipped SMOKE JUMPERS

by

S. R. WINTERS

Three smoke jumpers drift to earth carrying full emergency equipment.

Our vast forests are protected from major fires caused either by accident or by enemy saboteurs.

THE "Smoke-jumper," that venturesome individual who parachutes to the scene of a raging forest fire, has added a new item to his list of fire-fighting equipment—a tiny "hip-pocket" radio which keeps him in touch with the plane pilot and with his headquarters when he reaches the ground.

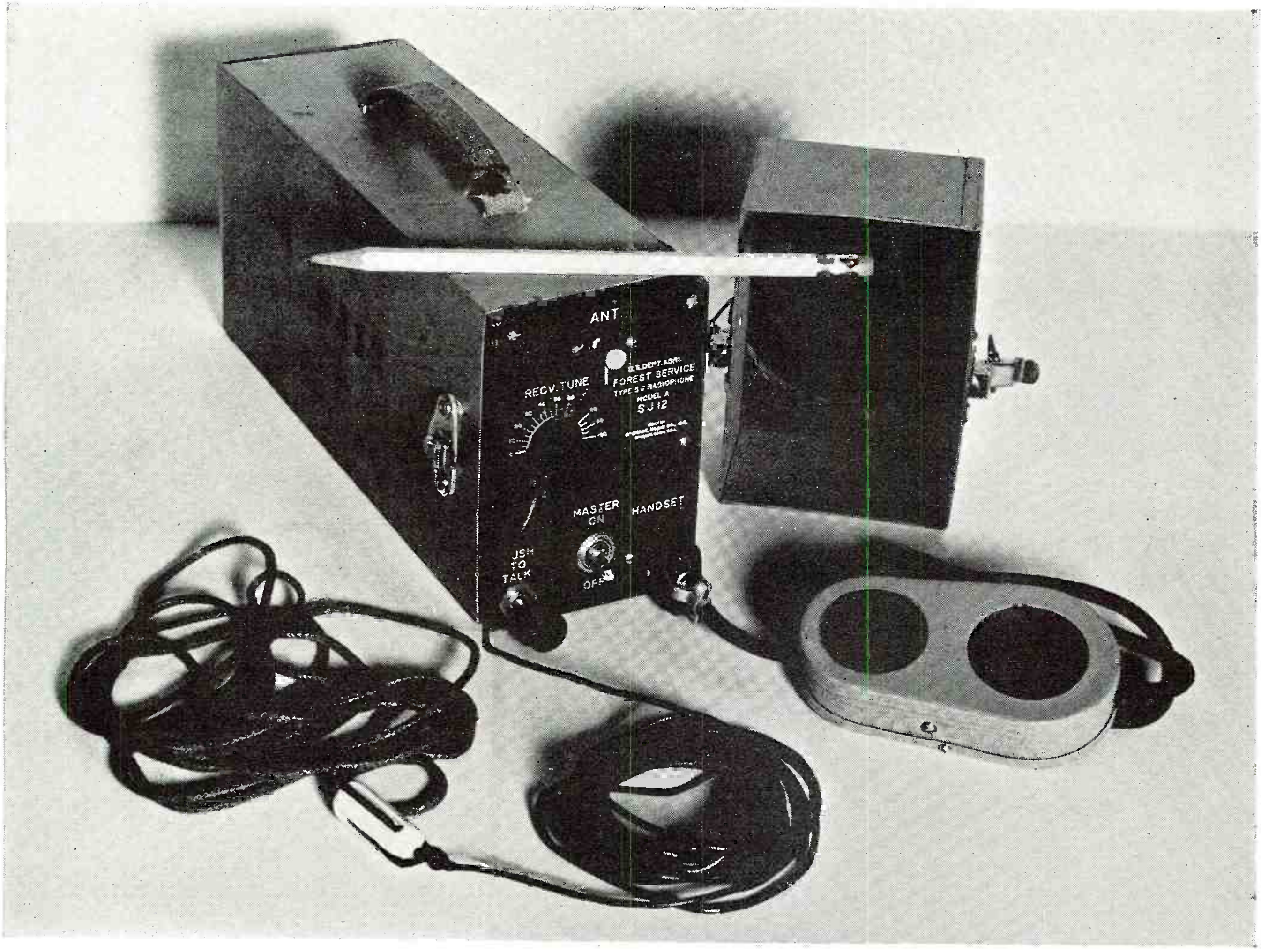
The small type radiophone developed by the *Department of Agriculture Forest Service* weighs less than six pounds with dry batteries and all accessories, and is not quite as large as a loaf of sandwich bread. It measures 2 by 4½ by 12 inches, and operates on ultra-high frequencies between 30,000 and 40,000 kilocycles, having a two-way communication range covering an optical distance which, with sufficient elevation, may be as much as a hundred miles.

The transmitting portion of the tiny radiophone is crystal-controlled, a system of maintaining accurate transmitting frequency heretofore used only in permanently located stations or in relatively bulky portable or mobile units.

The work of developing new and improved radio communication methods in fighting forest fires has received increased impetus since the advent of the war. Men responsible for our valuable forests realize too well that such forests make a target both long and wide, which could be completely destroyed by a few fast enemy fighting planes, flying high. The eighteen national forests of California alone cover more than 19,000,000 acres. It would be hard to miss such a target, and no fleet of large bombing planes would be necessary.

One small enemy plane could carry and sow hundreds of the small fire-starting chemical pills. Only if fire-fighting forces are strong enough, properly distributed, trained and equipped, can large scale fires be brought under control. Realizing that time is precious, the *United States Forest Service, State Forestry Organizations,* the *State Guards,* the *CCC,* and the *U. S. National Park Service* are making individual and joint plans whereby an adequate number of men will be trained and equipped to defend Uncle Sam's forests against destruction by fire.

The new hip-pocket radiophone, which is rapidly becoming a standard part of such protective equipment, was originally a direct result of the definite need for communication between fire fighters who were dropped from airplanes to put out small fires in some of the inaccessible back-country areas of the great National Forests.



Compact radio transmitter-receiver designed especially for parachute jumpers. Two-way communication between ground and plane proves effective.

★

Group of jumpers about to take off in Ford plane to engage in practice jump with static line. Note protective suits with plenty of padding.

Before descending to the isolated spot, the parachute jumper dons a specially designed parachute which has a rate of descent of about 12 feet per second and permits a certain amount of steering toward the landing spot. A special 'chute harness and protective suit and headgear were designed also so that the jumper is protected no matter where he lands. He may come down anywhere at any elevation—in tall trees, open spaces, or on rough ridges.

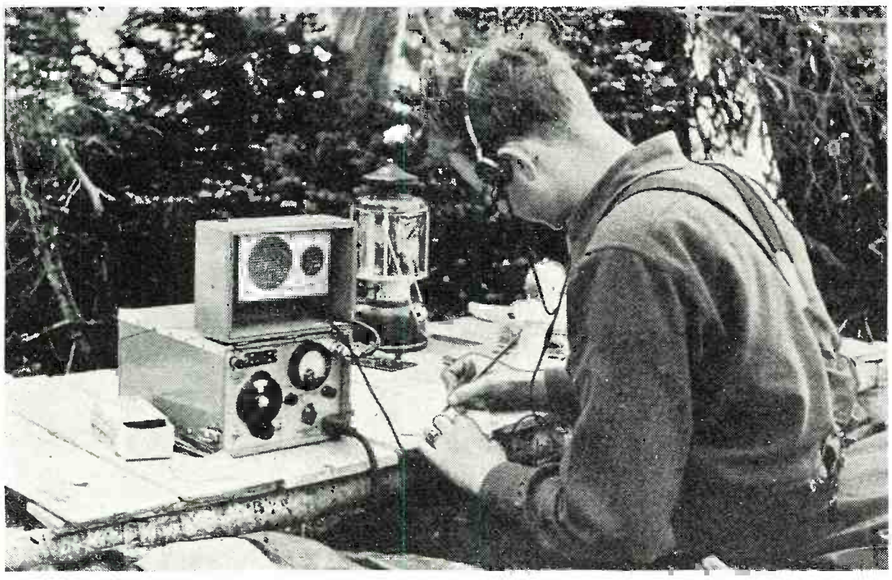
Jumpers who went down into stands of young lodgepole pine last fall christened them "featherbed landings" because the young pines will catch a parachute readily and absorb most of the shock on their bending, swaying tops. In order to get down from lofty trees, the jumpers carry a coil of light, strong rope.

Airplane pilots who deliver the parachuting fire-fighters locate the fire on their first trip over the spot, and drop a small test 'chute with a ten-pound sand bag to determine wind drift. They then circle back and make a second approach, at which time the parachutist descends, and by using the steering flaps on his parachute, generally manages to reach the ground close to the selected landing spot. On a third approach the pilot drops the

Two members of the famous "smoke jumpers" make ready for action. The sack on the right leg holds the rope used to descend from treetops.

These jumpers will bail out when the plane reaches proper position near the scene of fire. Pilot must always allow for wind condition.

Portable radiophone in operation at base camp. Note the special lamp and the clock. Compactness is essential to portability and comfort.



fire-fighting equipment kit which is carried down by a burlap parachute with a yellow streamer attached to prevent its being lost. The burlap 'chute pack contains necessary tools, rations, first-aid kit, and the like, but the parachutist carries in his own pocket his new lightweight radio so that he can contact the pilot or his headquarters immediately, if necessary, or can make reports later.

The plane leaves the landing field carrying one or more jumpers; after making altitude and sighting the smoke the course is set and approach is made into the wind at 2,000 feet above the target. At what appears to be the right position and moment, the weighted burlap test 'chute is dropped. As the airplane is banked, its descent and landing is observed by the pilot who circles and makes the next approach, having noted wind drift and made any necessary correction.

The "smoke-jumper" has moved into position by the door and upon signal from the pilot, bails out. His descent takes from 2 to 3 minutes, which gives him time to maneuver his lines. He lands in a tree, passes his special rope through a ring in the riser straps attached to the shroud lines, and lowers himself to the ground where he divests himself of harness and suit.

The pilot by this time has dropped the smoke chaser's pack. Immediately upon landing, the jumper gets into touch with headquarters. He radios the condition of the fire, and if necessary asks for more men to help him.

These doughty *Forest Service* fire fighters also use a condensed version of radio Type T, which has a crystal-controlled transmitter of two watts power. The receiver contains a 1A7G converter, three stages of 4,050-kilocycle intermediate-frequency amplification using 1N5G tubes, a 1H5G detector and audio amplifier, and a call-buzzer circuit utilizing a 1N5G tube. The intermediate-frequency band width is approximately 50 kilocycles. This comparatively wide band permits reception of modulated oscillators. The buzzer-alarm circuit is useful for night calls and permits installation of extension bells in the towerman's residence.

The low-drain tubes employed in this radiophone give reasonable dry-battery economy, even on continuous service.

Since fire behavior, suppression technique, and transportation facilities vary just as widely as do our many kinds of forests, the types of radio apparatus employed also vary. Another new all-purpose portable radiophone known as the type SX was developed last year. This complete unit weighs about 10 pounds and is applicable to uses of scouts, smokechasers, and others who require a radio as light in weight as efficiency will permit.

Provision for selecting any of three crystal-controlled transmitter frequencies adapts the unit for operation in fixed frequency networks or ready

(*Continued on page* 54)

RCA Photo

Sound coverage of this department store is had with special speakers that may be seen within the white circle. Equally suited to offices and war production plants.

SOUND AND THE VICTORY PROGRAM

by SAMUEL C. MILBOURNE

The use of Sound equipment is fast becoming a necessity to warn of impending danger from air raids or to broadcast special war news.

ANY traveler in the wilder portions of Africa has heard the deep, multi-toned, rhythmic beat of the signal drums, warning the natives of an impending visit, of a possible attack by another tribe, or giving other "jungle gossip." Also, he has heard another drum beat out the primitive rhythm of the dance, as black bucks stamped and gyrated crazily.

Travelers along the Volga River in Russia have heard the centuries-old chant of "Yo, heave ho!" to which boatmen strain and which was made famous in song some few years ago.

In many sections of our own country, a circular steel hoop is struck with a hammer to sound a local fire alarm.

These all appear to have no relation whatsoever to present-day sound amplification systems, but—believe it or not—they were the first primitive steps in sound amplification. Their modern counterparts can be recognized quite easily. In many American cities, Air-raid Warning systems using a signal generator, p.a. amplifier and loudspeakers now take the place of the primitive African signal drum. In many National Defense factories, intercommunicating systems announce visitors, carry orders, or page employees.

Music—of varied types—is used to stimulate factory production as much as 11%, especially during portions of the work-day when vitality is at low ebb. It may be the soothing strains of a waltz, a stirring martial air, or just plain "boogie-woogie," but its predecessors were the chant of the Mississippi negro as he loaded a steamboat, and the "reader" in a Cuban tobacco factory as he relieved the tedium of the cigar makers grouped around him.

Modern sound amplification systems as used in National *Offense* appear to shake down into six applicational groups. These are:

1. Paging.
2. Communication and inter-communication.
3. Air-raid or fire warning.
4. Music and entertainment.
5. Special equipment (recorders, moving pictures, etc.).
6. Combinations of above-listed equipment.

Sound amplification systems are being used for paging in industrial plants; government arsenals, forts, and flying fields; hospitals; hotels; and other locations where groups of people gather. A large number of airfields in the San Francisco area use sound amplification systems for paging officers and other military personnel.

Communication and intercommunication systems are used in a great variety of ways—in mills, industrial plants, refineries, government airfields, government camps, hospitals, etc. One unusual installation was made by the Leo J. Myberg Co. of Los Angeles, at Camp Cook, where a sound system is being used at the firing range. Results of firing can be reported quickly and instructions can be given over a wider area than possible before the system was installed.

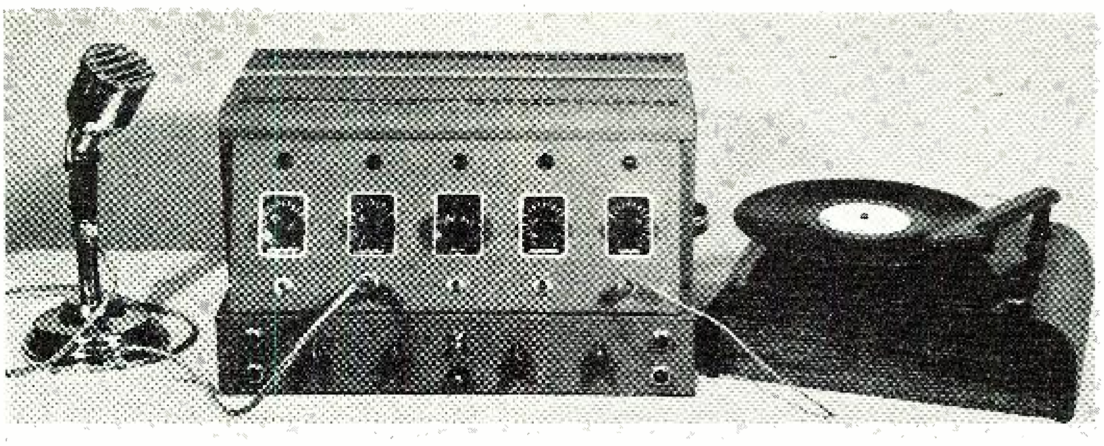
Another recently-installed system was at the Duval County Jail in Florida. The installation was made by the Southern Hardware and Bicycle Co. This system provides communication between the offices, yard and infirmary of the jail. Simplified control of prisoners, and a definite aid in the event of jail breaks, is thus provided.

One of the newest uses for sound amplification systems is for air-raid alarms. Usually, for this purpose, a special signal generator, feeding into one or more audio amplifiers which in turn work one or more loudspeakers, is used. The signal generator produces a distinctive sound which can not be confused with fire, police or other emergency alarms.

Trenton and Harrison, New Jersey; Boston, Mass.; Alameda, California; and other American cities use such air-raid warning systems. The number and power of the amplifiers, and the number of the loudspeakers employed, varies with each city, with the area to be covered and with the density of population in each area. Boston uses compressed air horns, while most other cities use electrical type speakers. In Trenton, the emphasis is on coverage of the business section. In Harrison, the one-square-mile area is covered by two stations, one in the center of town and the other in the housing project where houses are most concentrated.

(*Continued on page* 50)

ALL-PURPOSE P.A. AMPLIFIER



Dynamic mike and record player shown with the completed amplifier.

by ARMAND BESSE

This well-planned unit is capable of greatest economy by using a choice of output stages for low or high power.

FLEXIBILITY and economy are two of the prime necessities in these hectic days. Not only does this apply to our general way of doing things but can also include our equipment that we design for specific applications. Take for example the P.A. amplifier. Most of them are designed to furnish a certain amount of power and to be able to handle enough speakers to cover a designated area. There are many occasions where an increase in power is desirable. The usual solution is had by adding on a *booster* stage to follow the regular unit. There is a bit of inconvenience in doing the job in this manner. In the first place—the use of two power supplies is required. This makes for a rather complicated setup, especially if there is a limited amount of space available.

Greatest economy may be had if we provide for additional power within the main amplifier. The unit described in this article shows how this can be done with a minimum amount of equipment.

Because the state of war in our Country has caused a severe curtailment of radio parts, there was a question of using as few parts as possible for the best results. This is the reason for so many controls on the front panels. Compactness was achieved on one chassis through a novel arrangement of the head amplifier.

And now for a few details. There are five high impedance inputs. One for very low level velocity microphones, two for crystal or dynamic microphones or P.E. cell and, two for high-level sources such as phono pickups or another head-amplifier installed at a distance from the power job. Ordinary jacks are used for all inputs.

The high-gain input feeds into a 6SJ7. The crystal inputs use, each, one triode of a 6SC7. Four of the inputs feed into separate volume controls on which switches were installed so that when they are in use, a green pilot light is turned on.

One of the low-gain inputs also has a volume control with pilot light. The fifth input runs direct into the mixer as it is assumed that volume will be controlled at the source. This is the center jack on the sloped panel above which is the Master Gain control.

To avoid using a separate chassis for the low level inputs, a bracket was built on which were installed all tubes for these functions. The bottom of this bracket constituted a perfect shielded compartment for all the wiring of these high-gain circuits. A spare socket is also shown installed for future use. This bracket is bolted to the sloped front and connected electrically to the large chassis through a *Jones* plug and socket. Four screws and bolts are all that need be removed for servicing the front end of this amplifier.

These inputs after being properly mixed are amplified by a 6J5 which, together with another 6J5 as a phase inverter, feed a pair of 6F6's as triodes. By a switching arrangement, the output of the 6F6's may be used as a *low power* system.

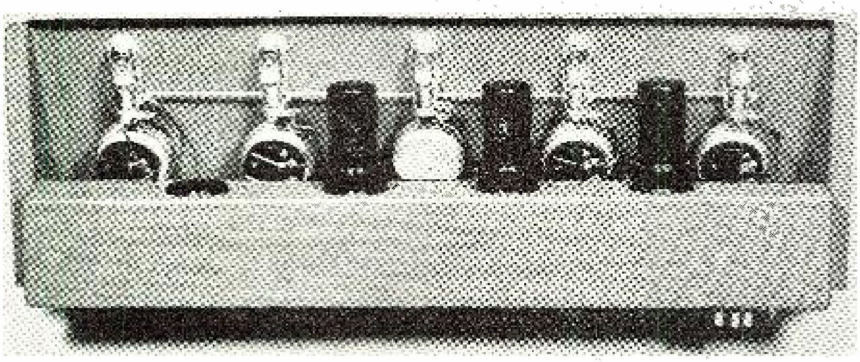
These low power output sockets are seen on the left hand side of the front panel. When they are used, the high voltage and filaments for the 6L6's is turned off. Next to these output sockets is a double-pole, double-throw switch used for cutting in either the low power output transformer or the push-pull input transformer feeding the 6L6's.

When a high power installation is required, connect the interstage transformer to the 6L6's and as much as 55 watts are available (right hand output socket). A ten-contact switch can be seen in the illustration. This makes available to all output sockets, voice coil impedances of 4, 8, 15, or 500 ohms.

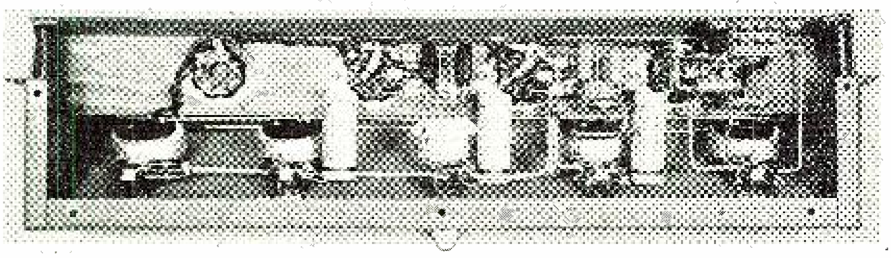
On the lower front of the chassis, there is a switch that disconnects the filaments and high voltage for the 6L6's when they are not in use. Another switch disconnects the filaments of all other tubes and the B voltage from the power transformer and is used when the amplifier is on mobile service and gets its A and B voltages from batteries and vibrapacks.

On the center of the front panel is the a.c. switch and fuse holder. On the rear are three sockets. One is a male socket for the line cable. The center is a four prong socket where the vibrapack connects when needed, and supplies A and B voltage to another head amplifier. So if at any time, we should require as many as eight inputs, we have a separate head amplifier having four inputs which may be plugged in on the center jack of this amplifier. The other socket is

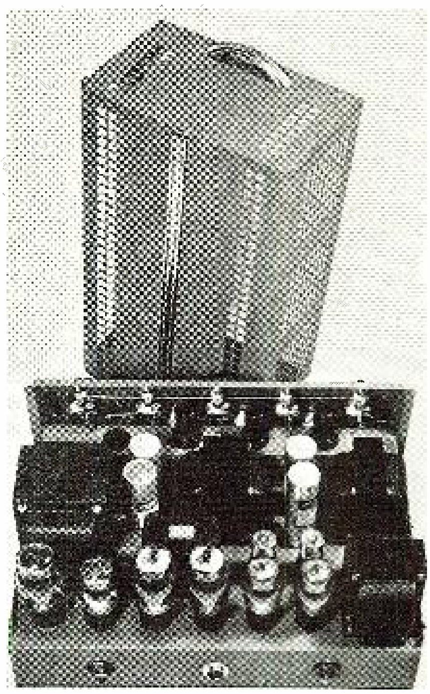
(*Continued on page* 59)



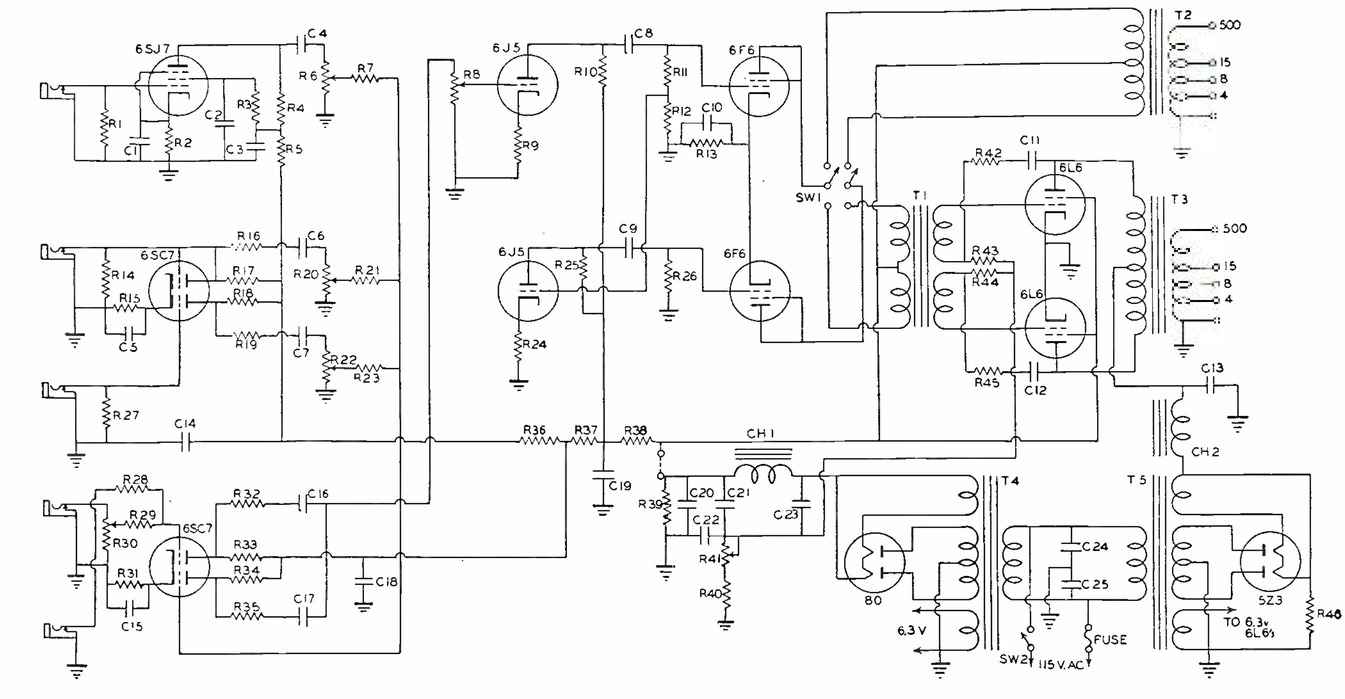
The pre-amplifier is assembled on a separate chassis. The connector plug may be seen below on the right-hand side just under the assembly.



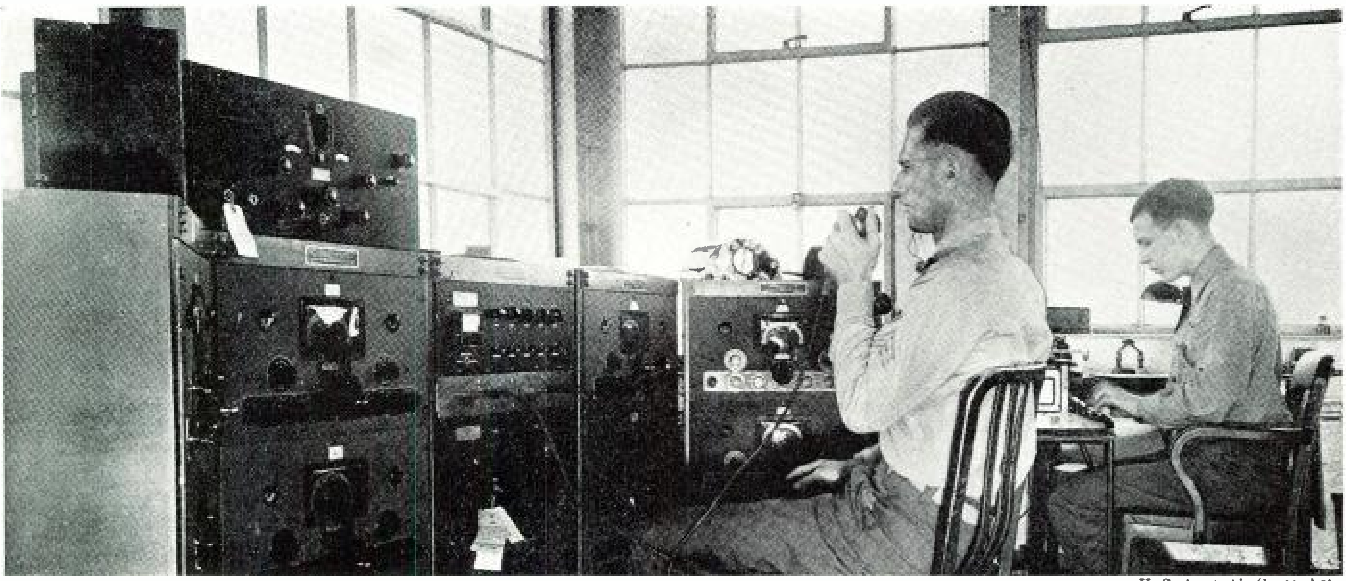
The underside of the pre-amp (head amplifier) shows where parts are mounted for best constructional technique. Note extensive cabling!



The completed amplifier with cover removed. Note pilot lights on top!



C_1, C_5, C_{10}, C_{15}—20 mfd., 25v. electro, Aerovox
C_2, C_3—10 mfd., 450 v. electro, Aerovox
C_4, C_6, C_7, C_8, C_9, C_{16}, C_{17}—.1 mfd., 400 v. paper, Aerovox
C_{11}, C_{12}—.04—1,600 v. paper, Aerovox
C_{13}—8 mfd., 600 v. electro, Aerovox
C_{14}, C_{18}, C_{19}, C_{20}, C_{21}, C_{23}—8 mfd., 450 v. electro, Aerovox
C_{24}, C_{25}—.05 mfd., 400 v. paper, Aerovox
R_1, R_{14}, R_{27}—1 meg. ½ w., IRC
R_2, R_{15}, R_{31}—200 ohm., ½ w., IRC
R_3—2 meg., ½ w., IRC
R_4, R_7, R_{21}, R_{23}, R_{26}, R_{28}, R_{29}—500,000 ohm, ½ w., IRC
R_5, R_{42}, R_{45}—50,000 ohm, ½w., IRC
R_6, R_8, R_{20} R_{22}, R_{30}—500,000 ohm, pot—Mallory
R —1,000 ohm, ½ w., IRC
R_{10}, R_{16}, R_{19}, R_{25}, R_{32}, R_{35}—250,000 ohm, ½ w., IRC
R_{11}—475,000 ohm, ½ w., IRC
R_{12}—25,000 ohm, ½ w., IRC
R_{13}—750 ohm, 10 w., Ohmite
R_{17}, R_{18}, R_{33}, R_{54}—100,000 ohm, ½ w., IRC
R_{24}—5,500 ohm, ½ w., IRC
R_{36}, R_{37}—5,000 ohm, 1 w., IRC
R_{38}, R_{43}, R_{44}—5,000 ohm, 10 w., Ohmite
R_{39}—10,000 ohm, 50 w., Ohmite
R_{40}—300 ohm, 10 w., Ohmite
R_{41}—200 ohm, 10 w., semi-variable, Ohmite
R_{46}—50,000 ohm, 50 w., Ohmite
T_1—PP6F6's to PP6L6's, Thordarson T17D04
T_2—PP6F6's to v. c. or line, Thordarson, T75S75
T_3—PP6L6's to v. c. or line, Thordarson, T84S58
T_4—350 v. @ 120 M. A., Thordarson, T13R14
T_5—560 v. @ 150 M. A., Thordarson, T19R30
CH_1—110 M. A. Filter choke, Thordarson, T57C53
CH_2—150 M. A. Filter choke, Thordarson, T13C30
SW_1—DPDT toggle, Arrow
SW_2—SPST toggle, Arrow
Cabinet and chassis—Par Metal



U. S. Army Air Corps photo

Airdrome control position. Operator is giving landing instructions to pilot.

AVIATION RADIO COURSE

by **PAUL W. KARROL**

Paul W. Karrol has a keen knowledge on radio subjects. His many years of experience in the Aviation Radio field qualify him as an authority on this all-important subject. The author has written an exclusive course designed to include all phases of military and civilian radio in the aviation field.

TODAY more than ever before there exists a crying demand for partially as well as fully trained aviation radiomen. Opportunities are abounding. Those who have the keen foresight and initiative to recognize and take advantage of these opportunities will inevitably avail themselves of positions of merit which will not only prove interesting but remunerative as well.

The period when radio equipment installed in aircraft was an experimenter's toy is gone forever. The period when it was just another piece of "equipment" is also gone. We find that aircraft radio equipment today is just as essential to the safe conduct of modern aircraft as is the propeller which keeps the ship in the air. It is now an integral part of modern aircraft.

The safety of modern aircraft in the air is dependent upon many factors; radio being one of the largest. Without radio equipment the modern day pilot could not be readily advised of variable weather conditions. Nor would it be possible to fly safely in conditions of poor visibility without the aid of his range receiver. To make many safe landings in inclement weather, radio is a dire necessity. Without the aid of radio our modern air transportation systems could not function properly nor could the aircraft of our armed forces operate effectively.

Aviation radio came into its own in 1927 when the *Civil Aeronautics Administration* (CAA) was then known as the *Aeronautics Branch* of the *Department of Commerce.* The first radiotelephone conversation between aircraft and ground stations was held in 1916. During that year the *U. S. Army Signal Corps* conducted many tests with various types of radio equipment for aircraft. The impetus necessary to launch aviation radio securely on its way was not started however until 1928 when the first radio range beacon was designed, constructed and placed in operation. The general public became "air-minded" immediately after the successful trans-Atlantic flight of Lindbergh. This resulted in more attention being given to the possibilities of radio as an aid to air navigation. Also much consideration was given communications possibilities between aircraft and ground stations.

After preliminary experiments had been completed it was found that radio equipment could easily be designed for use on board aircraft, our early transports were outfitted and ground stations equipped to carry on air-ground communication. There were many "bugs" that had to be removed from equipment then, but by persistent research many problems confronting those who foresaw inevitable advancement were scientifically solved. The experiences gained during the uphill climb of aviation radio proved invaluable as time went on, and today we find that both the airlines and our government services are employing thousands of men and spending millions of dollars to adequately take care of the still expanding air communications facilities.

But still, if we go further, we find that the aviation radio industry *needs* more men; preferably trained men. The employment saturation point will ever hardly be reached in the aviation radio industry because as more aircraft are manufactured for our armed forces, commercial and private aviation enterprises, more and more aviation radio equipment will also be manufactured and will have to be installed and maintained. There is no doubt in my mind regarding the stable future of aviation radio.

One may rightfully ask, "What positions are available to the trained and partially trained who desire to enter aviation radio and make the work their careers?" This question will now be answered.

It is of course realized that various positions require various degrees of skill. No two jobs are so similar that it is possible to draw a fine line between them and say, "If I study this one I can always do the other." Specialization and efficiency are the keynotes of success in any branch of aviation radio; whether it be airlines, radio operating, or aeronautical radio engineering.

In order to acquaint the novice as well as the veteran with aviation radio positions it was felt that the discussion concerned should be presented prior to actual lesson material, and should contain information not readily available to the reader.

Qualifications

The man for the job of aircraft factory radio workers is the average radio service technician. This position requires that the applicant have had experience in general radio work and a certain amount of training. With his knowledge of car radio installation and general knowledge of radio repair he is well suited for the type of work encountered in the aircraft factory. He must possess a certain amount of mechanical knowledge in order to cope with installation difficulties and must be highly proficient in the use and care of tools. Too, he should understand the "blueprint requirements" promulgated by the engineering departments of both the aircraft and radio manufacturer when it comes to actual installation work.

The foreman of the aircraft radio installation department (assembly) must have more than a general knowledge of radio and electrical installation. His mechanical skill must be of a high order and he must be able to supervise mass installation and thoroughly understand modern assembly practice. When radio equipment is installed in an aircraft, usually more than one technician is utilized. Exacting cooperation between installation personnel is a prime requisite to efficiency. Havoc is created if each man does not know what he should accomplish and in what order. The foreman, in order to maintain coordination of activities must continually exercise his supervisional skill and must be a capable instructor. The foreman is usually a "picked" man who has demonstrated his all-around ability.

In an aircraft factory the aviation radio worker may do installation work; testing of installed equipment; inspection of equipment for immediate installation; radio parts supply work; and he may even do a great deal of electrical wiring not associated with the radio installation.

Prior to the actual installation of radio equipment in an aircraft, an inspection is made of each component part to ascertain its condition. Even though a thorough and rigid inspection was performed at the aircraft radio factory prior to shipment of the completed equipment, the added precaution of a second inspection is usually taken. In most instances where Military or Naval aircraft installations are being made, a technical representative of either Service is usually on hand to effect inspection. Those who perform these inspections must be well trained and schooled in the matter of making micrometeric examinations in the least possible time. Remuneration for the average inspector's services is relatively high.

