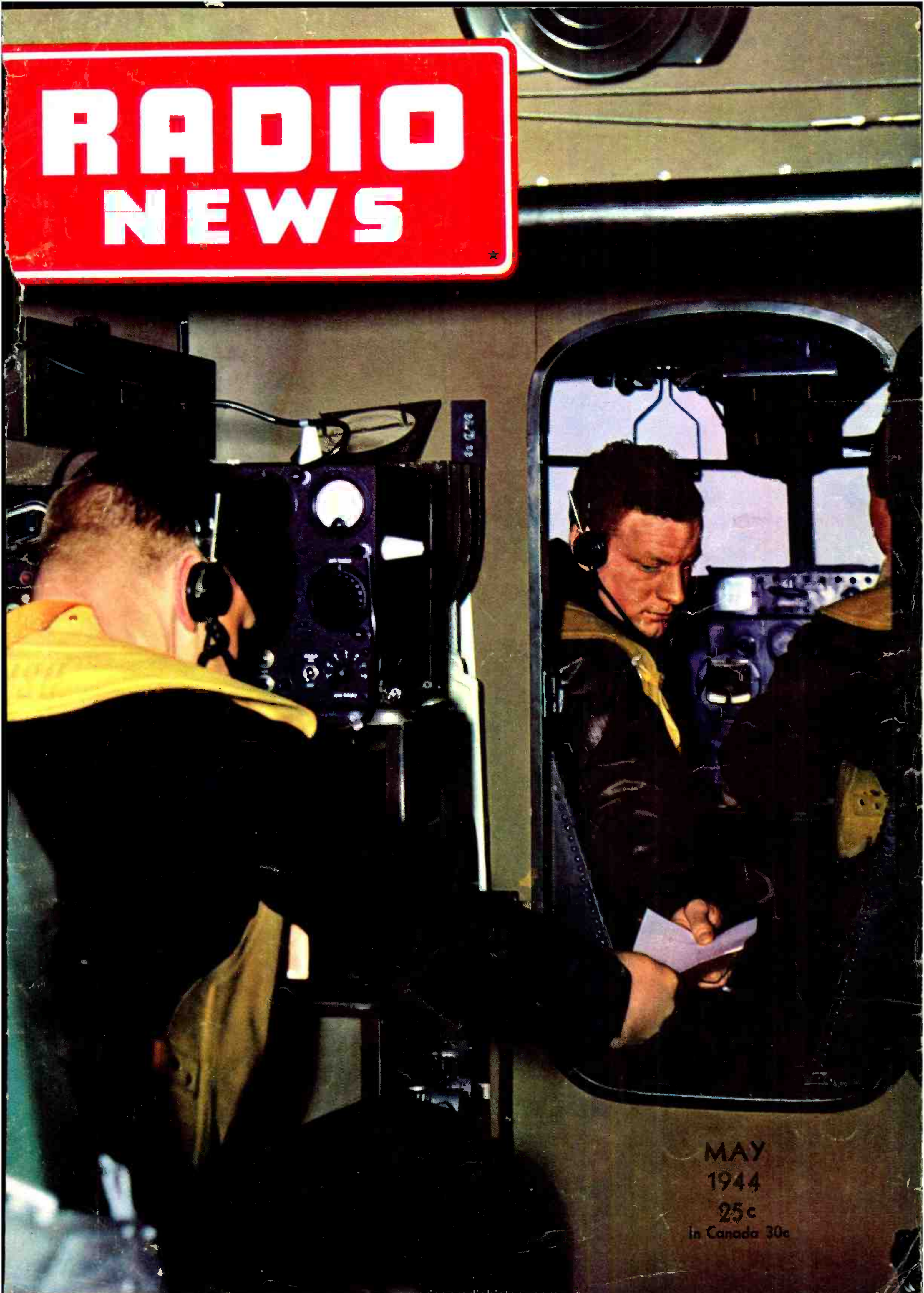
RADIO NEWS



MAY
1944
25c
In Canada 30c

What About Post-War Customer Design?

by don herold

We hear an awful lot about the wonderful new products that will appear after the war.

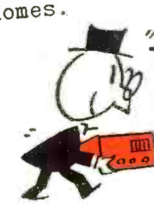
Every factory is designing them or planning to. Every dealer is counting on them to revive his business.

But a lot of factories and dealers are forgetting that customers, as well as products, have to be "planned."

We don't hear enough about post-war customer designing.

Right now is the time for every radio service man to be "engineering" and blue-printing a nice batch of friendly, receptive, prospective customers for the days to come.

Furthermore, every service man should be doing a whale of a lot of cogitatin' about the post-war products and services he'll be offering to the folks he's warming up now. He'll still be doctoring radios, and maybe he'll also want to sell them their new post-war radios...that is just good business. And maybe, too, he'll decide to pick up a lot of extra folding money by repairing other electrical equipment in their homes.



Friendly conversation will do wonders to win and keep us customers, even when you can't deliver when and what we want. And it inspires our confidence when you tell us you are using famous parts on our jobs -- such as International Resistance Units -- whenever you can get 'em.

No. 3 *in a series of special messages prepared by America's famous business writer, humorist and cartoonist, Don Herold. . . . In sponsoring these Don Herold "broadcasts," IRC pays tribute to the thousands of Radio Service Men who, whenever possible, specify and use IRC resistance units in their work.*

PREFERRED FOR PERFORMANCE · IRC · FIXED & VARIABLE RESISTORS ·

INTERNATIONAL RESISTANCE CO.

401 N. Broad St. • Philadelphia 8, Pa.

IRC makes more types of resistance units, in more shapes, for more applications than any other manufacturer in the world.

RADIO NEWS
"Reg. U. S. Pat. Off."

MAY • 1944

VOLUME 31, NUMBER 5

CONTENTS

FEATURES

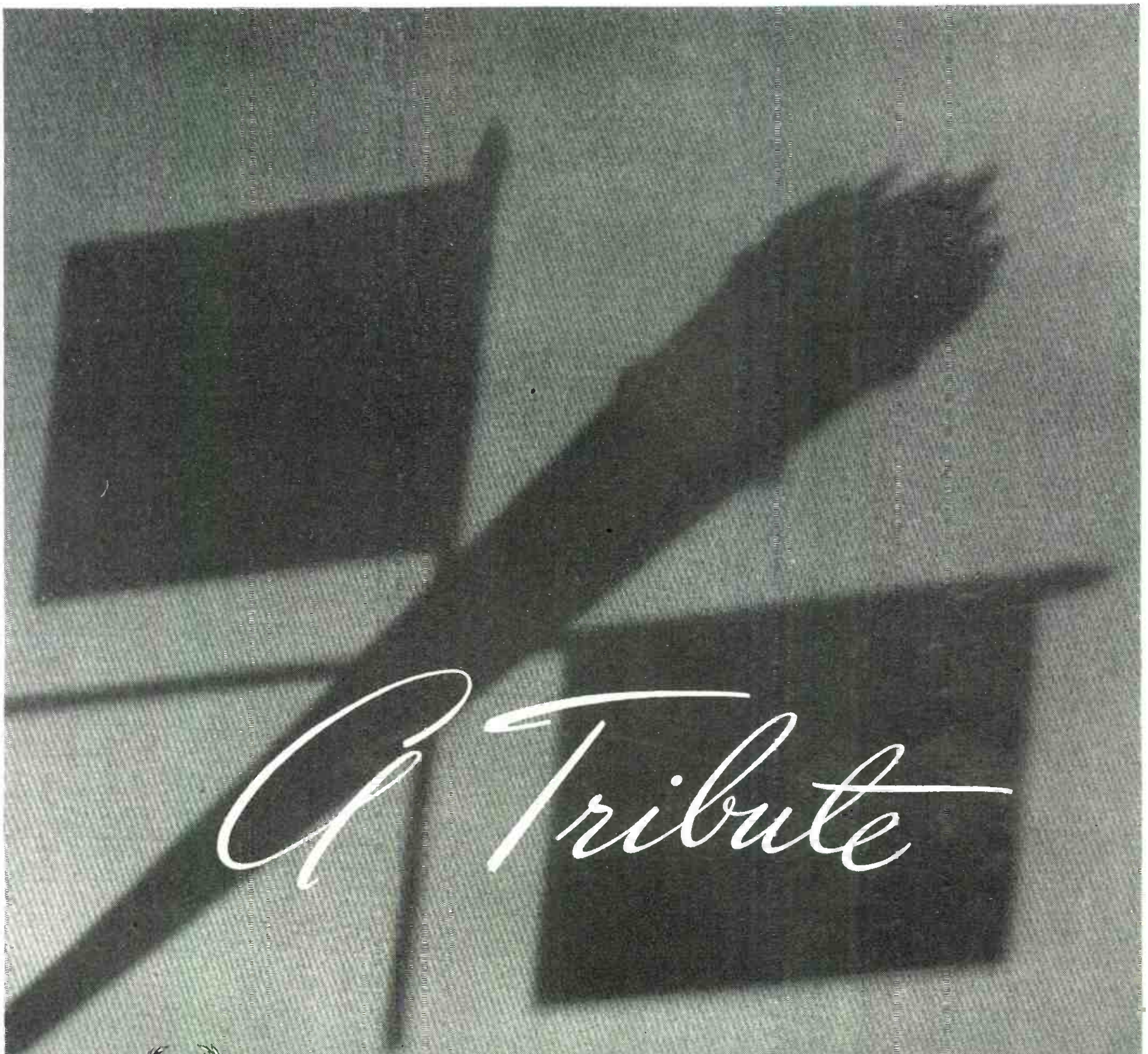
DEPARTMENTS

COVER PHOTO
BY RUDY ARNOLD

Pilot receiving message from radio operator. Radio operators of patrol planes play an important role, as it is necessary to constantly keep in touch with shore stations, ships or other planes.

ZIFF-DAVIS PUBLISHING COMPANY
Editorial Offices: 540 N. Michigan Ave., Chicago 11, Ill.
Member of the Audit Bureau of Circulations

RADIO NEWS is published monthly by the Ziff-Davis Publishing Company at 540 N. Michigan Ave., Chicago, Ill. New York Office, 270 Madison Ave. Washington, D. C., Office, Earle Bldg. London Editorial Representative, A. Spenser Allberry. Subscription Rates: In U. S. $3.00 (12 issues), single copies, 25 cents; in Mexico, South and Central America, and U. S. Possessions, $3.00 (12 issues); in Canada $3.50 (12 issues), single copies 30 cents; in British Empire, $4.00 (12 issues); all other foreign countries $6.00 (12 issues). Subscribers should allow at least 2 weeks for change of address. All communications about subscriptions should be addressed to: Director of Circulation, 540 N. Michigan Ave., Chicago, 11, Ill. Entered as second class matter March 9, 1938, at the Post Office, Chicago, Illinois, under the Act of March 3, 1879. Entered as second class matter at the Post Office Department, Ottawa, Canada. Contributors should retain a copy of contributions. All submitted material must contain return postage. Contributions will be handled with reasonable care, but this magazine assumes no responsibility for their safety. Accepted material is subject to whatever adaptations, and revisions, including "by-line" changes necessary to meet requirements. Payment covers all authors, contributors or contestants rights, title, and interest in and to the material accepted and will be made at our current rates upon acceptance. All photos and drawings will be considered as part of material purchased.



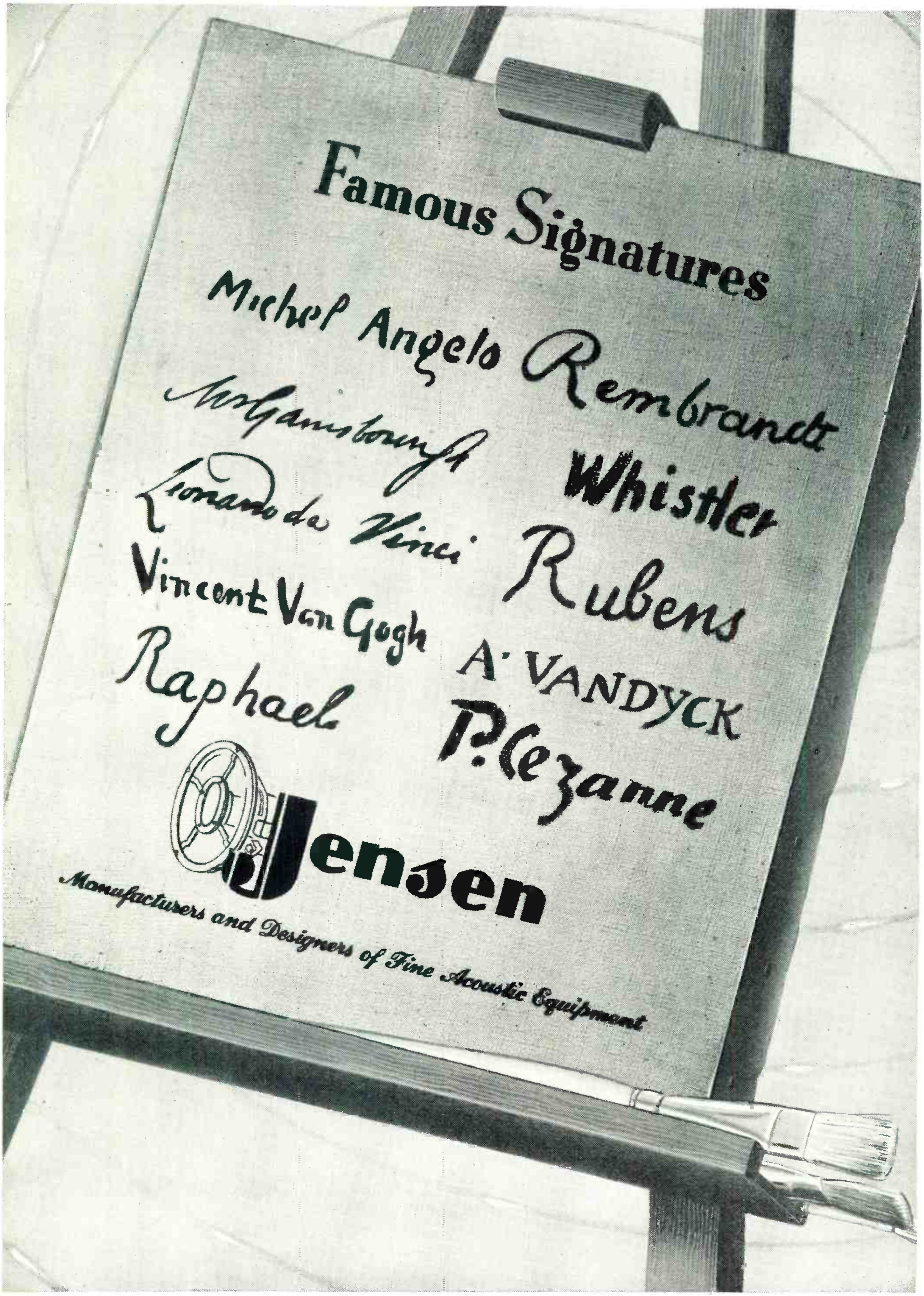
A TRIBUTE to the members of the Signal Corps, United States Army, for their great achievements in the field of military communications. On every front, from the development laboratory to the most remote outpost, they are doing their job superbly well.

Hallicrafters employees are proud of the part they are privileged to take in the design and production of radio equipment for the Signal Corps.

hallicrafters RADIO

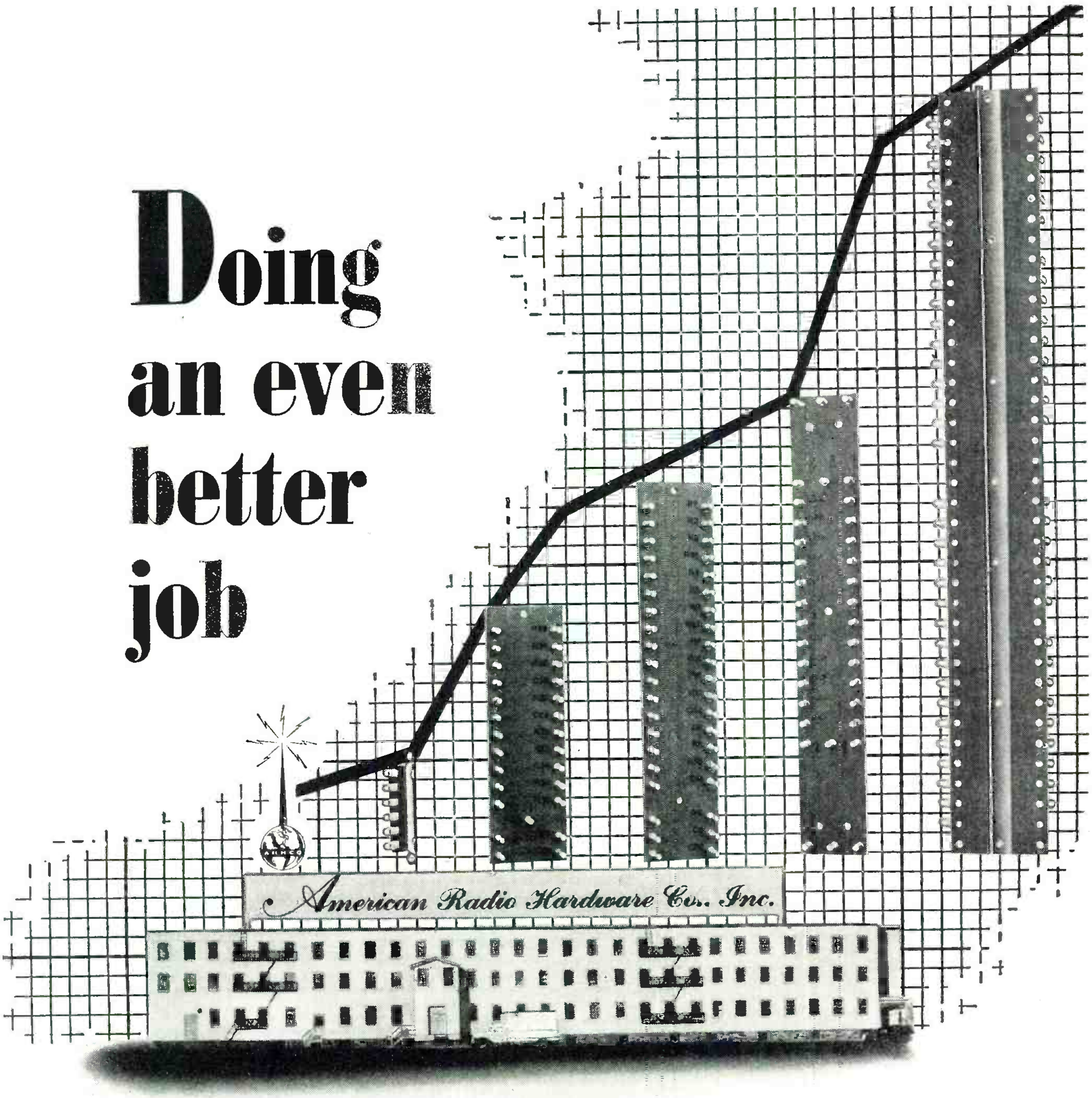
BUY MORE BONDS!

THE HALLICRAFTERS CO., MANUFACTURERS OF RADIO AND ELECTRONIC EQUIPMENT, CHICAGO 16, U. S. A.



JENSEN RADIO MANUFACTURING COMPANY, 6601 S. LARAMIE AVE., CHICAGO 38, U. S. A.

Doing an even better job



We were doing a splendid job of war production before the opening of our new plant. Today we're doing an even better job. Increased ARHCO facilities comprise the most modern manufacturing equipment . . . especially designed and developed for us. Every inch of space has been planned to yield the utmost capacity. Each worker utilizes his highest skill.

ARHCO components are dependable "right hands" in countless radar, radionic and electrical applications. They're made right. They work right. We've set our sights high for quality and efficiency . . . the performance of ARHCO components, under current rigid specifications, demonstrates our ability to make good. Your inquiries are invited . . . for present or peacetime techniques.