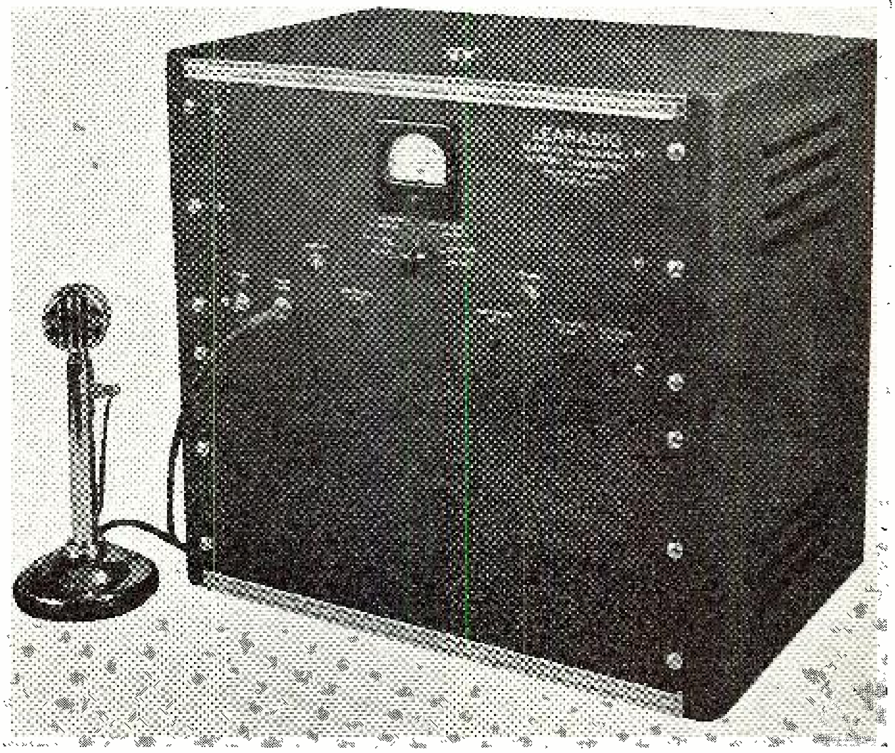
Testing the finished aircraft radio installation is a most responsible job and requires that the man doing this work have a great deal of experience. He usually is the proud possessor of a second class radiotelephone license obtained from the *Federal Communications Commission* (FCC) after passing a relatively difficult examination. His final word that the installation is working properly has comparable weight to that of the aircraft test pilot. His responsibility that the installation is made correctly and that each part of the installation is functioning at maximum efficiency before the aircraft is tested, is large. He cannot afford to be "slipshod." For his services he is accorded every possible consideration and is usually one of the highest paid employees of the radio and electrical departments in an aircraft factory.

At various airports scattered throughout the United States, there are a number of private aircraft radio service agencies. They are equipped to install and maintain aircraft radio equipment in private aircraft. Expert technicians having Government radio operator licenses are usually employed. Often, courtesy instruction given at the factory by trained experts is available to technicians working in the private aircraft radio service agency. This instruction furthers their radio training and contributes to their proficiency. The work in the aircraft radio service agency is very interesting and pays well. However, unless the technician has more than a passing interest in an agency proper, his work may not be steady. This is especially true when there is only seasonal work to do. The trained radio serviceman who owns the necessary testing equipment and the proper FCC license will have no trouble finding work to do if he proves that he understands aircraft radio.

With the advent of private flying, an immense and lucrative field presented itself to the active radio serviceman. With instruction books furnished by various manufacturers, a will to work and learn, and proper instruments, the trained radio service technician had little trouble finding enough work to do.

Even though installation is closely allied to maintenance, there are positions wherein only one or the other is performed by personnel. After the aircraft radio installation is completed at the factory and necessary "check-tests" have been made and the aircraft placed in service, maintenance then takes the upper hand. This work requires a great number of skilled workers. A systematic method of maintenance strictly adhered to prevents many costly troubles which may develop. All radio equipment in aircraft belonging to the government and the airlines after a fixed number of hours operation is inspected, cleaned and adjusted; thus assuring efficient operation at all times.

Methodical maintenance is carried on extensively in the *Army* and *Naval Air Forces* and requires many men trained specifically for this important work. This is a good paying field and is open to the untrained, partially and fully trained man. Those requiring necessary training are sent to school at no expense to them whatsoever. In fact,



Airport transmitters such as this will be analyzed in this course of instruction. Thousands of men are needed as operators or for servicing.

these men are paid while attending school.

Some airlines employ personnel who may be readily referred to as "traveling maintenance technicians." Covering their territories each month and oftener when needed, they replace defective parts; shoot trouble; make careful inspections of radio equipment and clean and adjust all equipment. This job is not interesting only because of its technical aspects but also because travel is involved. All such workers must possess a radio operator's license of the proper class in order that they may legally test and adjust various transmitters. In some stations operated by the airlines, however, the chief radio operator may do the necessary maintenance work. But for purposes of control and standardized maintenance, trained maintenance men are usually employed. The salary for this type of work often starts at $150.00 and it is possible to work up to $200.00, with expenses.

One of the most exciting positions to be found anywhere is that of airlines radio operator. The qualifications for this position are high; much higher than they were a few years ago. A knowledge of the International Morse Code is not exactly essential but is a great help. Some airlines employ code quite extensively. *Pan American Airlines* employ many radio operators both on the ground and in the air, as do the Naval and Military Air Forces. An airlines radio operator must be a cool quick thinker and possess keen judgment.

He must depend on his training every minute of the working day. It is the airlines radio operator who is the liaison between aircraft and ground, and the factor between safety and disaster. Armed with the information transmitted from ground stations, the pilot can evade bad weather on his route, make unscheduled stops at unscheduled stations to pick up passengers; and in the case of military aircraft, receive important military information. At the same time, the pilot can transmit useful weather information back to the ground stations for other pilots who will follow him.

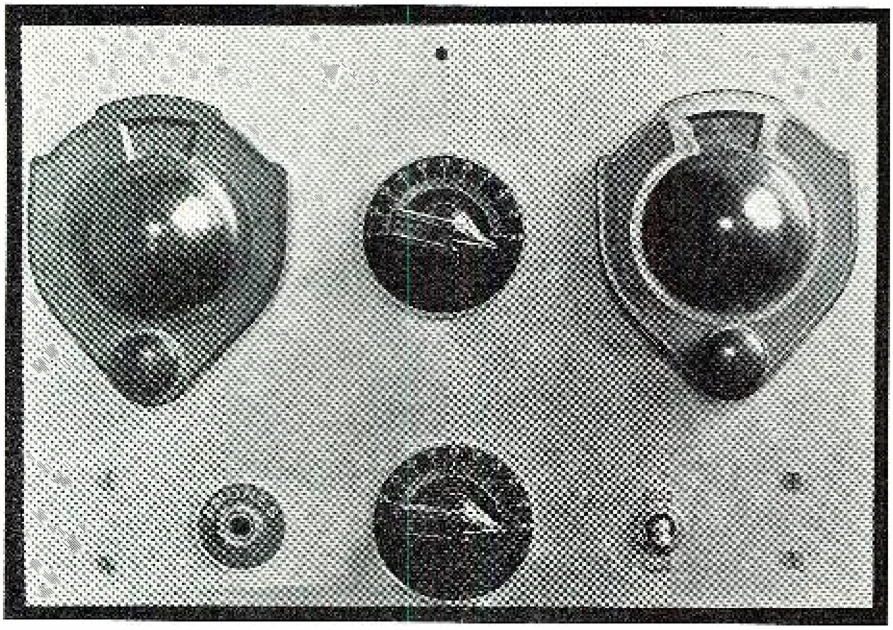
The writer was in an aircraft sometime ago which had to make an unscheduled landing on account of bad weather. After waiting around for approximately three hours for the weather to clear, and it being quite urgent that we reach our destination at a given time, it was decided to have an aircraft then on a scheduled flight radio back needed weather informaton. viz., whether icing conditions prevailed or not. While the aircraft proceeded through the overcast a radio report came in every few minutes giving us weather information. While the plane in which we were flying contained blind flying equipment, our deicers did not work properly; we did not wish to take the chance of being bogged down with ice.

Because of the low overcast we couldn't fly "contact" and not being able to see the ground would add to our plight! After a few favorable reports were received we thought we would take off. After flying blind for over four hours we found out by using our radio that our destination was "closed in." We were about 150 miles out then. If we had not had the use of our radio we would have flown to our destination and found we couldn't land, thereby making it necessary for us to fly back to an open airport; thus necessitating the use of more gasoline and valuable time. We were told by radio that we could land at one of the emergency fields on our route and were given implicit directions. Forty minutes later our aircraft was skillfully landed at an emergency airport and we were then taken to our destination by auto. With the assistance of both aircraft and ground radio facilities we saved both time and finances, to say nothing of the possibility of an unforeseen accident.

The average airlines radio operator must be neat appearing and be able to meet the general public because he often must arrange for reservations, tickets, etc., for passengers. His knowledge of touch typing and teletype operation will help him over many rough spots during a busy shift. Now that teletype is being used more extensively each day, it would be well for those contemplating this work to adequately prepare themselves. If you are a touch typist and can type 50 to 60 words per minute, learning teletype operation will be relatively simple. On the other hand, if your speed is any lower than forty words per minute and your "rhythm" not so good, the task may prove difficult. Not all teletypewriters have the "message keyboard." Some are equipped with standard weather symbols for the transmission of weather information. It takes much practice to operate one of these ma-

(Continued on page 47)

An AC Set for the Beginner



Inexpensive parts may be used to construct this one tube receiver.

Two-tube performance with plenty of sock is featured in this regenerative All-Waver.

by **FREDERIC U. DILLION**

FOR those who live in a district where alternating current is available, an electrically operated radio is more economical and is an improvement over the battery set. The advantages include a constant-voltage power supply and more sensitive tubes.

As far as diagrams are concerned, two-tube receivers might be said to all look alike, but experience shows that some work and others don't. The explanation of this is that: in designing a radio receiver for short wave reception, a circuit diagram tells very little toward its being a success or a failure. The thing that does determine whether it will work properly or not is paying attention to such things as smooth control of regeneration, noiseless tuning, and getting the most out of your antenna. These and many other features are presented in this article.

Discussing the above mentioned points, the doublet antenna gives a gain in signal strength to noise, while the usual flat top and similar types of aerials do not. The doublet used with this receiver is sixty feet long with insulators at each end and one in the center, to which the transposed noise reducing Zenith lead-in is connected. By twisting these two wires any noise picked up is eliminated by cancellation, thus reducing the noise level to a minimum, while bringing up the signal to maximum strength.

A point to remember in erecting any antenna system is to get it as high as possible and at right angles to high tension or telephone wires. The ideal aerial should be at least fifteen feet above all surrounding objects. There are several all-wave antenna kits on the market. One of these should be purchased. The best direction to run the antenna is northeast to southwest or northwest to southeast for world-wide reception.

After connecting an antenna to the set that will give the most signal strength, means of controlling this signal to the best advantage must be developed. This is accomplished by having a low resistance and noiseless tuning circuit with a good grade of tuning condenser, one mounted on isolantite or insulex which are, theoretically, the best type of material for short wave work. Therefore isolantite sockets are used. For the best results manufactured coils were employed. The beginner has quite a number to choose from, the best being those wound on forms of insulex.

It will be seen that a variable condenser (C-1) is parallel with the antenna coil or primary winding. This is a step toward better selectivity and a gain in signal input. If a commercial type of impedance matching device is used that has a variable adjustment, this condenser may be omitted. On the other hand, if a desired station is covered by interfering code signals, a slight shift of this condenser will change the position of the station to one where there is no interference from adjacent radio channels.

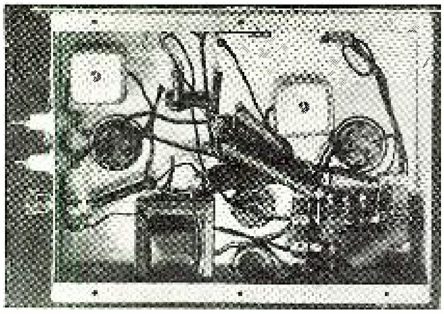
The detector circuit employs electron tuning, and the regenerative control (R-2) is placed in the screen grid lead of this tube. The line switch is on the back of this control and thus saves space on the panel. Looking at the schematic wiring diagram will show that there are two condensers by-passing the screen grid to ground. The reason for this is to eliminate any scratching noise in the regeneration control. The smaller one is mounted right at the socket and run to ground, while the other is mounted near the control and wired from the arm to ground.

If the grid leak and condenser (C-4, R-1) are mounted on top of the grid cap of the detector tube, (see photo), it will be found that, when the complete shield is in place, these parts will be completely shielded, eliminating one source of noise.

The detector tube employed in this receiver is known as a duplex tube, because the elements contained in the tube make up two tubes. It is composed of a pentode section similar to a 6C6 and a triode section similar to a 76 with the exception that they both have a common cathode and heater. The tube is known as a type 6F7 or the metal equivalent is a type 6P7 which, of course, takes an octal type socket, if it is used. Thus we have a super sensitive screen grid pentode as a detector and a high gain triode as a first audio amplifier all in one tube.

The shielded filter shown in dotted lines in the schematic, connecting the plate of the detector tube to the audio frequency coupling impedance, keeps stray r.f. currents from getting into the audio amplifier and causing oscillation.

The impedance unit (T-3) is used between the detector and the audio amplifier instead of the usual resistance. This type of coupling gives high gain and also helps to smooth out the regeneration by putting the proper voltage on the plate of the detector, thus allowing it to operate more efficiently. Resistor (R-4) is used to sub-



The cans shown in this underchassis view cover the radio frequency chokes.

due any audio oscillation that might occur.

Resistors (R-3 and R-6) limit the voltage in their respective circuits. The headphones are plugged into jack (J-1) which is connected to the output of the triode section of the 6F7.

The second section of the set is the power supply, and is designed for short wave receivers. The usual run of old style "B" eliminators hum. This spoils the possibility of good reception. The cause is usually a lack of sufficient filtering. The filter in this power pack uses choke input. It was chosen because of its ability to give smooth regulation of d.c. voltage.

The power transformer in this pack has an electric static shield and puts out 680 volts a.c. centertapped, which after it is filtered and rectified runs about 250 volts d.c. The majority of sets call for 250 volts.

Construction

Now to tackle the construction of the set. First, obtain all the parts listed at the close of this article. The whole set may be conveniently housed in a Bud metal cabinet, size 6"x10"x7". If you desire to use the metal cabinet no front panel or bottom piece will be needed. Having chosen either a panel or cabinet job, proceed to lay out the various parts as they appear in the illustrations.

The two main condensers (C-2, 3), are 1¾" from the ends of the panel and 2¾" from the top. The antenna condenser (C-1) is placed half way between C-2 and C-3 the same distance from the top of the panel.

The line switch and the phone jack belong 2½" from the ends of the panel and 1" from the bottom. The regeneration control (R-2) is mounted right below the antenna condenser. The blank hole in the top of the panel is for a green jewel six volt pilot light connected across the heaters of the 6F7. The screws that hold the panel are one inch from the ends and one inch apart, on each side.

To operate this set, a few minor adjustments are made. After the switch is turned on, advance the regeneration control until a rushing sound is heard. The set is now oscillating, and is in its most sensitive condition. Adjust the antenna condenser for maximum noise level. This procedure is done for each band before tuning.

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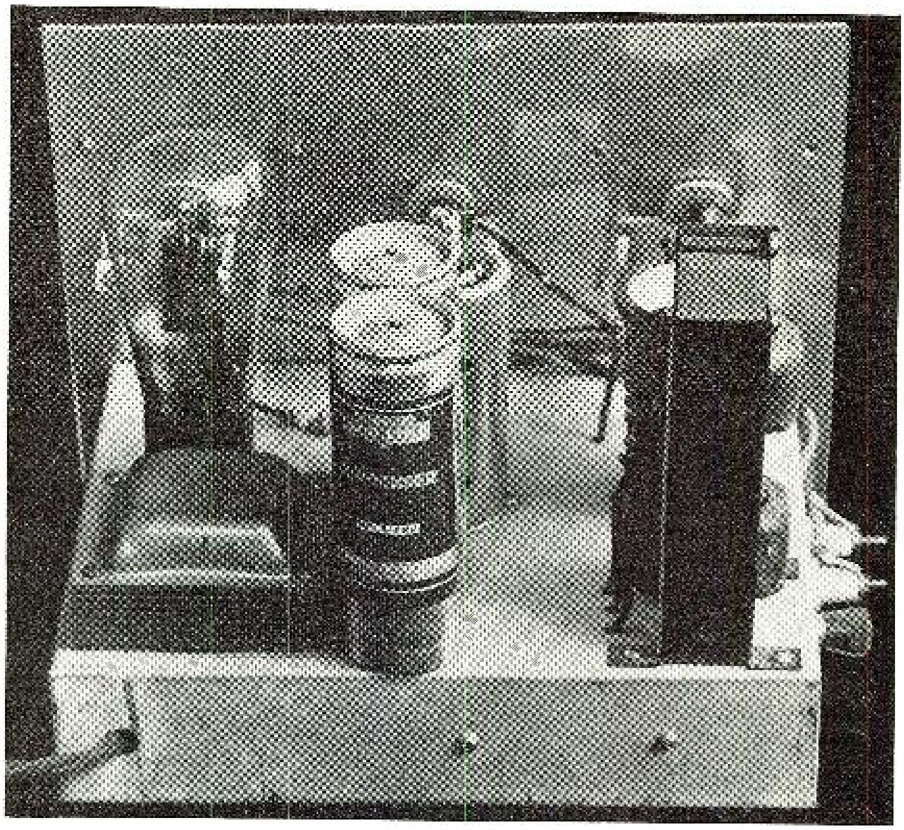

The dual-choke is mounted behind the plug-in coil and tuning condenser.

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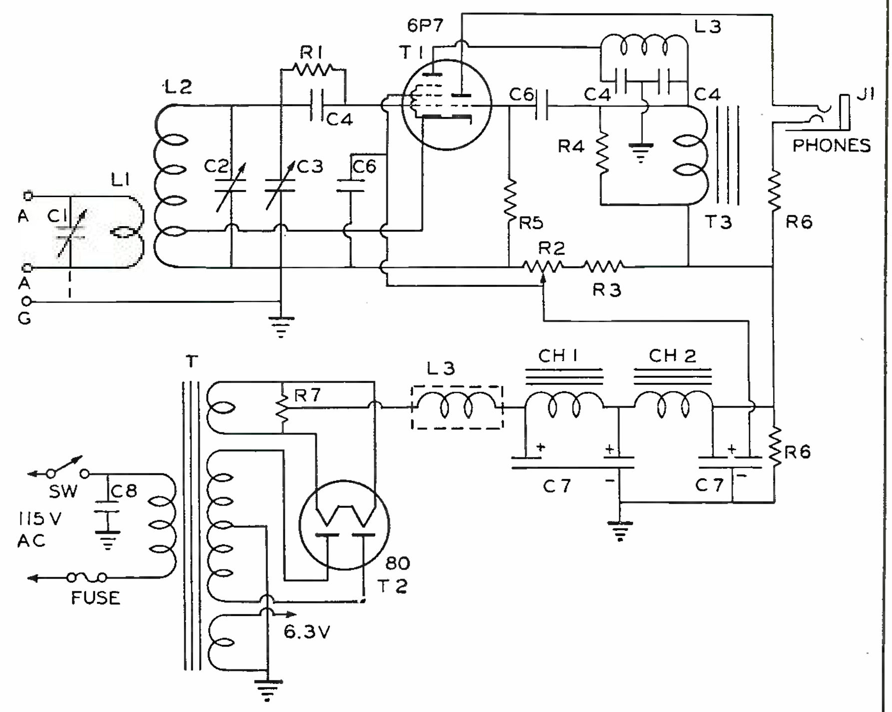
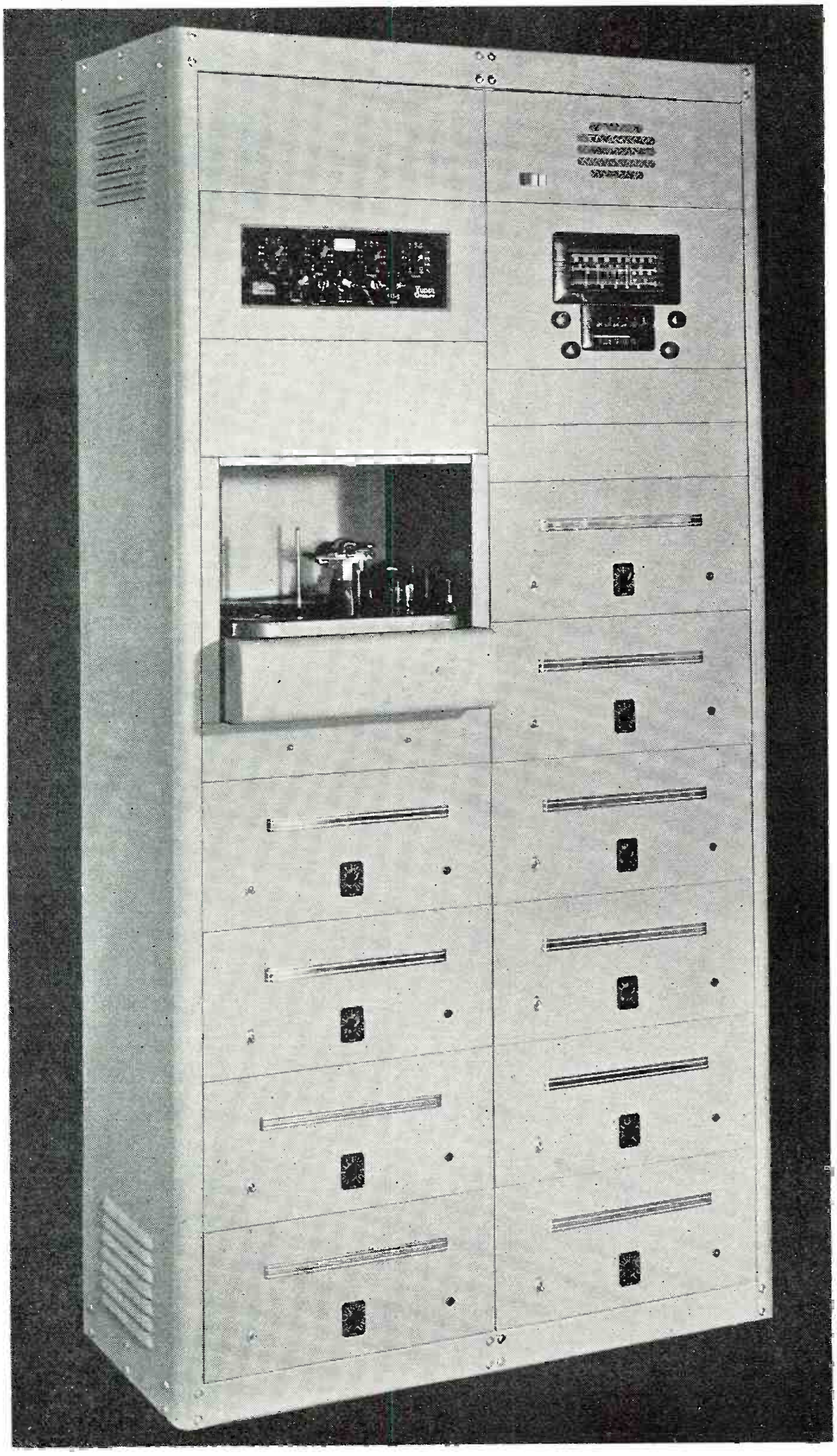


C_1, C_2—100 mmf. variable
C_3—35 mmf. variable
C_4—.0001 mfd., 400 v. paper, Sprague
C_6—.01 mfd., 400 v. paper, Sprague
C_7—8-8—450 v. electro, Sprague
C_8—.1 mfd., 400 v. paper, Sprague
R_1—2 meg., ½ w., Centralab
R_2—50,000 ohm pot, Centralab
R_3—150,000 ohm, 1 w., Centralab
R_4—250,000 ohm, ½ w., Centralab
R_5—1 meg., ½ w., Centralab
R_6—50,000 ohm, 1 w., Centralab
J_1—Double circuit jack, Bud
T—240 v. @ 40 MA 6.3 v. @ 2.0A, Thordarson T13R19
T_3—Coupling choke, Thordarson T2927
Ch_1, Ch_2—Double filter choke from old B. C. set
L_1, L_2—Set of Plug-In coils, Hammarlund
L_3—2.5 MHRF chokes
Cabinet and chassis, Bud

SOUND for DEFENSE PLANTS

Industrial PA systems are not new. The war has brought about the need for protecting our plants and personnel from either sabotage or bombings. This analysis therefore is most timely.



High-power Webster amplifier system built for service in defense plants.

By

RUFUS P. TURNER

IN a modern defense manufacturing plant, a good factory-wide PA system is invaluable in speed-up programs, so vital at this time; in the maintenance of management-personnel contact; and in the preservation of a high state of worker morale. In time of war, these are key jobs.

Some defense factories are acknowledging the new importance of industrial sound systems by installing amplifiers in their sprawling plants for the first time. Others, already equipped, are making those improvements and additions necessary to increase the reaching power of their equipment. Many a busy executive is at present exploring the potentialities of factory sound systems.

The plant which has not before been "wired for sound" is the usual case at this time. Managements of such plants inquire at once as to the value of amplifier systems in their industrial buildings, technical specifications for satisfactory equipment, and the extent of factory noise problems that must be solved. In some cases, the cost of installing and maintaining such systems is secondary to the points just mentioned. It is the purpose of this article to clarify some of these factors by directing attention to practical considerations.

Value of the Factory PA

The industrial PA system is not new. A number of factories have for several years been equipped with amplifier systems of appropriate coverage. The reasons for originally installing this equipment have been many and varied, individual purposes having been served. In some plants, for example, the amplifier system has been purely a medium of entertainment (although it might have been used occasionally for other purposes), supplying music to workers throughout the day for psychological reasons. In other instances, it has been used in lieu of bulletin-board notices for announcing information concerning large numbers of workers. These announcements have thus been made possible at the best psychological moment. In still other instances, the factory amplifier has enabled key executives to address large numbers of widely separated employees during times of labor trouble.

Each defense factory will no doubt find particular applications for sound systems. All managements will for reasons of economy and good investment, however, desire to know at the outset what will be the maximum utility of sound systems in our war effort. Not one, but several avenues of usefulness will be expected of any costly factory-wide sound system. And, in order to clarify this point, we list below a few of the leading roles in which industrial sound systems might aid in the general efficiency of the plant:

1. Factory-Wide Paging of Persons,
2. Fire Alarm,
3. Air-Raid Alarm and All-Clear Announcement,
4. Direction of Large Groups during Air Raids or Other Emergencies,
5. Factory Work Signals,
6. Special Announcements and Bulletins.

Projection type speakers are ideally suited for factory PA systems.

These are only a few of the possible defense applications of the factory sound system. Other uses will occur to those in charge of such amplifiers. The listed applications might be separately considered: (1) In paging persons over an amplifier system; considerable telephone switchboard time and manipulation is saved, as well as the time of persons who are needlessly required to answer their telephones during the search. (2) As a fire alarm device, the universal sound system is particularly efficacious in that all parts of the plant may be reached quickly with short, undisturbing signals and at the same time special announcements may be made to quiet any excitement. (3) The factory sound system permits air-raid and all-clear signals to issue from a point of authority, perhaps from an executive deputized to perform this task, and is invaluable for putting down rumors of impending danger. (4) If any plant is confronted with the job of handling its people during an actual air raid, it will find its sound system invaluable for appealing directly to the people to re-establish order and quiet and to bolster up the general morale. (5) Wherever desired, the factory sound system may be utilized to transmit factory work-time signals, although there would hardly be need for such application where there are already bell, whistle or horn signals. (6) The executive and production offices of the defense factory will be enabled by an interdepartmental sound system to reach their employees directly with special announcements and bulletins pertaining to the war, the war production effort, or the general factory business that must be known by the personnel. Spot sound announcements are superior in this case to the usual bulletin board in that a worker can hardly escape hearing the announcement, while he might not read the board, and announcements may be made at the best psychological moment.

Special Requirements for Factory Sound

The defense-factory sound system will differ from the usual PA installation chiefly in that the industrial system must compete with the high noise level of an industrial plant, and the power of the system must be sufficient to override the noise level efficiently. The factory speakers will be situated in areas of different noise level, so that provision must be made during design and installation for regulating the sound-energy output of each speaker to enable effective coverage of each area.

Speakers installed in offices, drafting rooms, laboratories, rest rooms, and other quiet places will be called upon to deliver less volume than those in the factory proper, hence can be operated at lower levels.

In most industrial installations, the speakers will accordingly require individual controls. Once satisfactory volume adjustments are made, however, the controls may generally be left permanently set until the noise levels are markedly altered by the addition or removal of machinery.

The defense-factory sound system must be smooth and clean in operation; it must be free from hum, clicks, grating, or any other extraneous sound that would tend to minimize intelligibility. It must be capable of covering the entire plant by means of efficaciously placed speakers, yet do so with a maximum of intelligibility and a minimum of acoustic shock. Sound delivered by a speaker in any department must be sufficiently higher than the local noise level to attract the worker's attention and convey a clearly understandable message, yet not loud, harsh, or distorted enough to be disturbing or exciting.

In determining the sound requirements of any factory, the investigator must make a careful study of the noise characteristics of each department in which a speaker is to be placed, of the desired coverage area in each proposed speaker location, the most effective type of speaker baffle in each case, and of the various electrical requirements for furnishing audio power throughout the total coverage area. These several matters will be taken up in this article.

Factory Noise Characteristics

Factory noise has two components important to sound equipment designers and estimators—volume and frequency. The actual volume of the noise will determine the amount of audio power that will be required for the speakers to be heard, while the frequency of the noise will determine certain tone-control characteristics that must be worked out in each case.

Regarding the frequency characteristic, noises are actually collections of many frequencies, rather than single frequencies. However, in almost every case there is a *predominant frequency component* and it is largely this frequency which distinguishes one kind of noise from another. For example; there are deep-pitched rumbles and higher-pitched roars, and there are rattles and clatters of widely different high frequency that are easily recognized by ear.

Factory noise is most efficiently studied with the *sound analyzer* and *sound level meter*. By means of the

(*Continued on page* 63)

Impedance Matching on a "Sound" Basis

by B. E. PHILIPPSEN

A technical analysis of one of the most important subjects in radio. Concrete examples aid in understanding the text.

THERE exists a trite old adage which so revealingly states that "a chain is no stronger than its weakest link." So when attention is drawn to the modern signal circuits of radio communications and sound amplification this antique proverb still bears down heavily on what is known as *impedance matching.* This "matching" condition prevails at many essential junctures in circuits where a maximum transfer of energy and optimum frequency response are prime essentials.

It is the purpose of this article to clarify or help create a better comprehension of this subject, in the hope that this knowledge will prove to be of a practical help to the reader. In the present emergency situation it becomes clearer, daily, that the most work can be accomplished by those who can utilize their technical knowledge in practical achievement. It therefore becomes almost a patriotic duty for everyone to arm himself "mentally" as well as mechanically. To gain a complete understanding of impedance matching it is necessary first of all to know the meaning of impedance itself, reflected impedance, and reflection loss. These will be analyzed individually.

Impedance is an electrical characteristic of a circuit element which resists or retards the flow of an alternating current. Such an element may well be a choke coil, condenser, transformer winding, etc. Remember, it impedes the flow of *alternating* current. As such it corresponds to a resistance which repels the passage of direct current. In this connection let it be known that an impedance cannot always be a resistance, but—a resistance is always an impedance, in an alternating current circuit.

On the other hand a capacity (condenser) is always an impedance in an a.c. circuit, but not necessarily a resistance in a d.c. circuit; since its d.c. resistance is considered infinite. In direct current circuits it is universally accepted that the resistance of a circuit is equal to the voltage impressed across it divided by the current flowing through it. This is merely Ohm's Law. Generally speaking this law also holds true for a.c. circuits when the "apparent" resistance of the circuit is equal to the impressed alternating voltage divided by the alternating current through the circuit. However, it is not the same value of resistance as would be read on an ohmmeter or resistance bridge.

This is due to a certain inductive or capacitive component which affects the apparent a.c. resistance. So to distinguish it from direct current resistance the apparent resistance in an a.c. circuit is called *Impedance.* Now that we have acquired at least a simple idea of impedance, it is possible to delve farther into some of the associated terms.

For instance, let's find out what is meant by *reflected impedance.* Assuming a tube is connected as a constant voltage generator (see Fig. 1), then the *reflected impedance* is the resistance in ohms, at a given frequency, which the plate of the tube must face, resulting from the load placed across the secondary of an output transformer. In actual practice the value "R" may be a loud-speaker as well as a Class C r.f. amplifier in a radiotelephone transmitter. As long as the load conditions are proper, the tube "V" cares not one particle into what it feeds its energy. As to the *reflection loss,* this is always a ratio and not a unit of fixed quantity. Therefore it is usually expressed in the number of db lost.

To illustrate reflection loss in as simple a manner as possible let's take advantage of a practical physical analogy. Looking at Fig. 2 we see a constant pressure water pump, tank "A" and ditch "B." The water leaves the pump flowing at a steady rate through tank A. However as it enters the narrower ditch "B" a turbulence is set up which retards the efficient transfer of the water. This turbulence is caused by some of the water striking the walls of the tank and being reflected back into tank "A."

Therefore at the precise moment this occurs during the flow of water and it occurs constantly, a loss of transfer occurs which is known as reflection loss. Now, returning to our electrical circuit of Fig. 1, compare the tube, as a constant voltage generator to the constant pressure water pump; look at the tank "A" as the transformer "T" and the ditch "B" as the load "R." As the tube generates a constant stream of electrical energy it becomes necessary that the impedance of the load be matched to the tube for a maximum transfer of power. In other words the ditch "B" to collect without loss, as much water as possible, should be as wide as tank "A." Or saying it still another way, when the resistance of the load equals that of the source a maximum of power is transferred.

On Mismatch

After all this discussion on equality of source and load for maximum power transfer it will come as a rather shocking revelation to some of us that in practice this is not always done. Where power transfer alone is the objective such as in transformer or industrial applications, this precept is adhered to. But, in sound or radio applications another consideration enters into the picture. This is distortion. Because the distortion introduced by a tube is, along with others, determined by the impedance into which it works, an effort must be made to keep it at a minimum.

An accepted means, other things being normal, is working the tube into

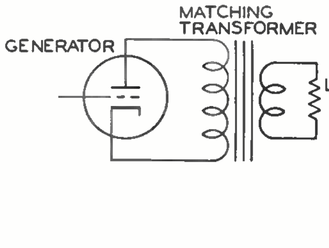


Fig. 1.

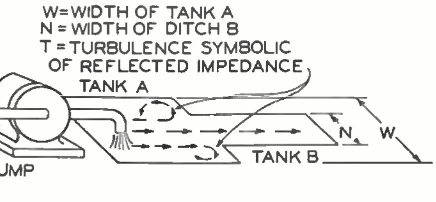


Fig. 2.