American Radio Hardware Co., Inc.
152 MACQUESTEN PARKWAY SOUTH · MT. VERNON, NEW YORK
MOUNT VERNON 8-4100 FAIRBANKS 4-4200
MANUFACTURERS OF SHORT WAVE · TELEVISION · RADIO · SOUND EQUIPMENT

Don't burn wastepaper . . . It's a vital war material

For the Record

BY THE EDITOR

THE TIME is fast approaching when the so-called "screw-driver" mechanic will no longer be able to compete with progressive radio servicemen who have kept their customers satisfied during the war, even when new parts were not available and when it was necessary for them to resort to tube substitutions and circuit changes in order to keep sets playing. It now appears that not only must the successful serviceman be entirely familiar with complicated broadcast receivers, but he must also learn the many intricacies of television sets, facsimile receivers and other electronic items which will be sold and serviced in his community after V-Day.

For many years the weakest link in the entire radio industry has been the so-called "screw driver" mechanic. Fortunately, this group is becoming smaller and smaller until finally most of them will be eliminated as competition increases. With thousands of trained radio mechanics and operators returning from our fighting fronts, there will be plenty of opportunity for these prospective servicemen to exercise their "know how" and to do a competent job on the *average* radio receiver. Others now receiving specialized training in ultra-high-frequency technique, servicing and maintenance will be highly qualified to take over jobs offered by the larger manufacturers of radio and electronic equipment. They will be sought for field positions for the installation and maintenance of their equipment.

The wide-awake serviceman now keeping sets operating on the home front will have equal opportunities to establish himself with these manufacturers providing he has seen fit to engage in a home study course and to become acquainted with the many new instruments which will be required for proper servicing of elaborate postwar receivers and electronic devices. Those who remain in the service shop must be prepared by applying themselves to serious study to keep abreast of the latest developments. Otherwise they will face some very serious business competition.

The serviceman cannot carry the *full* responsibility. Only by close cooperation with manufacturers can he be expected to do a good job in keeping their sets in working condition. It is up to the manufacturer to provide more complete instructions for proper installation and maintenance of his equipment. In the past much has been left to the individual serviceman and it has been necessary for him to engage in a great amount of research in order to intelligently service complicated receivers.

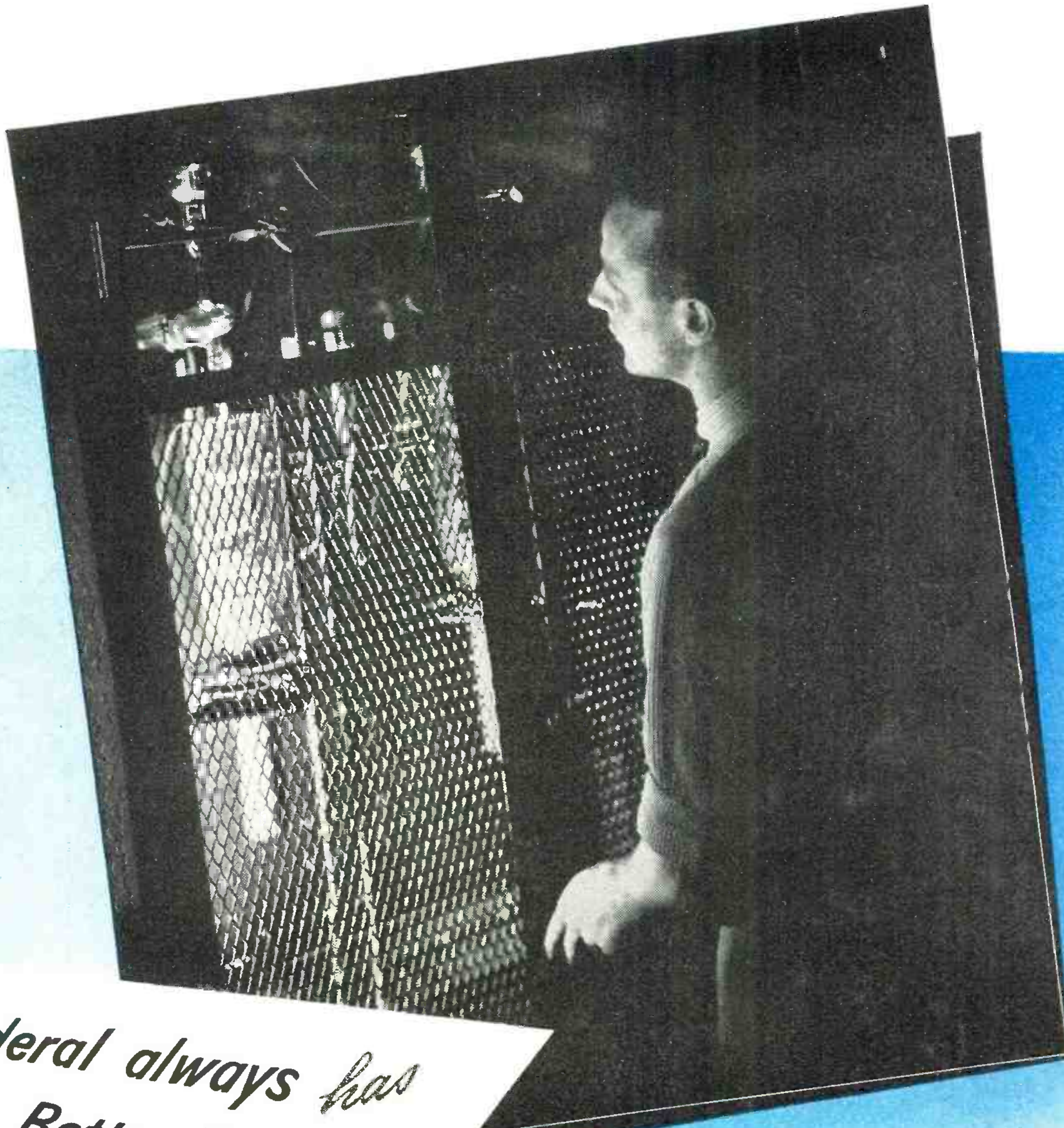
The development of military equipment has taught the manufacturer that there is much to be gained by simplified design and construction. If they continue to exercise this technique, it will simplify the matter of radio servicing to a great extent. In other words, the engineer must consider the *serviceability* of the sets they produce.

Television sets must be installed and maintained by men specially trained. Unlike the average radio receiver, these sets will be precision instruments. Higher standards must be established if television sets are to be used to fullest advantage. New test equipment will be required and must be used intelligently. This can only be done by the well-informed serviceman. Radio service dealers will have a tremendous responsibility in selling television to the public. Many a sale will be lost if his customers are not completely satisfied. Being a new gadget, first purchasers of television sets will proudly display them to their friends. If reception is good, new prospects will be born. If reception is bad, it will be very hard to explain to the customer the technicalities involved and why the set failed to produce or to meet their expectations. Here again the manufacturer must supply accurate and complete information as to the proper installation of the set and the dealer must spend considerable time with the customer in order that he fully understand the proper tuning of the set for satisfactory reception for both video and audio signals.

MOST of our readers will recall the contest sponsored by RADIO NEWS in 1942 in which prizes were offered for workable radio inventions.

Thomas M. Morse, the first prize winner of that contest has been accorded further honors for his invention. Recently Mr. Morse and Mr. Orville L. Dawson shared a $250.00 award given by Army Air Force for practical suggestions offered by the civilian employees of that branch. Mr. Morse submitted a practical working model of a photronic signal-impulse reproducer which is now being used to facilitate the training of code operators.

The corroboration of the judgment of the contest editors' selection is gratifying to RADIO NEWS and clearly demonstrates the value of the contest in which new and needed improvements in the radio field were sought.
. . . . O. R.



Federal always *has* made Better Tubes

For almost two decades Federal has made better tubes—tubes that surpass in design and construction, in quality of materials, in craftsmanship, in performance.

The background of this record of achievement is the intensive research and development of a scientific and producing organization that has set and continues to maintain the highest standards of the tube building art.

And in support of Federal tube quality and performance is Federal customer service, always ready and prepared to handle the problems of broadcast stations in meeting any requirement or emergency.

That is why Federal's established reputation for building better transmitting and rectifying tubes rests on an enduring foundation; why Federal tubes doubly ensure customer satisfaction.

This customer satisfaction, now enjoyed by many leading broadcast stations, is available to you. Whether you require tubes of standard types or whether you have a particular tube problem to solve, Federal service will prove profitable to your interests.

Federal's long experience and engineering talent also are available for designing transmitting equipment that will meet your specific requirements.

Federal Telephone and Radio Corporation

AN IT&T ASSOCIATE

Newark, N. J.

VACUUM TUBE DIVISION

Spot Radio News

By LEWIS WINNER
RADIO NEWS Washington Correspondent

Presenting latest information on the Radio Industry.

STRIKING EMPHASIS ON THE IMPORTANCE OF RADIO and radar appears in the recently announced budget of the Office of Scientific Research and Development. Almost fifty per cent of the 1944 budget, or $46,000,000 out of a budget of around $100,000,000, will be spent for radar and radio development. In view of the wide scope of scientific activities administered by this office, this large allotment of funds for one branch of science is most significant.

This office, under the direction of Dr. Vannevar Bush of the Carnegie Institution of Washington, was created within the Office for Emergency Management on June 28th, 1941, for the purpose of insuring adequate provision for research on scientific and medical problems relating to national defense.

LISTENERS IN AMERICA will be right on the front lines when the invasion begins, for the networks have made extensive plans to cover the forthcoming invasion. News rooms will go on a twenty-four-hour day emergency schedule when the first news flash that the invasion has begun comes over the air. The augmented schedule will include the use of additional monitors of both radio and wire type. Listening posts will be alert to all special flashes and programs that may either be broadcast directly or waxed for transmission as soon as conditions permit. All-night program service is also planned by some of the networks. In addition, the networks have issued memorandums to their affiliates, stating that as long as emergency conditions exist, programs may be interrupted or cancelled whenever it becomes necessary to broadcast invasion news.

The proposed coverage will undoubtedly be the most extensive in the history of broadcasting.

RAILROAD RADIO COMMUNICATION PROJECTS which have been shuttling between laboratories and executive offices for nearly two decades, now appear to have found at least a temporary haven, for Washington has brought this phase of communications up for legislative study. The all-important Senate Military Affairs Subcommittee on War Mobilization recently held a special session during which the properties of radio communications on railroads were analyzed by FCC experts and members of the industry. Senator Kilgore, who is chairman of the committee, reported that he looked with favor on the use of railway radio communications, particularly now, when it should serve to speed up traffic and thus aid our war effort.

According to the testimony offered, the Army has found radio communications extremely satisfactory in railroads. It is being used in railroad yards here and abroad, experts stated.

The interest in railway radio communications also has spread to the Radio Technical Planning Board. The Association of American Railroads has already been admitted as a contributing sponsor to the RTPB. Representatives of the New York Central, Southern Railway, Pennsylvania, Chesapeake & Ohio, and Illinois Central Systems will serve on Committee Seven of Panel Thirteen. This committee will be known as the Railroad Radio Communication Services unit. Among the most important problems facing this committee are those involving frequency allocation and method of transmission. Insofar as transmission is concerned, there are some who favor carrier-current transmission by direct induction, and there are still others who believe that greater flexibility can be achieved by overhead pickup.

The next few months will undoubtedly see the announcement of many railway communication developments in industry and Government.

OVER TWO-HUNDRED MILLION DOLLARS' WORTH OF TIME was contributed to the war effort by broadcasting stations during 1943. The Treasury Department was the largest user of time, according to the NAB research department who made the wartime broadcast study. They used close to fifty-million dollars worth of time. Others who were large users were the War Production Board, War Department, War Manpower Commission, Office of Price Administration, Department of Agriculture (WFA), Navy Department, Office of Economic Stabilization, Federal Security Agency (Public Health), American Red Cross, Office of Defense Transportation, National War Fund, Petroleum Administration for War, Rubber Administration, United Service Organizations (books), Social Security Board, War Shipping Administration, Office of Civilian Defense, Federal Bureau of Investigation, and Office of Lend Lease Administration.

These programs were broadcast over the facilities of 913 stations throughout the nation.

THE WAR PRODUCTION BOARD and the OPA appear to have lost patience with many radio dealers who have been repeatedly warned about price ceiling and receiver transfer violations. A mail order house in Chicago was recently brought to court because, according to OPA, it sold tubes at three times the allowable price. The OPA also cites that this dealer made it a practice to refuse the sale of a tube unless both the scarcer type of tube required and another tube easily obtainable were bought at the same time. Treble damages and an injunction are being asked by OPA.

Another dealer has been brought to court because he did not effect transfer of receivers in accordance with the general limitation order.

The price ceiling problem which has caused black markets to spring up, is also being brought to the attention of Congress. In many areas black market activities have so cut into the distribution of tubes that it has been practically impossible to buy the tubes that have been made available. Servicemen and dealers have petitioned their local representatives to exert their power and obtain Federal help for the release of these tubes through legitimate channels. In one New England area hundreds of receivers have been reported beyond repair because of the lack of tube replacements which seem to be available only through black market channels.

Concerted action by the WPB, OPA and Congress is expected soon.

THE PROBLEMS THAT FACE THE RTPB in proposing the use of AM or FM on the television sound channel, were outlined briefly last month in this column. We have since received additional details that further reveal the complexity of the problem. We have learned, for instance, that during a meeting of RTPB Committee Three of Panel Six on television, one of the members, in discussing his experience in using FM said that there was definitely no improvement in the use of FM in the television sound channel. He claimed that FM has several problems in multipath transmission, for the time delay difference between the two paths causes definite distortion in the audio output. In complete contrast to this, another member stated that FM is here to stay and no television receivers will be built without FM receiving units.

In a letter from the secretary of Committee Three to the chairman of Panel Six, receiver stability on FM was mentioned as another problem that faced Committee Three. The letter said that the committee was under the impression that all FM broadcast receivers built up to the present time have a fine manual tuning adjustment which is necessary to keep the carrier centered on the discriminator characteristic. Accordingly, the letter went on to say, careful adjustment is required from time to time. Thus the problem of drift is very serious, particularly since the television sound channels are on even higher frequencies than the FM sound channels. Panel Five covering UHF broadcasting was asked to consider this problem.

INCREASED SHIPMENTS OF REPLACEMENT PARTS AND TUBES have been reported by many dealers in metropolitan centers in the east and middle west. As a result of this improved condition, receivers that have been idle for months are now being put into service again. Many distributors and dealers believe that the parts crisis has been passed.

Replacment parts are being received with greater consistency than tubes. However, tube shipments should improve within the next few weeks, and in some instances may even surpass component availability.

FEW PIECES OF RADIO EQUIPMENT have played so important a role in warfare as the handie-talkie. A recent report from Col. Pierson A. Anderson, who in 1942 was director of the Signal Supply Division, European Theatre of Operations, shows that 11,-500 handie-talkies were supplied to Gen. Eisenhower for the North African invasion, during the summer of 1942. A rather peculiar problem arose when the request for these handie-talkies was made. It appears as if the batteries that are used in these units were not too fresh. It was impossible to secure batteries from America. Accordingly, it was necessary to aproach British manufacturers to supply new batteries. Fortunately, one British manufacturer was able to duplicate the type of battery required. Within five days, he produced all of the necessary batteries for the handie-talkies.

THE RUSSIAN RADIO INDUSTRY celebrated its fortieth anniversary in 1940, according to a technical paper in Izvestiya Elektropom, which has just been received here. According to this paper, the first radio workshop in Russia was organized by A. S. Popov in Kronstadt to supply the needs of the Russian Navy in 1900. Incidentally, radio had been used in Rusisa as early as 1897. The paper goes on to say that the workshop was later enlarged and transferred to St. Petersburg. Unfortunately, however, this pioneering effort was not matched by any progress until 1918. In this year a decree was issued by Lenin authorizing the establishment of a radio laboratory in Gorki.

The paper states that up to 1926 Germany had bought most of its high powered tubes from this laboratory!

SOME MONTHS AGO, we reported that several thousand American re-

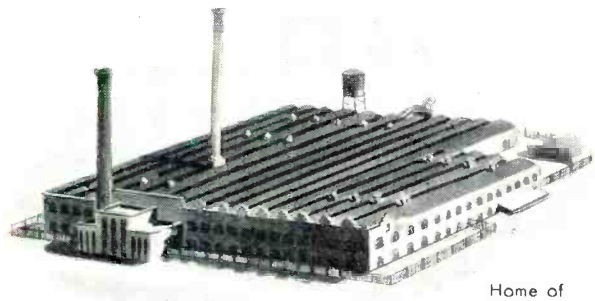
Today-

REACHING EVERY BATTLEFRONT

In the South Pacific—U. S. Marines shown setting up emergency radio outfit for communications with advancing patrol forces. INS Photo.

Tomorrow-

REACHING EVERY AMERICAN MARKET



Home of
TEMPLE RADIO
Mystic, Conn.

Tomorrow . . . in the peacetime era to come . . . the name Temple will not only identify the finest of radio receivers, but mark, as well, a sound, far-seeing sales and merchandising policy to insure and maintain both volume and profit for every Temple dealer. It will pay you to "team up with Temple".

TEMPLETONE RADIO COMPANY
MYSTIC, CONN.

FM . . . TELEVISION . . . RADIO-PHONO COMBINATIONS

Buy
U. S. War Bonds

Temple
RADIO

Licensed under
Armstrong & RCA Patents

HERE FM WILL ALSO MEAN FINEST MADE

ceivers had been received in London, under Lend-Lease operations. We now learn that thus far, over 30,000 receivers of American manufacture have been received in Britain, and now await power and price adjustments prior to distribution. The power adjustment involves rewiring of the power system so that receivers can be used on the higher power supply of Britain. There are battery models within the allotment too, and these may be sold as is, or converted for power operation.

There have been rumors that some 75,000 British receivers would be on the market early in 1944. Thus far, no definite word on the release of these receivers has been received.

The utility radio receivers also promised for the British market have not as yet materialized. A quarter of a million were scheduled for production and release sometime in May. These receivers were to be of plain wood cabinet construction, contain four tubes, and have a wide tuning range (no particular frequency coverage has as yet been stipulated). These receivers, designed for a.c. operation, were expected to sell for $40 plus purchase tax.

THE DECIBEL HAS COME INTO ITS OWN in Hollywood. A decibel specialist was recently appointed by a film company to study the decibel count of food. It appears as if the eating of some foods, such as celery and toast, produces quite a bit of noise during the filming of a food sequence. It has thus become necessary to make a study of all the foods that produce noise problems, and substitute "noiseless" foods. During the filming of a picture entitled "Mr. Winkle Goes To War," three hundred soldiers had to eat "noiseless lamb chops" because the stars of the picture, Edward G. Robinson and Robert Armstrong, had to talk during this sequence. The poor soldiers had to eat "chops" made of mashed potatoes colored with gravy, all because of db.

COPPER HAS BECOME A SCARCE ITEM again. According to Walter Janssen of the Metals and Minerals unit, Bureau of Foreign and Domestic Commerce, a change in battle plans and conditions has brought about this change. Copper has been diverted from a small arms program to the more urgent artillery, according to Mr. Janssen.

For a time it appeared as if copper would be available for civilian production. However, according to Mr. Janssen, the military requirements have become so enormous that it appears as if many months will pass before it will be possible to make any civilian production plans.

FOREIGNERS CAN NO LONGER HOLD POSTS as officers and executives in Argentine broadcasting companies, according to a recent decree. All officials holding such positions must be Argentine-born citizens. This is the first in a series of steps being taken by the Argentine government to eliminate all foreign interests.

DEPARTMENT STORE OWNER AND NEWSPAPER PUBLISHER Marshall Field is the new owner of station WJJD in Chicago. Mr. Field paid approximately $700,000 for this property. With this purchase went a construction permit for an FM station to serve Chicago's metropolitan area.

Mr. Field, who is publisher of the Chicago Sun and PM in New York, was formerly part owner of WJWC, Hammond-Chicago, which surrendered its license a year ago last January.

The newly acquired station operates on 1160 kc., and has a power of 20,000 watts on limited time.

INCREASING DEMAND FOR BATTERIES for the Armed Forces makes the possibility of increasing the supply of dry batteries for civilians in 1944 appear remote, the Consumers Durable Goods Division of the War Production Board has recently announced.

Production of some kinds of batteries used by civilians may even be lower than in 1943. The materials situation has improved, and the facilities of the industry have been greatly expanded, but the quantity of industrial and other essential civilian batteries will continue to be limited by the capacity of equipment that is not adaptable for production of military types of batteries. Shipments to civilians during 1943, however, were larger than has been commonly supposed.

Last year the dry battery industry produced the equivalent of 3,750,000 radio battery packs, compared with 3,500,000 produced in 1940. Less than two per cent of this quantity was used in industrial and technical equipment. All the rest went to the farm market.

The announcement stated that some farmers who live beyond electric power lines and depend on dry batteries to operate their radios may not have been able to buy batteries as often as desired, but this was due to increased usage of radios rather than to restrictions on production or distribution of batteries.

Shipments of No. 6 (6-inch) type batteries, including multiple types, were almost exactly the same in 1943 as in 1940. These batteries are used to a large extent in rural areas for telephones, gas engine ignition, and electric fences. Large quantities are used also by railroad, telephone and telegraph companies, by the fishing industry, and for protective alarm systems.

More than 55,000,000 individual cells were produced for assembly into hearing aid batteries. Final figures show that production of assembled hearing aid "B" batteries reached a total of approximately 1,600,000.

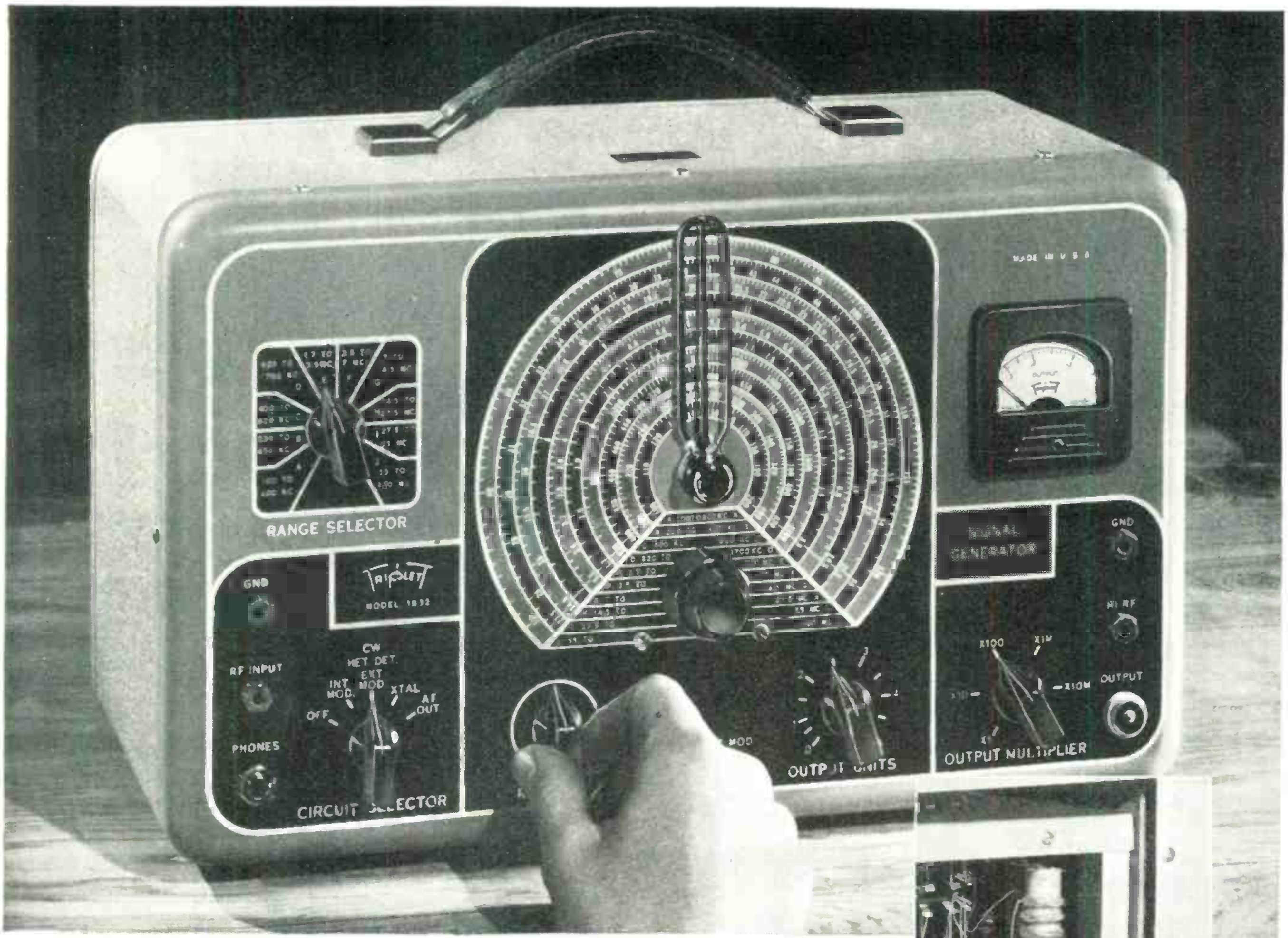
Lantern battery shipments were 85 per cent higher than in 1940. Almost

(*Continued on page* 116)

Echophone Model EC-1

(Illustrated) a compact communications receiver with every necessary feature for good reception. Covers from 550 kc. to 30 mc. on three bands. Electrical bandspread on all bands. Six tubes. Self-contained speaker. 115-125 volts AC or DC.

Echophone Radio Co., 540 N. Michigan Ave., Chicago 11, Illinois



MODEL NO. 1632

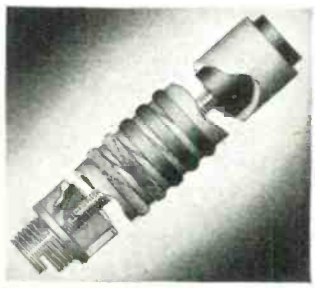
Signal Generator

CONTINUOUS COVERAGE—100 KC. TO 120 MC. • ALL FREQUENCIES FUNDAMENTALS

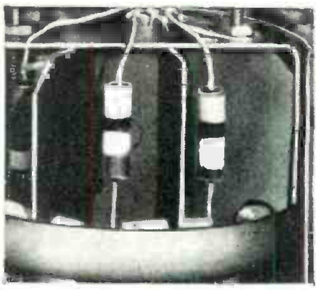
A complete wide-range Signal Generator in keeping with the broader requirements of today's testing. Model 1632 offers accuracy and stability, beyond anything heretofore demanded in the test field, plus the new high frequencies for frequency modulated and television receivers, required for post-war servicing. Top-quality engineering and construction throughout in keeping with the pledge of satisfaction represented by the familiar Triplett trademark.

Of course today's production of this and other models go for war needs, but you will find the complete Triplett line the answer to your problems when you add to your post-war equipment.

• Triple shielding throughout. Steel outer case, steel inner case, plus copper plating.



• All coils permeability tuned. Litz wire wound impregnated against humidity with "high-Q" cement.

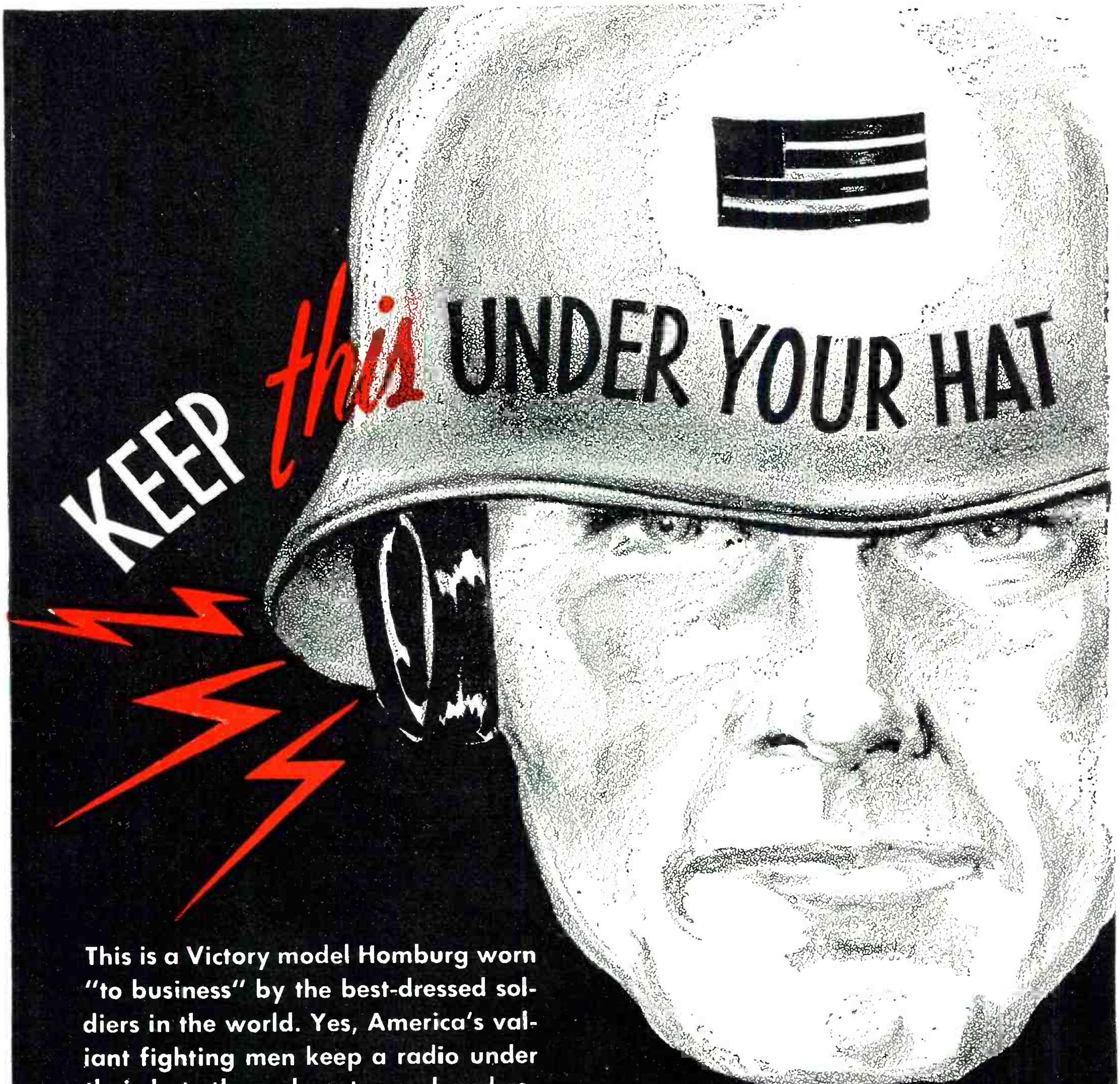


• Note sections individually shielded with pure copper. Entire unit encased in aluminum shield.

Triplett

ELECTRICAL STANDARDS ARE SET BY TRIPLETT **INSTRUMENT CO.**

BLUFFTON OHIO ★ ★ ★



This is a Victory model Homburg worn "to business" by the best-dressed soldiers in the world. Yes, America's valiant fighting men keep a radio under their hats these days to send and receive the terse messages that direct the movements of charging battalions, lead bombers to the target and safely home again, guide submarines and tanks to the places where they'll do the most harm. Tomorrow, the miracles born of the exacting demands of war will be interpreted by FADA in peace radios of unbelievable tonal faithfulness and enduring beauty.

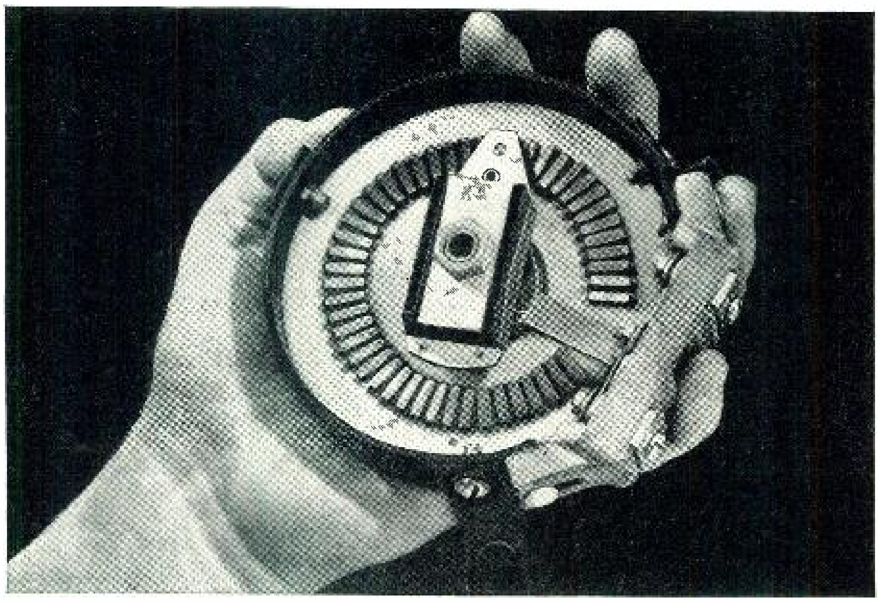
PLACE YOUR FAITH IN THE

FADA Radio

OF THE FUTURE

Famous Since Broadcasting Began!

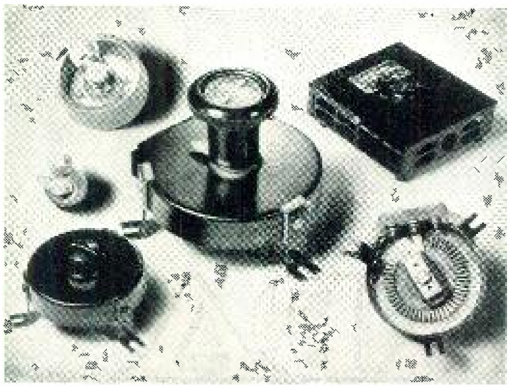
FADA RADIO AND ELECTRIC COMPANY, INC., LONG ISLAND CITY, N. Y.



A SMALL RHEOSTAT *with* *BIG* FEATURES

The fact that a Rheostat is small, in no way diminishes the importance of its functioning.

Ward Leonard recognizes this and has produced their 4″ Plate Type Rheostat with all the desirable features of their largest equipment. It dissipates heat from both sides. The contacts are solid metal blocks for durability. Action is smoothness itself. There are forty-three steps of control.



WL Rheostat Bulletins

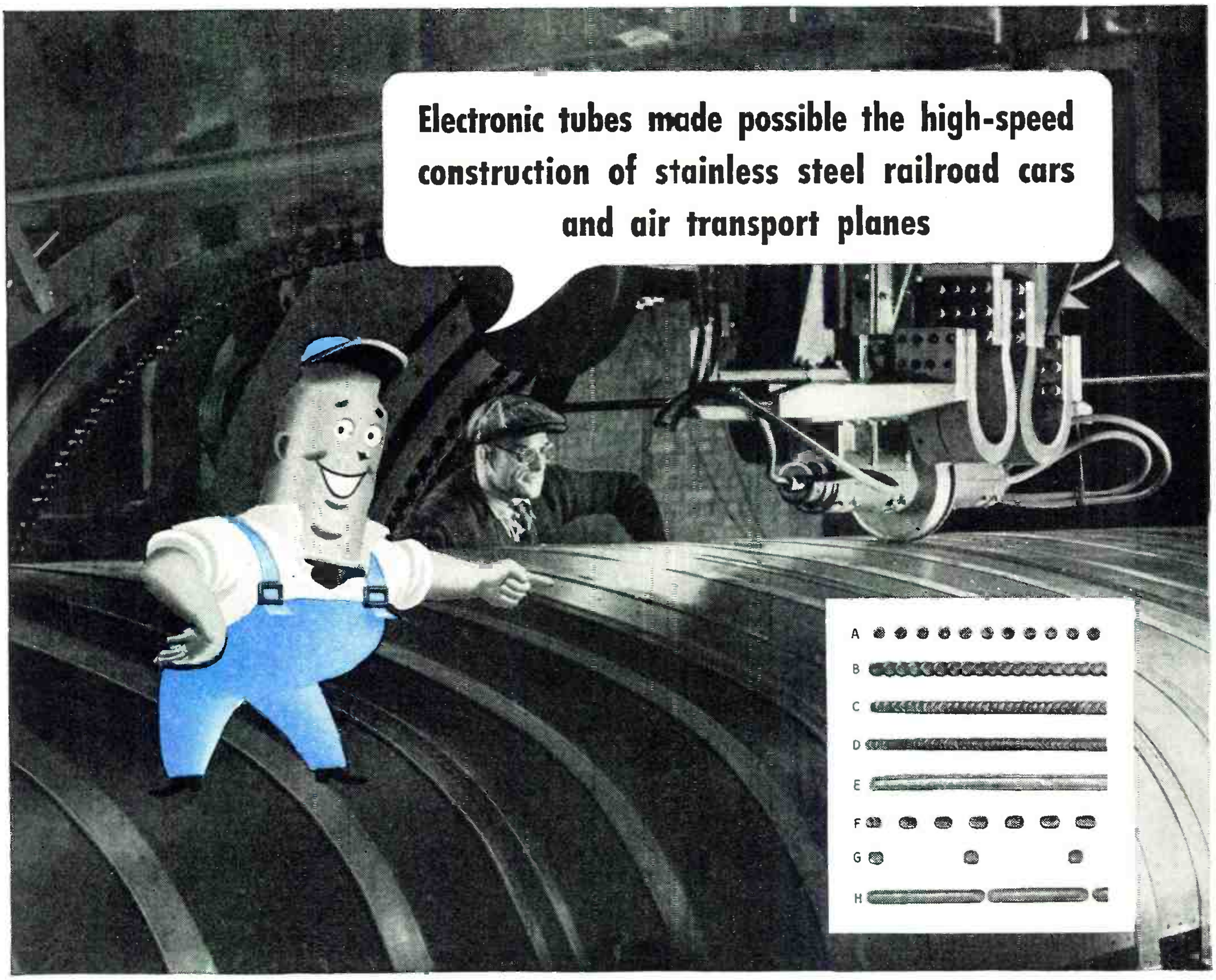
Bulletins are available describing the various Ward Leonard Rheostats. The line is complete including from the small ring types up to the heaviest duty, multiple mounted, power driven units. Write for data bulletins describing the type of Rheostats of interest to you.

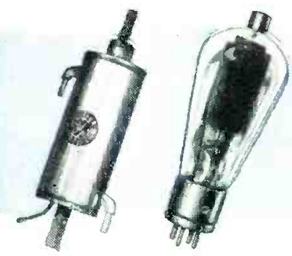
WARD LEONARD

RELAYS • RESISTORS • RHEOSTATS

Electric control WL devices since 1892.

WARD LEONARD ELECTRIC COMPANY, 47 SOUTH STREET, MOUNT VERNON, NEW YORK





The G-E ignitron controls the power.

The G-E thyratron does the timing.

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RADIO IN A THEATER OF WAR

Personal observations of electrical and electronic equipment that is being used by Allied Forces in the European Theater.

By KENNETH PORTER
RADIO NEWS War Correspondent

EDITOR'S NOTE: *During a period of nine weeks the writer has traveled thousands of miles over combat zones, by land, sea, and air. He has presented herein a comprehensive picture of items of interest in actual combat equipment, giving his observations on their possible postwar applications.*

THAT old remonstrative adage, "look but don't touch," might easily be paraphrased to read, "look but don't write," when the subject matter is radio in a theater of war. Security regulations prohibit even the mere mention, conversationally, of some types of transmitters and receivers. Others, although open to observation by properly identified personnel, still are guarded closely by censorship restrictions when presented editorially or pictorially.

These stringent protective measures are necessary, when the release of certain technical information might jeopardize the safety of the United Nations by aiding the enemy—particularly, when that enemy is but a few air minutes away.

Information relating to most radio equipment is evaluated by Allied security experts as MOST SECRET, SECRET, CLASSIFIED, or in rare instances, CONFIDENTIAL or RESTRICTED. As the equipment becomes obsolete through improvement, general development, or confirmed knowledge that the enemy has captured quantities of the equipment in question, changes are made in classification so that the general public may become aware of its existence.