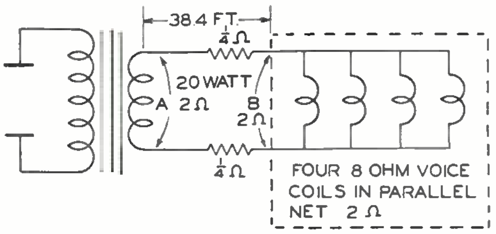
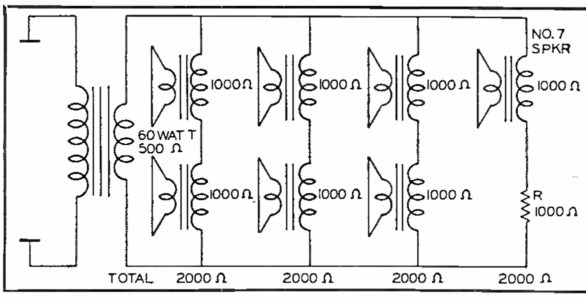
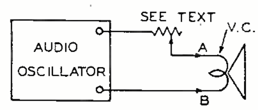


Fig. 3.

an impedance equal to about twice its plate resistance. The thought may be injected here that this condition holds true in the case of class "A" triodes which may be looked upon as constant voltage generators. In the matter of Class "A" prime the tube is no longer constant voltage generator and other factors outside the scope of this article may influence the load impedance. On the practical side of life, mismatching does not, as might be anticipated, detract nearly so much from the efficient transfer of power, due to reflection losses. However, the desirable frequency characteristic of the circuit is usually harmed. For instance, you might connect, as a last resort, a 200-ohm line to a 500-ohm line. Loss in power due to this mismatch will be barely audible but the resulting change in fidelity would most certainly indicate the need for an efficient line matching transformer. As it stands these circuit values constitute a mismatch of some 60%.

However from actual performance tests it can be told that a mismatch of 15% is acceptable without the danger of audible apprehension while 25% is just about the maximum permis-





Above: Fig. 8.

Left: Fig. 7.

the amplifier transformer "looks" down the line to the four speakers connected in parallel to a resultant 2 ohms. Does the output transformer see "2 ohms" for perfect matching? It does not! It sees 2 ohms plus ¼ ohm (line resistance) plus another ¼ ohm (line resistance); all told 2.5 ohms—a mismatch of 25%, the maximum allowable. From a mismatching point of view this should now be clear.

So when your sound system comes equipped with just 35 feet of speaker wire you are getting as much as it is possible to obtain and still remain within the bounds of permissible mismatching without the additional purchase of speaker-to-line transformers.

Again from $I^2R = W$; we arrive at $(.0399)^2 \times .5$ ohm (speaker line resistance) is equal to .0008 watts lost in the 500-ohm speaker line.

This comparison between 500-ohm or 2-ohm lines is not intended to prove the need for use of 500-ohm lines, and their associated transformers, for distances as short as 38.4 feet. This goes without saying so; however it does conclusively prove that for any distance greater than this, 500-ohm circuits are far superior, both from the point of line power loss as well as mismatching.

In retrospect on mismatching, recall that a total line resistance impedance of 0.5 ohm could cause a mismatch of as much as 25% on the 2-ohm line

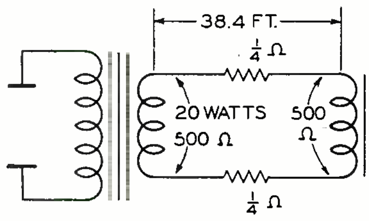


Fig. 4.

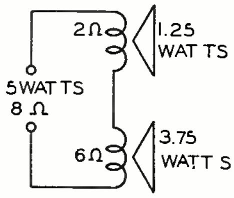


Fig. 5.

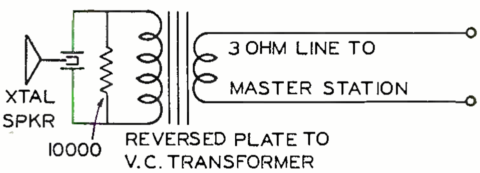


Fig. 6.

sible mismatch in present-day sound equipment. This brings up the question of when to use a 2 to 8-ohm line for sound system speaker installations and when it is best, from a distortion and power loss standpoint, to use a 500-ohm line. Some cannot understand why their sound systems do not come equipped with more than the usual 35 ft. of speaker cable. Behind this lies a very definite reason not prompted, as might be expected, from a wire economy measure on the part of the P. A. manufacturer.

Let's look into this further. Common practice is to supply a complete portable sound system with 35 ft. of No. 18 stranded zip cord, speaker wire. Why only 35 feet? Scanning the wire tables we find that 153.7 ft. of No. 18 stranded zip cord has a resistance of one ohm. One fourth of 153.7 feet equals 38.4 feet; also, one fourth of one ohm equals one quarter ohm. Looking at Fig. 3 we see a 20-watt amplifier, its output transformer tapped at two ohms to supposedly match, four parallel 8-ohm speakers whose net voice coil impedance equals two ohms. In the line are shown two ¼ ohm resistors, one in each side of the line.

These represent the resistance of 38.4 feet of speaker wire and this line obviously must have two wires. Suppose the two-ohm output winding on

As to power lost in speaker lines whether 2-ohm or 500 ohm lines are used the following is interesting:

From the equation: Current is equal to the square root of the power divided by the resistance we arrived at

$$I = \sqrt{\frac{20 \text{ watts}}{2.5 \text{ ohms}}}$$

where 20 watts equals the amplifier output and 2.5 ohms equals the impedance of the four parallel speakers plus the total line resistance.

Then I equals 2.82 amperes line current. There is a total of .5 ohm non-usable line resistance. So from the equation $I^2R = W$ we find that 2.82 amperes squared, times .5 ohm = 3.97 watts lost in the 38.4 ft. speaker lines.

Supposing now, that we used for the purpose of example the same 38.4 ft. speaker line, but replaced both the amplifier output transformer with one having a 500-ohm output winding. Also at the speaker end of the line we insert a 500-ohm to speaker voice coil transformer as in Fig. 4. The length of the speaker line remains unchanged at 38.4 ft. By applying the same formula as in the above paragraph:

$$I = \sqrt{\frac{20}{500.5}}$$

where 20 = 20 watts and 500 the impedance. Therefore the current is equal to .0399 amperes line current.

shown in Fig. 3. For that same value of resistance in a 500-ohm circuit the mismatch is of no mathematical consequence with a proportional reduction in all the disadvantages of reflection loss as evidenced in a 2-ohm line.

So, summing up, it can be very definitely remembered that in any sound installations where a few, or all speakers are located more than 35 feet distant from the amplifier, both experience and figures can prove that the use of 500-ohm speaker transmission lines offer the greatest economy of sound-power energy, greatest ease of accurate impedance matching with its attendant freedom from undesirable frequency discrimination.

Up to this point, all has been written with the *ideal* in mind and no one will dispute the need for maintaining ideals in any endeavor; but as equipment for "exact requirements" becomes daily harder to buy, a reflexive action necessarily develops which makes each of us ponder on the best way to do a job with the apparatus available at the minute.

For instance, there is no longer any question about the difficulty of obtaining "T" and "L" pads as quickly as formerly. Suppose then you find it necessary to install a system requiring a 5-watt amplifier in a mercantile

(*Continued on page* 51)

Phase Inverters and Feedback

by MILTON T. PUTMAN

Ass't Corps Area Radio Engineer, Chicago, Ill.

Phase-inverters have been used for many months as standard equipment but few radiomen understand the circuits involved.

THE purpose of this article is to present, as nearly as possible, a basic discussion of the various phase-inverter circuits and their practical application. The subject is perhaps a little more timely now than ever before, since the phase-inverter arrangement provides a very satisfactory means of eliminating the push-pull interstage transformers, which are not entirely unobtainable, but at least very difficult to obtain under the present circumstances. It appears that there has been very little interest as a whole in these circuits, but after a more complete understanding of the applications, it becomes more and more evident that we have been passing up an opportunity to improve our audio circuits.

Essentially, a phase-inverter circuit is a means of supplying two input signals to the grids of a push-pull stage in such a manner that the amplitude of these two voltages is equal, and the phase relationship with respect to each other is 180 degrees. The tube may or may not add to the gain of the amplifier, depending upon the type of circuit used.

Irrespective of the fact that we may no longer be able to obtain hi-fidelity transformers, there are a goodly number of advantages which would warrant the use of phase inverters by their own right. In general, it can be said that a phase-inverter circuit may be substituted for an interstage transformer at a considerable saving in the construction cost. A good hi-fidelity interstage transformer is quite an expensive item. We have been prone to use resistance coupling over transformer coupling for single ended amplifiers, and we may still use resistance coupled amplifiers for push-pull operation by the application of a phase-inverter circuit.

It is possible to obtain excellent frequency response by the proper choice of components in these circuits, comparable to the frequency response obtained by using the most expensive transformers available. In specific cases, where degeneration is inherent, the distortion would be reduced considerably.

The circuits to be discussed are divided into two distinct groups. One is the cathode-loaded type, in which only one tube is employed, and the other is the so-called self-balancing phase inverter which involves the use of two triodes or the dual triode.

The cathode loaded circuit to be taken up first, is the simplest type phase inverter. Any general purpose triode may be used and it is desirable to choose a tube with as low a cathode-to-heater capacity as possible, so that it does not create an unbalance at the higher frequencies. Another important point is in regard to the mu of the tube. A generality would be that the tube should have a fairly high mu. This is illustrated in detail later on.

An inherent characteristic of the cathode-loaded circuit is its susceptance to hum. Not from stray magnetic fields, but due to the fact that the cathode is operating at a fairly high impedance above ground, a hum voltage may be generated between cathode and heater, if the heaters are at ground potential as is the case in general. Our problem then, is to reduce the potential between the heater and cathode by causing the heater supply voltage to assume a potential near that of the cathode. Practically, this might mean that we operate the heater on this tube from a separate transformer floating above ground.

This is just an example of what might happen to produce hum in the output of the amplifier and should not be considered as too important. As a matter of fact, by proper location of the phase inverter, in any amplifier circuit, this difficulty may be minimized. For most applications, if the phase inverter is not driving a high gain push-pull stage so that this hum is amplified, it will never present a very serious problem. The phase inverter *should be* located as a driver for the push-pull output stage or power amplifier except under unorthodox conditions.

With one possible exception the voltage gain of the stage, which is the ratio of the input voltage (measured from grid to ground at the input), to the output voltage (measured from grid to grid of the push-pull output stage), is less than two. The fact that the voltage gain is not greater is due to degeneration caused by having a portion of the load impedance common to both the input and output circuits.

A detailed explanation is given under the discussion of the feed-back voltage. In the exceptional case, the input is taken between grid and cathode, and the full gain of the tube may be appreciated. This type of circuit has very few applications, and will not be considered. Obviously, it is not practicable to by-pass the cathode to ground to prevent degeneration, since by doing this we would unbalance the output. The effect would be to attenuate the higher frequencies just as in the case of the high cathode to heater capacity.

The ordinary cathode-loaded type phase inverter is shown in Figure 1. In order to understand the operation of the circuit, first let us view the situation in Figure 2, which shows the equivalent circuit of any resistance-coupled amplifier employing a constant voltage generator, that is, a triode with low plate impedance. The output voltage from the generator or tube in the middle frequency range is μE_s where μ is the amplification factor of the tube and E_s is the signal voltage applied to the grid and R_L represents the load resistance. R_p is the

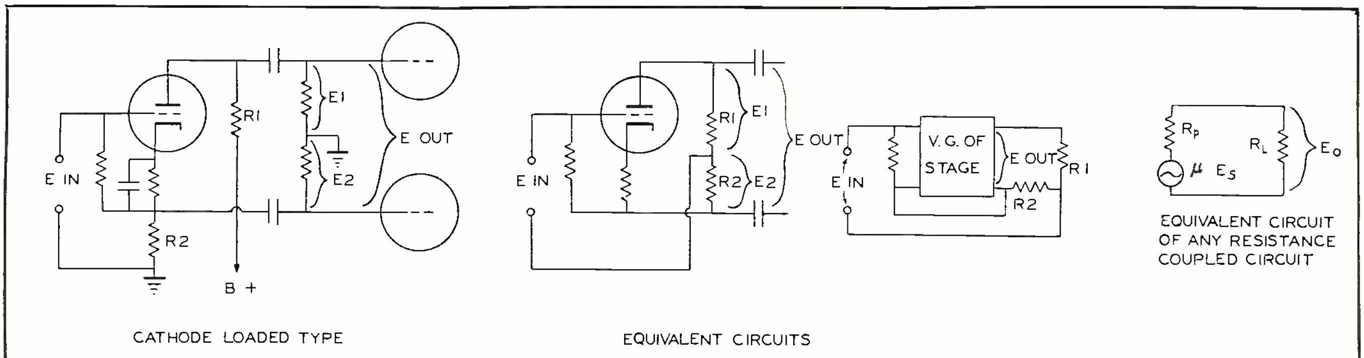


Fig. 1. Fig. 1A. Fig. 1B. Fig. 2.

plate resistance of the tube and might be thought of as the internal resistance of the generator.

In this case there is no feed-back or degeneration in the circuit and the gain of the circuit would be the ratio of E_s to E_o. If R_L is large in respect to R_p, it can be seen that the voltage gain would approach the mu of the tube. Now let us consider the case which applies to the cathode-loaded circuits. In Fig. 1 we see first of all that our loaded circuit is divided into two main parts, consisting of R^1 plus R^2. For all practical purposes let us consider them equal in value and, consequently, the voltages across the two are equal. Again we determine the voltage gain by the ratio of E_{in} to E_{out}. Since ½ the load circuit is common to both the input and output, we have ½ the output voltage fed back to the grid, 180 degrees out of phase with the signal voltage, and the result would be that the gain could not exceed 2 times. The equivalent circuits are shown in figure 1a) and 1b).

Specifically the gain is inversely proportional to the feed back voltage. i.e.:

VG with feed-back $= -(1/\beta)$.

Where:

> β equals the percentage of output voltage which is fed back to the input.
> (β is a negative quantity for negative feed-back.)

This shows that we cannot exceed a gain of two, if we feed 50% of the voltage back.

When the percentage of voltage feed-back is relatively large, as is the case in the cathode loaded type phase inverter (50%), the *actual overall gain of the stage with feed-back is substantially independent of the voltage gain of the tube.* It is merely a case of generating more voltage to feed back more voltage, which has the effect of neutralizing the signal voltage. There is one advantage, however, in choosing a tube which would provide more voltage gain under ordinary circumstances, and that is in regard to the reduction of distortion.

Specifically, the feed-back or gain reduction factor is $1 - A\beta$, where A is the voltage gain of the stage without feed-back. As shown previously, since β is for negative feed-back, it is a *negative quantity,* so actually we have $1 - A(-\beta)$, which gives us $1 + A\beta$. This then is the factor which determines the amount of reduction we will get in the total distortion by using feed-back.

This is shown in that:

$$\text{Distortion with feed-back} = \frac{\text{Distortion without feed-back}}{1 + A\beta}$$

It is logical to make the voltage gain of the stage as great as possible, thereby increasing the value of A and in this manner increasing the quantity $1 + A\beta$. It is impossible to change to other factor "β," which is necessarily 50% in these circuits as explained previously. We also mentioned that the *overall* gain is practically independent of the *voltage gain of the tube* and yet we have pointed out that it is possible to reduce the distortion a great deal by using a tube with a higher voltage gain. In order to feed back more voltage, we have made "A" a larger quantity. To summarize it in a few words, then, let's say that we can't do much about the gain of these circuits, but we can reduce the distortion by using a tube with a fairly high mu. An Illustration (figure 1) is shown giving the cathode-loaded circuit which may be used for practically any application.

These cathode-loaded type phase inverters provide the simplest form, involve the least number of parts, and consequently are cheaper to use. However, it is important to remember that they do not give an appreciable amount of gain and should be used where a gain of less than 2.00 is sufficient. The frequency response of this system on the balanced type is substantially the same and is not a determining factor in the choice of circuits.

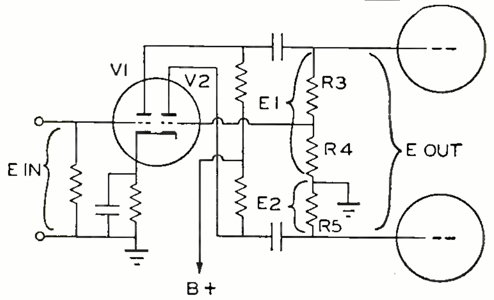
In considering the other type of circuit which involves the use of two triodes or a dual-triode, it might be well to point out that even though both of these circuits are referred to as the "balanced type," there is considerable difference in the two, and one is essentially more "balanced" than the other. There are some conditions which apply to both types in general, and we might mention these to be kept in mind in either case.

In most cases it is desirable to choose a dual-triode such as a 6N7, 6A6, or 6SC7, the latter being especially designed for this service. The cathode to heater capacity is not so important now and the problem of inherent hum generation is no longer present, since the cathode operates in a conventional resistance-coupled circuit and is only above ground by the bias potential. The cathode may be by-passed if it is necessary to eliminate hum, but otherwise it need not but it may help to balance the drive to the push-pull stage. The gain is not affected a great deal since it is the same situation as in the common cathode resistor in an output stage, in which case the two currents flowing through it are 180 degrees out of phase. The argument used for the by-passing of a cathode resistor in a push-pull stage in regard to eliminating the odd order of harmonics, could apply here, however.

The use of a tube with a high mu will allow a higher voltage gain just the same as in a conventional resistor-coupled circuit. There is a small amount of degeneration, but nothing in the order of the amount of the cathode loaded type. For practical assumption, the VG of this type is the same as in an ordinary resistance coupled circuit.

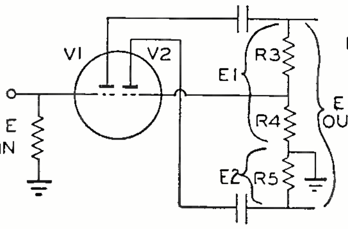
Where:

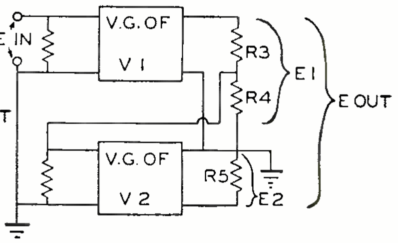
$$VG = \mu \frac{R_L}{R_L + R_p}$$



TAPPED OUTPUT TYPE

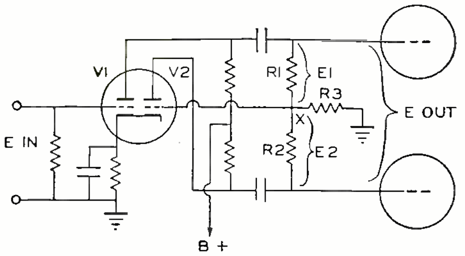
Fig. 3.





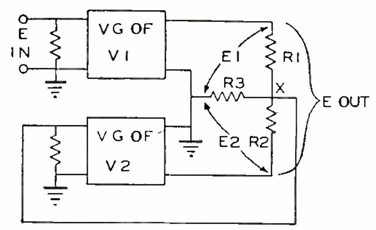
EQUIVALENT CIRCUITS

Fig. 3A. Fig. 3B.



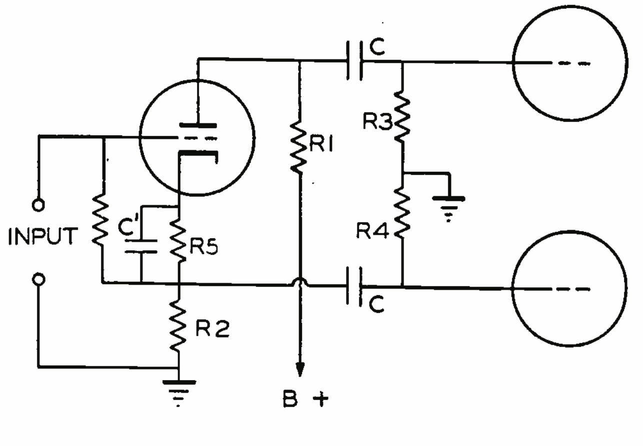
SELF BALANCING TYPE

Fig. 4.



EQUIVALENT CIRCUIT

Fig. 4A.



Cathode Loaded Type

B+ =250 Volts

LOW μ TRIODES	R1	R2	R3	R4	R5	C	C1
6C5-6	100M	100M	250M	250M	6000	.01	25 mfd

HI μ TRIODES	R1	R2	R3	R4	R5	C	C1
6F5—6SF5 etc.	100M	100M	250M	250M	1500	.01	25 mfd

Gain is always less than two (2).

Max. output grid-to-grid =20% plate supply voltage (B+) (appx.)

$$VG = \frac{2\mu \cdot R}{R(\mu+2)+R_P} \text{ where } R = \frac{R1+R2}{2}$$

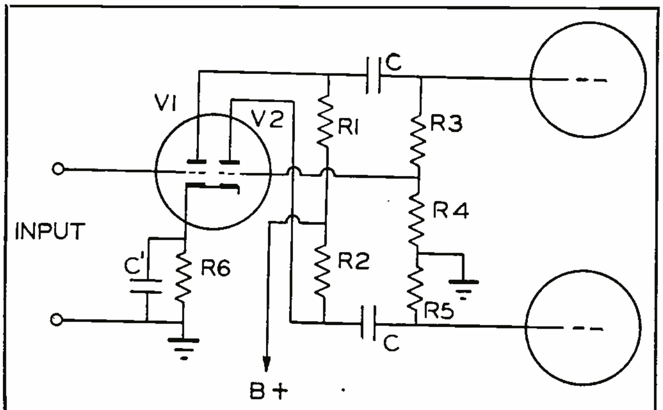
Fig. 6A (left) shows the circuit of a typical Cathode-loaded resistance-coupled audio stage.

VG = voltage gain
μ = amplification factor of tube
R_P = plate resistance of tube
R_L = load resistance of tube

First of all we will consider the circuit in figure 3, and the equivalent circuits in figures 3(a) &(b). In this type of phase inverter, tube V1 operates as a conventional resistance coupled amplifier feeding the grid of V3. As a means of providing a signal on the grid of tube V2, we tap off a portion of the signal voltage appearing across the grid leak resistor, of V3. The voltage on the grid of V2 is proportional to the voltage on the grid of V3 and has the same phase relationship. Next, consider the signal voltage at the grid of V2 as having the same phase as the voltage on the grid of V3, and after its signal is amplified in the tube V2 it appears in the output circuit in much greater magnitude and its phase relationship is now 180 degrees in respect to the voltage on the grid of V3. In order to balance the drive on the two push-pull output tubes it is necessary that the voltage output from V2 be the same as that from V1. In a practical case where the two triodes V1 and V2 are identical and perhaps a dual-triode, we consider them having identical characteristics and the amplification from each tube is equal. If, for example, the voltage gain of V_2 is 20 (i.e. would reduce the effective gain from V2 and tend to equalize the drive on V4.

On the other hand, assume that the gain of V2 is less than V1, then the voltage at point X would be *in phase* with the signal on V3 and *out of phase* with V4. Under these conditions the effective gain of V2 would be increased, since the signal on the grid would tend to reinforce the output of the tube. These two conditions are shown graphically in figure 5 under (e) and (f).

The resistor R3 is not of critical value, since it is common to the output of V1 and the input and output of V2. the ratio of the input voltage to the



Tapped Output Type

B+ =250 Volt

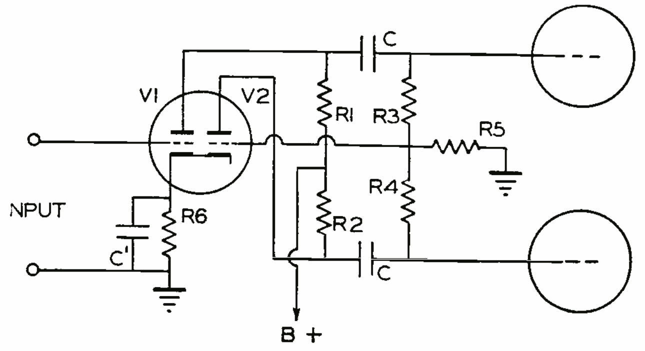
6N7 / 6A6	R1	R2	R3	R4	R5	R6	C	C1	Appx Gain
	250M	250M	475M	16000	500M	2000	.01	10 mfd	22

6SC7	R1	%2	%3	R4	R5	R6	C	C1*	Appx Gain
	250M	250M	475M	16000	500M	4000	.01	10 mfd	38

*May not be necessary unless hum is present.

$$VG = \mu \frac{R_L}{R_L' + R_P} \text{ App.}$$

Fig. 6B (left) illustrates the Tapped-type of phase-inverter. Values appear in table above.



Self Balancing Type

Fig. 6C (left) has been designed to employ the values given in the above formula and chart.

B+ =250 Volts

6N7 / 6A6	R1	R2	R3	R4	R5	R6	C	C1	Appx Gain
	250M	250M	250M	250M	100M	2000	.01	25 mfd	26

6SC7	R1	R2	R3	R4	R5	R6	C	C1	Appx Gain
	250M	250M	250M	250M	100M	1500	.01	25 mfd	45

$$VG = \mu \frac{R_L}{R_L + R_P} \text{ App.}$$

output voltage is 1 to 20), and we tap off 1/20 of the voltage across the grid resistor of V3 and apply it to the grid of V2 it develops a voltage across the grid resistor of V4 equal to that across the grid resistor of V3. We have accomplished the necessary results and the two signal voltages on tubes V3 and V4 are equal and 180 degrees out of phase.

Next assume that there is a slight difference in the amplification of the

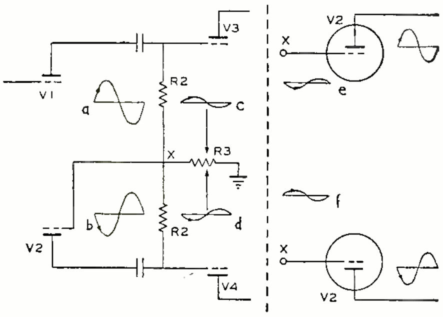


Fig. 5. Graphical Analysis of Balancing Type

a. Represents phase of signal voltage appearing on grid of V3: and also the voltage developed across R2.

b. Represents phase of signal voltage appearing on grid of V4: and also the voltage developed across R1.

c. Represents the voltage phase across R3 due to the signal voltage on V3 causing a current through R2 and R3 to ground.

d. Represents the voltage phase across R3 due to the signal voltage on V4 causing a current through R1 and R3 to ground.

e. Represents the condition when the gain of V2 is higher than V1—the signal from point x is shown on the grid. The output voltage shifts 180° through the tube and cancels a portion of the original voltage shown at b.

f. Represents the condition when the gain of V2 is less than V1—the signal from point x is shown on the grid. In this case, the output is in phase with that shown in b, and adds to it rather than cancelling part of it.

two tubes. This means that if V2 has slightly more gain than V1, we will not have to tap off as large a portion of the voltage across the grid resistor of V3 as before since it is going to be amplified to a slightly greater extent and will not require quite as much signal voltage to get the same output as before. A simple expression worked out to give a basis for determining the ratio of the two resistors R3 and R4 which go to make up the total grid resistor, is as follows:

$$R4 = \frac{R3 + R4}{VG}$$

Where VG = voltage gain of V2

Due to the fact that resistors, which would ordinarily be used for R3 and R4, may vary as much as 10 percent

(*Continued on page* 60)

SERVICE HINTS

Here are some more servicemen's aids that will help to increase his revenue.

THE two largest churches in Beaumont, Texas, St. Anthony and First Baptist Church, had a lot of trouble with echoes and they wanted a system to take out these echoes and the bouncing out of those walls. These churches had previously spent a lot of money elsewhere trying to put in some acoustical treatment to stop it, without result.

So Ed Flinn, of The Radio and Appliance Company, put small speakers on each side of the church walls, about every twenty feet apart, right down the wall, and tilted them down. That helped to throw the sound to the center of the church at a 45 degree angle, which stopped it completely.

A unique installation by Flinn was for the local Chamber of Commerce which runs busses out on good will trips to outlying territory. He put a long mike extension on with two speakers in the bus. "They use them for foolishness when on the road," Flinn explained, "but when they get to a town they take the mike out of the bus (has 150 foot extension) and walk all around the streets, wherever they want, thank the people for their welcome and hospitality, and the usual line of chatter. The speakers are mounted on the bus. They are portable also and can be moved anywhere you want to, being controlled by batteries.

"In a public address system at a local hotel we tried something from a technical standpoint. They wanted four mikes operating on the speakers' table for roundtable or open forum discussions. Instead of using different mixers we took four crystal mikes, high impedance, tied all four of them in the one input and gave a perfect reproduction. The volume level being essentially the same all the way through. It did a swell job so that many of the hotel managers who were there at the convention gave us many compliments."

Flinn also uses good selling tactics. For instance, a year ago he started a scrap book of articles appearing in the local newspapers about him and his work, which he uses in selling. That is, when he runs into a man he doesn't know, it goes a long way toward convincing him that Flinn is the man for the job.

This scrap book also contains photographs of various installations. It covers all angles of the business. In addition to that, from the selling standpoint, he takes letters from various people for whom he has done jobs and pastes them in here as recommendations to show other people.

QUITE often the serviceman detects internal noise, in a set but it isn't bad enough to be verified with any certainty. Every serviceman has an instrument that checks this very effectively. It is no more than his test oscillator with the modulation switch in the un-modulated position.

If you suspect the noise to be in the r.f., 1st detector, or oscillator stages, hook your test oscillator to the aerial and ground of the set in the usual manner but instead leaving the modulator switch in the modulation position you put it on the un-modulated position and instead of feeding a low level r.f. signal into the slit you feed a much stronger signal.

If the noise is in the radio proper it will be much louder than normal. By pressing and wriggling suspicious components the noise will be aggravated.

If it is the i.f. stages that is under suspicion and it is certain that the preceding stages are not at fault, the procedure is exactly the same except that the un-modulated signal (of the same frequency as the i.f.) is fed into the grid cap of the first detector and should be even stronger.

Noisy coils, transformers (that also includes audios), volume controls, and partially shorted or open condensers are easily located. The unmodulated signal is also very useful for showing and locating microphonics or acoustic feed back. —30—

CONTEST PRIZE WINNERS

Here are the winners in the recent Cash Prize Contest:

$100.00 1st Prize
Harry L. Poling, Box 221, Elkins, W. Va.

$50.00 2nd Prize
John S. Johnson, Jr., 1306 Adam St., Bowling Green, Ky.

$25.00 3rd Prize
Armand Besse, 7349 Lajeunesse St., Villeray, Montreal, Can.

$10.00 Winners
Frederic U. Dillion, 1237 N. Fairfax Ave., Hollywood, Calif.
Ben E. Long, 318 Linden Ave., Southgate, Ky.
Richard A. Strouhal, W. Burlington, Ia.
David Gnessin, 3444 Reiser Ave., S.W., Grand Rapids, Mich.
Edward Lovick, Jr., 416 Reese Pl., Burbank, Calif.
C. B. Kelley, 198 Shrewsbury St., Holden, Mass.
Bill Benner, 145 S. Maple St., Webster Groves, Mo.

Our congratulations on some mighty nice articles, fellows!
Watch for yours in RADIO NEWS. Ed.

Selecting Speakers for

SPECIFIED SOUND LEVELS

by **RALPH P. GLOVER**
Jensen Radio Manufacturing Co.

The author tells how to estimate the number of projectors and how much power is required to cover specified areas.

THE main problem in any sound installation revolves around the question of how many speakers of what type, located where and supplied with how much audio input power, are needed to produce the desired result. Most purchasers of sound installations do not know the answers to these questions and their solution is the specialized province of the sound engineer. Very often the sound man makes his survey and determines the equipment requirements on a "rule of thumb" basis evolved out of practical experience.

The main problem outlined above can be solved in industrial sound systems by relatively simple measurements and reference to the data and charts included in this article.

Noise Levels

How loud must the reproduced sound be in order to be clearly understood? To answer this question we must know the noise level at the particular location. Noise levels vary from extremely low values in the open country, up to very high levels which are almost painful in some factories. Some parts of a particular factory are much noisier than those sections more removed from the heavier machinery.

Sound levels are measured with a *sound level meter,* which consists of a microphone, amplifier and indicating meter, calibrated in decibels above the threshold of audibility. The threshold value has been standardized at 10^{-16} watts per square centimeter which is equivalent to a sound pressure of 2 ten thousandths dyne per square centimeter. A sound of this level, which is 0 db on the sound level scale, will be barely audible to a person with good hearing. At a level of 130 db sound is so loud as to be painful.

The most reliable method of determining the noise level is to survey the location and make a series of measurements with a sound level meter manufactured by a reliable firm of instrument makers. As an alternative, a fairly satisfactory sound level meter can be assembled using an inherently stable pressure-operated microphone in combination with an amplifier provided with a calibrated tapped gain control and an output meter reading in "db" or "VU." The apparatus must then be calibrated by comparison with a standard sound level meter, perhaps borrowed from an accommodating friend or institution, or the calibration can be made by a firm with acoustic laboratory facilities for a reasonable fee.

Great care must be exercised to provide stable gain characteristics so that reading will be reliable and reproducable for, unfortunately, it is rather difficult to approach the performance of the commercial product in a homemade device. The third alternative is to estimate the voice level from published tables based on average values of various kinds of noise in representative locations. Table I indicates representative noise levels in industrial locations, traffic noise and residential levels.

It will be evident from examination of the items in Table I that it can only provide an approximate answer to question of the noise level in a given case. In a few factories the noise level has been found to be as low as 60 db while levels as high as 95 to 120 db have been measured in others. Obviously noise levels differ in various parts of a particular factory.

Noise "masks" the speech sounds that we want to hear. We compensate for this by increasing the level of conversation until it is comfortably above the level of the ambient noise. Ordinary conversation level is 60 db and it is evident from examination of Table I that this is 18 to 30 db above residential noise levels. A level of 60 db however is inadequate under factory noise conditions of say 75 db, and the level of speech at the listener ear will be increased to 85 db or more. Usually part of the level increase is accomplished by closing up the separation between talker and listener, and part by increasing the speaking level.

Assuming that no sound level meter is available, we have no choice but to estimate the noise levels from Table I or similar data. Let us assume that the location is the interior of a factory equipped with heavy machinery and engaged in ordinance production. Consulting the table it seems likely that the noise level will lie between 80 db and 110 db. Inspection of the plant shows an area in which there is an intermittent source of very high level noise. The memory of what a boiler factory sounds like and the "hammer-on-steel plate at 2 ft." item leads us to conclude that the level around this particular machine is approximately 112 db. The noise decreases as we move away from the very noisy machinery and at the other end of the 400 ft. long building the noise level seems quite low so we make a conversation test to provide a rough check on the level. Perhaps the level seems relatively low because of the recent exposure of our ears to high intensity sound. This may be just imagination.

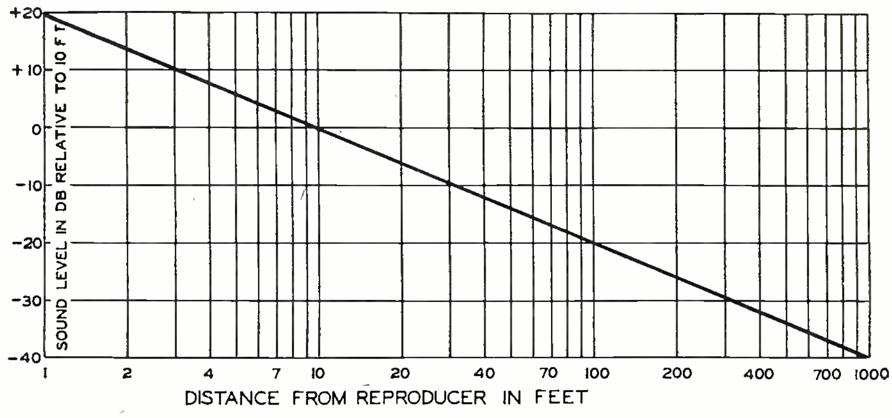


Fig. 1. Effect of Distance to Reproducer of Sound Level.

Speaking at what we feel is a normal conversational level, it is found that speech is masked by the noise at a distance of five feet to the listener. When the distance is decreased to one foot, the speech appears to be about as loud as the noise and is barely understandable. From the chart in Fig. 1 we compute the increase in level in changing from 5 feet to 1 foot and find it to be 14 db. The level at the listener's ear is therefore approximately 60 db (normal speech level at 5 feet), plus 14 db or 74 db which roughly checks the 80 db estimate previously made by reference to the table. It is decided to assume, conservatively, that the minimum level is 80 db in this particular factory.

Such methods of arriving at noise levels are not nearly as convincing as sound level meter data and are manifestly subject to considerable error due to the human element. However, we are at least practicing intelligent "guessing," the results are subject to practical check when appraising the final sound coverage, and judgment should improve in the light of systematic experience.

Overriding the Noise

The loudspeakers must produce a sound level adequately above the noise level. Indoors in relatively small rooms the level is increased above the direct sound level by diffuse energy due to reflections from the walls. This increase may be as much as 10 db. Out of doors there is only the direct sound to consider. In large enclosures, especially where the walls offer very little absorption, the diffuse or reverberant sound is troublesome and impairs the intelligibility of the reproduction.

It is desirable, therefore, to make the direct sound the principle component by employing multiple speakers located relatively close to the area which they serve. In industrial systems the transmission of speech is the main requirement and the objective should be a more than adequate direct sound level. Especially under present conditions when sound systems are vitally important in paging, production dispatching, antisabotage control, and alert warnings, there is no place for inadequate, underpowered installations in our industrial machine.

Experience indicates that in moderate-to-large indoor industrial systems, the installation should be planned to afford reproduction 20 db above the average noise level. It is desirable to attenuate the low frequency response below about 400 cycles to minimize reverberation and to provide power economy in the audio system. Approximately the same 20 db margin is applicable in out of door installations.

A special problem arises when the noise level is very high, for it becomes difficult to obtain speakers capable of ultra high-intensity reproduction, their cost is high and the required power is large, for example the 110 to 120 db noise levels found close to some of the heavier rolling operations in a steel mill. These intensities are close to the

(*Continued on page* 57)

Table I
Representative Noise Levels
(Compiled from Various Sources)

Source of Noise	Noise Level in Decibels*
Industrial Noises	
Threshold of pain	130
Airplane engine and propeller—18 ft.	120
Hammer blows on steel plate—2 ft.	114
Boiler factory	110
Pneumatic riveter—25 ft.	100
Factory, heavy manufacturing	80
Factory, medium manufacturing	75
Factory, light manufacturing	70
Factory office	65
Large office	65
Large store	63
Restaurant	60
Average medium city office	55
Garage	55
Small store	52
Hotel	42
Traffic Noises	
Subway	103
Very heavy street traffic—25 ft.	80
Busy street traffic	70
Residential street	58
Residential & Conversational	
Apartment, city	42
House, city	40
House, country	30
Ordinary conversation—5 ft.	60
Average whisper—5 ft.	18
Quiet whisper—5 ft.	10
Threshold of audibility	0

* Above 10^{-16} watts per square centimeter.

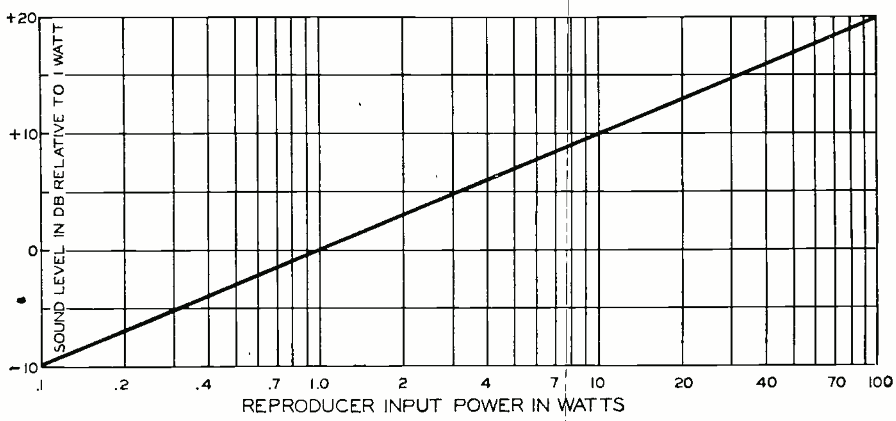


Fig. 2. Effect of Input Power on Sound Level.

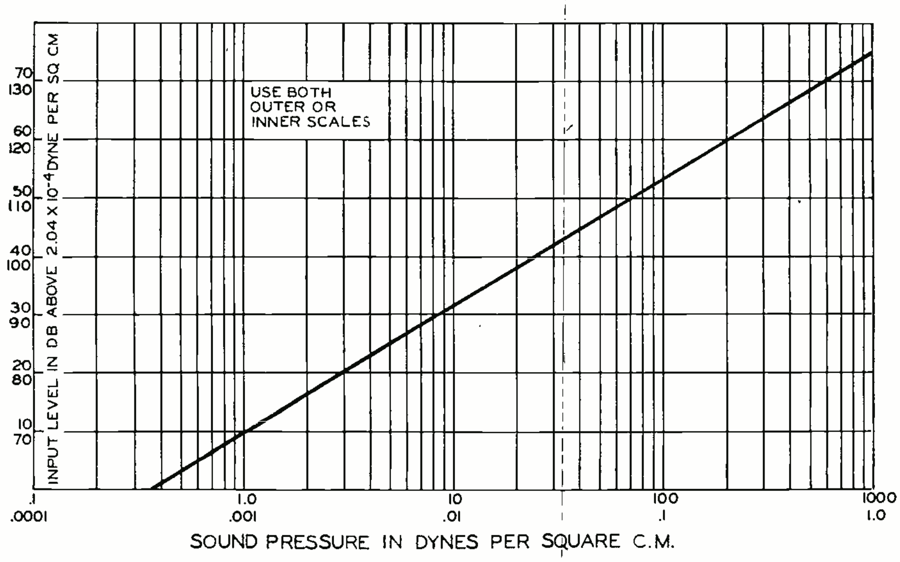
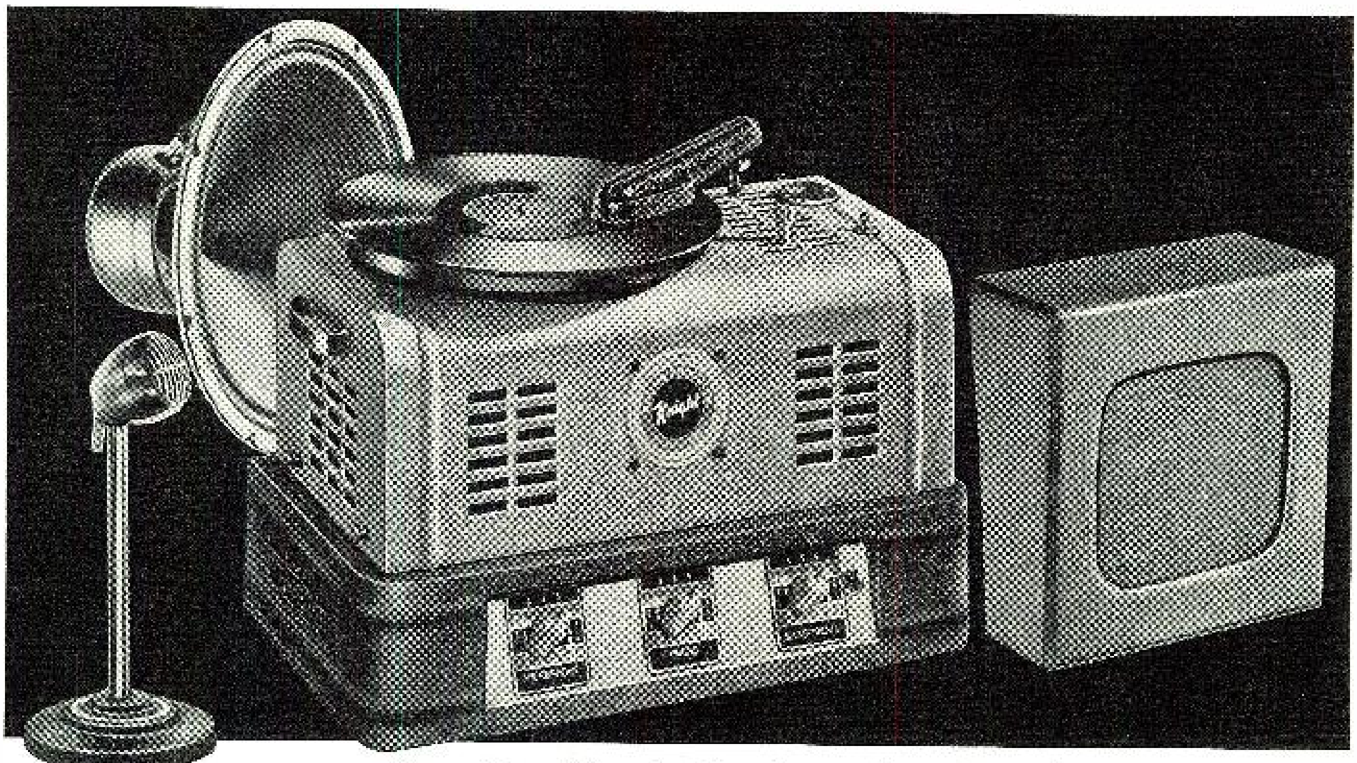


Fig. 3. Relationship Between Sound Level and Sound Pressure.



Commercial amplifier evolved from the principles applying to home-built units.

Designing a P.A. AMPLIFIER

by LOUIS M. DEZETTEL

It's easy to design an efficient amplifier if you apply certain fundamental formulae to its construction and basic requirements.

THIS article is directed to the readers of RADIO NEWS who might not be thoroughly versed in the *fundamentals* of a P.A. amplifier. We believe it will assist them to clearly understand the functions of the various parts of a P.A. amplifier.

We all know that a P.A. amplifier "amplifies audio frequencies" much the same as the audio channel in a radio. A P.A. amplifier, however, must meet certain requirements not ordinarily required in a radio and in this respect the engineering that goes into it is somewhat different.

First, a P.A. amplifier must have greater *usable* power output, and in the output there may be one or several speakers. The speaker or speakers must be carefully matched to present the proper load to the amplifier. This is necessary if you want the "mostest" from the amplifier. Second, the amplifier must have sufficient amplification to make the use of a low-output microphone possible. Third, the response to, or amplification of, all frequencies of the sound spectrum must be uniform. This is what is meant by "flat frequency response." Fourth, it must amplify sound without distortion. All amplifiers produce some harmonics of the frequencies they amplify. This is known as *harmonic distortion*. An amplifier having up to 10% distortion is considered distortionless for practical purposes. These are the fundamental requirements.

In addition to the above an amplifier must have other features which add to its flexibility. It must have a number of input channels—the number depending upon the use required. The minimum number are usually two—one for a microphone and one for a phono-pickup. If you plan on using more than one mike at a time, the amplifier must be selected or built, to have the required number of high-gain or mike inputs.

An amplifier must be capable of "fading" the inputs, one into the other. It ought to have at least one control for varying tone. Although the use of one violates the requirement of the flat response mentioned, it is sometimes desirable to produce certain effects, especially when playing music. And last but not least the amplifier should give not just the "mostest," but the "mostest for the leastest" when it comes to expense. Its tube line-up should, therefore be carefully selected.

Now, let's build ourselves an amplifier, on paper, of course, and see what goes into the design of one.

It is usual to start at the *back end* or power stage when designing an amplifier. Let us assume that the use of our amplifier will be for indoor halls of not more than about 5,000 sq. feet and outdoor fields of about 2500 sq. feet in area. These areas can be covered with an amplifier of from 12 to 14 watts output. The figures can be calculated mathematically but leading radio mail order companies have done this for us and publish simplified charts on this in their catalogs.

Our tube charts tell us (again we avoid mathematics) that a pair of 6V6GT's in push-pull, with 300 volts on their plates and screens is capable of producing 13 watts of audio power. 6V6's are beam-power tubes and have high power sensitivity. By this we mean that they produce comparatively large power output with small signal voltage input. This is in line with our policy of getting the "mostest for the leastest." Although beam-power tubes have a tendency to produce quite a bit of 2nd harmonic distortion, when used in push-pull the 2nd harmonic and all even order harmonics are cancelled out. The manuals and charts tell us that with 300 volts on the plates and screens of a pair 6V6GT's the total current consumption (in plates and screens) is 83 ma. without a signal and with 20 volts of bias on the grids. The recommended plate-to-plate load is 8000 ohms. This is called class AB1 service.

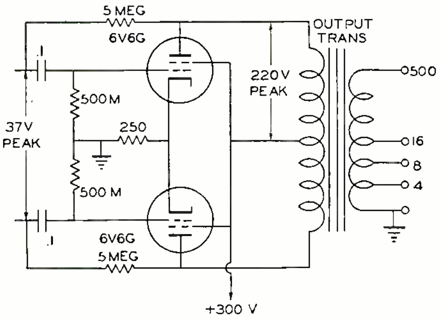


Fig. 1. Power Amplifier Stage.

Let's look into that class AB1 business for a minute. There are four classifications for the power stage—A, AB1, AB2, and B. In class A service, the bias for the power stage is of such a value that the tube operates over the straight portion only of the characteristic curve, the bias voltage value falling in the middle of this curve. This class is always used for a single tube power stage and sometimes for a push-pull stage. The output wave (considering one tube) is exactly like that applied to the input of the stage. Class A service produces the best quality (least distortion) but is low on power sensitivity.

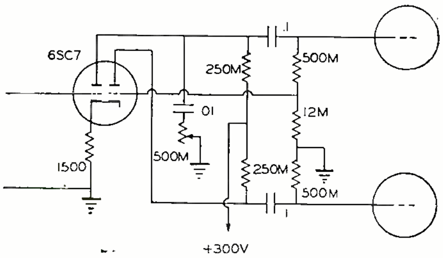


Fig. 2. Phase Inverter.

For class AB1, the bias is increased slightly (about 40%). The tube operates with its bias nearer the bottom of the straight portion of the characteristic curve. The output has high 2nd harmonic content but when two tubes are operated in push-pull the 2nd harmonic distortion cancels out. Class AB1 service has a little less quality but greater power sensitivity than class A.

Class AB2 is similar to class AB1 except that the stage is driven harder. In fact it is driven to the point where the grids go positive on voltage peaks. This requires a driver stage capable of delivering some *power*. The bias on a Class AB2 stage must be fixed and the power supply must have very good regulation. Class AB2 produces a considerably greater amount of power than class AB1.

In a class B stage the bias on the tube is of a value that almost cuts off the plate current. One grid or the other is nearly always positive. Greater power is required of the driver. From the same plate voltage and tube size (dissipation rating) class B service produces the greatest amount of power. The distortion content is higher than for any of the other classes, however.

Getting back to our 6V6GT push-pull power stage, let's draw a circuit diagram of it (Fig. 1). Although the 20 volts bias indicated in the tube manuals should be from a fixed source we are going to use cathode biasing. We divide the 20 volts bias required by 83 ma. current and find we can use a cathode resistor of about 240 ohms. The square of the current times the resistance equals the wattage dissipation in the resistor. This equals about 1.7 watts. Resistors are cheap enough so let's use a 10 watt resistor at 250 ohms for cathode bias.

Because of the cathode resistor our distortion will be slightly higher than the published 4% at 13 watts, but we are going to reduce it some later by adding inverse-feedback. In push-pull stages, the AC voltages across the cathode resistor are equal and out of phase, therefore no a.c. voltage appears across the cathode resistor. This resistor need not be by-passed with a condenser.

An output transformer is required for reducing the impedance necessary for the tubes (8,000 ohms in this case) to the impedance of a speaker (8 ohms). If two speakers are connected in parallel, their combined impedance is 4 ohms. If connected in series their combined impedance is 16 ohms, exactly as in the case of resistors. In addition, we may want to locate the speakers several hundred feet from the amplifier. At such distances the resistance of the line would cause considerable loss at 4, 8 or 16 ohms. Our output transformer should have a 500 ohm secondary tap, too. At the other end of the line a 500 ohm to voice coil transformer would be used. If of poor quality, the output transformer will have a tremendous effect on frequency response. It should be a good husky job, with plenty of iron and copper wire in it.

Up to this point we have dealt with *power*. From this point back, voltage amplification is what we seek. The manual says that our power stage requires a peak grid-to-grid voltage of 30. That figure is for a power stage with fixed bias. When cathode bias

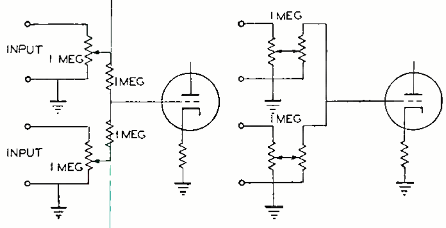


Fig. 3. Mixer Circuits.

is used we must have a voltage swing about 25% greater for the same output. Let's put our figure at 37 volts peak grid-to-grid. Because of the increased drive the dissipation requirements of the tubes are slightly higher, so at this point we switch to 6V6G tubes which have a little higher plate and screen dissipation rating.

It is necessary now to add a phase inverter ahead of our power stage. As a rule amplifiers do not operate push-pull all the way through. It is not

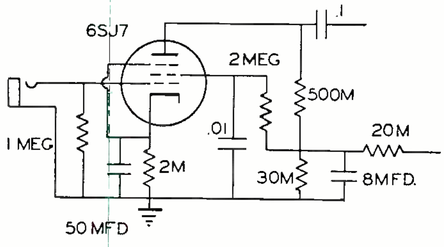


Fig. 4. Microphone Amplifier.

necessary because voltage amplifying tubes have negligible distortion, even when operated single ended. A phase-inverter changes the single phase voltage to push-pull. *There are many types of phase inverters and they are fully covered in another article in this issue.*—Ed.

Special requirements may dictate the choice of the phase-inverter cir-

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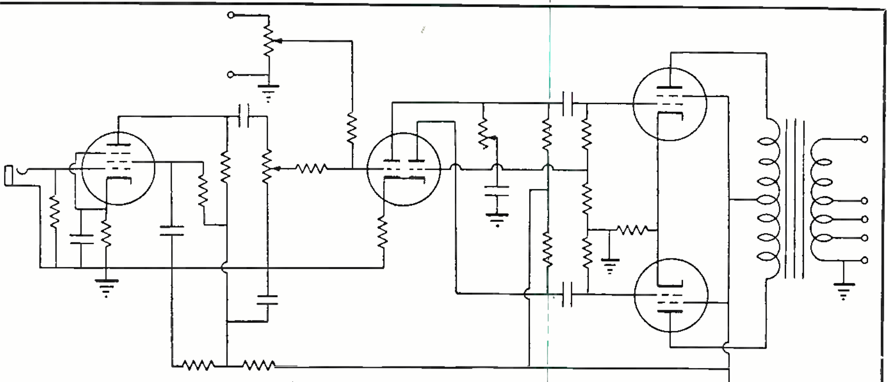


Fig. 5. Complete Amplifier.

SERVICEMAN'S EXPERIENCES

by LEE SHELDON

I THREW the door of the shop open hard when I came in to show how mad I was. Al was sitting at the *Salutary Sales & Service* desk, behind the partition that divides our sales department from the accomplishment section.

"It's me," I announced, so he wouldn't think I was a customer, and I slammed the toolbag down hard.

"What's with you?" my partner asked, "a bull elephant?"

"Aw, this business gets me down," I answered sulkily, shoving the tube checker back against the wall. "Some people want you to work for nothing!"

Al went "tsk, tsk," and rattled his newspaper.

"I mean it," I told him, walking back to the desk. "It's those doggone air raid wardens who 'phoned this morning. Just because *they* don't get paid, they have an idea that everyone else should give them things free!"

"Mmm," Al replied, with rising inflection, but without glancing over the top of his paper.

"This fellow Peterson's the worst," I explained. "He's a sort of a procurement board for the local outfit. Know what he did? They've got a vacant store on Walker Avenue they're using for a meeting place—rent free, of course—and they furnished it with a couple of old chairs and a rickety table. The owner of the delicatessen store next door rigged up a light for them from his own meter, and someone else lent them an oil burner. So guess what happened."

Al didn't guess.

"Peterson called me up," I told him indignantly, "saying he had a rush job for me. I went right over, and he showed me a broken-down *Majestic 72*. I explored under the dust for a while, and told him it needed everything between the drive cable and filter block before it would play again. Besides, if we took the job—"

Al whistled, but kept his nose in the paper.

"—if we took the job, the only thing that was worth salvage would be the escutcheon plate, and recommended a new set. 'Isn't there anything else on it that you can save?' he wanted to know. 'Well,' I told him, real sarcastic, 'perhaps if we were real careful, we could rejuvenate the pilot light. The rest of the set's as useless as the second *b* in obbligato.' He claimed the boys had chipped in on a lot of other things, and that they couldn't afford a new set. He insisted on a quotation, so what could I do? 'Well,' I said, 'twenty-five bucks for the whole job complete, which includes not saying anything to the Department of Sanitation.'"

"Read this morning's paper yet?" Al asked.

"Peterson sorta jumped when I gave him the price, but he said he had to get a receiver in his work somehow. Imagine—the guy actually wanted me to work for nothing, as if it was a patriotic duty, or a social responsibility to my community! 'Look here,' I told him, 'your needing a set is no sign—'"

"Boy, what an article I've been reading about the Marines on Wake Island!" Al said, admiringly, pretending he wasn't listening to me. "What a bunch of scrappers!"

"Wait a minute, Al," I said, "Lemme finish. This Peterson—"

"The fight at Wake began when our Marines were japped in the back on December seventh," Al informed me, with his head deep in the paper. "They say the exact reports won't be available for years, but it seems there were only about 400 Marines on the Island, and only twelve planes. After the first attack, eight planes were destroyed on the ground, and the field was unusable. Twenty-five men were killed by machine-gun fire, and others were injured."

"Al, please," I tried to say, "wait till you hear—"

"And then, on the next day, twenty twin-engined bombers raided the place. Wake Island is shaped like a hollow arrow-head, with each side about three miles long, and it's not more than a mile thick at any point. It's very flat—a tough place to be when an air force comes after you. There was another attack the same day, assisted by shelling from warships. The aircraft came in waves. Our men sank a cruiser, a destroyer, and got six planes. 'Transports were sighted, but they made no attempt to land.' Ah-ha—the yellow lads saw they were up against something tough. Eighteen planes came in once, but only sixteen rose out of the dive."

"Please listen to business, will you?" I asked. "Don't you think I was right in refusing to do that warden's job free, even if—"

"On the eleventh," Al went on excitedly, "a big four-engined bomber came in for the kill, but the boys weren't impressed. They shot it down. Oh, man! 'The convoy reappeared and was attacked, and one vessel was severely damaged.' Then they sank a Japanese submarine."

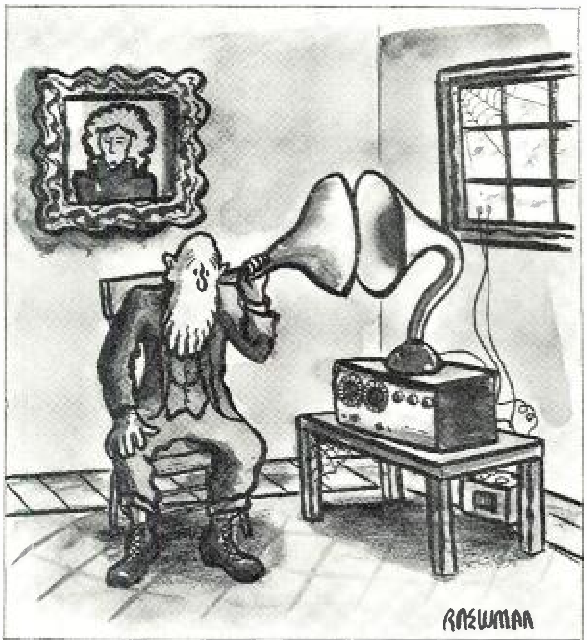
Al lowered his paper and looked at me for the first time.

"Isn't that rich?" he asked, without waiting for an answer. "They *sank a submarine*. Just like that—like a man would order dessert. They knew they were outnumbered, that they could be out-maneuvered, out-ranged, and out-shot by the enemy, but they didn't sit around talking about giving up. No, sir! . . . Let's see what else it says."

When his head disappeared, I tried again.

"They were good fighters," I agreed, "but how about this guy's *Majestic?* Do you think that if I only charged for what the parts cost—"

"Here we are—listen to this," Al interrupted. "On the thirteenth, the enemy bombed them by moonlight (our little playmates are getting cautious, eh?), and on the next day fifty planes attacked. The Yanks got three of them. Meanwhile, our planes were up in the air—all three of the four that hadn't been damaged. Then two went out of commission—one was hit on the ground, and the other smashed its landing-gear as it landed and hit a bomb crater. Sounds like a real American fight."



(*Continued on page 60*)

PRACTICAL RADIO COURSE

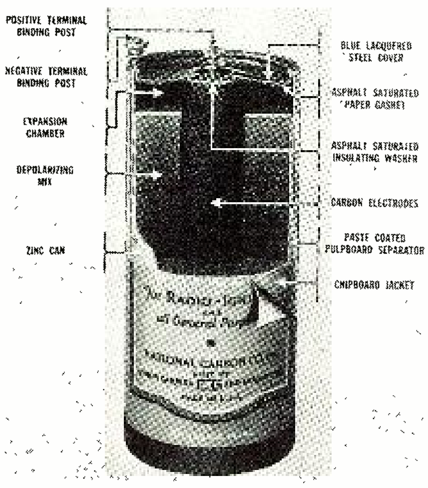
by ALFRED A. GHIRARDI

Part 3 in a radio course prepared especially for students

Sources of E.M.F.

THE most commonly employed sources of power for vacuum-tube radio receivers are the electric light lines. In some localities these supply direct current (d.c.) but in most sections of the country the supply is of the alternating current (a.c.) variety. This is fortunate because alternating current offers a number of advantages, one of the most important of which is that the voltage can be stepped up to any desired higher value, or reduced to any lower value through the use of simple transformers.

Direct current supply can be stepped up only by relatively expensive means that are usually not deemed practical for home receivers, therefore radio sets operated from 115-volt d.c. lines usually do not have applied plate voltage greater than this value. D.c. line voltage can, however, be reduced to any desired lower value through the use of dropping resistors of suitable value.



Conventional dry cell.

The electric-light lines constitute by far the most practical source of supply for most radio purposes. Where batteries are employed they require checking, periodic replacement (in the case of dry cells) or recharging (in the case of the storage battery), and thus involve a certain amount of bother and expense not encountered with line supply. On the other hand a battery operated receiver can be used anywhere without dependence on an electric light line. The automobile radio which operates from the car's storage battery is one example; the increasingly popular portable receivers, with a built-in compartment in which they carry their own dry-cell batteries or a small storage battery, is another.

Later in this series the operation of radio equipment from various sources will be considered in more detail. At this time, however, it is appropriate to consider batteries as a source of e.m.f. for operating radio equipment.

Wet and Dry Cells

If plates of two specified materials, such as carbon and zinc, are immersed in a suitable chemical solution an electrical potential will develop between them with the result that current will flow through a wire connected externally between the plates. This is the principle of the wet primary cell.

The action is purely a chemical one and is briefly as follows:

When by some means one or more electrons are removed from a normal atom, the atom becomes electrically unbalanced, due to the loss of a portion of its negative charge, and its overall charge becomes positive. Such a positively charged atom is known as a positive ion. The electrons thus removed are known as "free" electrons. Should one or more of them attach itself to another normal atom, that atom will assume a predominantly negative charge and becomes a negative ion.

When salts or acids are dissolved in water, many of their molecules become dissociated, yielding both positive and negative ions. When a plate of zinc and another of carbon are connected together to form a conducting circuit and are then placed in such a suitable chemical solution, positive zinc ions enter the solution, leaving some of their electrons on the zinc plate. The resulting accumulation of electrons (negative charges) make the zinc plate negative. The positive zinc ions entering the solution tend to repel other positive ions already in the solution, driving them to the carbon plate. There they attract electrons from the carbon and once more become neutral or balanced atoms but in extracting these electrons from the carbon, leave it positively charged.

The overcrowding of the negative electrons on the zinc plate, each tending to repel one another, pushes some of them off and these are drawn around through the conducting circuit by the attraction set up by the positive carbon plate. This repelling action, coupled with the attraction of the carbon plate constitute the electromotive force of the cell. This force causes a flow of electrons from the zinc to the carbon plates, through the external circuit. In conventional terminology of electrical current flow, the current is said to flow from the carbon plate, through the external circuit to the zinc plate. It is a direct current. Such is this current that if a low-power lamp or a bell is connected in this circuit it will be made to operate.

Typical B battery construction.

The much more common dry cell is similar to the wet cell in its action but its construction differs. The zinc negative electrode forms a container for the cell. The sal ammoniac electrolyte is in the form of a paste (the "mix") with the carbon-electrode in the center. Thus the dry cell is nonspillable and is, therefore, much more convenient for ordinary use because it may be employed in any position.

These dry cells vary in size from the tiny flashlight cells to the large No. 6 cells (illustrated). Regardless of size, the e.m.f. per cell is approximately 1½ volts. All other things being equal, the greater the zinc area exposed to chemical action in a dry cell, the greater is its current capacity.

A "battery" is a combination of 2 or more individual cells built or connected as one unit. In one type, a number of individual small cylindrical cells similar to the ordinary flashlight cells are assembled together and so connected that the total e.m.f is the sum of their individual e.m.f.'s. In the other type space is saved by making the individual cells in flat pancake shape and stacking them one against the next so they make direct contact with each other.

Other chemicals are employed (in addition to the basic electrolyte) to aid the functioning of the cell and can perform their functions only within certain limits of speed. For this reason current cannot safely be drawn from the cell in excess of specified limits. Moreover, the cell life is greatly extended if it is used intermittently rather than continuously because then the chemical actions have an opportunity during rest periods to catch up with their jobs.

Storage Cells and Batteries

The storage battery is not, as many believe, a storage place for electricity. Instead it provides means for converting an electrical charge into chemical energy, storing this and reconverting it to electrical energy as required. The usual lead-acid type storage cell contains specially constructed electrodes of lead peroxide and spongy lead immersed in a dilute solution of sulphuric acid and distilled water. The actual chemical action is a rather complicated one and it is hardly necessary to go into its details here.

An important advantage of a storage battery is that it is capable of delivering much larger currents continuously than is a dry cell of comparable size. Usually such a battery consists of three cells of 2 volts each and the voltage supplied by the battery is, therefore, approximately 6 volts and may be used for the direct operation of the filaments of 6-volt vacuum tubes. Its current capacity is ample to supply the requirements of even large receivers that employ many such tubes. Another advantage is that the storage battery can be recharged up to full capacity time and time again.

The storage battery can supply all operating power for a receiver through the use of a separate device known as a "vibrator power supply." This converts the 6-volt output of the battery to any higher desired value required for the plate circuits of the tubes. Such a vibrator device is built into automobile radio receivers so that the only voltage

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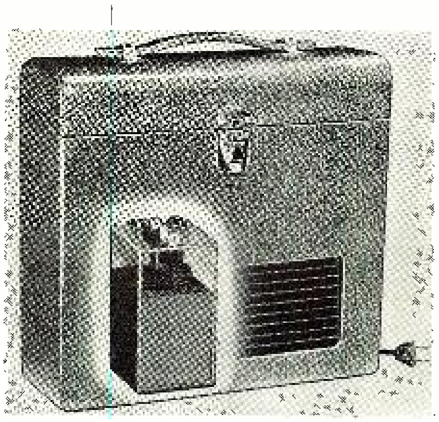

The special wet A battery.

Beginner's Dynamic Demonstrator

by DAVID GNESSIN

This home-built demonstrator can be used in teaching radiomen the theory and application of fundamental circuits used in everyday sets.

FROM the start let it be clearly stated: this demonstrator is designed to be built and used by the radio beginner. Every step will be carefully outlined with diagrams and photographs to thoroughly explain everything to the novice. So, let's begin:

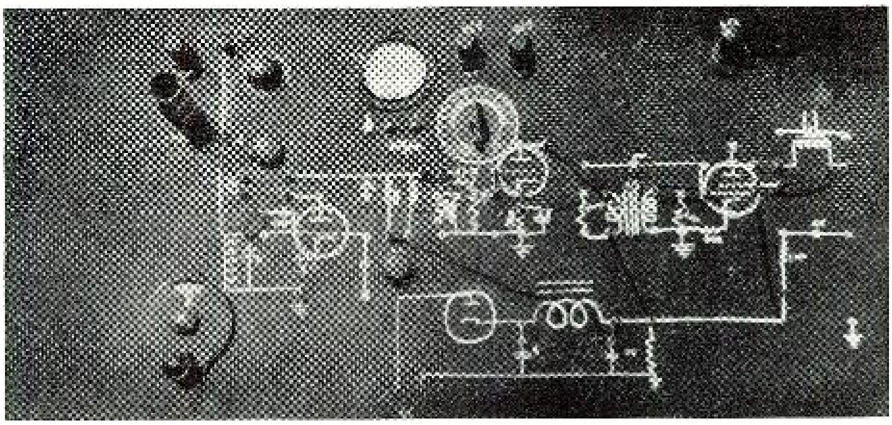
A Dynamic Demonstrator is a device which can be used to demonstrate and study operating principles while the apparatus is actually operating. At least one large radio manufacturer has a Dynamic Demonstrator for sale to schools, etc., priced at $75. That demonstrator is a radio receiver with provision for plugging in test devices and meters for trouble-shooting.

The Demonstrator we're going to build has all that and provision for plugging in dozens of circuits, such as:

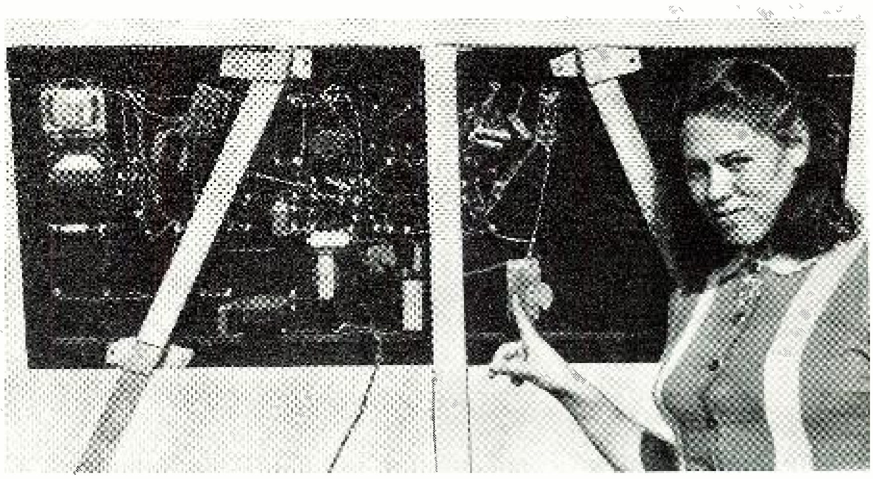
1. Speech amplifier with provisions for connecting carbon, crystal or dynamic microphone, with two stages of amplification, suitable for small public address system or intercommunications system.
2. Transformer-coupled amplifier. For general purpose amplification.
3. Resistance-coupled amplifier. For use with radio, phonograph, or any other audio amplification.
4. Audio oscillator. For code practice or signal generator.
5. Regenerative receiver. This feature alone makes the demonstrator worth building.
6. Phone or c.w. monitor. For monitoring your own transmission. This is an FCC requirement when operating a transmitter.
7. R.f. oscillator. For lining up receivers.
8. Crystal-controlled c.w. transmitter . . . and numerous other circuits.