Oddly enough, and this fact may have confused readers in the past, the publication of technical data in a neutral or non-combatant zone does not minimize the importance of the information in a theater of war. Thus, some equipment which may have been described in detail in United States publications,

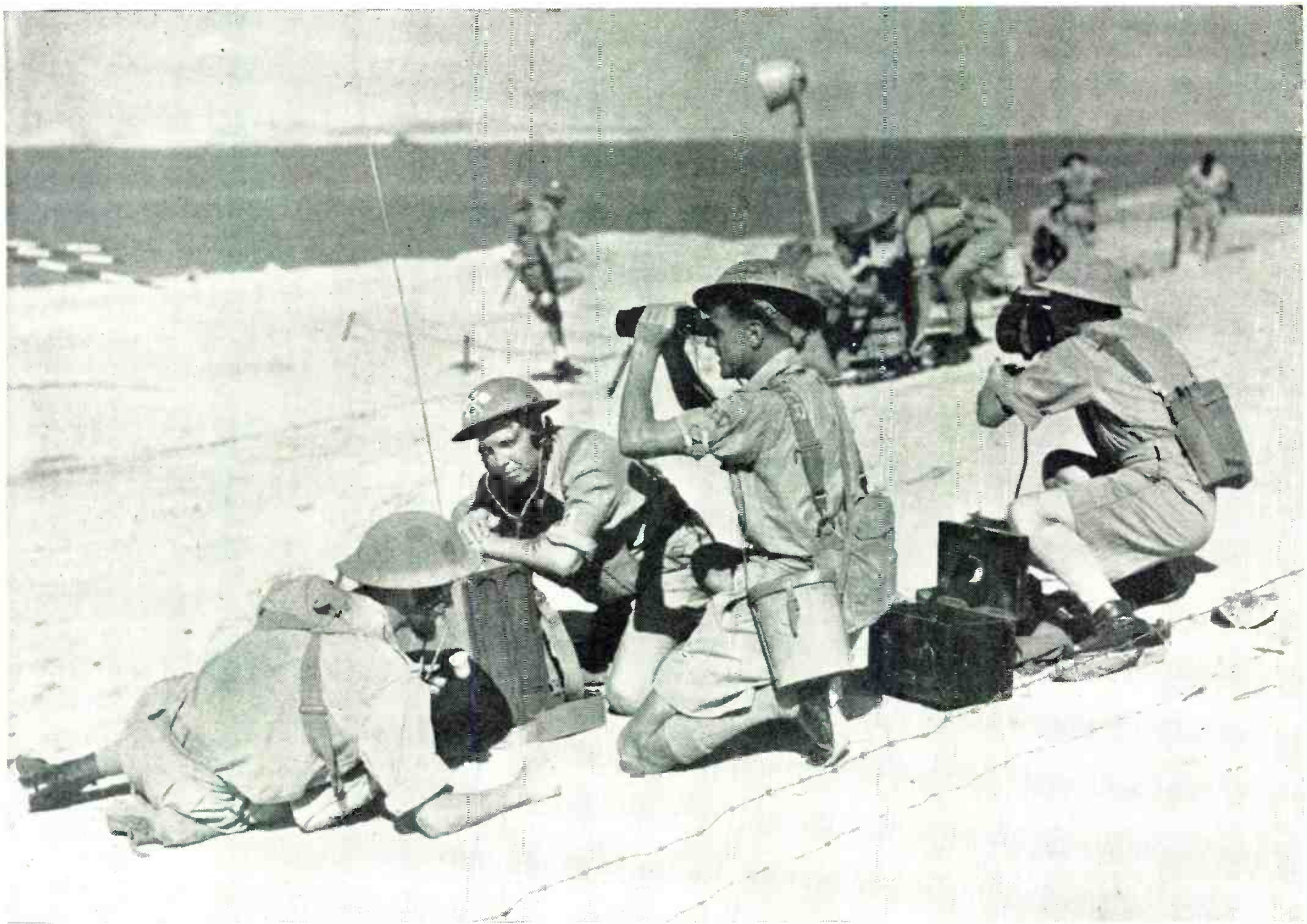
Morse code being used to transmit message. Greater range may be had from same set than would be possible with direct speech.

British troops taking part in large scale anti-invasion practice. Communications were maintained between units and headquarters by means of portable radio equipment.

still is treated as CLASSIFIED material in the European Theater of Operations. Security officers explain that Washington's orders reclassifying certain information need not be followed in combat zones, if, in the judgment of the Commanding General, the release of the information might adversely affect existing conditions.

Security officials both here and in Washington agree that the information contained in the following paragraphs may be presented to radio enthusiasts. The reader should bear in mind at all times, however, the fact that most of the equipment described is not necessarily the most advanced type now being used.

After four years of war, much of it in the air, the British have practically standardized aircraft radio design. Compact, rugged, simple in construction and easy to operate and maintain, receivers are of the push-button type, operating on a series of frequencies. Transmitters show a similar quality. The large plastic "buzzer" or Morse keys are particularly notable in that they may be operated even when heavy fur-lined gloves are worn. They are spaced throughout the aircraft so that all members of the crew have individual "stations." In the event one or more transmitters are damaged by enemy fire, men at the other stations may carry on.



Spearhead of an amphibious offensive—The Communications Division at work. Note signal lamp and loud speaker in background.

Certainly sea-air warfare never could have advanced to its present efficiency without the aid of radio. This was proved beyond a doubt during a recent tour of the British Fleet Air Arm, some time of which was spent aboard the aircraft carrier *H.M.S. Illustrious*. The men who fly in this service certainly have as high a regard for their radios as they do for their aircraft engines.

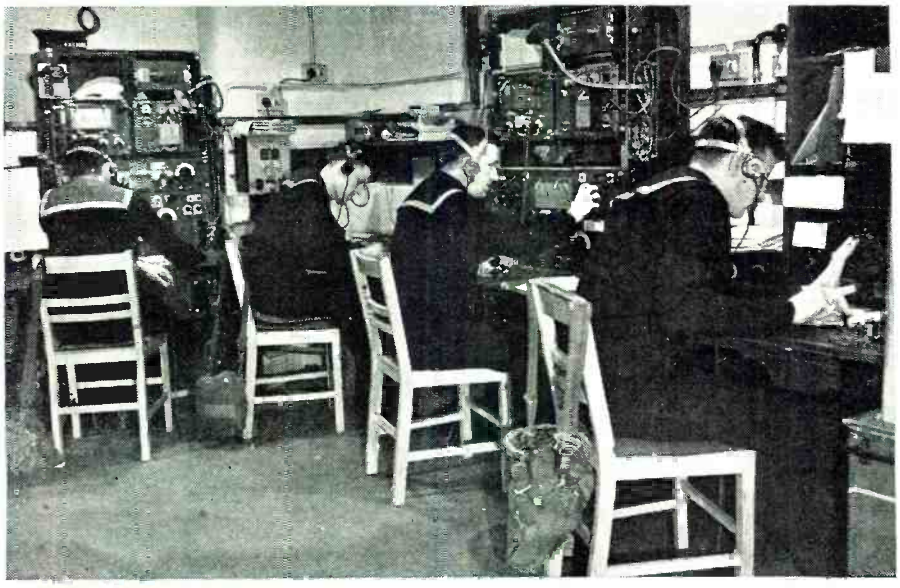
When a flyer has left the deck of a carrier which travels at 30 knots an hour, he must rely solely upon his instruments and radio to guide him during his flight over water. On the return trip, because his floating airdrome is not where he left it, he must be brought in by radio. The carriers are provided with several types of equipment similar to that used by fixed ground stations. Here, too, transmitters and receivers are to be found scattered throughout the ship as well as in the message center proper, for protection against possible damage to any section of the ship.

It is of interest that most seaborne radio is equipped with a new type of static eliminator which, while not actually removing interference, neutralizes it by an equalization or blending process that allows the message signal to be amplified above the modulated interference. Improvement is noted in reception which, were it not for the new eliminator, would be impaired by atmospherics, unwanted signals, or the effects of other electrical apparatus aboard the ship.

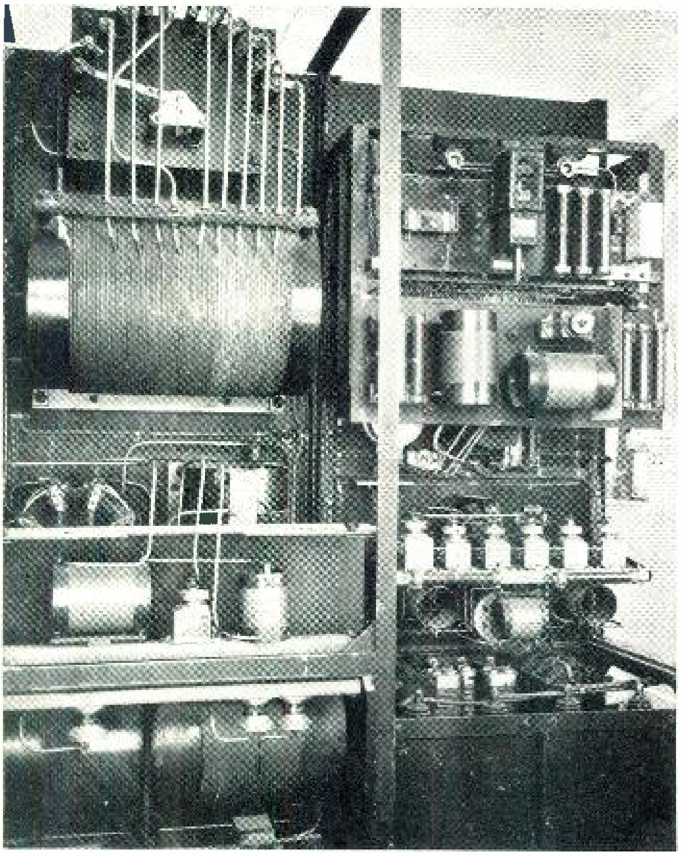
Back on land again, protection for pilots off their course over Great Britain is provided through the use of a radio device known as the "homing beacon." These beacons, situated at strategic points, are similar in purpose, construction, and operation to ocean lighthouses. They have, by actual record, saved the lives of hundreds of pilots.

It requires no stretch of the imagination, then, to picture a postwar world in which pilots, with little navigational training, will be guided to strange airports both on land and sea by homing beacons and other direc-

(*Continued on page* 64)



Wireless room in England where signals are sent and received to and from ships in the Atlantic. This post played an important role in the sinking of the *Scharnhorst*.



Obsolete transmitter, operating at 2000 meters and requiring 7 kilowatts input power, was sent to the writer for conversion to short wave for communication with the Byrd Antarctic expedition.

UHF vs. MICROWAVES—in two-way radio communications

By

SAMUEL FREEDMAN

Lt. Commander, USNR

ULTRA-HIGH frequencies are the long waves while microwaves are the short waves of the future and the regions of greatest postwar development. What will decide this trend is the amount of spectrum available in terms of kilocycles. The more frequency spectrum available, the more room and opportunity we have for two-way communications, facsimile, television, r-f heating and many other electronic applications.

Two-way radio communications for emergency services has in recent years made extensive use of ultra-high frequencies. Large as that spectrum is when compared to the lower frequency bands, it still is unable to accommodate many important and desirable services. For example, it is unable thus far to accommodate the communications requirements of railroads and commercial or private mobile vehicles. It becomes evident that additional frequency spectrums will be needed. The answer points in only one direction . . . *microwaves.*

In naming the various segments of the radio-frequency spectrum, differences of opinion may arise as to where to start and terminate each band of frequencies. For the purpose of this article, ultra-high frequencies are considered to be wave lengths from 1 to 10 meters although due to prewar equipment limitations, most activity was between 5 and 10 meters. This corresponds to frequencies of 30,000,000 to 300,000,000 cycles . . . or 30,000 to 300,000 kilocycles . . . or 30 to 300 megacycles. In that band of 9 meters in wave length difference, lies 270,000 kilocycles of frequency difference available for allocation.

On the other hand, merely the centimeter part of the microwave band covering 1 centimeter to 1 meter in wave length has a frequency range extending from 300,000,000 to 30,000,000,000 cycles . . . or 300,000 to 30,000,000 kilocycles . . . or 300 to 30,000 megacycles. In that band of 99-centimeters wave length difference, lies 29,700,000 kilocycles of frequency difference available for allocation.

These figures are deliberately enumerated in cycles, kilocycles and megacycles to make the reader realize what large domains remain to be conquered and utilized postwar. Fig. 1 compares these bands with the other bands used up to now for radio communication. Note that the centimeter

FIG. 1. THE USEFUL RADIO SPECTRUM INCLUDING THE MICROWAVE BAND

Wave Length in Meters	Band in Kilocycles	Maximum number of Channels (10kc)	Average Kilocycles per meter	Average Meters per Kilocycle	Band Designation
10,000 to infinity	0 to 30	3	infinitesimal (less than 1)	333 to infinite	Very Long Wave
1500 to 10,000	30 to 200	17	.02	50	Long Wave
550 to 1500	200 to 550	35	.36	2.75	Medium Wave
200 to 550	550 to 1500	95	2.71	.36	Standard broadcast band
10 to 200	1500 to 30,000	2850	150	.0067	Short Wave
1 to 10	30,000 to 300,000	27,000	30,000	.000033	ULTRA HIGH FREQUENCY or ULTRA SHORT WAVE
.01 to 1	**300,000 to 30,000,000**	**2,970,000**	**30,000,000**	**.000000033**	**MICROWAVE Centimeter portion (utilizable)**
.01 to .001	30,000,000 to 300,000,000	27,000,000	30 billion	.000000000033	MICROWAVE Millimeter portion (research/reserve)
Below 1 Millimeter	infinite	infinite	infinite	infinitesimal	Radio/heat/medicine etc.

FIG. 2. FUNCTIONAL COMPARISONS UHF vs. MICROWAVES

CONSIDERATION	ULTRA-HIGH FREQUENCIES	MICROWAVES
Wave length band.	1 to 10 meters.	1 centimeter to 1 meter.
Frequency band.	30,000 to 300,000 kc.	300,000 to 30,000,000 kilocycles.
Maximum number of possible channels for AM.	27,000.	2,970,000.
Maximum number of possible channels for FM using present 5 to 1 deviation ratio.	About 1,350.	About 148,500.
Suitability for FM.	Very desirable but is more suitable for AM because less space available and more power can be utilized.	Ideal. Functions with little power and as purely horizon proposition. Plenty of frequency space to use higher deviation ratios without exceeding receiver bandpass.
Natural receiver bandpass.	Usually less than 100 kc.	Can be a megacycle or more at the high frequency end of band.
Maximum deviation ratio feasible for maximum clarity and signal strength without exceeding receiver natural bandpass.	3 to 1 unless receiver has bandpass exceeding 100 kilocycles.	About 300 to 1. Signal clarity and signal strength can be 100 times greater than for UHF.
Effect of sky waves.	Definitely interferes with distant points frequently on the low frequency end.	Thus far unknown to have been picked up on sky waves. It would be phenomenal and rare if ever.
Frequency stability.	Good and lends itself to crystal control at low frequency end.	AFC which keeps receiver locked to transmitter frequency is dependable. Crystal control to stabilize transmitter still undeveloped.
Power output.	Any amount possible but little point to use over 25 watts.	Microwaves superior because able to use less than ¼ watt. Because of deviation ratios, receiver bandpass, signal to noise ratio and beamed transmission it is equivalent to 10,000 times that of AM, for same power.
Antenna design.	Must be conventional.	Can be a variety of types including the conventional types if cut for microwave band. Also wave guide and parabolic types.
Focussing and Beaming.	Possible but usually not done because of physical dimensions of antenna array. A half wave length may be as much as 16 feet long.	Very simple to attain. A half wave may be as small as a fraction of an inch or a maximum of 18 inches. Gains up to 2000 are possible.
IF stages.	Can be anything desired.	Usually at UHF.
Coaxial Cable.	Can be used reasonable distances.	Only feasible for very short lengths due to high attenuation. Better techniques available, because of frequency.
Circuit layout.	Conventional with leads kept short.	Must be properly designed so that inductance and capacitance will be minimized. New techniques are employed.
Fading.	The ground wave within horizon is stable. Beyond horizon it is unstable. FM may penetrate somewhat beyond horizon.	Stable within horizon line of sight.
Effect of secondary barriers such as trees, brush, small solid objects.	Usually unnoticed	Susceptible to objects larger than wave length employed and width of beam used.
Cost.	This is now somewhat stabilized. Police radio equipment about $500.	Not yet stable. One group claims it will be about $200 per station complete.
Interference.	Considerable on AM. Minor on FM.	Should be less on microwaves.
X-ray and diathermy effects.	None.	Very slight diathermy effect immediately in front of antenna within few inches if very high power used. No X-ray effect.
Effect of weather.	Works better and further in wet weather, such as rain, snow, high humidity.	Same to lesser degree.
Interelectrode capacitance.	Of minor importance.	Of major importance.
Size.	Moderate or small.	Will be much smaller.
Circuit transit time between elements. Its effect on phase and polarity.	Minor.	Important.
Future trend.	Zenith is in sight. More expansion by radical reshifting of stations.	Unlimited opportunities at present.

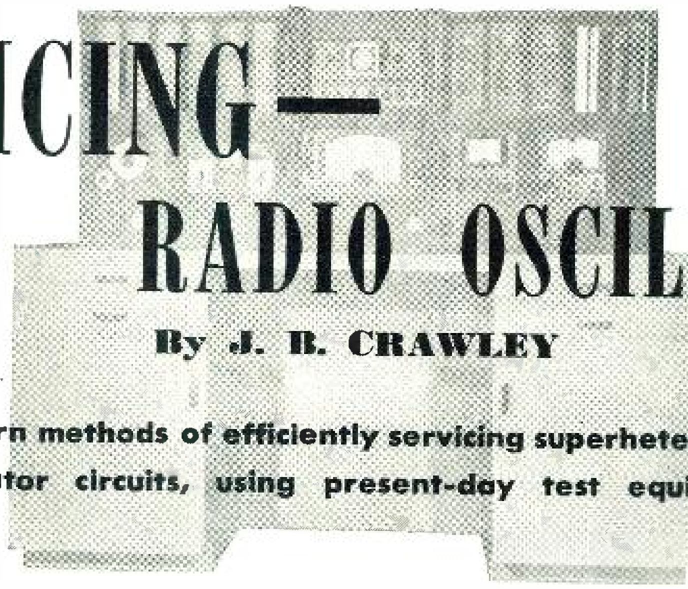
portion of the microwave band contains 30,000 times more channel space than that occupied by the entire standard broadcast band now serving broadcast listeners.

Prewar ultra-high frequencies were considered to be the wave lengths that scraped "the bottom of the barrel." It was based on sky-wave rather than ground-wave limitations. The microwave band was held, in effect, to be a dark and unknown region with development work confined to a few laboratories. Hereafter, the microwave band must be further subdivided, as it covers so much frequency spectrum as to make it virtually impossible to analyze and utilize it all at one time. It will be developed in sections with the remainder each time left as "fair game" for everyone to investigate.

We can expect to start out postwar with the "centimeter portion" of the microwave band for utilization and immediate development. In addition, there will be the "millimeter portion" of the microwave band still left for research and future frequency allocation reserves. No attempt at this time will be made to discuss wave lengths shorter than 1 millimeter as "first things should be considered first."

When we speak of the millimeter portion of the microwave band, it pertains to wave lengths between 1 millimeter and 1 centimeter. This corresponds to a frequency range between

(*Continued on page* 99)



SERVICING—RADIO OSCILLATORS

By J. B. CRAWLEY

Modern methods of efficiently servicing superheterodyne oscillator circuits, using present-day test equipment.