The photographs show the Demonstrator isn't too complicated. It uses four 6.3 volt tubes, namely, 3—6C5's and 6F6. However, it would work as well, with slight reduction in power, with 4—6C5's. This would make the replacement problem simpler. The slight circuit change is explained in the text. The tubes may be either metal, glass or GT type. They all have the same base and socket connections.

The demonstrator shown was constructed of old junk parts which lay about the cellar retrieved from old receivers. You'll probably have to buy at least the speaker and possibly the phone tubes. Oh, yes, the tip jacks and phone tip plugs will have to be purchased. They will probably constitute your greatest single investment. There are sixty of each. However, the investment is a good one. It guarantees you will never again have to solder or unsolder or mount a single piece or connection.



The front of the board shows approximate position for mounting the parts.



The author's XYL indicates the position of the variable tuning condenser.

All the units are mounted permanently on the back of the board. All connections are made from the front through the tip jacks. The tip plugs have solderless connections. Thus they may be renewed if a wire should break, without solder.

Since the unit is not designed to be stripped for parts when the creative urge calls, give some care to its components. The most important moving parts are the spring prongs on the tip jacks. Get the best jacks you can afford. You will be constantly plugging and unplugging, and cheap ones may foul with wear.

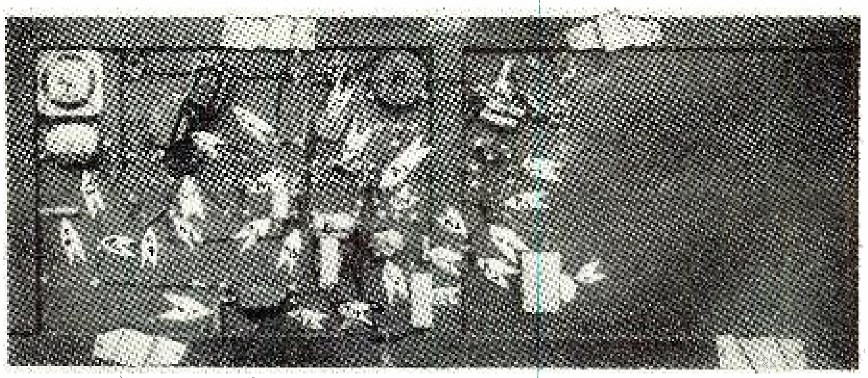
As the operator becomes more proficient with use of the demonstrator he may want to build circuits beyond the many this unit provides. In this case mount the extra permanent units, such as condensers, resistors or transformers in the back and bring out the leads to more tip jacks. Then draw in the schematic diagram on an unused part of the board and start plugging! If the board is big enough it can house a plug-in broadcast transmitter; HI!

Now, as to the item of cost. The unit shown cost the writer something under $10. No exact check was made, but a quick check of the list of parts will show that if you have one or two old receivers junked in the cellar (almost any vintage will do) the additional parts required will not come to more. In any case, new parts out of the latest catalog will come to a maximum total of less than $20. But think of the potentialities! In one instrument all normal (and even some abnormal) radio hook-ups for beginners is included. (It must be hastily added the meter shown is additional. It is not absolutely necessary. The only reason it is included is because this demonstrator was used in classroom instruction and the meter showed operating voltages and current.)

Even the younger students can be taught with the aid of this demonstrator.

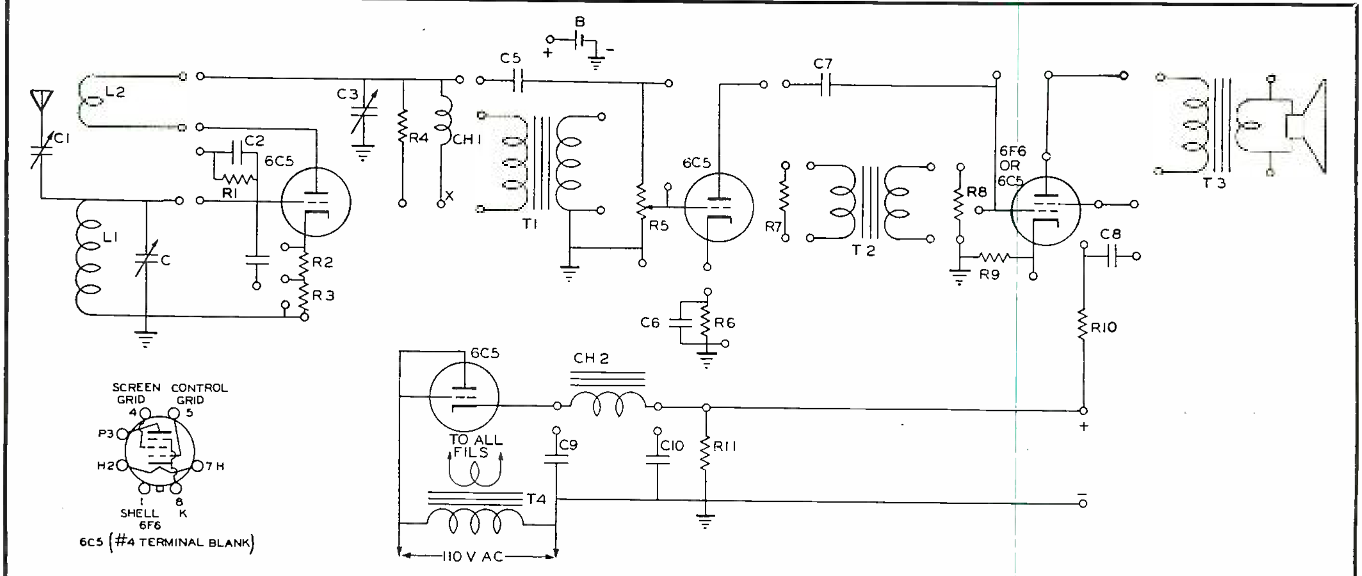
Construction

Now to the serious business of construction: While you're waiting for your parts order to come (you've previously torn out the list of parts and sent it with the necessary coin and are anxiously waiting to begin), you obtain a large section of composition board from the lumber yard. Get the best you can. The very cheap stuff will disintegrate as you cut and drill. The thickness should be anywhere near one-quarter inch. The length is 49 inches and the height 19 inches. If a piece is already smoothly cut a little larger or smaller than that, use it that size and don't risk spoiling it by cutting. Inspection of the photograph of the front view will show that this size not only accommodates all the units but has a third more room to spare. This is for a purpose.



The arrows indicate the various parts which make up the final layout.

Later, if the response warrants it the writer will develop the demonstrator to include the mixer-oscillator i.f. sections of a superheterodyne. Then the demonstrator will have everything! This extra section will just fit into that spare space. However, for the present, the unit has quite enough for the beginner! (If the builder doesn't want to wait for the superhet, he can just spread out the (*Continued on page* 55)



C, C₃—100 mmf. variable, Bud
C_1—15 mmf. variable, Bud
C_2—.00015 mfd. midget mica, Mallory
C_4—.01 mfd., 400 v., Mallory
C_5, C_7—.004 mfd. midget mica, Mallory
C_6—.5 mfd., 200 v., Mallory
C_8—.05 mfd., 400 v., Mallory
C_9, C_{10}—8 mfd., 450 v. electro—Mallory
R_1—2 megaohms, 1 w., IRC
R_2—2,000 ohms, 1 w., IRC
R_3—8,000 ohms, 1 w., IRC
R_4, R_7—250,000 ohm, 1 w., IRC
R_5—500,000 ohm pot., Yaxley
R_6—15,000 ohm pot., Yaxley
R_8—1 megaohm, 1 w., IRC
R_9—600 ohm, 1 w., IRC
R_{10}, R_{11}—100,00 ohm 1 w., IRC
Ch_1—2.5 M. H. R. F. choke, National R1000
Ch_2—10 hy @ 40 M. A. filter choke, Thordarson.
T_1—Microphone to grid, Thordarson, T86A02
T_2—Interstage transformer, Thordarson, T13A34
T_3—Universal voice coil to spkr, Thordarson
T_4—6.3 v. filament transformer, Thordarson
B—1.5 v. flashlight cell
Spkr—Utah P M
Tip jacks and plugs—Yaxley
Tubes—Hytron

TECHNICAL BOOK & BULLETIN REVIEW

MATHEMATICS FOR ELECTRICIANS AND RADIOMEN, by Nelson M. Cooke, chief Radio Electrician, U. S. Navy. Published by *McGraw-Hill Book Company, Inc.,* New York. Price $4.00. Contains 604 pages. Electrical and radio engineering students have need for a course in mathematics that is directly concerned with application to electrical and radio circuits. This book is intended to provide those students with a sound mathematical background and to further their understanding of the basic principles of electricity. Any student who can perform arithmetical computations rapidly and accurately is capable of mastering the principles laid down in this text, if he applies himself properly. The student who has had some high-school mathematics will find that the earlier chapters form a comprehensive review and will aid him in applying mathematics to radio and electric-circuit theory. This textbook is intended to provide a mathematical background adequate for the solving of practically all everyday electrical and radio problems. If the student desires to proceed into the realm of higher mathematics in the study of radio and electrical design problems, he will find that this subject matter will give him a firm foundation on which to build.

The text follows an electrical rather than a purely mathematical arrangement, although there is no loss of mathematical continuity.

A double system of article, problem, and figure numbering has been followed in order to facilitate cross reference to a given article, problem, or figure in a minimum of time. A most timely text book and suited admirably to help in guiding the many new students in Radio and Electricity.

HOW TO MODERNIZE RADIOS FOR PROFIT, by M. N. Beitman, published by *Supreme Publications,* 328 So. Jefferson St., Chicago, Ill.

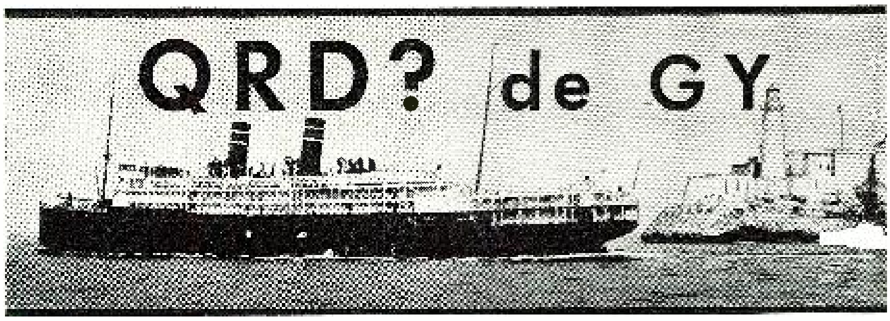
Because of the increased diversion of materials and factory facilities to war production, very few new sets will be offered to the public in the near future. Also a great many Americans will have more money to spend for improved radio reception and will be greatly interested, because of important news broadcasts, in keeping their radio receivers in tip-top shape.

In this manual you are told how to improve the appearance of any set by refinishing the cabinets, building new cabinets. or adding improvements to the old cabinets housing the radios. Hints on paints, finishes, removal of scratches are given. Suggestions for using bookcases, tables, and other pieces of furniture for holding the radio chassis are included.

Suggestions for adding late improve-

(*Continued on page* 54)

QRD? de GY



by JERRY COLBY

AFTER this war is won and we settle down to the humdrum life that existed before this shindig got started, we wonder whether the powers-that-be will begin all over again explaining that radiops are only superfluous gear carried aboard a ship just to satisfy government edicts. Or will they, perhaps, remember the heroism shown by American radiops sailing the Seven Seas as exemplified by Brother Robert S. Thorp of the former Unifruitco Freighter San Gil, which was sent to the bottom by a submarine off the Maryland coast on February 4th. Brother Thorp is credited with saving the lives of thirty-nine crew members and one passenger because of his initiative, ability and bravery in the face of enemy gun fire, freezing weather and a listing ship that threatened momentarily to heave him into the ocean as he rigged up an emergency antenna and transmitter.

It was ten minutes before midnight when the San Gil shuddered from the first torpedo fired by the U-boat. The radio shack was completely dismantled from the shock. Brother Thorp with years of experience as an operator did not have to think twice. And Captain Walter W. Koch says that if it weren't for this fact they might still be drifting about waiting for an Act of God to send succor their way, instead of which Brother Thorp's SOS brought rescue vessels just seven hours later. Of course we could pull a rave over the fact that auxiliary equipment was not aboard this boat as well as hundreds of other ships that are under American registry but we would only be rehashing our continuous lament of these many years. We hope, tho', that reports like these, and there have been many, and there will be many more before this fracas is done with, will be remembered by shipowners when radiops request the recognition accorded officers and heroes.

REMEMBER PEARL HARBOR!

AND speaking of heroism take a gander at the radiops who are daily playing checkers with Davey Jones, taking vessels out but not knowing when or if they would be bringing them back. When unsung heroes are to be "sung" someone should give these men a thought; the men who are making it possible for England, Russia, China and our other Allies to get the supplies so necessary for their existence and morale. Then there are thousands of radiops who are entering the Navy to do their bit towards making this a short and decisive victory for the U.S.A. Will the shipowners haggle over a few paltry dollars when representatives of these radiops request wages on a par with professional men? We hope not. In ye ed's own circle fifteen have already joined up with Uncle Sam's Navy and not having heard from them since they donned the uniform is plenty assurance to us that the Navy is out there stepping high, wide and handsome, and woe betide the enemy that gets in their way.

BROTHER J. C. HILL out of Ridgefield Park, New Joisey, wants to

(*Continued on page* 61)

"He says to QRT until the Lone Ranger is off!"

WHAT'S NEW IN RADIO

RCA Phonograph Instrument

A new table model *RCA Victrola* which achieves a tone quality unique in instruments of its type and size has been announced by Allan B. Mills, Manager of Television and Phonographs Sales.

Its output comparable with that of small console phonographs, the new instrument is none the less only 7 inches high, 8½ inches wide and deep. Its cabinet is of wood, and is carefully designed to act as a soundboard for

the 5-inch dynamic loudspeaker. Simulated leather is used to cover the cabinet.

"This instrument is entirely new in design and has been introduced to fill a long-felt need for a low-priced table-model phonograph with more than ample volume," Mr. Mills said. "It is ideal for apartments or homes where space is at a premium, but it will find a place in dormitories, dens, 'rumpus rooms', and a score of other locations where music for entertainment or dancing is desired. It is an excellent phonograph for children, altho in no sense of this word is it a toy!"

The instrument is designated as Model R-56. Its motor is self-starting, and the on-off switch and volume control is located handily on the top of the cabinet serving the dual purpose of a tone arm rest. Either 10- or 12-inch records may be played.

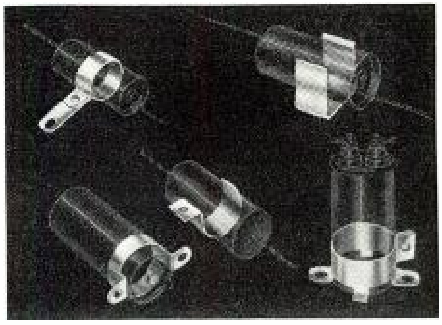
Compact Voltage Regulator

A voltage regulator, no bigger than an ordinary box camera, is now helping supply current to radios and instruments of planes, according to Sherwin H. Wright, aviation industry engineer of the *Westinghouse Electric and Manufacturing Company*. It is equally efficient in the steaming heat of Panama's jungles or high over Alaskan icefields.

Universal Mounting Feature

When it becomes necessary to replace defective capacitors in some receiver designs, complications are introduced for the service man by special mounting features incorporated in the original capacitor and not duplicated in the stock of replacement capacitors on hand.

The accompanying photo shows examples of the mounting hardware

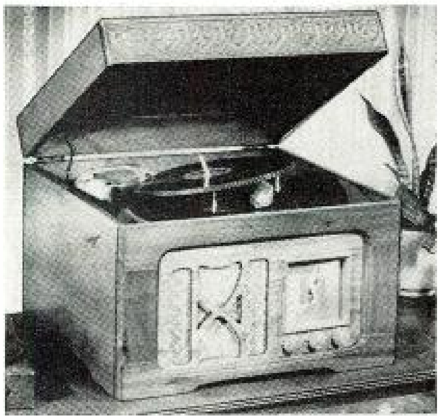


made available by *Cornell-Dubilier* for this purpose and supplied through regular C-D distributors. The two ring types shown are supplied for can diameters from 1" to 3½"; the clip type for diameters of ¾" to 1⅜"; the clamp type for diameters of ⅝" to 1½"; and the strap type for diameters of 7/16" to 1½".

By including a reasonable variety of this mounting hardware in his stock, the service man reduces to a minimum the number of replacement capacitor types required. Thus he not only insures maximum inventory economy but his ability to service just about any capacitor-replacement requirements that may present themselves.

Sonora Table Set

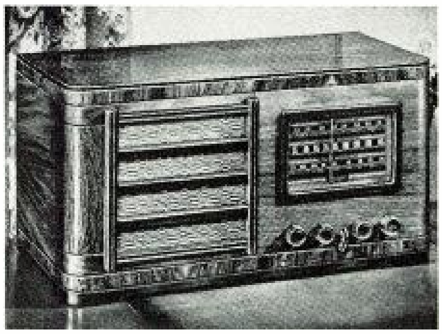
Music lovers who wanted the luxury of an Automatic Record Changer in an attractive table model instru-



ment, inspired *Sonora Radio & Television Corp.*, Chicago, to create this 5 Tube A.C. Automatic Phono-Radio. It plays twelve 10" or ten 12" records at a single loading, and enables the listener to hear his favorite records for thirty minutes without touching the instrument. The radio is a new 1942 Superhet; tunes 535-1720 kc. Includes built-in "Sonorascope" loop; clock-type Gemloid Dial; Dynamic Speaker; Automatic Volume Control. Cabinet is distinctly designed of contrasting-grain walnut veneers with carved-effect hinged lid. Size: 17" wide, 12¼" high, 15½" deep.

Knight 8-Tube AC-DC Superhet

Allied Radio Corporation, Chicago, presents a new All-Wave 8-tube a.c.-d.c. superhet table model radio, Model D-304. Tunes three full-wave bands covering all major radio channels:



2.25 to 7.2 mc. and 7.5 to 24 mc. for short-wave reception of foreign and domestic programs, Amateur, Aviation, and Police Signals; and 535 to 1650 kc. for powerful reception of American and Canadian standard Broadcast programs.

Advanced 1942 features include r.f. on all wave bands; new rotatable loop aerial; big slide-rule dial; three-gang tuning condenser; full a.v.c.; eight-inch Electro-Dynamic speaker, etc. The new 1942 circuit is licensed by RCA and Hazeltine and provides the latest efficient tubes: 6SK7GT as r.f., 6SK7GT as i.f.; 6SA7GT as osc.-mod.; 6J5 as a.v.c.; 6SQ7GT as det.-1st audio; 25L6GT as power output; 2—25Z6GT as rect.

The cabinet housing the *Knight 8* is constructed of choice walnut veneers with contrasting grain effect. Cabinet measures 22½" x 11¼" x 10½". Operation is from 110-120 volt, 40-60 cycles, a.c. or d.c. Model D-304.

A product of *Allied Radio Corporation*, 833 West Jackson Boulevard, Chicago, Illinois.

25-Watt Mobile Amplifier

A 25-watt amplifier, which uses either 6 volt battery or 110 volt a.c. power, is now offered by *John Meck Industries*, 1313 W. Randolph St., Chicago. Ideal for mobile cars, or for addressing large indoor and outdoor meetings, this Model BM-25C operates from any 6 volt battery without power pack, changeover from battery to a.c. being made by the flip of a switch.

A feature of this unit is the special "economizer" switch which keeps

(*Continued on page* 44)

Spot Radio News

IN DEFENSE AND INDUSTRY

WASHINGTON — Reports reaching here of the existence of a worldwide Nazi radio espionage network have aroused considerable interest in the Capital. The story here—which has its origin in "Free German" circles—is that the Nazis have succeeded in girdling the earth with networks of low-power transmitters which can be detected only with luck.

According to reports, this radio system was laid out years ago. The Nazis realized that there was not much chance of keeping high-powered transmitters secret, because of the advances in the art of monitoring. So it was decided to set up a series of small, portable transmitters, which would send weak signals over short distances.

These signals would be so weak that monitoring stations would not intercept them. The plan, of course, entailed a vast organization and the low-power transmitters could be used only on continental areas. Thus it would be possible to set up such a network throughout a continent like South America or Africa. Indeed, British Intelligence has found proof of the existence of such a network in Africa and the near East.

But to jump oceans, stronger transmitters were needed. It is believed that German submarines and surface vessels have cooperated with the weak shore stations and it is known that strong stations on this continent have passed on information gathered by German spies.

The terminus of the network in Europe is believed to be in Southern Greece. From there it stretches East into Asia and west into the Americas. Two Germans, disguised as Arabs, were arrested by the British as they traveled toward India in a caravan. Both were found to have small transmitters. If you've noticed the news from South America lately, there has been report after report of the seizure of radio transmitting equipment in the possession of Axis agents.

And in this country, almost every raid which the F. B. I. has staged on suspicious alien groups has produced radio transmitting equipment. No official information can be obtained on the specifications of this equipment, but it has been reported that much of it is of low quality, apparently designed for use over short distances—which strengthens the belief that the spy network may be operating on this continent.

In time of war, naturally, every obstacle is thrown in the way of a spy getting information of value. But it is recognized that it is not possible to conceal everything. Spies do have ways of getting information. And so one of the greatest efforts in combatting espionage is to keep the spy from getting any information back to his headquarters. For this reason, mail and other communications are carefully censored and are delayed if they appear suspicious. Radio, of course, makes possible the quick transmission of uncensored information.

For that purpose, direct radio contact with headquarters is the spy's dream. But since monitoring—particularly the effective system operated by the Federal Communications Commission — makes this next to impossible, the spy must be content to use the slower, but still uncensored, secret network.

But the system is far from perfect. The fact that reports of its existence have gotten out indicate that the counter-espionage agents of the United Nations know a great deal about the operation of the Nazi net. And it's a safe bet that, difficult as detection is, our own ingenious monitors will nail it down.

THE shortage of skilled personnel in the radio field daily grows more critical. Both in the Army and in industry, there is a constant, swelling demand for men with advanced training in radio. This situation has led to discussions in Washington of the advisability of launching a large-scale training program for radio.

The Army has once more appealed for radio engineers to come into service on a civilian capacity. The requirement of a college degree has been relaxed and men who can show experience which is considered equivalent of college work will be accepted. Throughout the Government, the same need for engineers is being felt.

The radio manufacturing industry, at last put on a full-time war production basis, is struggling to hang on to its skilled men. The problem which faces the manufacturers and the broadcasters has been called to the attention of Brig. Gen. Lewis B. Hershey, head of the Selective Service. It is pointed out that it often takes nine or ten months to train replacements for skilled men who are drafted by the Army. There are indications that instructions will be sent to local draft boards, ordering deferments for radio men who can serve their country better in the factories than on the firing line.

But the Army itself needs radio men. At the present time, arrangements have been worked out so that any man with radio knowledge who is inducted into the service is put immediately into the Signal Corps. Selectees who hold radio licenses are transferred to the Signal Corps replacement centers at Fort Monmouth, N. J., and Fort Crowder, Mo. The latter is a new training center.

At the same time, the Army is conducting courses to train civilian radio men for general communications work, so as to release enlisted men for other jobs. To get engineers, the Army is going into the colleges and setting up special training courses for undergraduates. At 40 colleges and universities, this program is under way. Students enlist in the Signal Corps Reserve, take work in electronics and physics and receive commissions upon completion of the work. They receive draft deferments while studying.

THE United States Conciliation Service, in the Department of Labor, solved the controversy between members of the American Communications Association (CIO) and the operators of 15 shipping lines over wage increases sought by the marine operators. The operators will receive wage increases averaging $26 a month, according to terms of an agreement signed by the union and the ship owners.

The announcement by the War Production Board that all radio manufacturers must convert their facilities to full military output struck a cruel blow at radio shop owners, but the manufacturers were pretty well prepared. The manufacturers were told that they must make nothing but military radio after April 22, or face the possibility of having their plants commandeered for some other kind of war work.

The conversion order had little effect on the "Big Five" of radio manufacturing. Western Electric and Bendix were already doing 100 per cent war work. Westinghouse was completely on Government production contracts. RCA and General Electric were doing 80 per cent war work and were preparing to convert their plants completely.

Among the other big manufacturers, Stromberg-Carlson had turned a great part of its facilities to war production, with emphasis on FM equipment; Farnsworth Radio and Television Co. was doing 70 per cent war work; Zenith had converted about 50 per cent, Majestic was on a 50 per cent basis but preparing to convert to 100 per cent in a few weeks; Crosley was doing 40 per cent and Philco had 160 million dollars worth of Government contracts on hand.

The smaller manufacturers were not all as well situated. Some companies

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LAST MINUTE *Flashes*

DCB Donald Nelson has just announced an alteration in the procedure of letting contracts of war materials. From now on it will no longer be necessary for manufacturers to secure contracts by competitive bidding.

OUR Technical Ed. Ray Frank is on leave of absence (for the duration). Uncle Sam needs more radiomen like W9JU. Good luck, Ray!

APPOINTMENT of four additional executives to the staff of the Office of Defense Transportation is announced by Joseph B. Eastman, Director of Defense Transportation. Edward A. Roberts has been named Associate Director, Division of Local Transport; Glenn E. Taylor has been appointed Assistant Director, Division of Inland Waterway Transport; Hallan Huffman has been appointed Assistant General Counsel; and John C. Howard has been named Assistant to the Director of the Division of Rates.

such as Finch, Hallicrafters, Aircraft Radio, etc., were in fine shape, since they have long been engaged 100 per cent in the production of highly specialized equipment for airplanes, tanks, etc. But a survey indicated that only 10 per cent of the facilities of the small manufacturers was being used for war production. They were reaping as much of the harvest of civilian broadcasting as they could. It seems likely that some of these small manufacturers will be allotted the job of turning out replacement parts for civilian radio. And before long, it is likely that some standard civilian radio sets may be produced.

Jesse L. Maury, presiding officer of the WPB Radio Industry Advisory Committee, expressed the belief that there are enough radio sets in service in the country now to keep the population completely aware of what is going on. There is some talk, however, that many of these sets will be beyond repair after another year and that it may be necessary to allow limited production of more civilian radio.

R. R. Guthrie, assistant chief of the WPB Bureau of Industry Branches, acknowledged in informing the manufacturers of the complete conversion that it would be impossible for some parts of the industry to turn to production of signal and related apparatus of a military nature. Mr. Guthrie told those manufacturers flatly that they had better find some other kind of war production. This time, Uncle Sam means business.

WHO says that the average workmen of America aren't in there pitching in the war effort? Employees of the Baltimore plants of the Bendix Aviation Corp. decided to work on New Year's day, without pay and on their own time. On February 12, a delegation from these plants presented to Major General Dawson Olmstead, Chief Signal Officer of the Army, a number of radio compasses which they had manufactured that day.

NEWS of the death in action in the Far East of Lieut. Col. William Herbert Murphy has been received in Washington. He is the first high-ranking officer of the Signal Corps, it is believed, to have been killed since our entry in the war.

Col. Murphy was 51 years old, had entered the Army during the last war. He was a graduate of McGill University and of several Army schools. He had been engaged in important communications specialist duties with the United Nations High Command in the Far East.

THE promotion to the rank of Brigadier General for Frank E. Stoner, commanding the Signal Corps Replacement Training Center at Fort Monmouth, has been announced in Washington. Gen. Stoner was transferred to the Signal Corps in 1923, took command of the training center at Fort Monmouth in October, 1941.

A NAVAL officer of outstanding ability has been named Director of Naval Communications to succeed Rear Admiral Leigh Noyes, who has been ordered to sea duty.

The new Director is Captain Joseph R. Redman, who was assistant director under Admiral Noyes. Big, ruddy and good humored Capt. Redman is an officer in the best tradition of the Navy. And beyond that he is one of the service's most expert radiomen.

He has spent more than 16 years—over half of his Navy career—in specialized duty in communications. He served in communications posts with the Fleet at sea, having served from November, 1927 to May, 1929, as Fleet Radio Officer of the staff of the Commander-in-Chief of the U. S. Fleet. On two prior occasions, he had been assigned to the Office of Naval Communications in Washington, on duty in the Ship Radio Installations Section, in the Technical Section and the Frequency Section.

Captain Redman attended International Radio Conferences at Copenhagen in 1931, at Madrid in 1932 and Cairo in 1938 as Technical Advisor of the United States delegation. His new job—taking charge of Navy communications in the midst of our greatest war—will be by far the toughest he has tackled, but those who know him believe the Navy couldn't have found a better man.

THE action of the *Federal Communications Commission* in resuming the issuance of amateur licenses was the first step in an effort to bring the amateurs into the drive for victory. This move was made before the *Defense Communications Board* took action on the plan presented to it by the *Office* of *Civilian Defense* to restore several thousand amateurs to the air for defense work.

The *War* and *Navy Departments* requested the *Federal Communications Commission* to resume the issuance of licenses. The objective was to make it easier to bring into Army service the men who had a knowledge of radio. Since the FCC stopped issuing licenses in December, some 1,500 applications had piled up. These were from men who had passed their tests and established their proof of citizenship. Many of them were being inducted into the Army and enlisting in the Navy and, since their licenses hadn't been issued, they had no ready proof of their knowledge of radio.

To overcome this difficulty, the FCC decided to issue these licenses, and licenses to others who meet the requirements. This represented a relaxation in the anti-amateur attitude of the Commission, which developed after some hams had abused the privileges granted them in the first days after our entry in the war.

Further evidence that the Government was preparing to use the hams, instead of continuing to ignore them, was the plan which the O.C.D. presented to the *Defense Communications Board*. This plan was based on recognition of the possibility that in any area where bombing occurred, telephone and power facilities might be knocked out. In this event, the entire civilian defense communications system, and to some extent the Army communications, would be disrupted.

To act as an auxiliary communications system, it was suggested that amateur radio operators be used. And so the Office of Civilian Defense prepared a rather detailed plan for use of the hams. Under this arrangement, certain hams will have the right to use the air for official business.

CAA Awards Contract

The *Civil Aeronautics Administration* of the *U. S. Department of Commerce* has awarded the *Federal Telegraph Company*, manufacturing associate of the *International Telephone and Telegraph Corporation*, a contract to manufacture the equipment for ten airplane instrument landing systems for installation at principal airports. This is in addition to systems of the same manufacture being installed this year at LaGuardia Field and the Municipal Airports at Atlanta, Chicago, Cleveland, Kansas City and Los Angeles.

This instrument landing system, which permits flyers to land "blind," entirely by instrument, if forced to do so by weather, was developed for the C.A.A. by I.T.&T. engineers. The equipment was tested and adjusted for several years at the C.A.A. Experimental Station at Municipal Airport, Indianapolis, and was then adopted for installation at the other airports. Many pilots have already been trained in its use at Indianapolis and the new installations being made throughout the Country are intended to familiarize all commercial air line pilots with its operation as a vital additional safeguard against sudden bad weather.

Chromium Conservation

Chromium, already strictly controlled, today was placed under a complete allocations system by the *Director of Industry Operations* by an amendment to Order M-18-a.

The amended order provides that no chromium may be melted except with specific authorization of the *Director of Industry Operations*. It is designed to prevent depletion of existing stocks, and to control further the flow of this important steel alloy.

Today's order, together with Order M-21-a which limited the uses of chrome steel, makes use of the metal completely subject to the Director of Industry Operations.

M-18-a, as amended today, revokes Order M-18 and takes effect upon issuance. It expires on June 30, 1942.

Industry Goes to War!

The radio manufacturing industry, whose civilian output already has been cut, was told recently it is next in line for conversion to the production of war material.

Speaking before a meeting of representatives of fifty-five set manufacturers, R. R. Guthrie, assistant chief, *Bureau of Industry Branches*, said the radio makers will be converted "as rapidly as is technically possible."

While no deadline was set, it is expected that the major part of the job will be done within three months. A program for conversion will be drawn after conferences between representatives of the industry and government.

"The problems of your industry in the war effort are at once difficult and pressing," Mr. Guthrie said. "The strategical objectives, and the broad dimensions of the task before you, are clear. It should be as gratifying to you as it is to me that these objectives and dimensions are no longer subject to change with the fortunes of war. We are, thank God, out of the period in which each succeeding military reverse meant a revision of our estimates of what we must do. We are demanding the utmost of your industry, and of every other industry, now.

General Suspension of Radio Production April 22

The radio industry was informed, at yesterday's meeting of the WPB *Industry Advisory Committee*, that receiving set production generally would be stopped on April 22 except in cases of individual companies whose limited extended operation would expedite conversion to military production.

The WPB program for conversion of the radio industry to a war basis was announced to over 100 radio executives attending yesterday's meeting by Mr. Jesse L. Maury, government presiding officer.

In a few days, Mr. Maury stated, WPB will issue an order to suspend all civilian radio production on April 22, the date of the expiration of the existing limitation order, L-44, except on an individual company basis to be determined by WPB. Appeals from the April 22 suspension order will then be considered, Mr. Maury stated, only on a basis of expediting and facilitating war production, with inventories only a secondary factor. Mr. Maury indicated that the larger companies with large military contracts and with facilities especially needed for war production probably would be closed down on April 22 so far as civilian production is concerned, but that temporary exemptions based entirely on their prospective war work would be given limited extensions on civilian production. The question of the amount and condtion of inventory will be a secondary major in the decisions. Possible transfer by manufacturers of their inventories of materials, including fabricated parts, to another set manufacturer was suggested by Mr. Maury.

Copper Benefits by Amendment

Copper mines in South America, which have been securing stipulated amounts of maintenance and operating supplies with the assistance of Preference Rating Order P-58, will benefit to a wider extent by the terms of an amendment, announced today by the Division of Industry Operations.

The A-1-d rating, provided for in the order, was previously applicable to purchases of maintenance and operating materials to be delivered before July 1, 1942, in amounts limited to the same quantities as were shipped to the mines from the United States between April 1, and September 30, 1941. It may now be used to expedite material to an amount double that shipped during the base period. The A-3 rating, assigned by the order to deliveries to be made between June 30 and October 1 of this year, may still be used to expedite such shipments, and the total of goods which may be acquired with the assistance of both ratings is now three times that shipped during the base period.

Tungsten Must Be Conserved

Further conservation of tungsten, vital in alloy steel, was ordered today by J. S. Knowlson, *Director of Industry Operations,* with issuance of Conservation Order M-29-b.

The order prohibits use of tungsten in grinding wheels, gauges, and as a coloring material for rubber, linoleum, paper or other similar materials after May 1, 1942.

Until that date, use of tungsten in these items is limited to 17½ per cent of the amount used during the year ended June 30, 1941.

All other users of tungsten, except those specifically exempted, must reduce their

GOVERNMENT

use between February 1 and March 31 to 12 per cent of the amount used in the year ending June 30, 1941. Such users, after April 1, are limited by calendar quarters to 17½ per cent of the amount used in the base year.

Exemptions to the Order include use of tungsten for Army, Navy, Lend-Lease and other Government contracts.