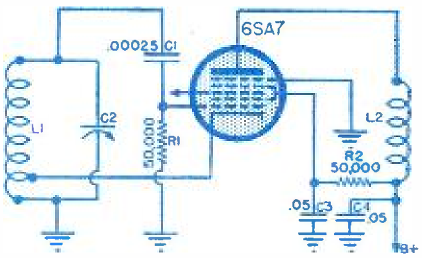


FIG. 1

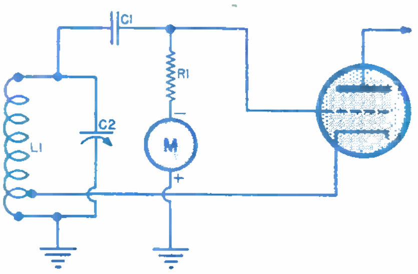


FIG. 2

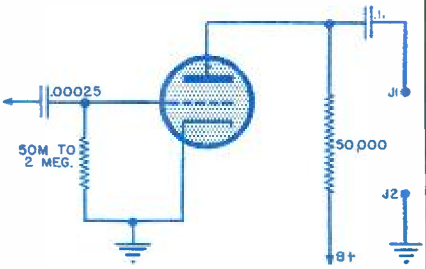


FIG. 3

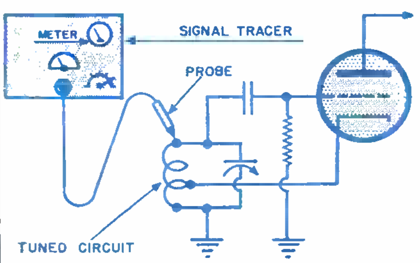


FIG. 4

OF ALL the circuits in the modern superhet, the local oscillator is the hardest for a serviceman to test. This is true for several reasons. First, oscillators are not as well understood by most radiomen as the a-f amplifier. Second, there has been very little test equipment developed specifically for oscillator testing. And third, there has been a dearth of oscillator-testing data published either in service texts or in manufacturers' data. As a rule, the manufacturer gives only d-c plate voltages, filament and screen voltages, etc. Oscillator grid voltage is usually omitted because it cannot be read with a 1,000-ohm-per-volt meter. Even such simple things as oscillator-coil resistance may sometimes be omitted.

Such data as tuned circuit impedance, Q, tube gain, coil feedback factor, etc., is never given because servicemen have neither the test equipment nor the information with which to measure these properties.

Testing Oscillators

With the advent of signal tracing, it became an easy matter to test in order to see if an oscillator was functioning, and if so, at what frequency. In the following paragraphs some methods applicable to oscillator testing are described. The circuit in Fig. 1 will oscillate as long as the tube and component parts are all right. The value of L_1 and C_2 determines the frequency of oscillation, while the strength of oscillation depends upon the tube, tube voltages, where the tap on L_1 is made, and a number of other factors.

If the tube is oscillating, a negative voltage will be present at the grid of the tube. This is caused by grid rectification of the oscillator signal, and if the tube goes out of oscillation for any reason, this negative voltage will not be present. Since the grid circuit is a very high resistance, this voltage cannot be read with an ordinary 1,000-ohm-per-volt meter. A 20,000-ohm-per-volt meter will show some indication, but not the actual voltage, since even a high-resistance meter requires quite a bit of current to operate it. A true indication of the amount of grid voltage present can be obtained only by a vacuum-tube voltmeter. Any reliable make may be used, but one having a signal-tracing type of probe in which an isolating resistor is used, is recommended; since such a lead does not affect the frequency of oscillation of the tuned circuit.

The amount of grid voltage produced by an oscillator will vary with different sets and may be learned best by experimentation. However, Table I may serve as a guide.

Use of a Milliammeter in Testing Oscillators

As mentioned previously, the oscillator grid is negative *only as long as the tube is oscillating.* Advantage may be taken of that fact to test an oscillator. If no vacuum-tube voltmeter is available, a milliammeter can be used to test for oscillation. Insert the milliammeter in the screen, plate, or cathode circuit. (Refer to Fig. 1.) Note the meter reading and then short either R_1 or C_2. If the tube is oscillating, then the meter reading should increase when this is done. The reason is that if the tube were oscillating, then a negative voltage would be present at the oscillator grid. Stopping oscillation by shorting of R_1 or C_2 removes this voltage, allowing an increase of current through the tube. If the tube does not oscillate in the first place, shorting of C_2 or R_1 will have no effect, and hence, there will be no change in meter reading. It is best to short C_2 when making this test because if the tube were not oscillating, the grid might be slightly negative due to contact potential. Shorting out R_1 would remove this bias and cause a slight change in meter reading, which might be confusing.

The method of oscillator testing, shown in Fig. 2, substitutes a milliammeter, or preferably, a microammeter, for a VTVM, to indicate the value of oscillator grid voltage. Only the grid and cathode elements of the tube are shown for simplicity. Break the connection of R_1 to ground and in-

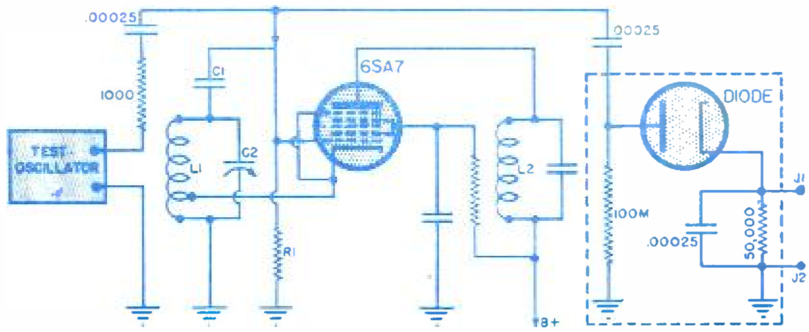


FIG. 5

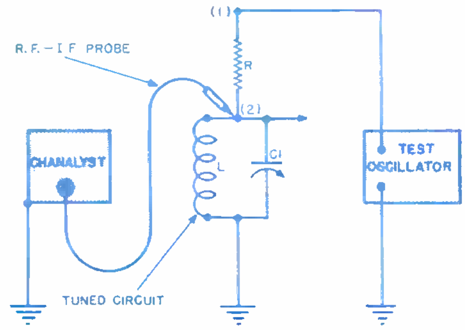


FIG. 6

sert the meter. In this way the meter will read the rectified grid current of the tube. If the resistance of R_1 is known and the meter current known, then the voltage across R_1 may be computed by Ohms Law. For instance, if R_1 were 50,000 ohms and the meter read .1 ma., then E = IR, or 50,000 ohms times .0001 ampere, would give 5 volts as the voltage at the grid of the tube. Fig. 12 is a chart showing the grid voltage for various milliammeter readings, assuming a grid leak resistance of 50,000 ohms. To use this scale, read the amount of current through the meter and locate this value of current on the graph. Then trace the current on the graph to where it crosses a horizontal line and read the voltage value indicated by the vertical row of figures.

Example:

Suppose a 0-1 ma. meter is used and reads .5 ma. Referring to the graph we find that this current through a 50,000-ohm resistor would give a voltage of 25 volts. The same chart may be used for other values of grid leak resistance as well as 50,000 ohms. For instance, if R_1 is 25,000 ohms, divide the graph reading by two, while the graph reading would be multiplied by four were the grid leak 200,000 ohms, etc.

If a microammeter is used instead of a milliammeter, remember that 1,000 microamperes make one milliampere. Divide microamperes by 1,000 to convert to milliamperes, and then use the graph as usual.

Testing Oscillators By Signal Substitution

Another method of telling if an oscillator is operating and at the same time seeing if the rest of the set is operative, is to substitute a test oscillator for the local oscillator in the set.

To do this, set the dial of the radio under test to a strong local station. Next, determine the intermediate frequency of the set by referring to service notes or by using an oscillator. The oscillator of most sets on the broadcast band operates above the station frequency, and, therefore, the test oscillator should be tuned to the dial setting of the receiver plus the intermediate frequency of the set. Consider a local station having a frequency of 840 kc. and a set having an i.f. of 455, then 840 plus 455 equals 1295 kc., which is the setting for the test oscillator.

Set the oscillator to this frequency and connect the low side of the output lead to the chassis of the set; connect the high side of the signal generator to the tuning condenser stator, and set the oscillator for maximum output. The local station should then be received at reduced volume. If it is heard, *but was not heard when the test oscillator was not connected,* then it may be safely assumed that the set's oscillator was not working.

The advantage of substituting the test oscillator for the set's local oscillator is to check whether or not the rest of the set is operative.

Use of a Detector and Phones

If two signals which have slightly different frequencies are fed into a detector together, a frequency will be produced in the output that is equal to the difference in frequency of the two input signals. The converter on a superhet works on this principle.

The oscillator circuit shown in Fig. 1 is shown connected to a diode detector, Fig. 5. A test oscillator is connected to the detector in parallel with the oscillator circuit. Exactly the same calculation is used in this setup as in the previous section. Add the i.f. frequency to dial setting and set the test oscillator to this frequency; connect a pair of headphones or an oscilloscope to J_1 and J_2. Rock the frequency of the test oscillator back and forth. When the frequency of the test oscillator is near the oscillator frequency a sound will be heard in the phones or seen on the 'scope. If the set is badly out of alignment the oscillator may not be working at the calculated frequency and it may be necessary to "hunt" for the signal.

(*Continued on page* 58)

Table 1. Grid voltages of modern receivers.

AC Superhets	—5 to —25 v. (Av. 15)
AC-DC Sets	—5 to —20 v. (Av. 10)
Battery Sets	—5 to —15 v. (Av. 7 to 10)

The voltage encountered is nearer the higher limit usually, rather than the lower limit. If no grid voltage is present or if the voltage is less than normal, it is an indication of oscillator trouble.

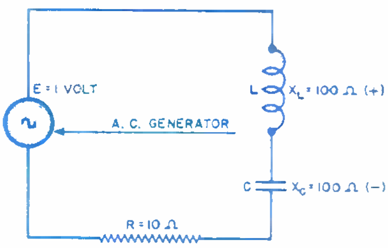


FIG. 7

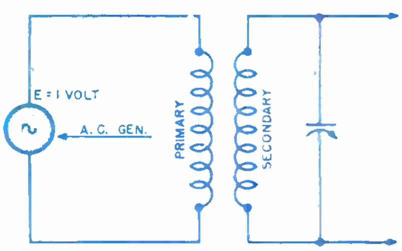


FIG. 8

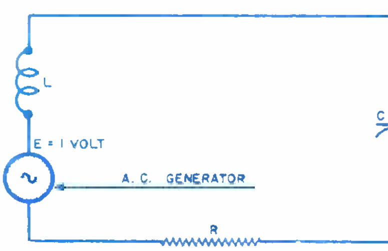


FIG. 9

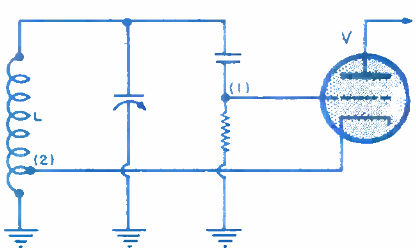


FIG. 10

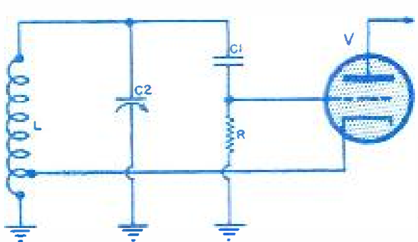


FIG. 11

Low-Frequency
RADIO TELEPHONE TRANSMITTER

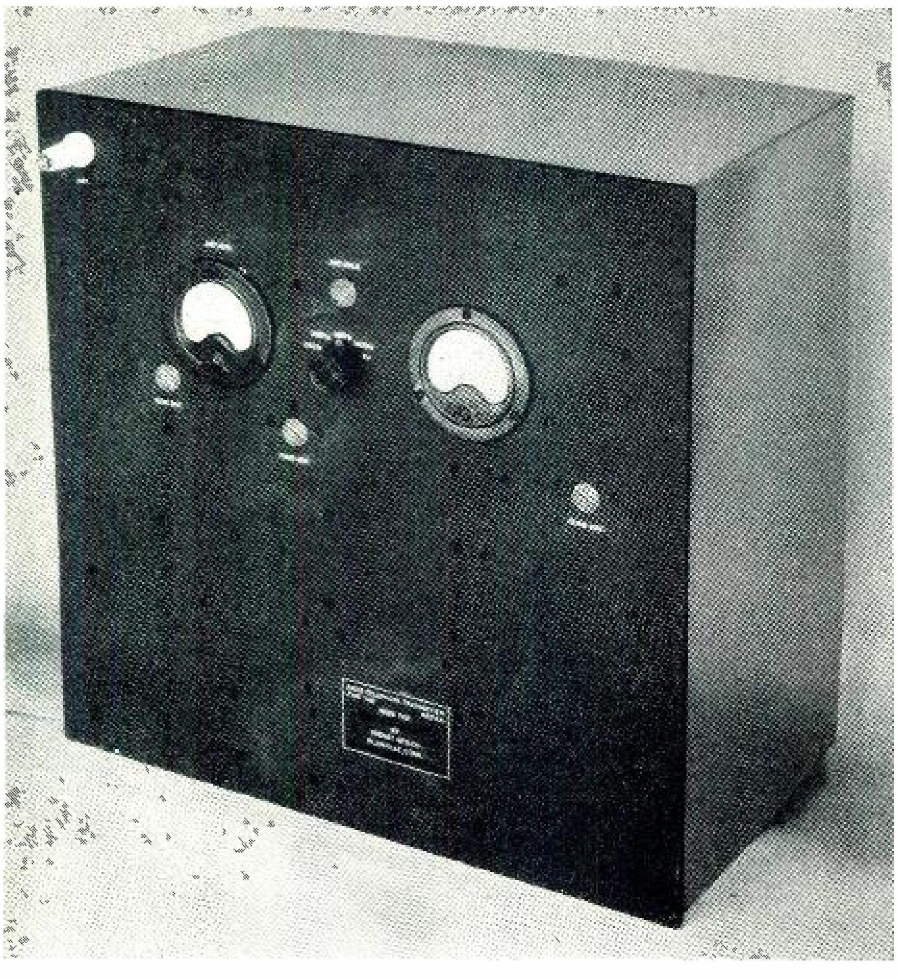
By McMURDO SILVER
Vice Pres., Grenby Mfg. Co.

Constructional details of a military-style transmitter, operating at the lower frequencies, 440 to 660 kcs., which are used for dependable communications.

EMPHASIS has been centered upon radio communication on high, ultra-high and now very-high frequencies and sight is often lost of the fact that the low and medium frequencies are still in most serious use. This is because their application, and the equipment permitting their application, is so "cut and dried" in engineering terms as to justify little notoriety. Upon the assumption of the truth of this statement, it is felt that the transmitter herein described will be of educational interest to at least the newcomers to radio, those old-timers whose memories may be pleasurably refreshed, and others by virtue of its somewhat unique construction—entirely without customary chasses.

This transmitter type was required with extreme urgency and speed for certain specialized military services. Carrier power required was conservatively estimated to be in the neighborhood of 50 watts. Voice modulation only was specified. A frequency range of 440 to 660 kcs. covered the intended service. Speed was of the essence. This being the case, there was no time available for material and component parts, procurement such as would permit rigorous adherence to the usual governing specifications of the using service in terms of corrosion resistance, moisture-proof impregnation of component parts, and all the thousand-and-one customary requirements applying to strictly military radio equipment. Commercial component parts had to be selected which were both available rapidly and measured up as closely as possible to regular military specifications. Judicious selection of standard catalog items yielded a helpful number of adequately high-quality components, thus reducing to a minimum the essentially special parts which had to be produced to make the equipment's operating realities.

Fig. 1. Panel layout with tuning adjustments as slotted, flushed polystyrene shafts.



The matter of physical design received much thought and consideration. In terms of the relatively few component parts involved, it was determined that the ideals of simplicity and easy serviceability could be best satisfied by a somewhat unique design dispensing with customary multiple chasses for r.f., a.f. and power sections in favor of mounting all components of these major sections directly upon the rear face of a single 19" x 19" steel panel ¼" thick. Turned down upon its panel face, this type of construction gave what amounted to a laboratory "breadboard" layout. Discreet grouping and positioning of parts upon the rear face of the panel operated to effectively subdivide the whole assembly into functional groups, as can be seen upon examination of Fig. 2. The elimination of chassis saved critical metals and simplified construction, a distinct advantage in a situation in which time was of vital importance.

Circuit-wise the transmitter consists of a 6V6 electron-coupled oscillator driving a pair of 807 tubes parallel-connected as a final Class "C" amplifier, in turn modulated by two 807 Class "A Prime" ("AB1") push-pull modulators driven by the two triode sections of a single 6SN7GT tube. The first 6SN7GT section is used as a voltage amplifier; the second as a balanced phase-inverter, thereby saving a critical modulation driver transformer, unnecessary and undesirable in any case where the modulator is operated other than Class "B" or "AB2" and consequently no grid driving power is required. The power supply employs two 866 mercury-vapor rectifier tubes in a full-wave circuit to furnish 550 volts at something over 200 ma. through a two-section filter using only hermetically-sealed, oil-impregnated filter capacitors. Power input is arranged for 105/125 volts, 50/60 cycle alternating current, the usual source of a-c power available for radio equipment operation.

A carbon microphone is the logical choice for serious speech communication, since its frequency response is specifically designed for best speech-range performance (300 through 2500 to maybe 3000 cycles) and its high output-voltage level makes unnecessary high audio-frequency amplification, always a disadvantage in narrow-band speech modulators in terms of sensitivity to r-f pick-up and consequent quality-garbling. Forming a part of the microphone is the customary push-to-talk switch button. Pressing of this button by the operator holding the microphone, transfers the antenna from receiver to transmitter, provides a circuit to mute the receiver during transmission, and energizes the primary circuit of the high-voltage power supply to provide operating plate voltage for all tubes only during transmission. Releasing pressure upon the microphone button reverses these operations. Send-receive change-over is therefore under thumb-tip pressure control.

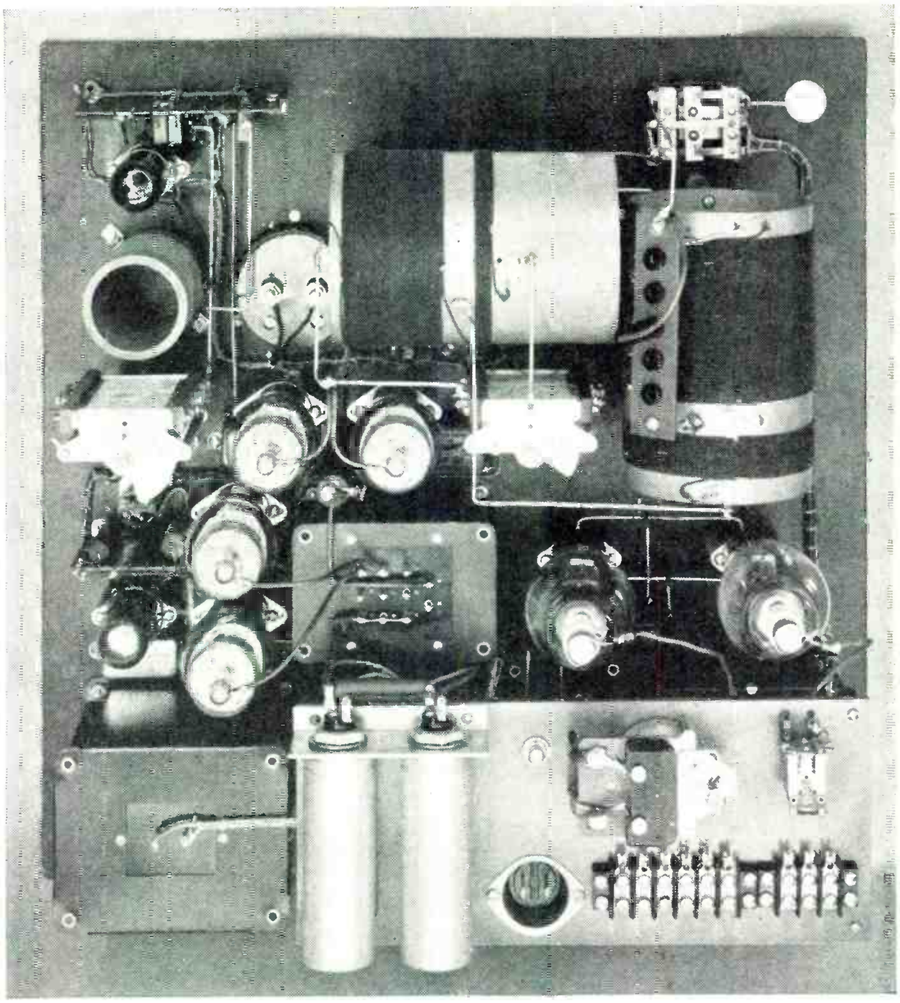
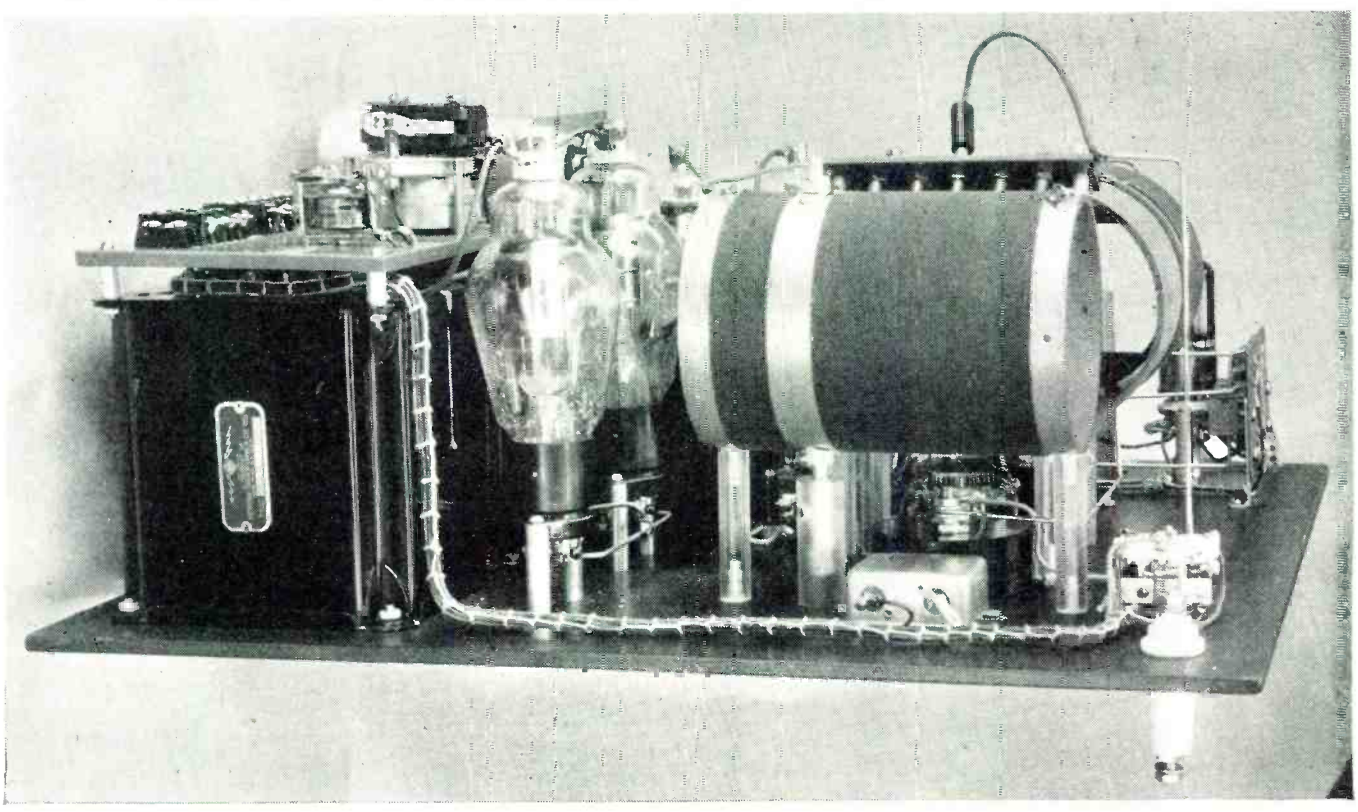


Fig. 2. Component assembly, showing all parts mounted directly on the back of the panel.

Fig. 3. Constructional details, illustrating method of mounting inductors, other components, and cabled wiring on back of panel.



Actual operation of the transmitter is from a point remote from its actual physical location. It was required that the transmitter be turned on and off and its operation entirely controlled from a remote point, all with the minimum inter-connecting cables and in terms of known-to-be-always available power sources. The actual remote control unit is a small 4" x 4" x 2" metal box containing a pilot lamp to indicate primary power "on," a primary on-off switch and a three-circuit jack for the microphone. At first glance, since the 115-volt a-c mains circuits may be presumed to be continuous sources of power, it would appear logical to use such power to turn the transmitter on and off, and to derive a low-current d-c voltage from the transmitter power supply for microphone and push-to-talk, send-receive relay operation. Because of the comparative complexity of cabling and possible hum pickup in long microphone leads, this course was abandoned in favor of four 1½-volt dry "A" batteries connected in series to provide a source of 6 volts direct current. This allows the send-receive relay to be operated through one conductor and the shield of the two-wire microphone cable, with microphone circuit completed through the remaining conductor and the common shield. It further allows connection of the s.p.s.t. push-to-talk switch in such a manner as to open or close both the microphone circuit itself as well as the relay circuit. Battery current is used only in the few intermittent moments of transmission, and at so low a rate that battery life is close to estimated shelf-life. Batteries are located adjacent to the remote-control box.

Mains power is remotely controlled over the 115-volt a-c circuit by a toggle switch which actuates relay L_6 of Fig. 4. L_6 closes the transmitter primary circuit to energize filaments and actuates time-delay relay "TDRY" of Fig. 4 which delays application of plate voltage to the 866 rectifiers until 30 seconds after their filaments have been turned on. Thus all primary power energization is controlled by s.p.s.t. toggle switch over but two remote wires. Once turned on, the transmitter is ready for instantaneous operation after the first 30 seconds have elapsed, which is required inasmuch as it is kept in "standby" condition for long periods of time, ready for instant use.

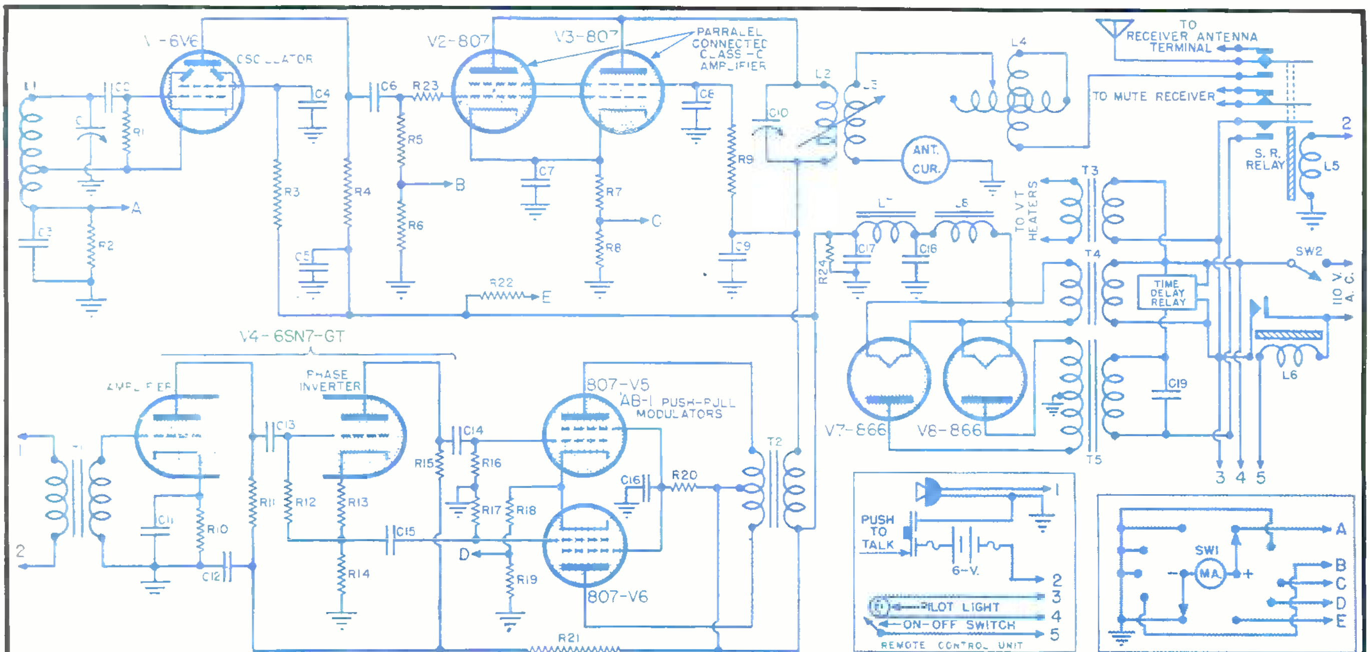
Low-frequency operation involves different concepts of tuning capacities, coupling, bypassing, isolation, spacing and shielding from those usually associated with high-frequency operation. For example, oscillator and power amplifier tuning capacitors C_1 and C_{10} are of 520 μμfd. maximum capacity, such large values being necessary not only to yield circuit stability in LC tuned circuits, but to provide suitable circuit Q for the plate-and-screen-modulated Class "C" final amplifier. Grid-coupling capacitors assume the gigantic proportions of 4000 μμfd., compared to the 10 to 100 μμfd. conventional for above 1500 kcs. By-passing and circuit isolation are simple in that they involve only simple capacitative decoupling circuits, without usual resistors or inductors. On the other hand, tuned circuit inductors become so large physically as to introduce serious inter-coupling-field problems, necessitating careful positioning for optimum location and relation of successive circuits of instability is to be avoided.

Coupling of electron-coupled oscillator to final amplifier is simple, involving only the pure resistive load in the oscillator plate circuit, R_4, which with R_3, the screen-dropping resistor, is made of sufficient value to drop the total plate supply voltage for modulator and Class "C" amplifier down to about 275 volts. The resistors at R_{11}, R_{14} and R_{15} similarly provide good load-relationship at the same time that they drop the total plate voltage to values proper for the 6SN7GT a-f amplifier-phase-inverter tube.

Skin-effects and power losses in solid wire preclude its use in all r-f inductances at low to medium frequencies. Only multi-strand Litz wire is suitable if space is to be a minimum and efficiency a maximum. Thus L_1

(Continued on page 72)

Fig. 4. Wiring arrangements of the 50-watt 440-660 kc. radio telephone transmitter.



C_1, C_{10}—520 μμfd. var. cond.—Cardwell MR260BD
C_2, C_6—.004 μfd. mica cond.
C_3, C_4, C_5, C_{13}—.01 μfd. mica cond.
C_7, C_8—.01 μfd. mica cond., 1000 v.
C_9—.01 μfd. mica cond., 2500 v.
C_{11}, C_{12}—.1 μfd. oil cond., 200 v.
C_{14}, C_{15}, C_{16}—.1 μfd. oil cond., 600 v.
C_{17}, C_{18}—4 μfd. oil cond., 600 v.
C_{19}—1 μfd. oil cond., 400 v.
R_1—50,000-ohm ½-watt res.
R_2, R_6, R_8, R_{10}—meter shunt-hand wound on 1-watt res. for particular meter employed
R_3—75,000-ohm, 2-watt res.
R_4—7500-ohm, 10-watt res.
R_5—10,000-ohm, 2-watt res.
R_7—500-ohm, 10-watt res.
R_9, R_{16}, R_{17}—25,000-ohm, 1-watt res.
R_{10}, R_{13}—6,000-ohm, 1-watt res.
R_{11}—250,000-ohm, 1-watt res.
R_{12}—500,000-ohm, 1-watt res.
R_{14}, R_{15}—30,000-ohm, 1-watt res.
R_{18}—500-ohm, 10-watt res.
R_{20}—25,000-ohm, 10-watt res.
R_{21}—25,000-ohm, 2-watt res.
R_{22}—1-megohm, 1-watt res.
R_{23}—10,000-ohm, 1-watt res.
R_{24}—50,000-ohm, 10-watt res.
TDRY—Hayden 30-second 115-volt Time Delay Relay
SW_1—2-pole, 5-position switch
SW_2—On-off switch s.p.s.t.
T_1—Microphone transmitter—U.T.C. O-2
T_2—Modulation transformer—Kenyon T493
T_3—Filament transformer—Kenyon T378
T_4—Filament transformer—Kenyon T352
T_5—Plate transformer—Kenyon T668
L_1, L_2, L_3, L_4—See text
L_5—Kurman Relay Type 250 make two unenergized; make three energized; 6-v. d-c coil
L_6—S.p.s.t. Relay 110-volt 60 cycles
L_7—Filter reactor—Kenyon T166
L_8—Filter reactor—Kenyon T510

Staff Sergeant directs air traffic by radio from the control tower at Scott Field. Officer in charge checks the station log.

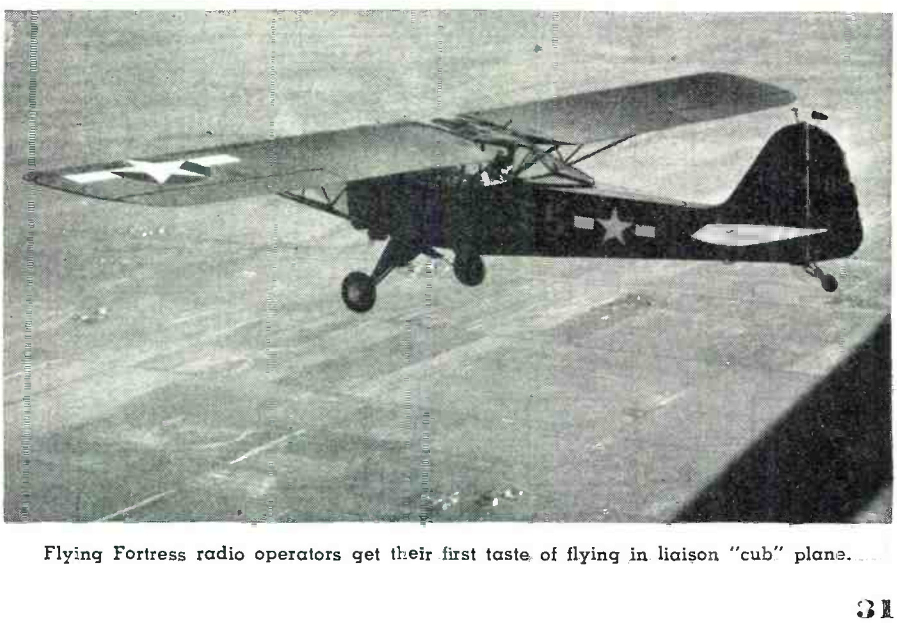
AACS Airways Radio Station

Communications between ground station at Scott Field and planes in flight are maintained at all times. Army Air Forces radio students are taught communication techniques during actual flights.

As ARMY airplanes come and go, day and night every day in the year, the Army Airways Communications System operators stand ready in the AACS Airways radio station at Scott Field to give pilots and radio operators on board a variety of services.

Capt. William B. Hinds, St. Joseph, Mo., and S/Sgt. Fayette Harder, Jr., St. Louis, Mo., station chiefs of the AACS airways station, are in charge of a group of radio operators who have but one concern, and that is to answer every airplane's call quickly. On duty in front of a battery of highly sensitive radio receivers, they often have the problem of working several airplanes at the same time, either by radiotelegraph or radiotelephone. This is like carrying on separate conversations with several people on different sub-

(*Continued on page* 128)



Flying Fortress radio operators get their first taste of flying in liaison "cub" plane.

LOUD SPEAKER RESPONSE MEASUREMENTS

Prepared by the TECHNICAL SERVICE DEPT.
Jensen Radio Manufacturing Co.

Part Two. A continuation of acoustical laboratory measurements and the possible misinterpretations of frequency-response curves.

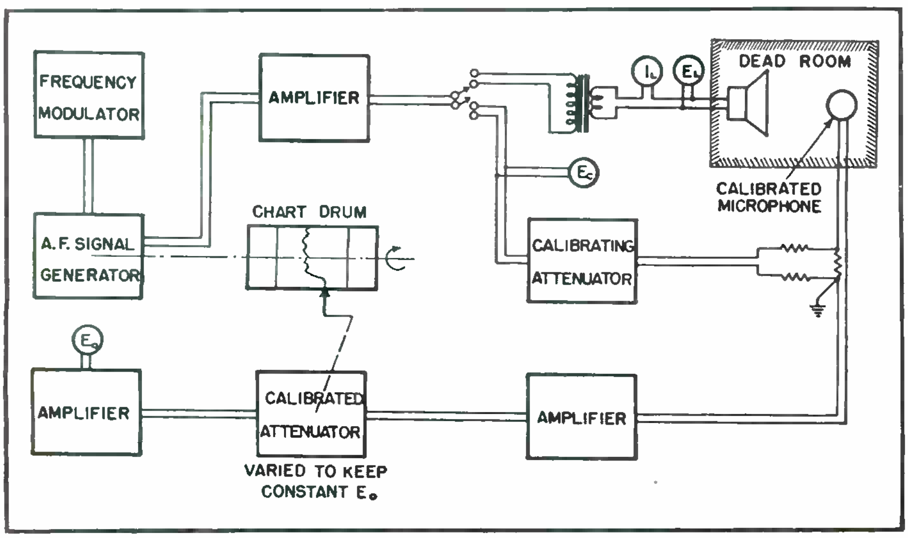
BASICALLY the equipment required for loud speaker response measurements comprises an audio-frequency oscillator, a driving amplifier for the speaker, the speaker under test which is located in a designated acoustic space into which it is to radiate, a microphone suitably located in the acoustic space as a means of indicating the sound pressure, microphone amplifying equipment, and an output meter. Important auxiliary elements of the measuring system include voltage and current meters to determine the input to the loud speaker, a calibrating circuit with which to measure the voltage generated by the microphone, and recording means to eliminate the necessity for tediously plotting the point-by-point response curve. A schematic diagram of one of the measuring systems used in the Jensen laboratory is shown in Fig. 5. Semi-automatic curve recording is employed in the system illustrated, but fully automatic recording equipment is also used. Although speaker and microphone are shown located in a dead room, the acoustic space for particular measurements may be outdoors, a free-space room, or a live room depending upon the nature of the performance characteristic to be determined.

Axial response frequency measurements for design and development purposes are conveniently made in a small dead room measuring 18 feet 9 inches long, by 15 feet 6 inches wide, by 12 feet high. Direct-radiator speakers may be mounted in an end wall so that only the front side radiation is involved, or in a suitable cabinet or special enclosure when the performance of the complete acoustical system of the reproducer is under study. The microphone is usually placed 24 inches from the speaker to minimize room effects.

EDITOR'S NOTE: This is the concluding installment of an article on loud speaker response measurements. Part One appeared in the April, 1944 issue of Radio News.

For indoor measurements involving considerable distance between microphone and speaker (a necessity in the case of reproducing devices of large size), an unusually large "free-space" sound room is provided in the Jensen laboratories. This room has a total volume of 77,574 cubic feet and affords an interior working space measuring 41 feet 8 inches long, by 44 feet 4 inches wide, by 42 feet high. The room is sufficiently large to permit the determination of the directional characteristics of large low-frequency horns such as are used in theater reproducing systems.

Fig. 5. Diagram of loud speaker measuring system employing semi-automatic recording.



In making outdoor measurements, it is desirable that the speaker and microphone be as high above the ground as possible and well away from walls or other reflecting surfaces. This is especially important when measurements are to be made at considerable distance from the speaker, a necessary condition when studying the performance of speakers with large-dimension radiating surfaces. This is accomplished at the Jensen laboratories by suspending speaker and microphone from a long beam projecting from a tower atop the free-space sound room building. The speaker is pointed diagonally away from the building and is located out from the corner a considerable distance. The usual height of speaker above ground is approximately 50 feet.

Living room conditions are approximated in a laboratory room measuring 20 feet long, by 18 feet 6 inches wide, by 11 feet high, having average absorption characteristics. A number of procedures are possible in determining loud speaker performance in such a room. The effect of various combinations of location of loud speaker and listener within the room can be obtained by response curves with speaker and microphone placed to simulate the desired conditions. Such response curves are highly irregular due to room effects, but these effects are likewise present when listening under the same conditions. Curves obtained in this manner are characteristic of the particular room and do not hold for a different, even though similar, room. Another procedure which is routine in live-room measurements in this laboratory involves the use of an 8-microphone array. These microphones are mounted at selected positions in a plane parallel to the floor and at approximately the same height as that of a seated listener's ear. Motor-driven switches connect each microphone in rapid sequence to the input of the measuring system with the result that an average of the sound pressures over the array space is indicated. This method, though providing a purely arbitrary integration of the pressure-space function, has been found advantageous in many respects. In the first place, it shows a probable sound pressure-frequency characteristic to which a listener within the array would be exposed. Secondly, it eliminates the more violent fluctuations in response due to room modes which show up in single microphone curves and tend to confuse visualization of the general trend of the response characteristic. Lastly, a rough approximation of the total radiation characteristic is afforded because the array automatically takes into account speaker directivity.