Radiosonde Order Extended

The War Production Board today extended to April 30, 1942, its P-38 order assigning an A-1-d preference rating to deliveries of material that will enter into the production of radiosondes for the Weather Bureau. The order would have expired February 28.

Another amendment to the order eliminates the clause limiting the application of the preference rating. In the original order it was provided that "the preference rating may be applied only to deliveries of material included under the current Priorities Critical Lists, as amended from time to time." This limitation no longer is in effect.

T. S. Walmsley Resigns from OCD

Director James M. Landis of the *Office of Civilian Defense* announced today that he was accepting with regret the resignation of T. Semmes Walmsley as of February 25. Mr. Walmsley has been ordered to active duty with the Army. He was recently transferred from the position of Chief Inspector General to Consultant to the Director. In accepting Mr. Walmsley's resignation, Director Landis said:

"I am sorry that you have to leave. Both in the field and here I knew at first hand the contributions that you have increasingly made to the cause of the *Office of Civilian Defense*, particularly in its early and formative days. Its building has rested largely on your shoulders."

New Form for Preference Ratings

On February 2 a new form of application blank for individual preference ratings was made available by the *Division of Industry Operations*. Use of the new form is optional until March 2, mandatory on and after that date.

The use of the new form is covered by Priorities Regulation No. 3. The most important feature of the new system of granting individual preference ratings is that these ratings may now be extended to suppliers and sub-suppliers of the original applicant by a simple endorsement on purchase orders.

The Army and Navy have also begun to use a new form of individual preference rating certificate assigning ratings to their orders, and these ratings, on PD-3A forms, will also be extendable by a simple endorsement on purchase orders.

New Radio Chief

The appointment of C. M. Jansky, Jr., to be chief of the radio section of the Communications Branch of the *War Production Board* was announced. Mr. Jansky will, in effect, be the czar of the radio manufacturing industry—since that industry is now going on a 100 per cent war production basis. He will have charge of surveying factory apparatus, production facilities and determining radio equipment requirements for all phases of communications.

INDUSTRY

Stovers Resigns RSA to Join RCA

The many friends of Don Stovers will learn with regret of his resignation as Executive Secretary of the RSA, in order to take a position with the Service and Installation Division of the *RCA Manufacturing Co.*, in Camden, N. J.

Don's work for the past seven months as Executive Secretary is unsurpassed and cannot be praised too highly.

All RSA wishes him well and the very best of success in his new job.

The Executive Committee appointed Alfred A. Kilian, past Secretary of the Chicago Chapter of RSA, to succeed him and hopes, that membership and Chapters will show continued generous cooperation with the new management. The new address of the National Headquarters of "RSA" is: 414 Dickens Avenue, Chicago, Illinois.

Think Nationally!

Radio is national in scope. If we as servicemen want national representation for the Service Industry we must have a National Organization, and the stronger that organization, the more effective our voice will be.

Our local problems can, and are well taken care of through local organizations. Fortunately, the setup of the R.S.A. provides complete freedom of action for each and every one of its Chapters for the handling of just such matters, however, even here, the advantage lies with the local group which has affiliation with a National Organization such as R.S.A., and can therefore exert its influence much more effectively than a local group which hasn't this national prestige.

It is with this thought in mind that we ask each and everyone in the Service Industry to help build this great National Organization into the effective unit it should be. First thing to do is:

Join RSA yourself. Second: Go out and get other servicemen to join. Third: Form a Chapter in your locality if it has ten or more servicemen. We will help you all we can to get started and to put it across. RSA can show a healthy growth this year—it's in the cards. But it won't happen if you yourself won't do your part.

AROUSE YOURSELF! EXERT YOURSELF! ACT!

Nothing great has ever been accomplished without enthusiasm!

Materials Saved by RCA Go for War Production

Tons of metals and chemicals desperately needed for the United States war production program are among the strategic materials conserved by an all-embracing program worked out by development engineers of the *RCA Manufacturing Company*. The program, affecting every department of the Company, antedates by many months Government restrictions on radio production to save needed materials.

In addition to discovering alternate materials—and then alternates for the alternate materials—RCA engineers have also been able to develop domestic alternates for imported materials, thus freeing shipping space for other commodities.

Meissner Sales Manager on Western Tour

Ben Miller, Sales Manager of *Meissner Manufacturing Company*, Mt. Carmel, Illinois is on a tour of *Meissner* jobbers. Among the cities to be visited are: St. Louis, Kansas City, Los Angeles, San Francisco, Portland, Ore., Seattle, Spokane, Minneapolis, St. Paul, Milwaukee and Chicago. Mr. Miller expects to return to the home office the latter part of February.

New RCA Executive Chairman

George K. Throckmorton, for the past five years President of the *RCA Manufacturing Company, Inc.*, of Camden, N. J., was today elected Chairman of the Executive Committee of that company. Robert Shannon, former Executive Vice-President, was elected President.

The promotion of RCA's two senior manufacturing executives was announced by David Sarnoff. President of *Radio Corporation of America* and Chairman of the Board of *RCA Manufacturing Company, Inc.*

In announcing these organization changes Mr. Sarnoff said:

"The new President of the RCA Manufacturing Company is a man from the ranks. 'Bob' Shannon, as he is affectionately known by thousands of employees, started as a factory worker thirty years ago. He has occupied various executive positions in the R.C.A. organization during the past twelve years."

George Greaves Becomes KPO Engineer-in-Charge

One of the most important San Francisco appointments in connection with the recent separation of the Red and Blue networks of the *National Broadcasting Company*, was the selection of George Greaves as engineer in charge for the NBC station, KPO.

Greaves succeeds Curtis D. Peck. now a lieutenant commander in the *United States Navy*, and has assumed the duties of his new assignment.

Greaves has been field supervisor, in charge of special events and remote pickup broadcasts for KPO and KGO while both were under the management of NBC. He is a native of Ladysmith, British Columbia, Canada, and has been with NBC since May 7. 1928.

D. C. Patrick Named Sylvania Rep in Denver

D. C. Patrick has been appointed *Hygrade Sylvania* representative in the Denver territory for all of the company's products including *Sylvania* radio tubes, Hygrade fluorescent lamps, Miralume fluorescent fixtures, fluorescent accessories and *Hygrade* incandescent lamps.

Mr. Patrick, familiarly known to the radio trade around Denver as "Pete," has been in radio selling in that area for fifteen years.

Mr. Patrick recently spent several days visiting the *Hygrade Sylvania* radio tube and fluorescent plants in Pennsylvania and New England. He is now back in Denver at his home headquarters, 1100 Colorado Boulevard, Denver, Colorado, carrying out his assigned duties.

Given Leave to Do Research Defense Work

William B. Lodge, engineer-in-charge of the radio frequency division of *Columbia Broadcasting System*, has been given a leave of absence, E. K. Cohan, network director of engineering, announced today.

This temporary leave of absence was given Lodge so he could do research work for the *National Defense Research Council*.

During his absence, Warren White, his assistant, assumes the responsibilities of the radio frequency division as acting engineer-in-charge.

Philco Going Full Speed

In response to requests for a statement regarding Washington advises that civilian radio production will soon be terminated to allow full conversion of the radio industry to war work, James T. Buckley, president of *Philco Corporation*, authorizes the following:

Philco is in entire accord with the Government's policy. For many months past, *Philco* has been contributing on an ever-increasing scale to the victory program. Plant facilities in Philadelphia, Sandusky, Ohio, and elsewhere are being rapidly converted to handle the special types of radio equipment needed by the Government.

RCA Sound Installations Continue at High Pitch

With commercial installations of RCA sound systems feeling the pinch of material shortages, installations of sound amplifying networks in war industries for communication and air raid warning uses has taken a turn to new heights. According to George Ewald, *RCA Commercial Sound Division* Manager, during a recent 30-day period 106 RCA sound systems were installed.

During this time plans were completed for the installation of RCA Municipal Air Raid Warning Systems in Harrison, N. J., and Alameda, Calif. These systems will employ a signal generator producing a "warble" signal different from any fire, police or other type alarm. Standard amplifiers, speakers and microphones round out the systems, with the power and number of amplifying stations varying with the needs of each individual city.

RCA Names Lancaster Plant Manager

Appointment of H. F. Randolph as Plant Manager of the new RCA tube manufacturing plant being erected at Lancaster, Penna., has been announced by Eugene W. Ritter, Vice-President in charge of Manufacturing and Production Engineering of the *RCA Manufacturing Company*.

Mr. Ritter also announced several other executive appointments, and the opening today of a temporary office by the Company at 139 East King Street, Lancaster. Miss Patricia McEvoy, of 759 Reservoir Street, is the first employee to be hired for the new plant, and will be in the office, where job applications will be received and information imparted.

Other appointments announced by Mr. Ritter included that of H. R. Seelen, of the Company's Harrison, New Jersey tube plant, as Research Laboratory Manager; Harry D. Hanafus, also of the Harrison plant, as Purchasing Agent; and Harold T. Albright, of the Camden headquarters, as Personnel Manager. All four men will make their homes in Lancaster.

National Union in New Headquarters

The *National Union Radio Corporation* of Newark, New Jersey, manufacturers of receiving tubes, transmitting tubes, cathode ray tubes, panel lamps, condensers, etc., have leased the entire tenth floor of the American Insurance Company Building at 15 Washington Street, Newark, New Jersey.

Radio Transmission Knows No State Boundaries

Judge Emmerich Freed of the *United States District Court* for the Northern District of Ohio, Eastern Division, in the case of United States of America v. Betteridge and Wolf, in an opinion dated February 6, 1942, stated that operation of *any* radio transmitter within the United States or certain of its territories or possessions must be licensed by the *Federal Communications Commission* and conducted by a licensed operator. The opinion points out:

"It is needless to go into a lengthy dissertation on the inherent natural characteristics of radio transmission to arrive at the inescapable conclusion that all transmission of energy, communications or signals by radio, either use an interstate or foreign channel of transmission or so affect interstate or foreign channels by licensing or otherwise if the announced purpose of this section; that is, as to require the regulation of their use the retention of control in the United States of all channels of interstate and foreign radio communication, is to be carried out effectively. The daily use of the radio, even to a lay mind unacquainted with the science of radio transmission or its engineering intricacies, has clearly demonstrated this conclusion.

"A careful analysis of the prohibited operation of a radio transmitting apparatus without a license discloses that the section is so all-inclusive that it would require great imaginative faculty to find an instance where the operation of a transmitting apparatus would not be embraced within the provisions of the Act. *In fact, I am bound to come to the conclusion that all the operations of a radio transmitting apparatus fall into one or the other or several subsections of the statute and that under the Act none can operate without a license.*"

This case involves the prosecution of two individuals who had operated an unlicensed transmitter at Thistledown Race Track, near Cleveland, Ohio, in August, 1941, in connection with a scheme to best the bookies by signalling "tips" while the races were being run. The defendants contented that the five-meter ultrahigh frequency transmitted which they were using was incapable of sending signals beyond the boundaries of Ohio. Monitoring officers of the Commission offered no proof of actual interstate interception of the signals or interference with interstate communication, but evidence was submitted to the court to establish that these radio signals were capable of receipt at great distances from the point of origin, depending upon atmospheric and other conditions. In considering that point, the court said:

"There is evidence to the effect that such transmissions could not be controlled by the sender except as to volume and would transmit energy, signals, and communications in radiated directions and that such transmissions would interfere with any other radio transmissions using the same frequency at the same time either from outside the State of Ohio, to points within the State of Ohio, or from inside the State of Ohio to points outside the state."

The court pointed out that the intent of the defendants to transmit only within the state was immaterial; that all that is necessary to commit the offenses described in Sections 301 and 318 of the Communications Act of 1934, as amended, is to operate a transmitter without proper licenses.

One defendant was sentenced to a term of imprisonment of six months and another to three months.

The Commission warns against violation of the Communications Act by the unauthorized operation of a radio transmitter, regardless of the limitations which may exist with regard to the range of ground wave transmission. This warning is directed particularly to potential operators of 2½ and 5 meter ultrahigh frequency transmitters who have sometimes felt themselves to be beyond the jurisdiction of the Commission.

FM Keeps Transit System Working

A new two-way frequency modulation radio system is keeping the *Cleveland Railway Company's* transit system working at highest efficiency. The equipment

COMMUNICATIONS

consists of a 250-watt dispatcher transmitter and ten 25-watt mobile units. The headquarters transmitting antenna is mounted 270 feet above street level. All equipment was supplied by the *General Electric Company*.

Since the installation of this new FM emergency communication system, delays in car service have been shortened and in some cases entirely eliminated by the ability of zone supervisors to reach a congested area quickly and to restore the flow of vehicles or direct the replacement or repairs of damaged equipment.

SHORTS

FM Goes to College

Radio's infant prodigy, frequency modulation, has graduated from the realm of things you've heard about from friends with special receivers to things you can actually hear on your own regular set—**if** you go to college.

The campus broadcasting systems of *Yale, Wesleyan, University of Connecticut,* and *Columbia* are now carrying regular FM broadcasts daily. The *Columbia University* station has been rebroadcasting programs of WOR's New York frequency modulation station, W71NY, since November. And last week Franklin M. Doolittle, general manager of Hartford's WDCR FM unit, announced that permission to carry all Station W65H's programs had been granted to the Husky Network of the *University of Connecticut,* the Cardinal Network of *Wesleyan University* and the *Yale* Broadcasting System.

All these college radio stations, operating as members of the Intercollegiate Broadcasting System, use extremely low-power transmitters sending signals over their "wired wireless" systems. This method of broadcasting has two significant results. No receiver outside the prescribed area of the wires can pick up the college station's programs: and, although long-wave and working on amplitude modulation, they are in effect staticless. In other words, the campus stations can rebroadcast FM programs which can be picked up by ordinary receiving sets on their campuses with no loss of the fidelity of tone quality and clarity which FM makes possible.

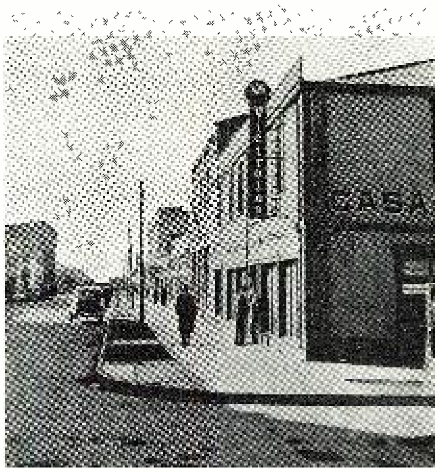
Normandie Fire Televised

The television audience was treated to still another video program thrill recently, when the burning of the giant steamship *Normandie* was flashed on televisor screens. From their lofty station quarters on the 42nd floor of the skyscraper at 515 Madison Ave., dominating the metropolitan New York area, *Du Mont* camera operators covered the Hudson River waterfront with the further aid of a powerful telephoto lens. Although shooting against the sun, or working under adverse lighting conditions, the pickup aimed at the piers where the huge ship was berthed, showed the billowing clouds of smoke which soon filled the entire sky over the river.

The transmitter is operating on about 2 kw. input now, but the final stage of amplification is soon to be cut in for full-power operation. Even on the present sub-power basis the transmitter is putting out a strong signal of excellent pictorial quality.

Far, Far Away!

This huge electric sign advertising RCA Victrolas is the first thing mariners see when they turn their binoculars on Punta Arenas, Chile, on the Straits of Magellan. *RCA Victor* dealer Casa Jacobs holds the distinction of being located in the last building on the last street of the last city in the world. The picture was taken by J. R. Dewson, of Chicago, while he was on a visit to the city.



Uncle Sam's FCC Stations on the Job

"Monitoring" to see that domestic radio transmissions obey ordinary ether traffic rules has been a practice since the early days of radio regulation. However, this normal function of the *Federal Communications Commission* has now been augmented to meet national defense requirements. This supplemental duty is in charge of the *Commission's National Defense Operations Section,* which was established on July 1 of last year. Our ether highways are now so effectively patrolled that trespassing or erratic driving thereon is quickly detected. Each FCC monitoring station, in effect, patrols a particular ether "beat." Oftentimes such a station will itself spot an unlawful transmission. At other times suspicious signals are reported by broadcasters and other licensees—often by amateurs, who do an excellent job of policing their own bands.

No signal is too weak for a monitoring station to pick up and record. When a strange or "reckless driver" is detected on the ether lanes, "direction-finding" apparatus is called into play to trace the culprit.

Sometimes three or more stations will collaborate in thus getting a bearing on the suspicious signal. Their beams are plotted on a map. Eventually and inevitably two lines will cross. This point, or "fix," marks the general location of the sending set under surveillance.

The final task of running down the offender is performed by FCC monitoring officers. Such men, highly skilled in radio engineering and radio operation, are assigned to monitoring units dispersed strategically throughout the United States and its possessions. For obvious reasons, locations of such auxiliary "ears" are not made public.

These monitoring posts are provided with automobiles, to all external appearance ordinary cars but which are fitted with the latest and most efficient type of detection equipment. Included are direction-finders, all-wave receivers and recorders. All this apparatus can be operated from the car's battery while the auto is in motion or, upon being removed from the machine, from the power supply of a dwelling, tourist camp, store, etc.

Operation of the mobile equipment follows much the same procedure employed by the monitoring stations in the first instance. Directional beams finally "fix" the location of the transmitter in question. Even if the hunt narrows to an apartment house, hotel, or other large building, an FCC officer can, by using a device concealed in his hand or in his pocket, proceed from floor to floor, and from door to door, and so determine the exact room in which the illegal equipment is being used.

—30—

Practical Radio Course

(*Continued from page 29*)

that need be supplied to such a receiver is that from the 6-volt car battery.

Charging may be accomplished in various ways. The most common charging source is the electric light lines, but in rural sections wind-driven or water-driven generators are often employed to drive charging generators.

Direct current must be used for charging, and provision must be made for limiting the charging current—usually to a value not exceeding 10 amperes for radio batteries. Where the charging current is to be drawn from an alternating-current light line a suitable rectifier unit must be used to convert the alternating current into direct current, and at the same to limit the current flow to a suitable value. Charging from direct-current light lines requires only that suitable resistance be connected in series with the battery to limit the charging rate. This may conveniently be one or more 100-watt lamp bulbs. One such bulb in series with the 115-volt line and battery will limit the charging current to about 1 ampere. Two bulbs connected in parallel with each other, but in series with the battery, will provide 2 amperes of current, and so on.

A compact non-spillable type storage battery in a transparent plastic case has been employed in the recent model portable receiver illustrated. It is provided with a built-in automatic charging arrangement so that the battery may be charged either while the set is playing—or during periods when the set is not being used. Automatic charge indicators tell at all times the state of the battery and the need for charging.

In the case of auto radios, the car battery is automatically charged by the low-voltage car generator while driving. In older cars in which the charging rate is relatively low and where headlights are used excessively, the added drain of the radio may cause the battery to run down at times. In such cases it is often possible to advance the charging rate of the car's generator sufficiently to take care of this added drain. In newer cars this is not usually a problem because their generators are designed and adjusted to amply care for the added drains of radio, heater, defroster and the other electrical gadgets so common on the modern car.

Grouping Dry Cells

A number of dry cells can be connected together to provide higher voltages, but proper polarity must be observed. The correct method in this case is to connect the positive terminal (usually marked "+") of one cell to the negative terminal (–) of the next, the positive terminal of this one to the negative terminal of the next and so on. This will leave the negative terminal of the first cell and the positive terminal of the last without any connections.

These then become the terminals by means of which the entire battery is conneced to the device to which its e.m.f. is to be supplied. This arrangement is known as *series* connection. The total voltage supplied will equal the sum of the voltages of the individual cells, and each cell will contribute the same amount of current. Figure 1(a) shows a group of cells connected in this manner.

In a case where a device will operate from a 1½ volt source but requires higher current than can safely be delivered steadily by a single dry cell of the size available, several cells may be connected in *parallel* as shown in Figure 1(b). In this case the total e.m.f. will be 1½ volts but each cell is now called upon to deliver only a part of the total current. Thus if 1 ampere is to be drawn from a group of four parallel-connected cells, each individual cell will contribute only 0.25 ampere.

Where both higher voltage and higher current than can be delivered by one cell are required, a group of cells connected in a suitable *series-parallel* arrangement will serve the purpose. Figure 1(c) shows an arrangement with four parallel groups of two cells each. The cells of each pair are connected in series, therefore each pair will provide an e.m.f. of 3 volts. These pairs are

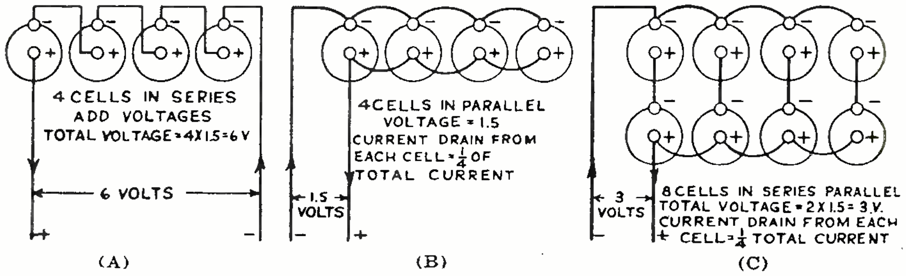


Fig. 1.

then connected in parallel and are thus made capable of delivering four times the current of a single pair.

Resistors and Resistance

There is no such thing as a perfect electrical conductor. Every material including all metals, offer some resistance to the flow of electric current. It has already been shown in the previous article of this series that where there is resistance in an electrical circuit there is necessarily loss of electrical energy because a certain amount of the applied voltage is expanded in forcing current through this resistance.

Resistance in a circuit may be an evil or it may be put to a useful task just as is friction in mechanical devices. In the automobile, for instance, every effort is made to reduce friction in the drive mechanism. But, on the other hand, the brakes are designed to provide as much friction as possible. The unavoidable friction in the bearings, gears, etc., of the drive represents sheer undesirable loss of mechanical power. Not so in the action of the brakes.

So, in electrical circuits, the wiring is usually of copper to insure the lowest practical resistance to current flow; yet in portions of the circuit high resistance may be purposely introduced to perform some useful function.

This useful purpose may be served by resistors inserted to reduce the value of applied voltage to some lower required value, for example, as when it is necessary to reduce the 115-volt light supply to perhaps 50 volts required to heat the filaments of a group of tubes in a radio set.

The resistance to the flow of electric current varies greatly with different materials. The resistance of copper is so low that we consider it a good *conductor*. Carbon and certain metal alloys have resistance up to several hundred times that of copper and these we utilize as *resistors*. Still others, notably some of the ceramics such as porcelain, and compositions such as bakelite, have such extremely high resistance that in ordinary applications current will not flow through them at all. These serve as *insulators*.

The resistance of a wire depends not only on the material in the wire, but also on its length and cross-section area. Thus the resistance offered by a one-foot length of a given wire will be only half that of a 2-foot piece of this same wire, or twice that of a 6-inch length. Or if the one-foot piece is replaced by one of the same length and material, but of twice the cross-section area, the resistance will be only half as much.

Resistors now widely employed in radio are of two general types—carbon and wire-wound. Carbon resistors, made of carbon particles mixed with an insulating powder and pressed into the shape of small cylinders or rods, are employed where extremely high resistance is required and currents are small. The proportion of carbon employed in the mix determines the resistance of such a unit, which may vary from a few ohms to many millions. The advantage of this type of resistor lies in its cheapness and compact size. Sizes vary according to the electrical power which such resistors are capable of dissipating continuously without excessive heating and damage. The largest sizes commonly employed in radio receiver circuits are rated at 2 watts and are approximately 1¾" long by 5/16" in diameter. Other common ratings are ½ and 1 watt.

Wire-wound resistors usually are made of special resistance wire wound on a tube of insulating material (often porcelain) then covered with a heavy baked-on coating of heat-resisting enamel or cement which not only protects the fine wire from physical damage but secures the turns in place to avoid short-circuits between them. The wire employed may be any of several special high-resistance alloys which have been developed for this use. Included among such alloys are Advance, Constantin, copper-nickel, Manganin, Nichrome, etc. Their special characteristics include the ability to withstand heating without deterioration and to maintain their resistance relatively constant over a wide temperature range.

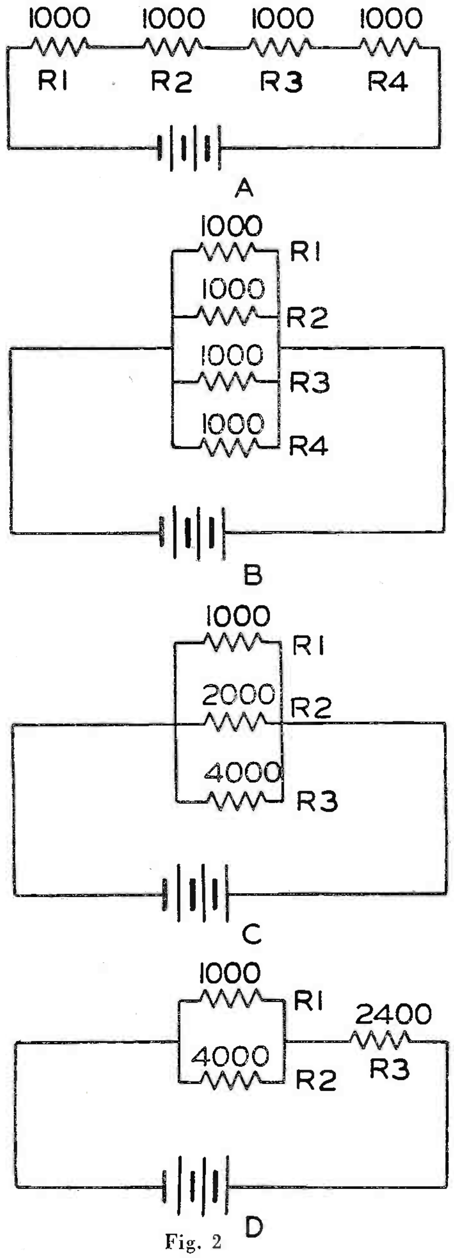


Fig. 2

These characteristics are of great importance, as is also the ability of the coating material to conduct heat away from the resistance wire, because the power consumed in a resistor must be dissipated in the form of heat. Operating at full power rating the external temperature of a wire resistor rises to high levels—sometimes to 400 degrees F. or higher. In enclosed spaces where this heat cannot be radiated effectively such resistors cannot be safely operated at full power rating. For this reason it is considered good practice in radio, where the resistor may be under a radio chassis or enclosed within a cabinet, to employ resistors with power ratings two to four times higher than the actual power they will be called upon to dissipate. Otherwise the excessive heating might result in damage not only to the resistor itself but to other nearby components. The larger the power rating of a resistor of given resistance value, the larger is its physical dimensions and the more costly it is.

Wire-wound resistors are usually employed where applications necessitate dissipation of power in excess of 2 watts. Their widest applications in radio are in the power-supply circuits and the ratings most commonly used are 5, 10, 25 and 50 watts. The dimensions of typical wire-wound resistors with these ratings vary from 1¾" x 5/16" to 4½" x ¾" respectively.

In addition to the fixed resistors just discussed, both wire-wound and carbon resistors that are variable in resistance value are available. The volume and tone controls on radio sets represent common applications of carbon variable resistors, the control knobs actuating a contact slider which moves over a circular resistance element.

Wire-wound variable resistors are usually similar. The resistance wire in this case is wound on a flat strip of insulating material, then this strip is formed into a ring and so positioned that the contact slider wipes along one edge. Another form of wire-wound resistor is the adjustable type. This is similar to the fixed type except that an exposed strip of the resistance winding extending the full length of the resistor permits contact to be made with any portion. A ring contact is slipped along the resistor winding to the desired point and there fastened in place with a locking screw.

The resistances in the circuits of a radio receiver are not only those of the wiring and the purposely inserted resistors. For example, each vacuum tube offers very definite and oftentimes rather large resistance to the flow of current through its plate circuit, and its filament constitutes another resistance. Chokes and transformers also have appreciable resistances because of the long lengths of oftentimes fine copper wire employed in their windings.

Grouping of Resistances

Where two or more resistances appear in a single circuit they are said to be in *series*, in *parallel* or in *series-parallel*, depending on their arrangement with respect to one another. The series arrangement is illustrated in Figure 2(a). This is one where all the current flowing through one resistor must likewise flow through the others. Resistors in parallel are those which offer separate paths for the flow of current. In other words, any of them could be removed from the circuit and current could still flow through the others. This arrangement, which is also spoken of as a *"shunt"* or *"multiple"* arrangement, is shown in Figure 2(b).

Resistances in a circuit may be grouped in a series-parallel arrangement as in Figure 2(d). Here R1 and R2 will be recognized as a parallel pair which is in series with R3.

Resistances in series are additive. That is their total effective resistance is the same as that of a single resistor having a value equal to the sum of the individual values. Thus in Figure 2(a), where there are four resistors of 1000 ohms each connected in series, the total resistance is 4000 ohms. For any combination of series values, the total is:

$$R = R1 + R2 + R3 + R4, \text{ etc.}$$

When connected in parallel, as in Figure 2(b), the net effect is just the opposite and the total resistance presented becomes less than that of any of the individual resistors. Two parallel resistors of equal value result in two paths for current flow, therefore twice as much current can flow for a given value of applied e.m.f. If the 4 resistors of Figure 2(a) are reconnected in parallel as at (b), then 4 current paths are provided and the total current flow will be four times as great as it would be through only one of the resistors. The total effective resistance of the circuit of (b), or of any circuit in which equal resistances are paralleled, can be readily calculated by dividing the value of the individual resistances by their number, thus in Figure 2(b):

$$R = \frac{1000}{4} = 250 \text{ ohms.}$$

Where the paralleled resistors are of different values the formula for determining their combined value is:

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}, \text{ etc.}$$

In the case of Figure 2(c), the total resistance would work out:

$$\frac{1}{R} = \frac{1}{1000} + \frac{1}{2000} + \frac{1}{4000} = \frac{7}{4000},$$

therefore R = 571 ohms.

Oftentimes, we find circuits in which resistors appear both in series and in parallel, as in Figure 2(d). Here the combined resistance of R1 and R2 is in series with R3. Using the formula for parallel resistors as given above, the effective total of R1 and R2 is found to be 800 ohms. Added in series with the 2400 ohms of R3, this makes a total resistance of 3200 ohms for the entire circuit.

(To be continued)

DON'T MISS the article "Impedance-matching on a 'Sound' basis" in this issue.

What's New

(Continued from page 34)

tubes warm for instant operation, but cuts battery drain in half between announcements.

Separate controls are provided for microphone and phonograph input. Dual action tone control. Either one or two 8-ohm p.m. speakers can be used with no rewiring or switching. Also available with two speakers built into carrying case, so that entire amplifying system is easily portable.

New Record Cabinet

The latest convenience for every family with a phonograph—a beautiful new record album cabinet to provide a handy library for phonograph records—has just been introduced by *Philco,* it was announced today by Larry F. Hardy, manager of the Home Radio Division.

The cabinet is marked by beautiful simplicity of design which makes it adaptable to any furnishings or period furniture. The top, of hand-rubbed walnut, is large enough to accommodate practically every kind of table model phonograph.

"With the fast-increasing popularity of radio-phonograph combinations, we believe that the public wants and needs a place to keep its records so that they will not only be well-protected but easily accessible," Mr. Hardy said in announcing the new cabinet. "In addition, the record cabinet must be a handsome, striking piece of furniture that will add to the appearance of the home. Both these artistic and utilitarian requirements have been met in the new Philco record album cabinet."

Latest Record Cabinet.

The *Philco* record album cabinet is provided with four 12-inch albums and four 10-inch albums, each of which contains twelve record-pockets. In addition to these albums, several regular commercial albums can be accommodated, so that the cabinet will hold more than 100 records.

Height, 30¾ inches; width, 20½ inches; depth, 15½ inches.

Elapsed Time Meter

For making life tests on radio transmitters, tubes and beacons, a new meter to indicate elapsed time in minutes or hours is announced by *Westinghouse Electric and Manufacturing Company.*

Using six counter units instead of the usual five, the meter consisting essentially of a synchronous driving motor, a gear train and six numbered wheels. The motor operates at 600 r.p.m. on a 115 volt, 60 cycle circuit. Synchronous operation is not affected by voltage variations of from 75 to 125 per cent of rated value. Life time bearing lubrication is provided by an oil storage reservoir. Gears are precision, machine cut and gold plated to resist corrosion.

To operate, the meter is connected in parallel with the apparatus of which total hours of operation are to be measured. Meter circuits are closed when the machine operates, causing the synchronous motor to run continuously.

"Symphonic" Album Announced

"Symphonic," a new record album, designed to harmonize with today's planned interiors, has just been issued by *Peerless Album*. Norman D. Ravis, president of *Peerless*, expects this model to answer the long-felt need for a finer, slightly higher-priced album.

"Symphonic" is covered with a heavy, padded Fabrikoid that gives the impression of genuine leather binding. The back of the cover is gold-stamped in a simple, decorative design. The heavy, metal-eye-lettered envelopes are slung on steel collars firmly attached to a steel plate, all metal being brass-plated, which is riveted onto the sturdy wood back, an exclusive *Peerless* feature. Further information may be had by addressing *Peerless Album Company, Inc.*, 38 West 21st Street, New York City.

Crolite Precision Coil Forms

The production of precise coil forms in *Crolite*, combining mechanical and electrical characteristics meeting the most rigid specifications, is one of the many National Defense activities in the recently enlarged plant of *Henry L. Crowley & Co., Inc.*, in West Orange, N. J. These coil forms range from a fraction of an inch to several inches in diameter, are helically grooved to take different sized wires and winding pitches, and have a plurality of different holes accurately positioned for winding taps as well as threaded holes for mounting screws. Various *Crolite* "bodies" or formulae are utilized in meeting the radio characteristics required at different operating frequencies, particularly in the ultra-high-frequency spectrum.

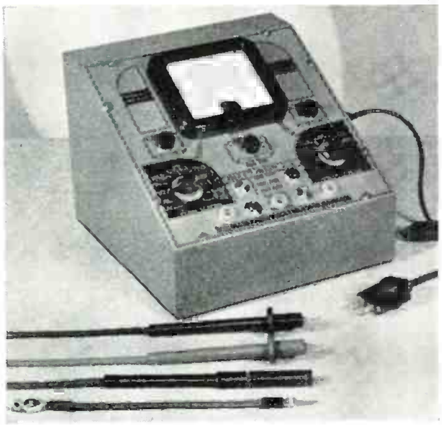
These precision coil forms start from solid extruded rods or tubing, of *Crolite*, which are subsequently turned and bored to correct outside and inside diameters, followed by grooving and drilling and tapping. The pieces are then fired at critical temperatures in kilns, assuming the final rock-hard characteristic of *Crolite*.

These forms fill many military and civilian requirements.

R.C.P. Electronic Multitester

An electronically operated, high sensitivity, multi-purpose meter instrument has just been announced by *Radio City Products Co.*, 88 Park Place, New York City. Known as the RCP "Electronic Multitester," Model 662, it will find wide application in radio and electrical measurement work and is particularly well adapted to the requirements of industrial laboratories and testing departments because of its versatility and negligible loading of circuits under measurement.

This 662 model provides a total of 27 measurement ranges to take care of voltages, both a.c. and d.c., up to 6,000 volts; resistance to 1,000 megohms; capacities to 2,000 microfarads. The low ranges for each of these types of measurement are such that values as low as 0.1 volt, d.c., 1.0 volt a.c., 0.2 ohms and 30 micro-microfarads (0.000,03 microfarads) can be read directly from the meter scale without interpolation or estimating fractional scale



divisions. Any one of the 27 ranges is selected by means of two rotary switches, one of which selects the type of measurement desired, the other the numerical range.