Comparative Results

To illustrate in detail the comparative results obtained by the various methods of measurement discussed, and to demonstrate some of the acoustic phenomena involved in both listening and objective tests, a comprehensive series of measurements was made on a loud speaker. The speaker consisted of an extended range 12-inch direct-radiator unit mounted in a total enclosure so as to provide the simplest type of radiation, i.e., from the front side of the diaphragm only. A *Bass-Reflex* enclosure would have improved the low-frequency response, but was not used because such an arrangement provides two sources of sound at low frequencies.

To illustrate outdoor performance and the directional characteristics of the test reproducer, a group of four curves were taken at azimuths of 0 (on axis), 30, 60 and 90 degrees, using the outdoor tower. These are shown in Fig. 6. The total ambient acoustical background level due to wind and noise prevented the extension of all curves to the same limiting upper frequency, but the trend is sufficiently well established to illustrate the progressive loss in response at the high frequencies with increasing azimuth angle. Below approximately 200 cycles per second, the curves are substantially identical, indicating that the reproducer is non-directional in this range. For the extreme cases of 0 and 90 degrees, there is a difference in response at 2,000 cycles per second of about 18 db which would result in a considerable reduction in observed loudness, crispness and intelligibility of speech, and brilliance of musical reproduction. This would limit the use of this speaker to smaller angles, or require more speakers for wide angle coverage. This, of course, is under outdoor conditions. Indoors the situation would be quite different, for such angles between source and listener are improbable for the usual speaker locations, and multiple reflections and room effects have the effect of increasing the sound energy density at probable listening positions.

Fig. 7 illustrates the kind of differences which were obtained between the outdoor and indoor responses determined under dead-room and live-room conditions. "A" is the outdoor response on the axis (0 degrees) at 10 feet from the speaker. "B" shows the dead-room indoor response measured on the axis at a distance of two feet from the speaker which is mounted on the approximate center of the end wall of the room. "C" and "D" show typical live-room results with the speaker mounted on an end wall midway between floor and ceiling; in "C" a single microphone located near the center of the room was used, while for "D" the 8-microphone array was employed.

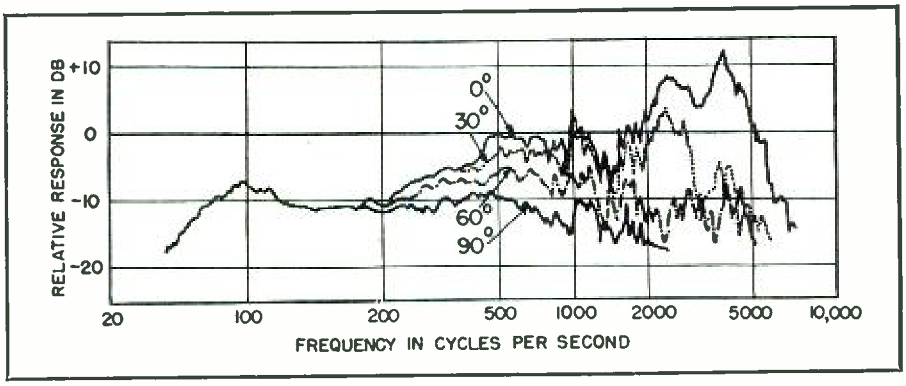


Fig. 6. Outdoor response curves at various azimuth angles.

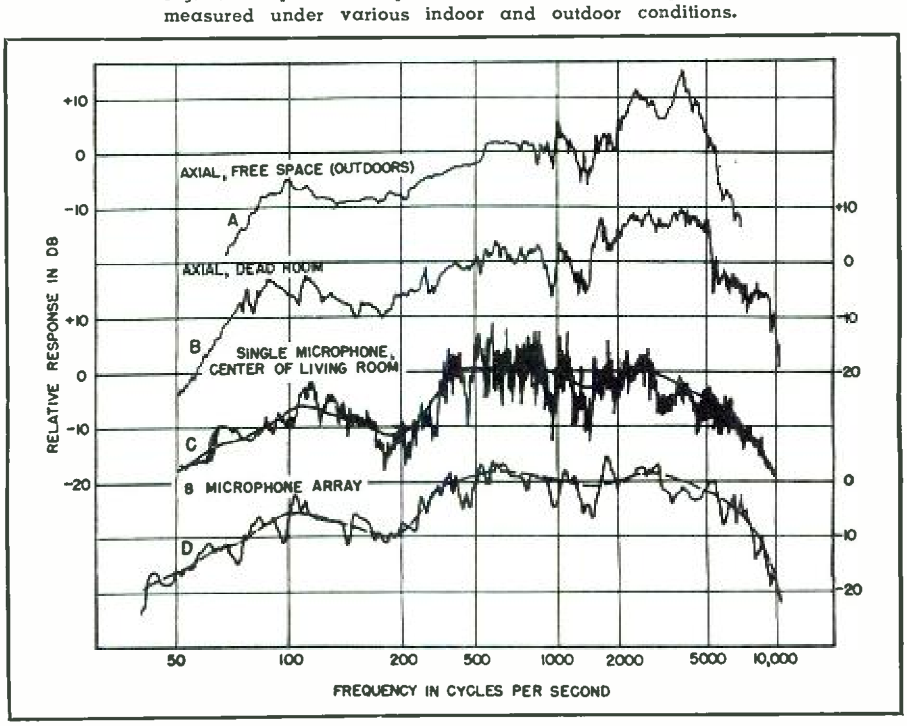
The outdoor curve "A" shows the performance of the speaker under the simplest possible acoustic surroundings, that is, in essentially free spherical space in the practical absence of obstacles and reflecting surfaces. This is of interest to the loud speaker designer as it gives him an insight into the inherent electroacoustic performance of the speaker system itself.

If curve "A" is compared with the dead-room curve "B," a general similarity is at once apparent. Moreover, many of the individual irregularities apparent in "A" also show up in "B." The differences between the two curves are due to the room and to phase difference and diffraction effects due to the small separation between speaker and microphone in dead-room curve "B." The low noise level in the dead room made it possible to extend the measurements over a considerably wider frequency range than for the outdoor case.

Curve "C," taken in the live room with a single microphone centrally located, shows the preponderant influence of the room under conditions representative of those found in the average home. The normal room modes, relatively widely spaced at the low frequencies and increasingly closer spaced at the high frequencies, are evident with their accompanying wide variation in response. A graphical average drawn through the record bears scant resemblance to curves "A" and "B." As will be illustrated later, the curve obtained will vary considerably with the position of the microphone in the room.

The smoothing effect of the 8-microphone array is at once apparent in curve "D." Because of the shifting pattern of sound within the room as the middle and higher frequency modes are successively excited, the individual microphones of the array are exposed to different field pressure conditions at any particular frequency

Fig. 7. Comparative response curves for the same speaker, measured under various indoor and outdoor conditions.



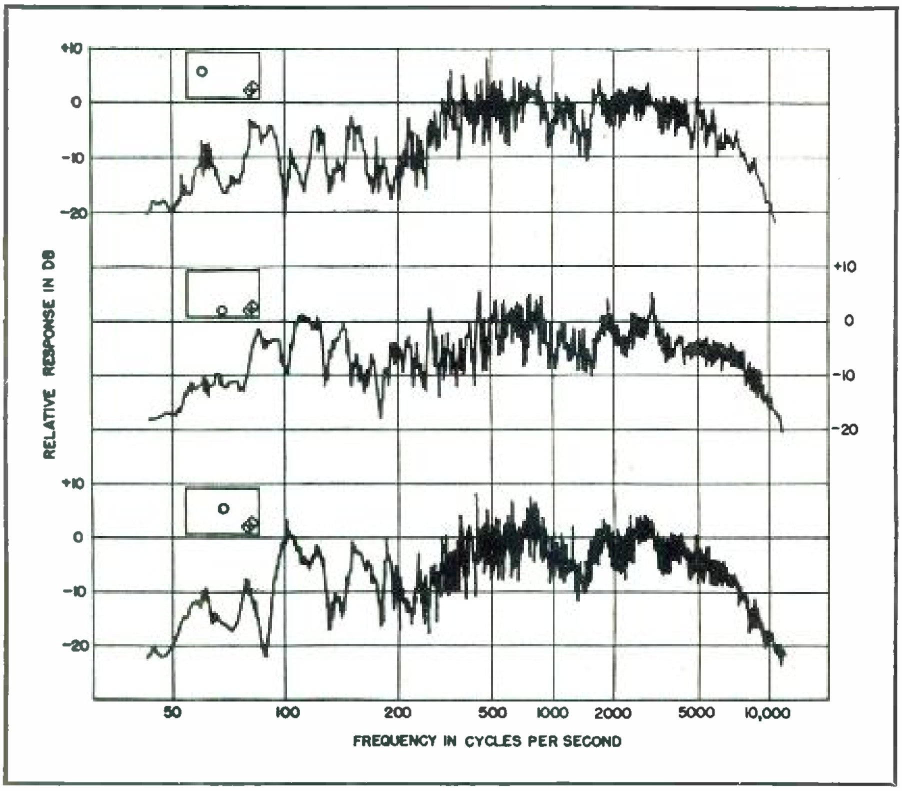
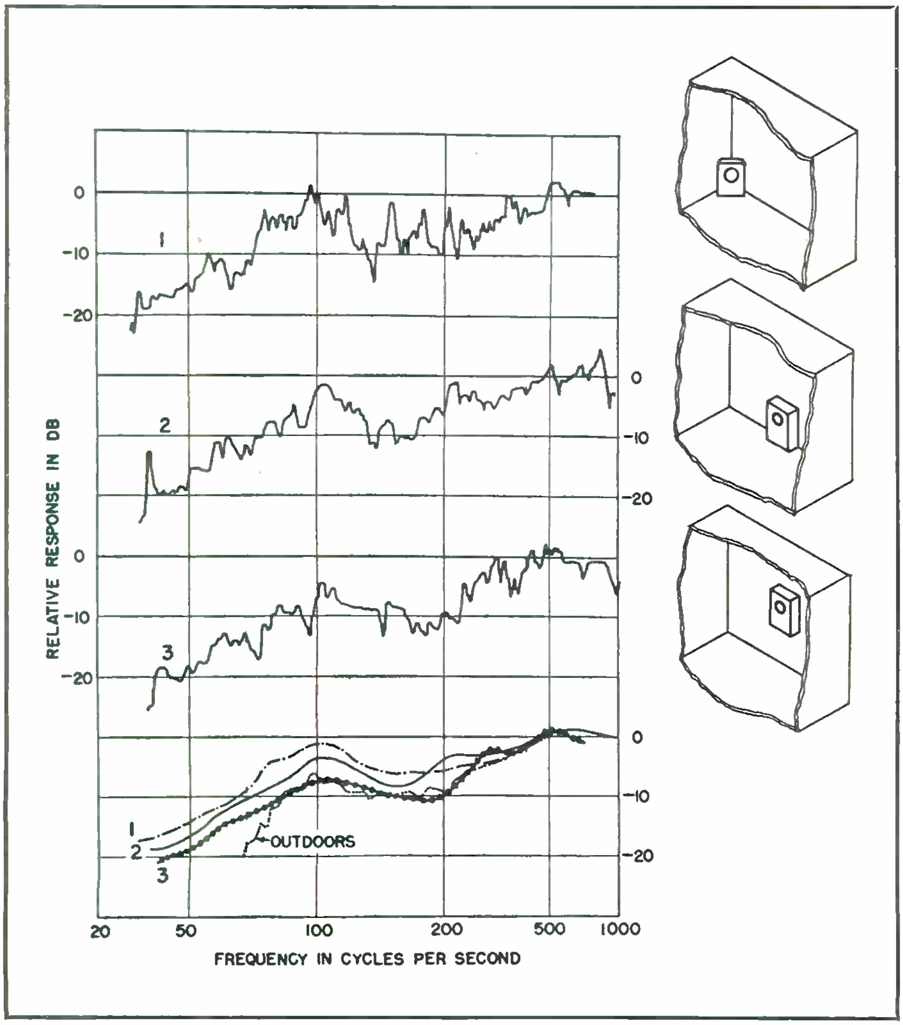


Fig. 8. Variation in response characteristic at different observation positions in a live room (speaker located in corner of floor with single microphone at designated position).



in this range, and as would be expected, the integrated output of all the microphones eliminates many of the modes from the final record and the variations around the graphical mean are much less extreme. A curve of this type is rather easily interpreted visually and has been found to give good correlation with listening tests in the same room and for the same speaker location. The graphical means in "C" and "D" correspond rather closely, which tends to validate the premise that the array will indicate the general type of response characteristic to which a listener in the array region would be exposed. The actual point field conditions at the listening position are, of course, similar to those shown in "C." All of our indoor listening experience is acquired under conditions characterized by complex room behavior. This is one of the reasons why the satisfaction obtained from outdoor listening or indoor listening in highly absorbent acoustically-treated rooms, is considered to be relatively low and marked by an impression of lifelessness and lack of brilliance compared to that experienced in a relatively live room.

It is interesting to compare the axial pressure response curves "A" and "B" with the array curve "D" in the 2,000- to 6,000-cycle range. The axial response shows a relatively high rise in this region which is lacking in array curve "D" which is a measure of the total radiation. This illustrates the point made earlier that the axial pressure must increase as the frequency is increased if the total radiation is to remain constant. The radiation is not maintained at high level above about 7,000 cycles in curve "D" but the characteristic has been found to be more than adequate for critical extended range listening with average listening test material.

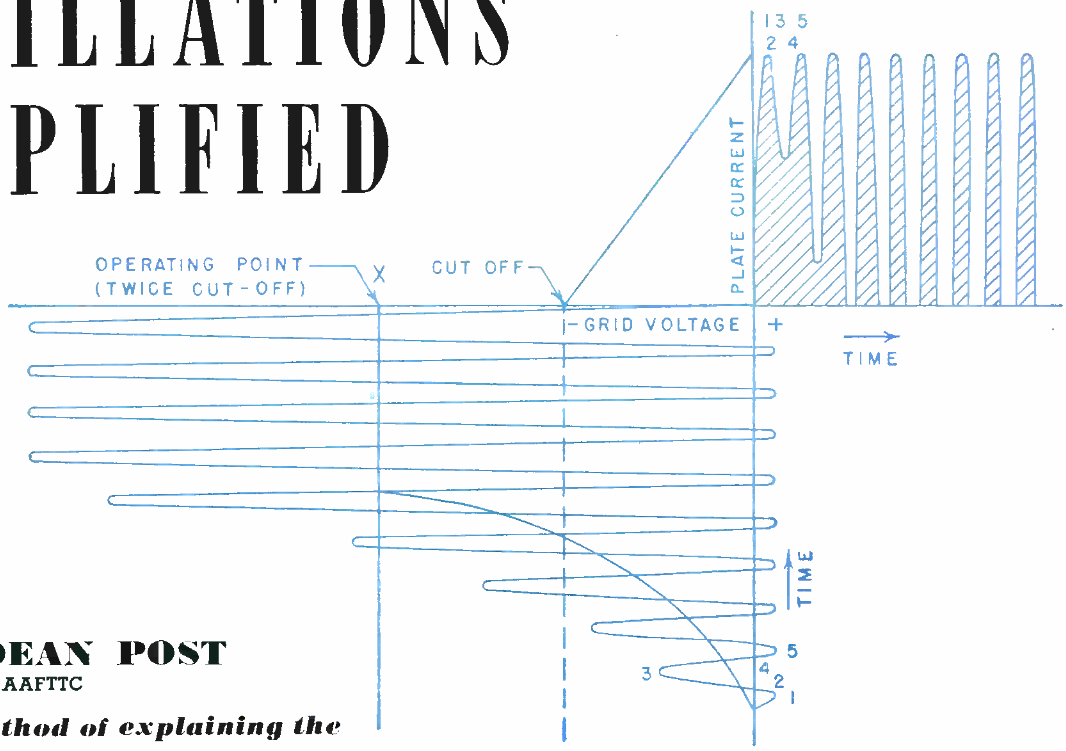
The group of curves in Fig. 8 shows the rather considerable differences which were obtained in a given room with fixed speaker location as the listening position is shifted. No conclusions should be drawn as to the results which would be obtained in another room, even of approximately the same size, for the data holds for the test room only, with its particular arrangement of reflecting and absorbing surfaces and other acoustical details. The most pronounced differences between the test positions show up in the low frequency region below 500 cycles per second. This would be expected, because at low frequencies, a change of position would greatly alter the relative predominance of the various room modes which influence the field conditions. Position differences of this

(*Continued on page* 110)

←

Fig. 9. Live room response for speaker in designated locations. Curves 1, 2, and 3 are 8-microphone array curves for indicated speaker location. Lower group of curves shows superimposed graphical means of curves above, to illustrate comparative efficiency of the various speaker locations.

OSCILLATIONS SIMPLIFIED



By M. DEAN POST
Senior instructor, AAFTTC

A novel method of explaining the basic operation of oscillators.

Fig. 2. Dynamic characteristic curve used to determine cause of oscillation.

MUCH has been written by competent authors on the subject of oscillation, but most of these articles seem to be slightly evasive on the matter of how oscillations behave during the first few cycles of operation. It is easy enough to prove a given circuit will oscillate if certain components and adjustments are used: "this builds up, that builds up; as a result, the whole thing repeats, and the circuit oscillates." But a rigorous proof requires considerable mathematics, which is generally beyond the scope of those without formal engineering training. This article is intended to present an attack which will explain operation from the instant of closing the plate voltage switch, and which will not require mathematics for a full understanding.

Let us consider the typical oscillator circuit of Fig. 1.

Initially, of course, this circuit is electrically at rest, except for the heated filaments. Thus there is no negative bias on the grid—a necessary condition if oscillation is to start. Now close switch S, which will apply a positive voltage to the plate of the tube, through the inductance L_o. This initial voltage impulse induces a voltage in L_g, which is wound in such a direction with respect to L_o that a positive impulse will appear on the grid. The grid impulse does not attain a maximum value immediately; likewise, the plate current does not rise to its full value immediately, for the following reasons:

1. When S is closed, current through L_o will rise at a rapid rate. (It cannot become maximum at once because of the inductance L_o.)

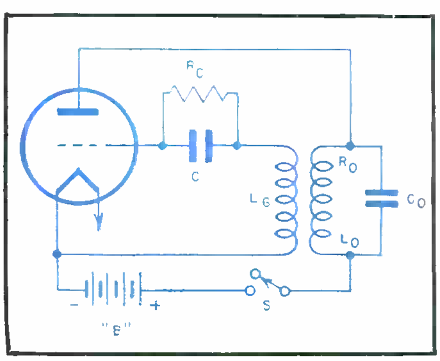
2. As current builds up through L_o, a rising voltage is induced in L_g.

3. Since the grid is also going positive now, plate current will rise even more rapidly.

We can show what has happened thus far by Fig. 2, using the dynamic characteristic curve of the tube, which, for the sake of convenience, is assumed to be a straight line and not curved at either end as is actually the case.

Voltage on the grid is started from zero and built up in the positive direction to point 1, which is the saturation point of the tube. Plate current is increasing all this time (it cannot start at maximum because of the lag introduced by the inductance) by reason of

Fig. 1. Typical oscillator circuit.



the positive-going grid, but the increase stops when saturation is reached. It is at this point that the question arises as to how the grid voltage starts in the negative direction. Vague answers are the usual result, and most articles jump boldly and with haste from point 1 to the downward stretch.

Suppose we consider a tuned circuit as in Fig. 3.

If this circuit had *no resistance* (ideal situation) and were excited from some external source, electrons would move around the circuit, storing energy in the condenser C_o, first in one direction, then in the other. (This goes on in the manner of a spring which has been pulled down, and snaps back as soon as the stored energy is released.) Such a condition of free oscillation would continue forever were it not for the unfortunate fact that there *is* resistance in the circuit, and this resistance quickly damps out the oscillations, so that we must supply power from an external source if we hope to continue oscillation. This alternate storage and release of energy is similar to a fly-wheel effect.