The indicating instrument, which is set into the face of the all-metal cabinet, is a 4½ inch square type D'Arsonval microammeter guaranteed accurate within 2% of full scale. Its direct-reading scales are laid out on a 100-degree arc. Protection is provided which avoids the possibility of burnout or other damage to this instrument through improper range selection or attempting measurement of live resistors, etc.

New Shure "556" Broadcast Mike

A new *"Super-Cardioid"* Broadcast Dynamic Microphone is announced by *Shure Brothers,* "Microphone Headquarters," Chicago. This new Series "556" introduces a "Super Cardioid polar pattern that is twice as undirectional as the Cardioid, from the standpoint of receiving front sounds and rejecting rear sounds, yet has wide-angle front pick-up. Decreases pick-up of reverberation energy and random noise 73%. The axial polar pattern is symmetrical at all frequencies.

Improved "Ultra" wide-range fre-

Shure 556 mike.

quency response from 40 to 10,000 cycles assures full reproduction of music, crisp reproduction of speech.

New moving-coil unit is highly immune to mechanical vibration and wind noises.

This new "Super-Cardioid" performance is made possible thru the patented *Shure* "Uniphase" single-unit construction which eliminates the necessity of using two dissimilar microphone elements in one microphone for true undirectional operation.

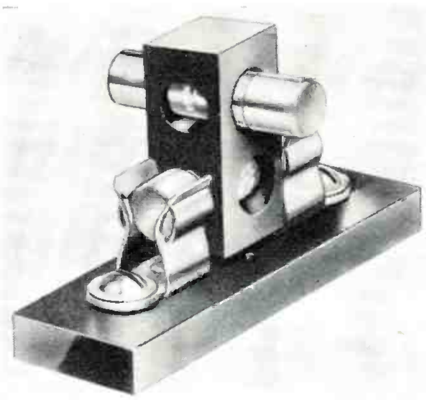
The new Microphone is functional in design and beautifully modern in appearance. Compact, sturdy construction makes it easy to handle.

The Super-Cardioid is available in three models: Model 556A for 35-50 ohm circuits, Model 556B for 200-250 ohm circuits; Model 556C, high impedance.

For full details, write to *Shure Brothers,* 225 W. Huron Street, Chicago, Illinois.

New Littelfuse Unit

An entirely new convenience for changing fuses in close quarters—replacing a blown fuse in a twinkling—



and giving notice on inspection that another spare is required, are features compactly embodied in a Spare Fuse Holder & Puller combined, just announced by *Littelfuse, Incorporated,* 4757 Ravenswood Ave., Chicago.

Aviation Radio Course

(*Continued from page 13*)

chines at 45 "words per minute." In the usual CAA communications station one will always find two or more of these machines constantly "batting" out weather information.

It is possible for a pilot flying over Seattle, Washington, to ask for and receive New York weather by radio. I think this adequately demonstrates the efficiency of our modern communications and weather systems.

We will subsequently discuss the technicalities of airlines and aircraft radio operation as well as control tower technique.

The airlines prefer to obtain applicants for airlines radio operating positions who have had some college education. However, a college education is not prerequisite for entrance into this well paying field. Of course, every operator must have the proper class of radio license depending upon his duties and the type of station in which he is employed. Those having a fair knowledge of radio and electrical theory may obtain the second class radiotelephone license (the class more often required) by diligently studying one or more text books now published on the subject or by attending a recognized radio school for three months or more, then taking the FCC examination. It cannot be stressed too highly here that the possession of a Federal license is usually declarative of a person's acquaintance with radio and electrical theory, rules, regulations, etc.; that is, to some degree. Even though war has affected all industries to a very marked degree, our airlines will operate day in and day out as long as it is possible to do so . . . air transportation has grown that important. Good radio operators are always needed; are you qualified now?

A position akin to airlines radio operating is that of control tower operator. This position requires that the applicant have knowledge relative to air traffic. His voice must be pleasing and like the airlines operator must be a very cool, quick, precise person. A restricted radiophone license is the class of license needed by personnel who work in the average airport traffic control station.

The *Civil Aeronautics Administration's* vast network of aviation communications stations, beacons, etc., provide the essential facilities for the aviation services. Extending some 32,000 miles the airlanes of America are supervised by the utilization of radio, teletype, and direct interphone (intercom) connection between stations. Since 1928, millions of dollars have been spent on improving communications facilities, radio aids to air navigation, blind landing systems, and aids to air traffic control. Cooperating with other governmental agencies and commercial aviation enterprises, the CAA is rendering invaluable service. Their research staffs are constantly testing new equipment and improving the old. During the past few years, the air traffic problem, especially at large airports has taken on tremendous significance. Notwithstanding the fact that our *National Defense* has occupied the center of consideration, the CAA has made gigantic strides toward increasing the safety of aircraft in the air.

How often during the past 18 months have you seen *Civil Service* announcements giving information on the radio positions offered by the CAA to those who could qualify? Quite a few times, no doubt.

(*To be continued*)

For the Record

(*Continued from page 4*)

in conjunction with circuits employing *Feedback*. A very complete treatise on this subject will be found on page 20. Don't miss this feature!

In response to many letters we are beginning a new series of articles on *Aviation Radio*. This complete course will run for the next twelve months and will offer a thorough background for the student or present radiomen of all classifications. It has been prepared to cover all requirements that are dictated by the air services, both military and civilian. This is an *exclusive* RADIO NEWS feature and one which should prove to be of great interest.

Do you begin the design of an amplifier at the input or at the output? Read the informative article titled "Designing a PA Amplifier" on page 26.

That old bugaboo *Impedance* is with us again. This time the subject takes the *offensive* rather than the *defensive*. Don't miss the technical feature beginning on page 18 in this issue. It tells how to analyze this subject and to apply fundamentals to everyday applications.

The radio serviceman is shown how to construct a "Dynamic Demonstrator" on page 30. Will come in mighty handy for you lads that are teaching radio classes!

Having trouble getting a turntable? W. E. Brown advises purchasing an old Dodge flywheel—the one driven by a 12 volt chain motor. A buck should buy one. Better hurry!

Hams—Take Note!

RADIO hams are being asked to sell their transmitters and receivers for use by the armed forces of the United Nations, according to an announcement by the *American Radio Relay League,* which is centralizing information on available apparatus on behalf of the government agencies concerned.

Only commercially-manufactured communications-type receivers and transmitters for which standard instruction manuals are available are required at present. Such equipment is more readily used and understood by military operators than homemade units, even though the latter may be of comparable quality, it was explained.

Urgent shortages of communications equipment required for defense needs led to the call, manufacturers finding themselves unable to make deliveries sufficient to fill the intensified demand as the theatre of war expands in widening circles.

Amateurs willing to turn over their apparatus to their country are requested to advise the ARRL at West Hartford, Conn., giving model number, condition, and the price for which it can be delivered crated to a local transportation agency. Only standard manufactured equipment should be offered, it was reiterated, homemade or "composite" equipment not being required at present.

The biggest need is in transmitters, it was stated. According to League statistics, approximately two-thirds of the receivers found in amateur stations are factory-made but only 5% of amateur transmitters were purchased from manufacturers.

Vacation? Oh Yeah!

WHO said radio was at a standstill? We are fast reaching a point where a goodly amount of manuscripts will have to be held over "for the duration" as the amount of new material approaches a new high. Our job is to get this information in print and into your hands as quickly and as accurately as possible. Oh well, we can't get tires for that vacation trip anyhow!

We'll see you with another big special issue next month. Remember the January Defense edition? Well, you will certainly not want to miss any of the outstanding exclusive features in the May issue. And so to work!

—73, O. R.

Designing a P.A. Amplifier

(*Continued from page 27*)

cuit to use. Generally it is best to stick to resistance type circuits. The output transformer mentioned previously is a necessity. The phase-inverter diagram in Fig. 2 has been the most popular for years and still is. Its operation is simple and it works well.

The first triode portion of the 6SC7 dual-triode tube operates as a straight triode amplifier. The resistor values are obtained from a tube manual and with those used, the tube will have a gain of 42. By dividing the grid resistance of the following tube (across which, of course, appears the output of the first triode of the phase-inverter) at a point about 1/42 of the way up we have a source of voltage equal in value but out of phase to that fed to the grid of the first triode of the 6SC7. This voltage is applied to the grid of the second triode of the tube.

The output of the second triode portion then drives the grid of the second power tube out-of-phase, but equal in voltage to that on the first power tube. The cathode bias resistor does not need to be by-passed for the same reason given for the power stage. So far, we have added a gain of 82 to our amplifier (from input of phase-inverter to push-pull input of final amplifier). The phase-inverter input peak voltage required for full output is now about ½ volt.

Let us now add some inverse feed-back to our amplifier. We've read quite a bit about inverse feed-back and know its value. It reduces distortion and hum. It increases the frequency response but it does reduce the gain.

A feed-back resistor of about 5 megohms as shown in Fig. 5 gives us a feed-back value of about 17% in this circuit. This is how we get it: Considering one feed-back resistor, we must base our figures on ½ of the circuit or a single-phase. One-half of the peak output voltage of the power stage is about 220 volts. Divide that by the quotient of the feed-back resistor divided by the parallel resistance of the plate resistance of the preceding tube, its plate load resistance and the grid resistor of the following tube, gives us about 2.2 volts. This is about 17% of ½ the input peak voltage of the power stage.

The loss in gain and effect on output impedance can be calculated, but it is negligible.

Time, now, to think about mixing microphone with phono-input, and to think about tone control.

The favorite phono-pickup today is the crystal type. Being of high impedance, it feeds directly into the grid of a tube. It has high bass output and gives record playing the "boom-boom" that most people like with their music. Their output varies from .6 volts to 1.5 volts, the better and lighter ones having the lower output. These values are R.M.S. volts at 1,000 cps. We are concerned with peak a.c. volts which is 1.4 times the RMS voltage. On loud musical passages, the maximum output may be several times the above figure. Let us assume that the maximum peak voltage is around 2 volts.

One of the simplest mixer systems is that shown in Figure 3A. The 1 megohm series resistors prevents shorting of the grid when one of the volume controls is at zero. While there is some interaction between the control settings, it is not serious. Figure 3B is a preferred circuit using L pads. There is practically no interaction between controls and there is no loss of voltage as in the case of Figure 3A. The circuit of Figure 3A is less expensive.

With a loss of ½ of the 2 peak volts from the phono-pickup as a result of the type of mixer we are using, we still have twice or more voltage than we need. The volume control will never be at maximum when we operate the amplifier.

Here is a good place to introduce some sort of tone control into the circuit. There are many forms of "tone control." They may be used for bass boost, treble boost, bass attenuation or treble attenuation. An entire article could be written on this one subject alone. Most people like some bass boost to their music. Treble attenuation produces the same apparent effect as bass boost and is easier to accomplish. Let's select the simplest circuit, requiring only a fixed condenser and a variable resistor.

When the plate load resistance of a tube is changed, the amplification of the tube is changed. By using a condenser in parallel with the normal plate load resistor, the effective impedance is lower at higher frequencies, resulting in less amplification at the higher frequencies. That results in treble attenuation. If a variable resistance is connected in *series* with this condenser and to ground, we can vary the amount of treble attenuation. A .01 mfd. condenser has a capacitive reactance of 15,900 ohms at 1,000 cps. With all of the condenser used, the amplification of the 6SC7 would be reduced to about 30% of the normal value at 1,000 cps.; less at lower frequencies, but attenuated still more at higher frequencies.

The microphone stage must give us an output of 1 volt peak for full output. What amplification do we need here? Well, that depends on the output of the microphone. Unfortunately not all manufacturers use the same standard of rating the db output of a microphone, varying from 0 db = 1 mw. to 0 db = 12.5 mw. Let us use the lowest figure so that we will have sufficient gain for all mikes. The load resistance is usually assumed to be 100,000 ohms. Outputs may vary from —50 to —60 db. This represents a voltage of about .01 volts R.M.S. in the extreme. To build this up to 1 peak volt we need an amplifier with a gain of about 70. A 6SJ7 operating at only 180 volts can be made to have a gain of as much as 192. That's good, because we should have more than we need so that close talking into a microphone won't always be necessary.

Additional mike amplifiers may be designed in the same way if simultaneous operation of several mikes are required. Output mixing of another stage may be handled in the same way as suggested here, although some form of electronic mixing is preferred.

Note that the microphone stage has been decoupled from the plate supply of the following stages. This is necessary to prevent motor-boating, because the first stage carries voltage in-phase with the last or power stage. Two adjacent stages need not be decoupled.

We seem to have strayed away from the matter of frequency response. Frequency response is determined by the value of grid resistors and coupling condensers in all stages and by cathode and screen by-pass condensers and plate load resistor in the first stage. While it is possible to calculate accurately the response, based on the values of condensers and resistors, it is only necessary to use adequately large condensers, such as we did here, and we can assume that the low frequency response is good. The lower the grid resistors, the better the high frequency response. The values used are a good average value for good response. If you can sacrifice gain, reduce the values of all grid resistors, and thereby increase the response to high frequencies.

Power supply design is conventional. It is important that the filtering be adequate and regulation good. Poor regulation will increase the harmonic distortion in the power stage.

Lay-out of parts, isolation of input from output, reduction of hum and licking other bugs is a story in itself. These factors are not governed so much by cold facts as by the ingenuity of the builder and requires practice to obtain proficiency.

—30—

Sound and The Victory Program

(*Continued from page* 9)

A special sound-amplification type air-raid alarm system has recently been installed in the Central Hanover Bank, located on Wall Street in New York City, by Commercial Radio-Sound Corporation. Because of the number of burglar and other alarms already in use, an air-raid alarm system was provided with a very distinctive signal.

The use in arsenals, steel mills, ship yards, aircraft factories, textile plants, and other industries, of recorded music to encourage greater efficiency by easing fatigue and brightening the working day, is comparatively a new idea in the United States. However, it has been a strong factor in increasing German war efforts, and music in South American factories is common-place. The "reader" formerly employed in Cuban cigar factories has been replaced in most cases by recorded music played through sound-amplification systems. *Eighty percent of the English industrial plants use music as a morale builder.* Why shouldn't we?

In the United States, the RCA Manufacturing Company at Camden, New Jersey, has pioneered the application of music in industry. One of its notable achievements is at the plant of the Botany Worsted Mills at Passaic. Botany's sound system provides a wide selection of music for thousands of workers who are turning out vast quantities of clothing material for the armed forces of the Nation. It adds pleasure to the working hours of others who are cutting next fall's cravats, sewing next winter's robes and weaving material for a dozen kinds of wearing apparel.

The RCA Intra-plant Broadcasting system used by this mill consists of loudspeakers suspended from the ceiling at 50-foot intervals, a number of powerful amplifiers, twin turntables permitting two simultaneous record programs to different parts of the plant, and numerous microphones for paging and announcements. An employee in charge of the system prepares the music programs and operates the equipment.

Other representative users of "Music in Industry" are the Curtiss Wright Corporation, Buffalo, New York; Owens Illinois Glass Company, Bridgeton, N. J.; the Oregon Shipbuilding Corporation, Portland, Oregon and the Piccatinny Arsenal at Dover, N. J.

According to W. L. Rothenberger, RCA's Manager of Industrial Sales, "Research has revealed that efficiency and morale reach their low ebb near the end of the morning and afternoon work periods—the so-called peak fatigue periods. To give employees a 'lift,' or 'pick-up,' at these times, bright, cheerful and lively music fills the air. During the luncheon period, a soothing, restful type of music helps them to relax and 'take it easy' before starting in the second half of the day. Music used in this fashion, as a 'refresher' during working hours and a 'relaxer' at noon, is helping to send workers home in better spirits.

"Lowered fatigue, because it permits closer attention to the work being done, logically tends toward fewer accidents and errors. By adding a note of pleasantness to everyday occupations, industrial music improves employer-employee relationships, fortifying good will and morale and lowering labor turnover. As one worker put it, 'Music makes you look forward to coming to work.'

"Furthermore, tests conducted in England by the Medical Research Council show that industrial production 'with music' has run from 6% to 11% higher than the same activity under identical conditions, but without music. The use of music helps eliminate work slumps at peak fatigue periods, and thus sustains the level of production throughout the day."

Commenting on the use of music in industry, William Green, President of the American Federation of Labor, calls industrial music a "friend of labor, for it lightens the task by refreshing the nerves and spirit of the worker." William Bristol of the Bristol Meyers Company says, "We believe that music, news, and other types of informative and entertaining programs will help plant and office workers to do a good day's work with a minimum of fatigue." A. H. Dente, Business Manager of the American Business Magazine comments, *"Music is what makes a parade, so why shouldn't we use it to keep up the production parade?"*

Turning to the special uses for sound amplification systems in National *Offense,* we find them many and varied, with most of the uses considered secret during war time. However, some of the already-known uses such as for recording, moving picture equipment and coverage of large outdoor audiences can be pointed out.

Finally, it must be remembered that there are many applications where sound-amplification equipment is used for more than one purpose. That is, an audio amplifier and one or more loudspeakers which are fed by a pickup and turntable can also be fed by one or more microphones, a tone signal (such as for air raids), etc.

An excellent example of a "combination system is the one installed by Commercial Radio-Sound Corporation in Saks Fifth Avenue, a large New York department store. A total of 195 loudspeakers are mounted throughout the store, and the system provides for air raid warnings, instructions to personnel, announcements to patrons, paging and musical reproduction.

The Leo J. Meyberg Co. of Los Angeles recently installed a "combination" sound system in the North American Aircraft factory. The system is a decided help in maintaining morale, as well as providing the usual paging features. The facilities for music and speech reproduction are utilized for entertainment, and for educational programs during the lunch hour, as well as for air-raid alarms and addresses by visiting officials. Sports results and war news are sent over the system at specified times.

Now, how does this newly developing field pertain to the radio serviceman? First of all, he has a golden opportunity to sell sound equipment as never before. National *Offense* production *needs* sound amplification —and he is the man who, by his experience, can do the job of selling and installing the necessary equipment. Second, such equipment must be kept in perfect running order at all times. National *Offense* sound equipment is *important*—like a gun, or a tank. It is being used to help win the war. It must not break down at the wrong time. Here is the opportunity for radio and sound service men to work out a periodical inspection routine whereby all sound equipment is checked every so often and kept in perfect operating condition as a result.

Radio and electronic service men—here is another chance to help your country, as you help yourself.

—30—

Impedance Matching

(*Continued from page* 19)

establishment as a one-way call system with two speakers specified. But the volume at one speaker must not be more than one half the volume of the other since one speaker is in a noisy location while the other is inside a cashier's glass cage with substantially lower noise level.

Necessary "T" or "L" pads can be bought, but not soon enough to suit your client. What to do? While the series connection of voice coils is not recommended because the resonance of two speakers very seldom occurs at the same frequency this is a case of absolute necessity — a situation where service overrides the finer aspects of best practice.

To go on then—you *can* obtain an 8-inch, 6-ohm p.m. speaker and also a replacement type, 5 inch, 2-ohm p.m., battery radio speaker. Your 5-watt amplifier has the usual 8-ohm output terminals. In Fig. 5 are shown the two speakers in series. As will be explained, the two ohm speaker will be placed in the cashier's cage and deliver a maximum of 1.25 watts while the speaker in the noisier location will deliver 3.75 watts maximum. This should satisfy the requirements as specified above.

For clarity let us see how these values were arrived at. First remember (still looking at Fig. 5) that the impedance of the amplifier output transformer should be equal to the sum of the voice coil impedance in series. We have placed a 6-ohm and a 2-ohm voice coil in series to total 8 ohms. The next step is finding the current in this series circuit. From Ohms Law we know that Current (I) is equal to the square root of the power (W) divided by the impedance.

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

Therefore

$$I = \sqrt{\frac{5 \text{ watts}}{8 \text{ ohms}}}$$

which equals the current flowing through *both* voice coils; since the current in a series circuit is always the same.

To find the power in each speaker use, $I^2R = W$. Therefore (I^2) .625 times 2 ohms equals 1.25 watts in one speaker; the same procedure follows for the second speaker .625 times 6 ohms equals 3.75 watts in the 6-ohm, 8-inch speaker.

With this arrangement of speaker power distribution it must be remembered that the power ratio between speakers is always constant as related to the other. Retarding the gain control on the amplifier will always reduce volume by the same percentage in one speaker as in the other. With this system understood there is no doubt that others will suggest themselves as a definite solution to the immediate problem.

Makeshifts such as these under normal business conditions would be frowned upon, still today they sometimes reflect the ingenious thinking of a mind under pressure and they do solve seemingly impossible riddles arising from the lack of equipment.

Along with this information it may be helpful for some to recall the following equation. Two voice coils in series;

Total impedance in ohms $= Z_1 + Z_2$

For two voice coils in parallel the

$$\text{net total impedance in ohms} = \frac{Z_1 Z_2}{Z_1 + Z_2}.$$

When more than two voice coils are connected in parallel the total impedance in ohms is equal to

$$\frac{1}{\dfrac{1}{Z_1} + \dfrac{1}{Z_2} + \dfrac{1}{Z_3}}$$

Permit me to cite an incident quite parallel to this situation. As the auto tire ban was placed into effect it occurred to the author that a means of guarding the family car in its garage would be worthwhile. An intercommunication system is already an integral part of the home with one unused station available. All individual outlying stations incorporate a 4-inch, 3-ohm p.m. speaker as combination microphone-speakers. After discovering that these would be available "sometime soon" it was decided to cast around for a likely substitute.

A bit of "hunting" brought forth a 5-inch *Brush* crystal speaker unit. The lines terminate at the master station with a 3-ohm impedance. But the *Brush* unit had an impedance of 80,000 ohms. How to couple for maximum gain and best fidelity? The workshop produced a discarded pentode-to-voice coil transformer (10,000 ohms plate to 3-ohm voice coil).

As shown in Fig. 6 this was connected in reverse with the crystal unit across the high impedance primary and the original voice coil winding connected to the line. A 10,000, 2-watt resistor was shunted across the crystal unit for better loading and optimum matching. Compared to any of the other p.m. dynamic stations this unit has entirely acceptable tone quality and is equally sensitive on pickup. Because of the crisp tonal characteristics of the crystal it appears to be even a bit more sensitive than the others although no "meter" measurements have been up to date.

Suffice it is to say that it is working without criticism even from those who are aware of its substitute makeup. This personal note from real life, although minor in its consequence, has been injected into this writing as a means of proof, that where a shortage of essential materials exists it is usually possible, without too much brain racking, to produce results with the equipment on hand or that which is readily available.

There are instances when the number of speakers and universal speaker transformers available are not proper for the kind of installation desired. In such a case the use of pure resistance may be introduced as an impedance to balance an otherwise awkward situation. But and let this *BUT* be extremely imperative before this means is brought into use, it is wise to try various impedance combinations with pencil and paper first. As a final resort, and then only, permit its use. The reason for this caution is the undeniable fact that while a resistor in an a.c. (signal) circuit can be looked upon as an impedance, it nevertheless follows only the laws of power loss, I^2R, turning the current through it into so much heat and never produces an audible note! Fig. 7 shows a circuit using seven speakers each with a 1,000 ohm transformer each to deliver the same power.

For purposes of example we will say that there is no other means of handling this particular sound installation, both from an electrical and physical standpoint. Seven speaker transformers are connected in a series with the seventh speaker to complete the necessary circuit requirements. While a glance at this particular circuit will immediately indicate the need of a 1,000 ohm value for R, it is best to determine how it is arrived at mathematically. The amplifier output terminals have an impedance of 500 ohms. To match this all speaker output transformers must be so connected so that their combined or net resultant impedance facing the output transformer also equal 500 ohms.

In this particular instance each speaker output transformer primary is tapped at the 1,000 ohm terminal. Each transformer is in series with another across the 500-ohm line. As a result there is a total impedance of 2,000 ohms at each one of the points indicated in Fig. 7. Since we have four legs of equal value it is only necessary to divide 2,000 by four to arrive at 500 ohms as the mean impedance of the group.

Since visual inspection indicates that each leg demands 2,000 ohms impedance, it is only a matter of subtracting the 1,000 ohm impedance of No. 7 speaker from 2,000 ohms to determine the 1,000 ohm value of R. Now to determine the power rating of this "matching" resistor.

Again using the equation

$$I = \sqrt{\frac{W}{R}},$$

$$\text{we have } I = \sqrt{\frac{60 \text{ watts power}}{500 \text{ ohms}}}$$

$= .346$ amperes in the series parallel circuit. Since the current in this case is equally distributed through four legs, the current through R will be one fourth of this value or .084 amperes. Then I^2R gives us $(.084)^2$ times 1,000 ohms or 7.056 watts power dissipated by the resistor. In actual use a 10-watt resistor would be wired in. The above series parallel combination as well as other similar ones can easily be determined from the formula:

$$\frac{1}{\frac{1}{Z_1 + Z_2} + \frac{1}{Z_3 + Z_4}}$$

where $\frac{1}{Z_1 + Z_2}$ equals one of the series members and $\frac{1}{Z_3 + Z_4}$ equals another.

Obviously this equation holds true for voice coils in series parallel as well as for output transformer primary impedances.

Generally we always speak of a speaker voice coil as having an impedance of so many ohms, but as has been mentioned before, this impedance is correct only at the frequency at which the speaker manufacturer measures it. Distributors' catalogs sometime give this information such as "8 ohms at 400 cycles." When it is impossible to determine this data as on a speaker without name or information stamped upon it, the following may be of value in eventually arriving at a correct impedance match.

In Fig. 8 is shown an audio oscillator of either the fixed or variable type. If only a 400 cycle output is desired a fixed frequency type is fine. If 60 cycle measurements be satisfactory then a 2½ volt filament transformer with a potentiometer across it for controlling voltage output will do the job. The variable resistor "R" should be non-inductive, calibrated in ohms and preferably have a somewhat greater resistance than the expected value of the voice coil under test.

In a real pinch "R" might also be a group of separate resistors with various values, hooked in for the test. Also required is a vacuum tube voltmeter. Procedure is as follows: With the audio oscillator or transformer turned on and the unknown speaker voice coil connected across the points A and B, measure with vacuum tube voltmeter the voltage developed across "R" and then across points A and B. Adjust R until the voltage across it and across A and B are equal. The value of R in the circuit at the time is equal to the voice coil impedance at the frequency of the audio oscillator. While the purists will find fault with this method for various reasons, it will measure voice coil impedance with sufficient accuracy for all practical purposes.

In this article some effort has been directed toward clearing up distorted views on the subject of impedance matching. Much remains to be said on this all important factor in communications.

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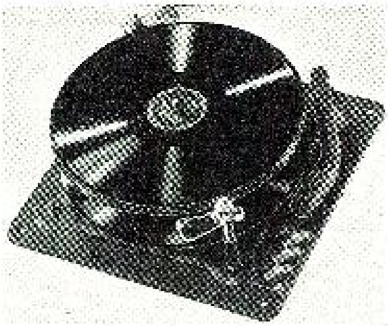

Book Review

(*Continued from page* 32)

ment such as tuning eye tubes, newer tubes, s.w. adapters, push-button tuning, and recording equipment follow.

Every repair job can be turned into a profitable modernization task. Just a suggestion of a new airplane dial, dual speakers, or remote tuning is usually enough. This manual teaches you how to obtain this work, what modernization to suggest to a particular owner with any special radio set, and how to carry out the actual repair work.

A.S.T.M. STANDARDS ON ELECTRICAL INSULATING MATERIALS, published by *American Society for Testing Materials,* 260 South Broad Street, Philadelphia, Pa. The latest edition of this annual publication is considerably enlarged by the inclusion of new specifications and tests and several reports and papers. It provides in their latest form as of December, 1941, the same 58 specifications and tests issued by A.S.T.M. covering this field. Outstanding activities carried on by A.S.T.M. Committee D-9 on Electrical Insulating Materials are covered in certain reports, one on punching quality of laminated phenolic sheet; a study of measurements of power factor and dielectric constant at ultra-high frequencies; a report on round-robin tests of power factor and dielectric constant for glass; and several discussions on the significance of tests of insulating materials, including dielectric strength.

Seven of the specifications and tests cover insulating varnishes, lacquers and their products and thirteen provide standardized test methods for molded materials. The section covering plates, tubes, and rods includes nine standards and there are six standards in the field of mineral oils, ceramic products and solid filling and treating compounds. Two test methods cover insulating paper; four apply to mica products; and there are eight specifications — four each for various rubber products and textile materials; and four standards give tests and tolerances for various types of glass products and for woven tapes. Six standards give tests covering arc resistance, dielectric strength, power factor and related properties and tests.

This publication, which includes for the first time a detailed index, also includes two tables of contents, one listing standards in numeric sequence. The 1941 report of Committee D-9, with its recommendations on standards, is given.

Copies of the 450-page publication can be obtained from A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia, at $2.25 per copy, heavy paper cover.

THE HISTORY OF COMBAT AIRPLANES, by Charles G. Grey, No. 7 in the *James Jackson Cabot Professorship* series at *Norwich University,* Northfield, Vermont; 158 pp.; $1.00.

This seventh publication in the series covers the evolution of fighting airplanes from pre-World War days to the middle of 1941. The author has divided the history into four periods, the first ending with the Armistice in 1918, the second dealing with progress between wars, and the third covering World War II developments. In Part three, by the way, Mr. Grey has gone into considerable interesting detail regarding the Battle of Britain, as he terms the heavy air fighting over southern England and the Channel in the late summer of 1940. Part four has to do with armament and armor and to some extent, with the tactics of modern combat airplanes.

Non-technical in his treatment, the author neatly avoids catalog style by frequently interspersing comments and discussions, based on his thirty-odd years of experience as an aviation writer and prompted by mention of airplanes and events by now often almost forgotten.

The British Radio locater is given due credit within the pages of this book.

Erratum!

MARCH ISSUE, PAGE 13

Screens of both 6SK7GT tubes should be fed from B+ through a 40,000 ohm, 1 w. resistor.

Smoke Jumpers

(*Continued from page* 8)

switching from one network to another. Another useful feature is a panel pushbutton which provides a marker signal and permits setting the receiver on any of the three transmitter frequencies.

For emergency lookout use a kitbox is supplied with the type SX, which contains heavy duty batteries and an additional unit containing an audio amplifier and loudspeaker.

General use of ultra-high frequencies in mountainous regions has required the development of an automatic relay station. The transmitter section is conventional design and where—as is usually the case—dry battery is the only source of power, has an output of two watts. In the receiver, twelve tubes are used, distributed as follows: Two signal radio-frequency stages, first detector, crystal oscillator, frequency multiplier, three intermediate-frequency stages, second detector AVC, fifteen-kilocycle noise amplifier and rectifier, relay control tube, audio amplifier.

According to *United States Forest Service* records, the annual number of forest fires in the 208,000,000 acres which are its responsibility, are increasing, although the average size of the fires is becoming progressively smaller. Improvements in communication facilities have undoubtedly played an important part in reducing fire losses. It is obviously true that the quicker one can attack a fire, the fewer men are needed to put it out—a fact which indicates the importance of faster communication and transportation.

Although most forest protection agencies do not yet have sufficient communication facilities, the extent of the existing systems is surprising. The *U. S. Forest Service* operates about 3,500 radio stations, while state and private forest protection agencies have approximately 1,500 radio stations.

Before the advent of radio, communication along the fire line was largely by messenger, which at best is a slow and uncertain method. Consequently, there was often a conspicuous lack of coordination among the various fire-fighting units attacking a single fire. With the development of portable and mobile two-way radio, astonishing improvements in fire-fighting tactics become possible. The entire forces can now be controlled from a single headquarters, and men and machines shifted along the line as the vagaries of the fire dictate.

Various state forest agencies have used radio communication in fire fighting, also with successful results. The *Forest Protection Division* of Wisconsin, because of definite achievements in the past, plans an intensification of its radio coverage. Radio schools for its personnel have been established, and practically every member now holds a radiotelephone operator's license, which permits him to operate such equipment.

More and more is the need for adequate fire protection. Radio men might look into future possibilities of this service.—Ed.

Almost unlimited possibilities are envisioned for the use of radio communication in fire-control work. Radio communication may be used for service to emergency lookout points where the cost of radio would be more economical than the construction and maintenance of telephone lines. Radio is also to be used to advantage for contact with stand-by crews to be located at strategic points during periods of high fire hazard.

It is used to contact CCC crews on work projects in the forest areas, and thus make them instantly available without interfering with their regular conservation activities. Also, on large fires, scouts are stationed at various points along the fire line to report the requirements on the entire front. Beyond any doubt, the use of radio in fire-control work is writing a new page in the forest-fire history of the United States.

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Beginners Dynamic

(*Continued from page* 31)

components to fill the board.)

While the board itself is fairly rigid, reinforcing with 2 inch wood strips will permit greater strength, and provide means for mounting. This makes a framework in back and is glued and screwed to the board. This is clearly shown in the back view. Note the mountings for the two side strips which slide in for the tripod. The mountings are made of galvanized metal sheeting, hammered over a vise to fit the 2 inch wood strips.

The standing tripod strips are 2 inches wide and six feet long. The two side ones slip through the mountings (pointed ends up), while the center strip is hinged to the top of the board. This hinge has a removable pin. This pin can be seen half-inserted in the rear view of the unit mounted for demonstration. With the tripod staves removed the whole outfit is knocked down for transportation. When it's set up it's just the right height for classroom demonstration. (It may be helpful to attach a string from the center hinged staff to the board. This will keep the staff from sliding too far on a smooth floor.)

With the board mounted on the frame a few coats of shellac or varnish should be applied overall to seal the surface. Then follow with one or two coats of black enamel. Allow sufficient time between coats for proper drying.

The diagram has to be sketched on the front. This may be done direct, or sketched on paper, then transferred. It is very important when sketching the diagram to allow for the tip jacks. Look out for the framework. Don't drill a half inch to get through an eighth inch board then find you're going through the framework.

The diagram which goes on the front of the board, it must be remembered, is not exactly like the schematic diagram. The painted diagram on the board is simplified, since it is desired to keep the demonstration as simple as possible. The tube filaments, for instance, aren't shown, since they're all in parallel, connected to the secondary of T_1, which also isn't shown. Then too, the rectifier tube has a grid which is wired direct to the plate, making it a diode. In the painted diagram it's simply shown as diode. Then, all grounds are connected together. In the front diagram, however, they simply go to the ground symbol. It was necessary to simplify this because otherwise lines would clutter up the whole demonstrator diagram.

If you have the tip jacks available, measure the diameter for the hole. They will probably require ¼" to ⅜" drills. If you're not certain of the size, then use a small drill as marker. Then drill all the tip jack holes from the front carefully, using sharp bits.

Try to keep the board from shredding. Then varnish or paint the edges of the holes to keep out the moisture. Now, using the holes as guides, sketch the same diagram on the back. (Of course, it will be reversed.) This sketch can be rough. It's only to aid in the placement of parts on the back.

Using the close-up rear view of the demonstrator as shown for a guide, sketch on the back the placement of the component parts. If the actual parts are available put them on the board and carefully mark their positions. It is not necessary that the parts be directly next to their schematic counterparts. The parts are labeled for identification. Keep the leads short if possible. Keep the transformers and chokes well separated. In the photograph the audio and microphone transformers are a little too close. Separate yours a bit if possible.

Remember to allow for the staves of the tripod. They have to be slid in along the back of the board. Keep that area clear. Move the parts along the back like chessmen until there is room for all parts. See that they don't cover the holes for the tip jacks. Later, if you find that hum persists, it's probably due to the position of some choke or transformer. Turn each one till the hum changes. Then move to position of least noise.

With the parts definitely marked, drill the cut-outs for the speaker, tube sockets, dials, and meter, if used. Sandpaper all the edges of the cuts, and paint to seal against moisture. Use small bolts to hold parts to the board, and screw the larger parts to the frame. Mount the speaker behind a heavy piece of window-screen screening. If possible, shellac or paint the screen to the board. Otherwise it might vibrate with the speaker. Mount the tube sockets as shown in the photographs, near the top of the board. Then mount everything else: transformers, chokes, tip jacks, etc., using the tip jacks to support small items, such as condensers and resistors.

As is customary, we wire the filaments of all tubes first. This is done with heavy twisted wire. All tubes are in parallel and are connected to the secondary of the filament transformer T_4. Keep a.c. wiring away from the speaker and output transformer. This is necessary to avoid hum in the output. Also, when the speaker is used as a microphone it is very susceptible to picking up 60 cycles from the a.c. wiring.

Now wire the transformers, chokes, condensers, everything. Make clean tight connections. Use rosin-core solder only. In the first stage (first tube circuit) especially keep the plate, cathode and grid leads well separated. Use fairly heavy wire and keep them put. This tube will be used as detector, and as such will be very sensitive. A loose wire will make it "bloop."

A brief explanation of the layout might be useful here. Look at the close-up front view. Notice the layout features the actual tube plugged in a little above the diagram of itself. The two are connected in back. That is, the plate of the tube socket is connected to the plate tip jack of the diagram, the grid terminal to the grid jack, etc. In Fig. 1 the terminals to the elements are shown. This is looking from the bottom of the socket, as in soldering. The pins are numbered going clockwise from the key, thus the ground terminal is number one, etc.

Back to the layout, now. Starting from the left we have the detector tube. Underneath it is the coil. This is plugged in just like a tube. The socket is connected to the jacks of the coil diagram. Below is the tuning dial which is connected to the tuning condenser. Then at the top is the antenna. The antenna binding post is at the top of the mast. Next comes the meter, (an 0-15 ma. meter with shunts and multipliers to extend the range. The dial next to the antenna is the meter switch). An external meter would serve as well. For complete meter details, see the article on meters in RADIO NEWS for September, 1941, page 15.

Underneath the meter switch is the dial for the antenna condenser. There's another dial just like it way below the meter. This is for the regeneration condenser. Directly below the meter are the meter jacks and the battery jacks. The latter are for the single battery cell used as mike battery for the carbon microphone.

The next tube is the rectifier, corresponding with the rectifier drawing at the bottom. Below the rectifier is the dial for the volume control R_5. Tube No. 3 is the audio tube. The last tube is the power tube. To replace this with a 6C5, like the others, simply leave out the screen grid from the diagram on the panel. The socket and other connections are identical.

A really difficult job is now before the constructor. If you can get an artist friend to paint the schematic diagram on the panel, better do so. It isn't easy. If the board has become dirty in the other work you'd best give the front another coat of black enamel first, then get to the diagram. Use ordinary white house paint, mixed thick. Draw the straight lines with a ruler. The coils will have to be drawn free hand, as will the circles.

If you make a mistake, wipe it off with a rag dipped in light oil, then paint the line in again. There will probably be some touching up later. Remember, get this diagram directly from the close-up photograph of the demonstrator, not from the diagram in Fig. 1. However, if you'd rather copy from Fig. 1 no real harm will be done.

Except for the coil, which we'll cover in the June issue, your Dynamic Demonstrator is now complete. Give it a good drying out. In the June issue we'll hook up the different circuits and test the operation of the Demonstrator.

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Selecting Speakers
(*Continued from page* 25)

threshold of pain and it is neither desirable nor practical to reproduce sound with the usual margin above the reproduced speech will sound "thin," but appears to "cut through" the noise rather than override it.

There are cases in non-industrial applications where no attempt should be made to reproduce above the maximum noise level. When the crowd cheers at 30 to 40 db above the average

Table 2

Description of Reproducer	Sound level at 10 feet with 1 watt input	Max. total coverage angle	Recommended Maximum Power Input
Metal diaphragm unit with Reflex Horn (20″ diameter bell)	105 db	54°	15 watts Av. 25 watts Max.
Cone driver speaker (5″ diameter) in small reflex horn (10″ bell) ..	82 db	80°	3.5 watts Av. 6.0 watts Max.
Rear enclosed desk type speaker (5″ diameter)	79 db	140°	3 watts Av. 5 watts Max.

noise. Experience has shown that highly intelligible sound can be transmitted at levels equal to or actually somewhat below the sound level meter noise indications because of the difference in character of the noise and the reproduced speech.

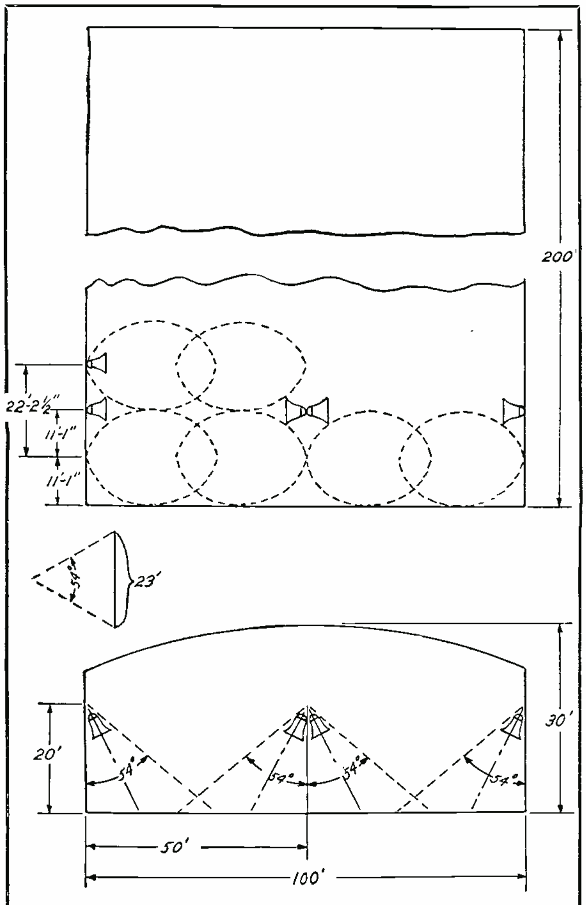

Fig. 4.

In such a case the installation calls for some experimentation but entirely satisfactory results are possible if the low frequencies are suppressed below 400-500 cycles per second and a sufficient number of speakers are employed, strategically placed and operated at relatively high intensities. The noise level at athletic events, it is more appropriate and practical to wait for the noise to subside than to attempt effective announcements at such moments. The average noise level under non-cheering conditions is the one to use for such installations, allowing 5 to 15 db margin in the reproduction; lower intensities are permissible because a fair degree of attention can be assumed, as contrasted with the concentration on work in industrial plants and the consequent importance of *commanding* attention and insuring intelligibility with relatively high level sound.

Loud Speaker Ratings

We need to know *what* sound level the proposed loud speaker will provide at the working distance and how much audio power must be supplied to afford the required sound level. We also need to know the angle throughout which the sound is projected at uniform level. With this information and the power handling ability of the speaker, we can select the proper type and number of reproducers and work out the location and orientation of the units to a high degree of accuracy.

Sound level information on loud speakers has not been generally published in the past because acoustical standards have been in a formative stage and there are still all too-few well equipped acoustical laboratories capable of accurate absolute measurements. The future will undoubtedly show progress and some manufacturers are already prepared to supply this type of rating data.

We need not be concerned with response-frequency in industrial applications *provided* it has been designed in accordance with the best practice for speech reproduction. What is required is a reproducer with maximum efficiency in the approximate center of the speech range and a falling characteristic at the upper and lower frequency limits.

The average efficiency in the mid portion of the reproduced range can then be used as a basis for comparing speakers for speech applications and for rating the sound level produced on the axis by a specified audio input power. An input of 1 watt to the speaker, warbled in a specified manner from 700 to 1,300 cycles per second is frequently used for this purpose and the sound pressure in decibels above the standard reference value (2.04×10^{-4} dynes per square centimeter) is measured on the axis ten feet from the speaker under free field conditions in the laboratory. As will be illustrated, this figure can be quickly converted to give the sound level at any distance for any input power. Measurements off the axis are used to establish the angle over which the sound level is essentially uniform, allowing a maximum drop of 3 db below the axial level.

Table 2 shows sound level, coverage angle and rated power data for three particular commercial loudspeakers suitable for speech reproduction in industrial applications. It should be understood that the ratings, while roughly indicative, are *not* to be taken as exact information on all devices of similar description due to the marked effect of differences in magnetic circuit efficiency, effectiveness of horn design and similar factors on performance.

Fig. I is a chart showing the effect of distance to the reproducer on sound level. Suppose we wish to find the drop in sound level if the distance is increased from 10 feet to 40 feet. This is read off directly, giving a drop of 12 db. If we are considering the metal diaphragm unit and reflex horn combination in Table 2, this would mean that at 40 feet the sound level would be 105 db — 12 db or 93 db with 1 watt input.

Fig. 2 gives the sound level change with input power. For the speaker discussed above we have determined the sound level at 40 feet to be 93 db with 1 watt input. If the input is increased to 10 watts, what will the sound level be? The chart shows an increase of 10 db or a sound level of 93 db + 10 db or 103 db at 40 feet with an input of 10 watts.

Sometimes the speaker performance is stated in terms of the sound pressure in dynes per square centimeter and it is convenient to be able to convert the data to a sound level basis. Figure 3 gives the relationship directly.

Applying the Data in Practice

Suppose that an industrial sound system is to be installed in a factory 100 feet wide, 200 feet long with a headroom of 30 feet. The noise level is estimated or measured at 90 db and is relatively uniform throughout the plant. Next a plan and elevation sketch is made rather accurately to scale as in Fig. 4. Since the noise level is rather high, we assume a highly efficient unit (first Item in Table 2). Taking the given maximum total coverage angle of 54 degrees, we try various arrangements in the elevation sketch, arriving at the one shown which employs four reproducers to cover the 100-foot width with a slight overlap from adjacent side units. If the speakers are mounted 20 feet high, the axial distance from speaker to floor level is scaled-off to be 22½ feet. The sound level required at this distance is 90 db (noise level) plus 20 db margin or 110 db.

The speaker has a sound level of 105 db (10 feet, 1 watt). From Fig. I we find a drop of 7 db for 22½ feet or a sound level of 98 db (1 watt). The required level is 110 db or an increase of 12 db over the 1-watt sound level. From Fig. 2 it is determined that this corresponds to a 15 watt input per speaker which is a satisfactory value and within the rating.

To find the horizontal coverage afforded by each row of speakers, construct to scale the triangle shown and scale off the base, which in this case proves to be 23 feet. Dividing the length of the building by 23 we get 8.7 which we call 9 rows, closing up the spacing to 22 feet 2½" between rows.

The total number of speakers is 36 (9 rows of 4). The required audio power is 36 times 15 watts or a total of 540 watts. Five 100 watt amplifiers would probably be sufficient, particularly if the low frequency response is attenuated in the driver amplifier.

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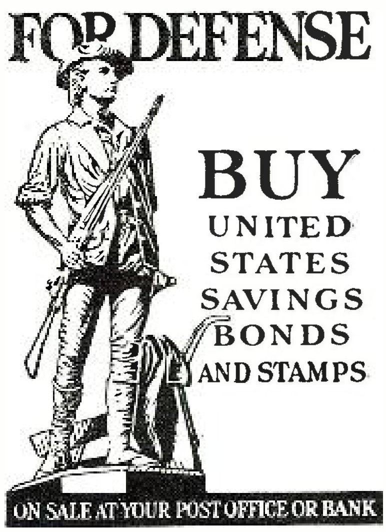


AMERICA ON GUARD!

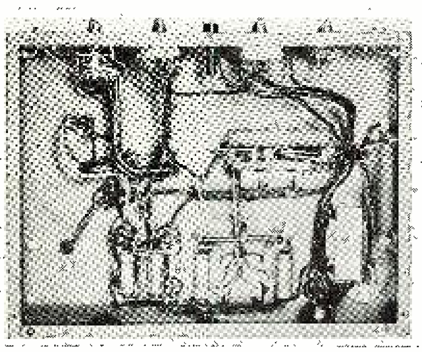
Above is a reproduction of the Treasury Department's Defense Savings Poster, showing an exact duplication of the original "Minute Man" statue by famed sculptor Daniel Chester French. Defense Bonds and Stamps, on sale at your bank or post office, are a vital part of America's defense preparations.

P. A. Amplifier

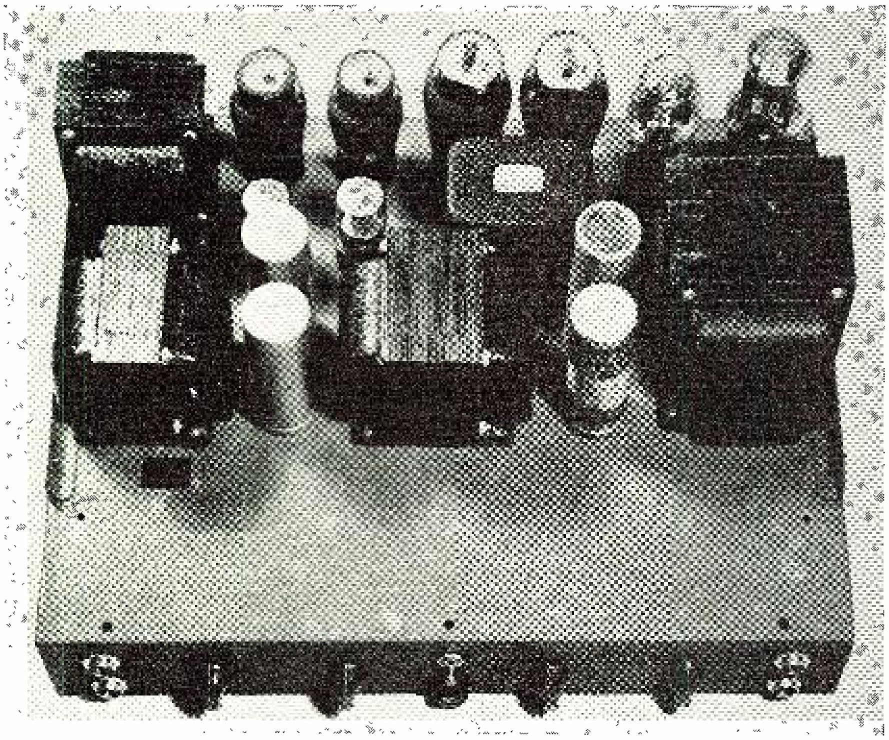
(*Continued from page* 10)

merely an a.c. outlet which comes in very handy when a record player is called for.

The plates of the 6L6's have a separate voltage supply using an 83. The screens of the 6L6's and the other tubes derive theirs from the 80 rectifier and in its negative return there is an adjustable bias supply for the 6L6 grids. R-41 is 200 ohms variable



Bottom view of amplifier.



How the amplifier looks with pre-amp removed.

and is adjusted so that a current meter inserted in the cathode circuit of the output tubes reads 100 ma. with *no signal.*

This arrangement insures a very steady voltage even when the output tubes are driven quite hard.

In the list of parts, all resistors not otherwise mentioned are all rated at ½ watt. By-pass condensers were paper, rated at 400 volts. Inverse-feedback condensers are 1600 volts (working).

By-pass condensers were connected across the power transformer primary to cut out the hum and for most installations this will be sufficient but an outside ground might still be better in some cases.

The input jacks were re-located after the head amplifier was first tested. This change was made so as to have the fifth input on the diagram in the center of the panel as it does not have a volume control and the control above it is actually the Master control feeding into the first 6J5.

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Power Rheostats in Production

An already large and growing department for the exclusive production of power rheostats is now set up in the plant of *Clarostat Mfg. Co., Inc.,* 285-7 N. 6th St., Brooklyn, N. Y. The production capacity is adequate to take care of large radio, electrical and industrial requirements over and above the heavy demands of military aircraft. One or more of these power rheostats of the armored type, or encased in a perforated metal housing, are now standard equipment on fighting planes, especially for panel-illumination control.

Although thousands of *Clarostat* power rheostats are being made each month for National Defense needs, the production capacity can take care of other requirements as well, according to Vic Mucher who heads *Clarostat* sales. For the present the efforts are concentrated on the 25-watt size (which actually handles 25 watts even at one-third setting), but a 50-watt size will soon be added to the line.

Phase Inverter
(*Continued from page 22*)

it would be impractical to attempt to determine these values to any greater extent than we have. If it is necessary to have an *exact balance,* the ratio of the resistors should be determined by experiment and actually by measuring the signal on the two push-pull tubes. A very simple way to determine if any of these systems are unbalanced is to connect the plates of the two output tubes together temporarily and if you hear any signal at all with the gain all the way up it will indicate that one plate is being driven with more signal input than the other. The circuit which we have just discussed is quite satisfactory and the only objection would be that it requires a little more careful adjustment than the one which we are going to take up next.

This phase inverter is the one which was referred to as the most perfectly balanced of the two "balanced phase inverters." The operation of this circuit varies slightly from the one which we just discussed and it might be well to start from the beginning in explaining the operation just as we have done previously. The circuit for this arrangement is found in figure 4 and its equivalent circuit is found in figure 4a.

In explaining the "self-balancing" effect first of all assume the condition when the gain of V2 is higher than V1. This would mean that most of the voltage across R3 would have the phase condition shown in figure 5 under (d). By applying this voltage back to the grid we have degeneration in V2, since V2 shifts the phase 180 degrees from the grid to the plate. This R1 and R2 are usually the same. It is possible to attain a complete balance and this has been shown mathematically, but again in regard to the practical case where standard resistors are used this seems rather unnecessary. Using this system we do eliminate the possibility of a large unbalance occurring and counteract the effect of the same type tubes having slightly different characteristics.

In concluding we have shown in figure 6(a) (b) and (c) the various practical applications of all these circuits, giving the tubes that can be used conveniently, as well as the circuit constants employed. These circuits that we have discussed are all satisfactory and by keeping their respective merits well in mind it is quite simple to use one type or the other for practically any application where an interstage transformer would ordinarily have been used. Good results can be obtained quite easily and do not require such critical adjustment or the use of any high priced testing equipment.

Mr. Putnam is preparing more of these interesting radio subjects.—Ed.

—30—

Serviceman's Experiences
(*Continued from page 28*)

"It sure does," I agreed. "You know, I'd like to go back to Peterson and make him a present of—"

"They didn't get much sleep that night. Why? Because they stayed up to *repair the damaged plane.* After they buried their dead, I'll bet. I can just see them." He lowered his paper

COMING NEXT MONTH!
"RADIO IN WAR"

and gazed toward the molding. "A short prayer for the victims, a curse for the enemy, some cold food, and a trip back to the airship, where they worked by artificial light. Lee, if the nation ever lets men like them down, hell's too good for us! . . . Let's see what else happened." He raised his paper again.

"I'll go over and tell those wardens we'll do the job for nothing," I blurted.

"On the sixteenth, 25 bombers came across," Al continued. "They made two raids and dropped hundreds of bombs. Right here is when they made that classic crack—remember? Someone from another island asked them if they wanted anything, and they came back with: 'Sure. Send us some more Japs.' Oh, brother! On the eighteenth, all the buildings had been destroyed. There were no attacks the next day. There they were, holding off the whole Japanese nation, almost, and the enemy was afraid to attack! The Jap board of strategy must have been holding an emergency meeting, but I'll bet the Marines weren't worried. Ten to one they serviced their equipment, and spent the rest of the day playing pinochle. The 'war of nerves' wouldn't phase *that* bunch."

"I gotta go, Al," I said. "That set is needed if an alert is—"

"On the twentieth, some more bombers came over, making a little more wreckage. On the following day, nothing happened. (I hope they played pinochle again—with spades double!) On the twenty-second, a 'large force' attacked the Island. The remaining two planes went up to meet the invaders, and the ground crew fired with whatever they had left, *sinking two destroyers*. The day's communique ended with the statement that the outcome 'was still in doubt.'"

Al threw the paper on the floor. "Lee," he said, "if the whole bunch of us don't get behind the war effort—" Then he suddenly relaxed, leaned back in the chair, and drummed the desk with his fingers.

"If it's all right with you," I announced, "I'm going to take a *Majestic* filter block and some other stuff out of stock, and *give* them to Peterson without charge. I hope he'll let me explain—"

"You know," Al said, tilting his head, "that's not a *rising* sun on the Japanese flag. Confidentially, it sinks."

"Ah, what's the use?" I muttered, picking up the toolbag and starting for the door.

"Wait a minute," Al called. "What was that long-winded story you were trying to tell me?"

"Never mind, never mind," I said, walking to the truck.

"Where you going?" Al asked innocently, and I knew he'd been listening.

"Out to give a bunch of air raid wardens a pleasant surprise," I called as I pulled away from the curb.

Al laughed and raised his right thumb in approval.

—30—

QRD? de Gy

(Continued from page 32)

know how the Six-months Law affects a Ham graduate. Also he craves the knowledge of which is the best union to join "for I have been given to understand that join you must to secure a berth." S'funny thing that radio schools do not have a special class in FCC rulings and how they will affect embryo radiops as well as a class on "How and Where Jobs Are Found." We believe these facts of life should be told the young men for floundering around gumming up "Buzzer Rooms" will break down their morale and make them easy prey to other billets for which they may not be fitted. Although today a radiop, even a "ham" is at a premium not only aboard a ship but also in any of the aviation industries, we advise Brother Hill (if he has not already been nabbed by one of the various billets that need his professional services) to contact Fred Howe, Radio Officers' Union, 265 West 14th Street, New York City, for the dope.

APROPOS of this ed's thoughts on this date, we publish one reader's ideas quote The day of the windjammers is but a memory, and a most unwholesome one to all but those romantic souls who thrive on adventure fiction and were never subjected to the dubious privilege of "sailing before the mast." Yet, paradoxical as it may seem, we still have a number of backward lawmakers and shipping officials who persistently think in the stagnated terms of, and govern their decisions by, the antiquated policies of a bygone sailing ship era. In particular, we refer to the esteem they hold for the radio operators of the American Merchant Marine. These venerable gentlemen simply cannot or possibly will not awaken to the fact that deepsea working standards do not remain as changeless as the sea itself; that our Merchant Marine, both on the surface of the sea and in the air over the sea, is rapidly becoming modernized and streamlined; that within this revolutionary process no single man aboard a blue-water ship or transoceanic plane commands a more vital role in the integral task of navigating a gigantic carrier across the seas than the raidiop.

Some shipping executives who are stubbornly reluctant to acknowledge this indisputable truth, cling to the obsolete myth that "Sparks is merely a nice kid who is making a trip or so to sea in order to see the world before he settles down to a comfortable broadcast berth ashore, and so, will work for little or nothing and will put up with almost anything since he is only here temporarily anyhow."

Those days are gone forever and the sooner it is realized by everyone in the passenger and cargo business, the happier all hands will be. Everyone knows that radiotelegraphy in the present conflict has proven itself to be

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one of the most potent and decisive factors. And modern radio equipment without a thoroughly competent radio operator-technician to man it can certainly be likened unto the proverbial ship without a sail. Wireless telegraphy provides the voice and ears of our merchant fleet and it is most important that this power of speech and hearing be not impaired. Far too long now has the shipboard radioman been relegated to the status of a "seagoing misfit" who is neither seaman nor landlubber.

The time-worn terms of "excess baggage" and "necessary nuisance" are no longer justifiable. Modern marine radio operating is no longer for adolescents. Radio telegraphy has exchanged its diapers for full length trousers. A crack radiop of today must have ample educational background supplemented by an intensively specialized technical training together with a general knowledge of the steamship or transport plane business. He must be alert, unexcitable, and above all, he must possess the ability to think quickly on his feet in an emergency. His profession, a specialized branch of a comparatively new industry, has made cyclopean strides during the past decade; regulations and laws have become more intricate, apparatus maintenance and operating conditions more exacting.

All this calls for an increasingly higher calibre of radio operator-technician. Consequently, this requisite skill and responsibility is unquestionably deserving of larger remuneration and consideration. He resents further discrimination in a host of irritatingly petty matters, for he is no longer that "kid sparkie just making a cupla sea trips." He is here to stay, to work at his chosen profession, and is not merely making a few voyages in order to wear out his old clothes. He is an adult, a conscientious and patriotic American seafarer striving to earn an honest and fair living for himself and his family.

His is a most responsible position and he deserves equal rights with, and full recognition as an officer of our expanding merchant fleet. Ability and indispensability should be no longer ignored; longwhiskered tradition may indeed be a noble institution but it must not be permitted to impede progress. The time has arrived for a complete revaluation of the marine radio operator. Since his services aboard ship and plane are admittedly essential, his social and official status must be legally acknowledged, and as such, his compensation and privileges should be on a par with parallel ratings of other shipboard officers.

The past year with its manifold radio opportunities ashore and in the military services has witnessed an exodus of many of the finest marine operators in the business. At the present time our merchant marine needs these lost men in the worst way, and undoubtedly many of them could be induced to return to their ships if only the shipping officials would right the wrongs that made them so eager to grasp the first attractive shore-side offer. And needless to say, a large number of those remaining intend to leave the sea forever unless the guiding fathers of our American Merchant Marine put their radio house in order. Unquote.

WITH the above for a thought to our FCC and shipowners and "to whom it may concern" we say 30 to those brave radiops who went down with their ships since we last went to press. And with a 73 . . . ge . . . GY

—30—

Sound for Defense Plants

(*Continued from page* 17)

CHART I.

Output Watts	DB
5	29.2
10	32.2
15	33.9
20	35.2
25	36.2
30	36.9
35	37.6
40	38.2
50	39.2
60	40.0
75	40.9
100	42.2
250	46.1

CHART II.

Area Sq. Ft.	*Output Power (Watts)*
500-1500	5-10
1500-2500	10-20
2500-7000	20-40
7000-15000	50-75

analyzer, the predominant noise frequency (and its harmonics) may be discovered. If the predominant noise frequency is high, speakers in the vicinity of the noise-making machine, should have low-frequency emphasis in order to prevent "pitch blending." Conversely, speakers located near sources of low-frequency noises should be fitted for pronounced high-frequency response. The ear will not then be called upon to separate laboriously the speaker signal from the surrounding noise.

Note that we have concentrated our remarks upon the speakers themselves. This is because we realize the impossibility of "tone-controlling" a single master amplifier to take care of the widely divergent noise frequencies throughout an entire plant. To care for the desired frequency characteristics of individual speakers, one of the following systems might be employed: (1) high-power semi-fixed speaker tone control consisting of a high-wattage, slider-type resistor and fixed condenser; (2) low-pass filter or high-pass filter of suitable power-handling capability; or (3) speaker dividing network.

If separate output amplifiers are used "on location" with each speaker, a small tone control may be included in the input circuit of each such amplifier. Such a control would be identical with the tone control of any conventional audio amplifier. Its location in the grid-input circuit would obviate the need of its handling any large voltages or powers.

The factory noise level, like the frequency determinations, must be measured in each department, and the volume of each speaker individually preset in accordance with surrounding interference. Here again, we concentrate on the speaker itself, since the volume level of a single master amplifier could not possibly take care of the divergent noise interference conditions in all departments of a factory.

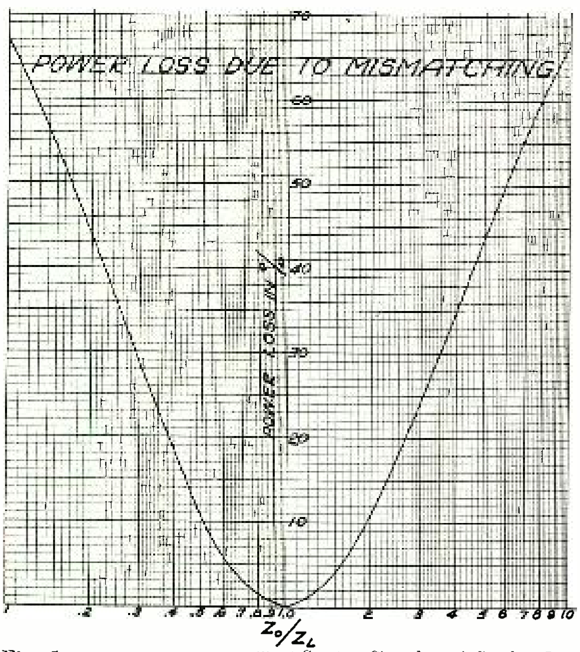

Fig. 5. Chart Courtesy Cinaudagraph Speakers Inc.

A power-type semi-fixed volume-pac (attenuation network) of the T- or H-type, made up of high-power slider-type resistors, is recommended to reduce the volume of each speaker by the proper amount, leaving wide open only those units in extremely noisy locations. In a sound system emloying separate output amplifiers at each speaker, an individual volume control as well as tone control, may be included in each "station."

To determine the maximum power output to be required of the sound system, it is necessary to know the average noise level in each department in which a speaker is to be located and the total number of speakers to be employed. The average noise level, figuring in the usual

(db), is determined in each department by means of direct indications taken in several parts of each department with the sound level meter. The amplifier is then chosen such that its db output will have a reasonable relation to the noise level at the department of highest interference. Chart I lists the ratings in decibels corresponding to various common values of amplifier output power.

When a single master amplifier is to supply all of the speakers without auxiliary speaker-amplifier stations, the number of speakers to be supplied and the maximum power required for the efficient operation of each must also be considered, since the total amplifier output power will be divided among these speakers.

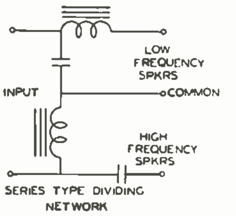

Fig. 3.

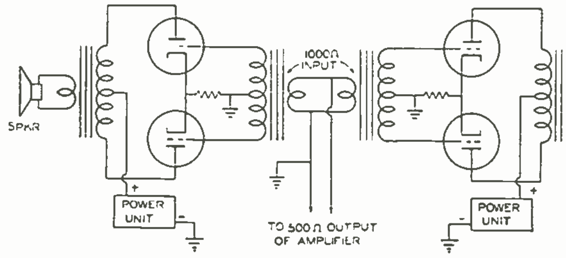

Fig. 4.

Single Amplifier vs. Speaker Stations

Obvious advantages of the separate output amplifier (speaker station) at each speaker location are that volume and tone may be satisfactorily controlled at each location with simple components, and that the line from the master amplifier (a voltage amplifier) is not required to carry appreciable power. If factory size requires that speakers be located some distance from the master amplifier, it may become a necessity to adopt the speaker-station scheme to prevent large losses of power in the line. Figure 4 illustrates the speaker-station scheme.

Leading disadvantages of the speaker-station system are that the separate amplifier must operate continuously if instantaneous response is to be obtained, or else some (often elaborate) provision must be made for switching it in from the master-amplifier position; the low-level line connecting the master amplifier and the speaker stations must be better than ordinarily shielded to prevent induced interference and must frequently be filtered for the same reason; and initial and maintenance costs for the system are high.

When it is practicable to supply all speakers from a single amplifier, however, the power output of such an amplifier needs be sufficiently high to supply power to all the units throughout the factory. The line must be capable of handling this power safely and with a minimum of loss. And (a distinct disadvantage) separate speaker volume- and tone-controlling components must be capable of handling the relatively high audio power with as low insertion loss as possible.

Area vs. Power

The effective power output (0.707 of the peak output, when the amplifier is so rated) to be delivered by the factory amplifier through its speakers will depend upon the size of the departments to be supplied; and, as we have already pointed out, upon the general noise level and method of supplying the speakers.

Areas usually supplied successfully in noisy interiors by various effective power output levels are given in Chart II. These figure represent an average of the values given separately by the engineering departments of several amplifier and speaker manufacturers. This table may be used as a preliminary guide and sound level meter measurements as a final check.

Frequency Response

The frequency response of the defense-factory amplifier and speakers will depend upon the uses to which the system will be put. If tone-signals for alarm purposes are to be transmitted, the amplifiers, lines, and speakers will need to be capable of handling such tone frequencies with fidelity. This is particularly important if the factory management chooses to employ several tones for various purposes—say, one for fire alarm, another for air-raid alarm, one for the "all-clear," and another for work-time signals. If music is to be transmitted, then the frequency response of the entire system must be as flat as possible between 70 and 7000 or more cycles per second. If only announcements are to be made, the system must have its best response in the band of frequencies which include the average male and female speaking voices; 100 to 3500 cycles per second.

Speaker Selection and Placement

The type of speaker and speaker baffle employed at each location will be governed by the size and shape of the area to be covered and, to some extent as well, upon the reverberation characteristics of the room. Location of the speakers will depend upon the above factors and upon the location of workers and noise-making machinery within the room.

In small factory rooms with relatively low ceilings, where workers are closely congregated, flat wall-type cabinet speakers may be mounted on the walls a foot or two below the ceiling and inclined slightly from their bottoms to direct the sound in the direction of the workers. These speakers may also be employed in larger departments, in this case being supported on columns or posts and faced toward (and a few feet above) the work-benches. The wall-type speaker is likewise adaptable to quieter locations, such as offices and laboratories.

In the noisier sections of the plant, best results will be obtained with dynamic motors in exponential horns, parabolic deflectors, or other standard sound-directing devices of the projector and trumpet types.

Very large and noisy departments with high ceilings are best supplied with multicellular horns which may be suspended from the ceiling or provided with special center-of-room mountings.

All speakers must be so arranged that the sound energy they deliver will be spread evenly over the area which is to be supplied. The normal position of workers functioning within the room must be considered carefully in the placement.

Central ceiling suspension of a cluster of trumpets pointing in various directions around a circle and each inclined slightly downward is efficacious in departments where workers operate throughout the room and noise-making machinery is unevenly distributed.

Uniformly-spaced wall-shelf mountings of deflector- and projector-type speakers are recommended in cases where workers form a border around the sides of a large room and noise-making machinery is grouped toward the center. These mounting shelves are inclined slightly downward so as to direct sound toward the workers.

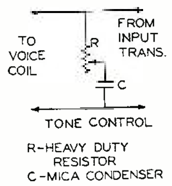

Fig. 1.

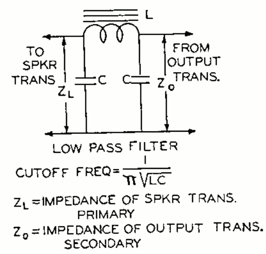

Fig. 2.

Very large, high-ceilinged rooms and corridors in which a large number of work-benches are grouped are perhaps best supplied by individual speakers placed one on each small bench. And where benches are exceptionally long, say, up to thirty feet, a speaker should be placed at each end and faced toward the opposite end.

Impedance-Matching and Phasing

Proper impedance-matching of the speakers (connected in parallel) and the output circuit of the master amplifier is essential to low-distortion reproduction. The graph of Figure 5 shows clearly how serious audio power losses result from impedance mismatching. In this drawing, the quantity Z_o/Z_L is the ratio of the amplifier output impedance (Z_o) to the speaker input impedance (Z_L). This latter quantity is the impedance of the input transformer primary on speakers with transformers.

When two or more speakers are operated in the same vicinity, they must be properly phased; i. e., their cones must all move in or out together. When they are out of step, the sound energy output will be reduced at low frequencies and interference will also result.

To check the speakers for correct phasing, they are all connected in the normal manner; and, if they are of the field-coil type, the field supply power is switched on. A voltage of 50 to 60 d.c. is then applied through the speaker input transformer and the direction in which the cone moves at this instant carefully observed. The other speakers are then examined. The d.c. voltage is subsequently applied to each. For correct phasing, the cone of each speaker should move in the direction of the first one. If this is not so, either the voice coil leads or field coil leads of each offending speaker must be reversed. When, upon application of the d.c. voltage, all cones move either in or out *together*, the speakers are properly phased. —30—

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