If this information is applied to our original pulse, which has by this time reached its maximum and needs encouragement to start in the negative direction, we can see that the tuning condenser C_o, having been energized fully in one direction, will try to lessen the strain of electrons on its plates and return to a resting condition. When

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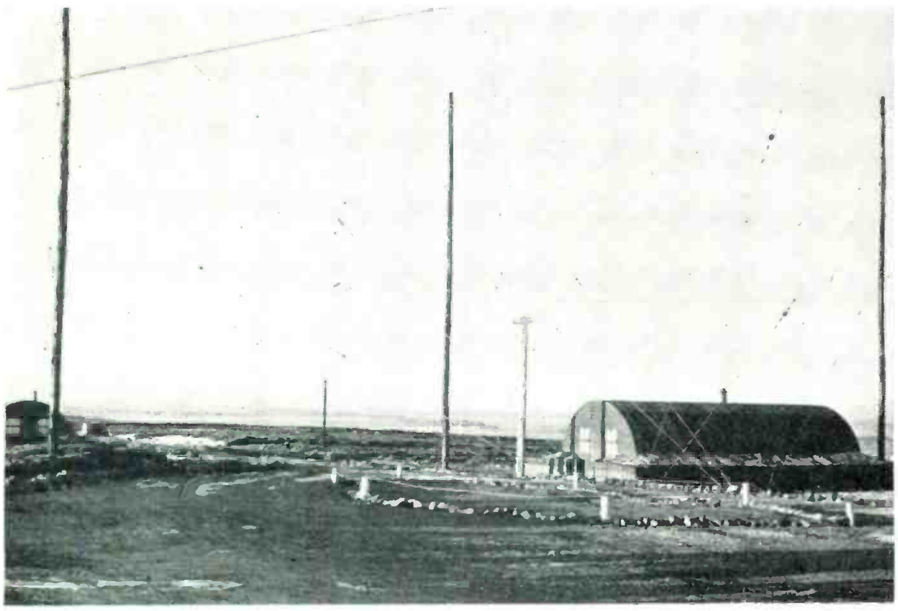
RADIOMEN IN ICELAND

By CPL. ORLANDO AGUERO
Radio Operator, U. S. Army

Personal observations of transmission difficulties caused by the northern light effects upon radio waves.


Commercial power lines used to supply power to transmitter equipment.

WHEN I speak of the Radiomen of Iceland, I am referring to the "cw" men, or radio operators of the military service, known in the Army as "fixed-station operators"—in the Navy and Merchant Marine as "Sparks." Every radio operator who hits the circuit of the only fixed station in Iceland and stays on that circuit must be good—above all have patience.

There were many that came—the typical "Ham" who carries the handbook as if it were his bible, another his "bug," and still another who needs an extra pocket stitched in his coveralls for the collection of pencils and fountain pens he is never without. Nor must we forget the serious, quiet type with an extra pair of glasses and a Sterling's manual. Yes, all types, but as I said, very few of them stay on this circuit.

When our Signal Corps outfit pulled into Reykjavik almost two years ago, the fixed radio station had not yet been completed, while our radio equipment was still "somewhere in the Atlantic." Where? I do not know, but it was two months before we saw it. By the time we were set up, it was summer, though to this date I fail to see the difference in temperature between any of the seasons. Winter stands out nevertheless, with its snows and short hours of daylight. It is of this season I write particularly.

Our battalion lost no time in organizing the few fixed station operators. From nearly six hundred, only three were picked. Of course, other outfits made their contributions. But when we all met at the station, there were only seven qualified "cw" men—not counting our Communication Officer with his First Class Radio-Telephone ticket and the Chief Operator with a Second Class Radio-Telegraph ticket. Here was the line-up of the rest of the operators that opened the station as qualified watch standers: FP, KC, GF, WX, HB, CF and OA.

Our equipment was all streamlined, with Hammarlund's Super-Pros doing the receiving. The transmitters were all remote-control units doing a good job on pure "cw." From June until the end of September our station just could not be surpassed. Everyone was happy and contented—for the time being.

With the coming of November, we experienced our first difficulties. The main channel failed to come in. I tried the other two, but they were also dead—except for the harmonics of my own sending. I called up the transmitting station asking for a check. The answer came back that all TX'S were putting out.

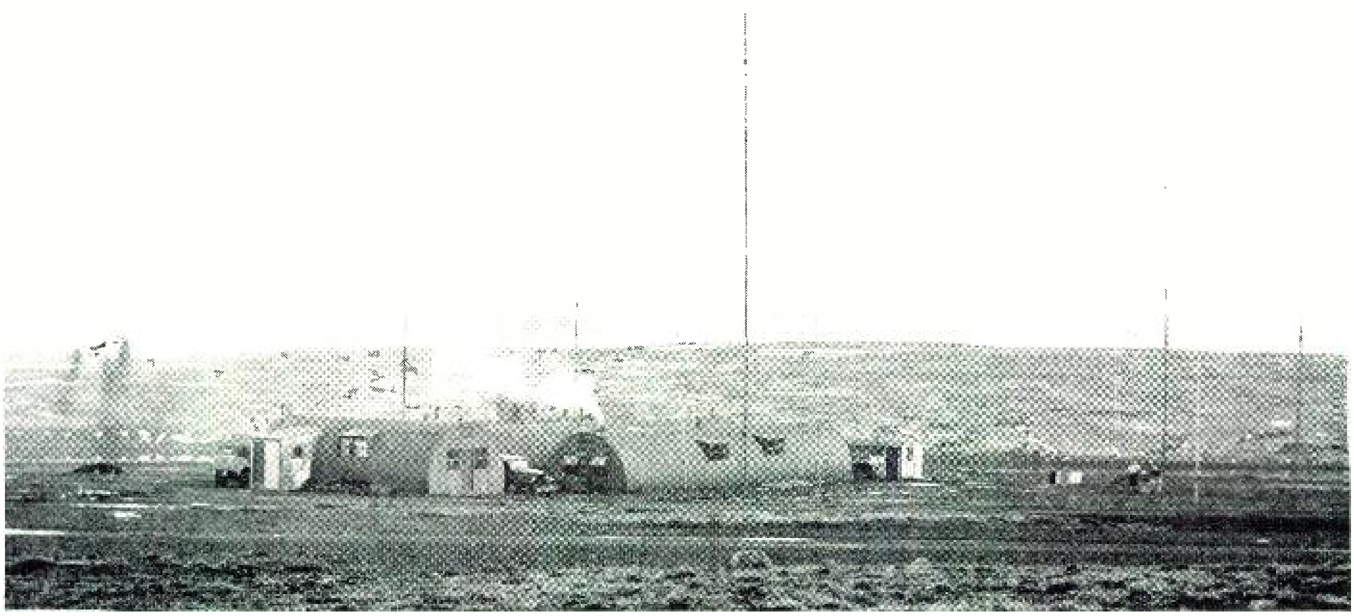
Disgusted, I made my way out of the radio hut to take a look at the receiving antennas. What greeted me outside was the so-called northern lights. Classified as very beautiful by a majority of people, it was not so to me at that moment, for I was looking at an enemy. I took an interest in this enemy.

From experience, I had found there were actually two defects rendered by these lights. One, the incoming wave; that is, the radio wave transmitted from some point remote and out of the "field" caused by the northern lights, is dampened or reflected

(*Continued on page* 92)

Complete equipment consists of nine super Hammarlund Super-Pro receiving and transmitting sets, one teletype printer, one code machine, and one Syphon recorder.

Radio-equipped Army tanks crossing lava fields of the barren countryside of Iceland.



Control station for the island radio net, handling all intra-island administrative communications.

PRACTICAL RADIO COURSE

By ALFRED A. GHIRARDI

Part 23. Practical methods of obtaining current and voltage inverse feedback in amplifiers and their effect on response characteristic.

VERY often when inverse feedback is applied to an amplifier, conditions are such that the amplifier oscillates or howls at a fairly high audio frequency. This is due to the fact that the total phase shift within the feedback loop is at least 180° from the normal amount, so the feedback voltage fed back to the input of the amplifier is no longer in direct opposition to the signal voltage throughout each cycle but actually is *additive* during at least a part of each cycle.

The cause of oscillation is readily apparent when it is remembered that basically an oscillator is an amplifier having sufficient voltage *of the proper phase* coupled back from the plate to the grid to overcome the losses of the grid circuit. Accordingly, in a feedback amplifier, this means that we can avoid oscillation by arranging the circuits so that the feedback voltage is normally out of phase with the applied signal, and so that there is no frequency at which the feedback factor βA is *positive, real* and *greater than unity.*

With this in mind it is apparent that the amplification and phase-shift characteristics of a feedback amplifier are of fundamental importance in determining whether or not the amplifier will be stable.

It was shown in Fig. 2 in Part 22 of this series that the phase shift in a single-stage resistance or impedance-coupled audio amplifier may *approach* 90° *lead* at low frequencies and may *reach* 90° *lag* at the high frequencies, while the phase shift in a single-stage transformer-coupled amplifier may *approach* 90° *lead* at the low frequencies but may *reach* 180° *lag* at the high frequencies, or at the series resonance frequency.

Oscillation in Two-Stage Feedback Circuits

Consequently, if two resistance-coupled stages are included within the feedback loop, since the *total* phase shift will then be the sum of the phase shifts in each stage, this will *approach* 90° × 2 = 180° *lead* at the low frequencies, and *reach* 180° *lag* at the high frequencies. In such amplifiers, because this maximum phase shift normally occurs at very low or high frequencies where the gain is zero, the conditions for oscillation are not satisfied, and the circuit normally is stable. However, should

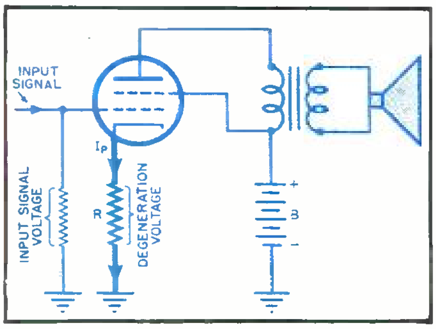
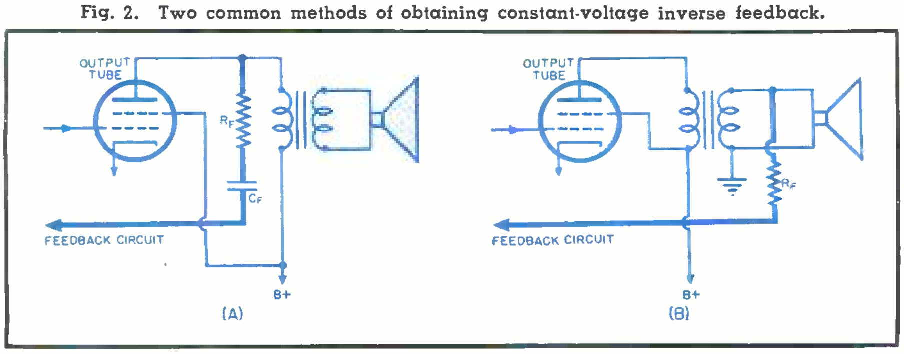


Fig. 1. Constant-current inverse feedback obtained by omitting bypass condenser across cathode resistor. Bias resistor R then becomes common path to grid and plate currents.

the feedback circuit also introduce phase shift, a two-stage resistance-coupled feedback amplifier may oscillate. In such cases, the gain of one or both stages at the frequency of oscillation should be made nearly zero in order to prevent it.

If a resistance-coupled stage is connected to a transformer-coupled stage within the feedback loop, the *total* high-frequency phase shift *approaches* 90+180=270 degrees *lag,* and is sufficient to make the amplifier susceptible to oscillation. Such two-tube feedback circuits must, in general, use an interstage transformer with a not-too-high loading resistance shunted across the secondary. Under these conditions the two stages will give a maximum phase shift of 180° (at the extreme frequencies where the amplification drops to zero). Interstage transformers with open-circuited secondaries, and other arrangements which give 180° phase shift per stage must be avoided, since with them the total shift will reach at least 270°, and considerable gain is possible where there is a 180° phase shift that changes the feedback from negative to positive.

Fig. 2. Two common methods of obtaining constant-voltage inverse feedback.



Oscillation in Three-Stage Feedback Circuits

When feedback over three stages is employed, the possibility of oscillation is great. For example, if two resistance-coupled stages are connected to a transformer-coupled stage, a phase shift of 90+90+180=360 degrees is possible at extreme frequencies, and oscillation is very likely to occur. Even if all three stages are resistance-coupled, since *each* stage can introduce a possible phase shift of 90 degrees, a possible *total* phase shift of 90×3=270 degrees at extreme frequencies can occur. The criteria for oscillation is then easily satisfied since the troublesome 180° phase shift will take place at a frequency where the amplifier gain is still relatively high, and accordingly, the feedback voltage will usually be large enough to cause oscillation, unless the amplifier is specially designed to prevent it.

Two expedients may be employed to avoid oscillation where feedback over three or more stages is used. Two stages of the amplifier are designed to have a frequency response very little, if any better than that required for the purpose at hand, while the third stage is designed to have a substantially flat frequency response with negligible phase shift up to frequencies much lower and much higher than the remaining stages. The third stage, therefore, introduces a negligible phase shift (except the reversal of polarity produced by the tube action) up to those high or low frequencies, where the remaining stages cause the amplification to drop greatly. Consequently, the feedback factor βA can be made to drop to less than unity as a result of the falling off in amplification A before the additional phase shift introduced by the third stage is sufficient to make the total shift of all three stages reach 180 degrees. The maximum permissible mid-frequency value of the feedback factor βA under these conditions is determined by the flatness of the third stage characteristic compared with the response characteristic of the other stages.

However, it may not be easy to adjust the output voltage at low and high frequencies to the desired values at a reasonable cost. In this case, it may be desirable to use one feedback circuit from the output of the third stage to the input of the second stage, and to use a second feedback circuit from the output of the first stage to the input of the first stage.

From the foregoing, it is apparent that when inverse feedback is applied to an amplifier comprising two or more stages, proper design precautions must be exercised if instability or oscillation is to be avoided.

Additional Oscillation Preventatives

A simple oscillation preventative applied to an amplifier in which degeneration is applied over a single stage may consist of a 120-ohm suppressor resistor connected in series with the power tube grid.

In some cases, multi-stage inverse feedback amplifiers may also be prevented from becoming unstable or oscillating by designing them so the amplification falls to a sufficiently low value at the frequencies for which the phase shift has increased to 180 degrees; that is, when the feedback becomes *positive* rather than *negative*, the feedback factor βA should be reduced to less than unity. Methods used to accomplish this include the insertion of suitable coupling networks in the amplifier or in the feedback path itself, and even an auxiliary path connected in shunt with the main feedback path; this comes into operation at the higher frequencies to decrease (or change the phase of) the feedback voltage sufficiently to prevent instability. Another method lies in the use of a special form of feedback applied to operate upon one or more stages separately in the amplifier.

General Methods of Obtaining Inverse Feedback

There are two general methods of obtaining inverse feedback in practice, but they both do not produce exactly the same results on the performance characteristics of the amplifier, nor do they offer the same advantages. It is, therefore, important to consider the circuits, operation and effects of both of them in some detail.

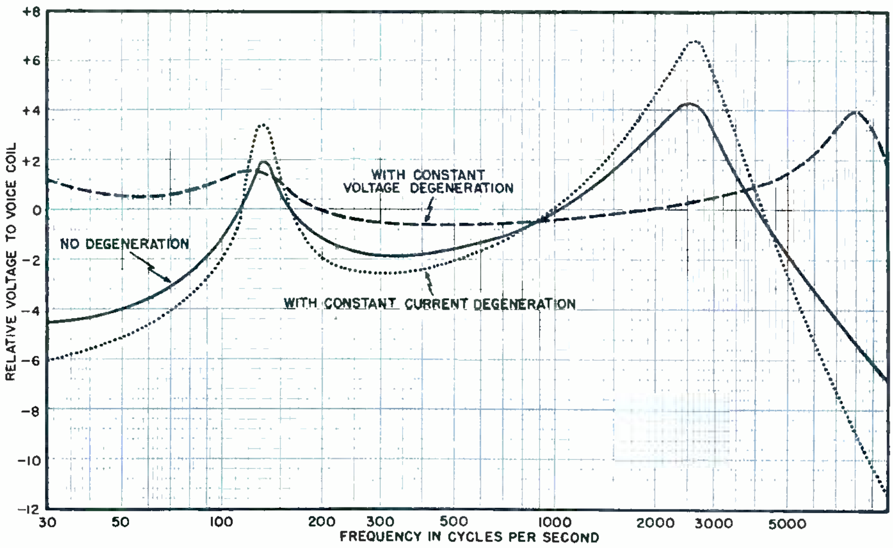
Inverse feedback circuits may be subdivided into the following fundamental types:

(a) constant-current
(b) constant-voltage

A combination of the two is generally spoken of as the "bridge" type circuit. Bridge feed-back circuits are sometimes used for specific over-all applications, but it is not easy to maintain the proper proportion of the amounts of constant-current and constant-voltage feedback in them over an appreciably wide frequency range.

Constant-Current Inverse Feedback (Cathode Bias Resistance Method)

In the constant-current system of inverse feedback the feedback voltage is made proportional to the output signal *current*. Perhaps the easiest



Fidelity curves illustrating the effect of adding inverse feedback to an amplifier. Note superior performance obtained through use of constant-voltage degeneration.

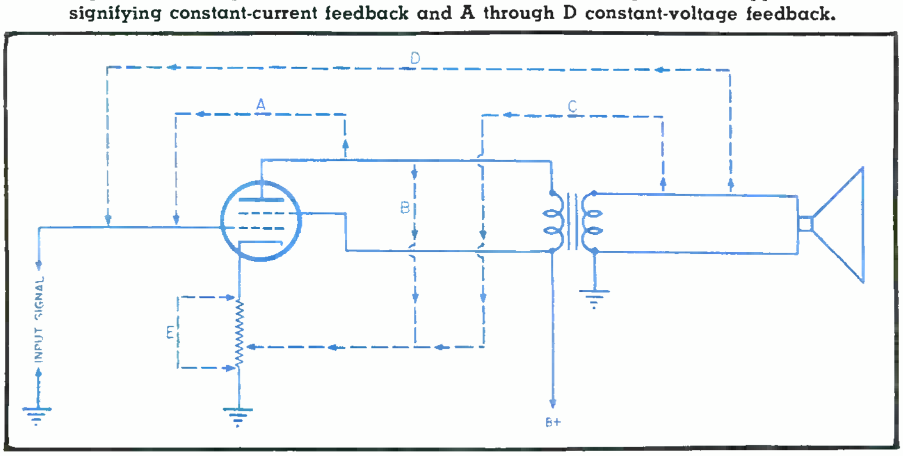
method of obtaining it is simply to eliminate the by-pass capacitor across the cathode bias resistor R as illustrated in Fig. I. (In push-pull stages a separate bias resistor must be used for each tube.) Notice that the bias resistor R is common to both the plate and grid circuits because the plate- and screen currents flow through this resistor and the resistor also forms part of the input circuit between the input grid and cathode. The effective potential upon the grid of the tube at any instant is equal to the input signal voltage plus the voltage drop across R at that instant.

Under no-signal conditions, the plate-and-screen current is steady, and therefore an unvarying voltage drop occurs across R, producing a fixed value of grid bias voltage. However, when a signal voltage is applied to the grid, the plate current fluctuates in accordance with the signal voltage variations, and corresponding variations, therefore, appear in the voltage drop across R. Specifically, on each *positive* half-cycle of the input signal, the plate current *increases*, producing an increased voltage drop across R which tends to *increase* the negative grid bias upon the tube, thereby *opposing* the positive signal voltage. On each *negative* half-cycle of the signal the grid is made more negative, with a consequent reduction in plate current. The reduced plate current flowing through the bias resistor reduces the voltage drop across it, tending to make the grid *less* negative (or *more* positive) and so again oppose the signal voltage. This action is clearly a case of degeneration, so the action is one of inverse feedback. Notice that the voltage drop produced by the a-c (signal) component of the cathode current flowing through R produces the degeneration voltage that is *opposite* in phase to the signal voltage and is effectively in *series* with it with respect to the grid and cathode of the tube. Thus cathode degenerative action results in some distortion cancellation but, as we shall see, it is not as effective in this as is constant-voltage (plate) type degeneration.

In cathode degeneration the feedback voltage is proportional to the variations in the *plate current*, and does not depend upon the characteristic of the load impedance or the voltage developed across it. Hence the only distortion contained in the feedback voltage is that due to a non-linear plate current characteristic.

(*Continued on page* 86)

Fig. 4. Various paths over which inverse feedback voltage can be applied. E signifying constant-current feedback and A through D constant-voltage feedback.

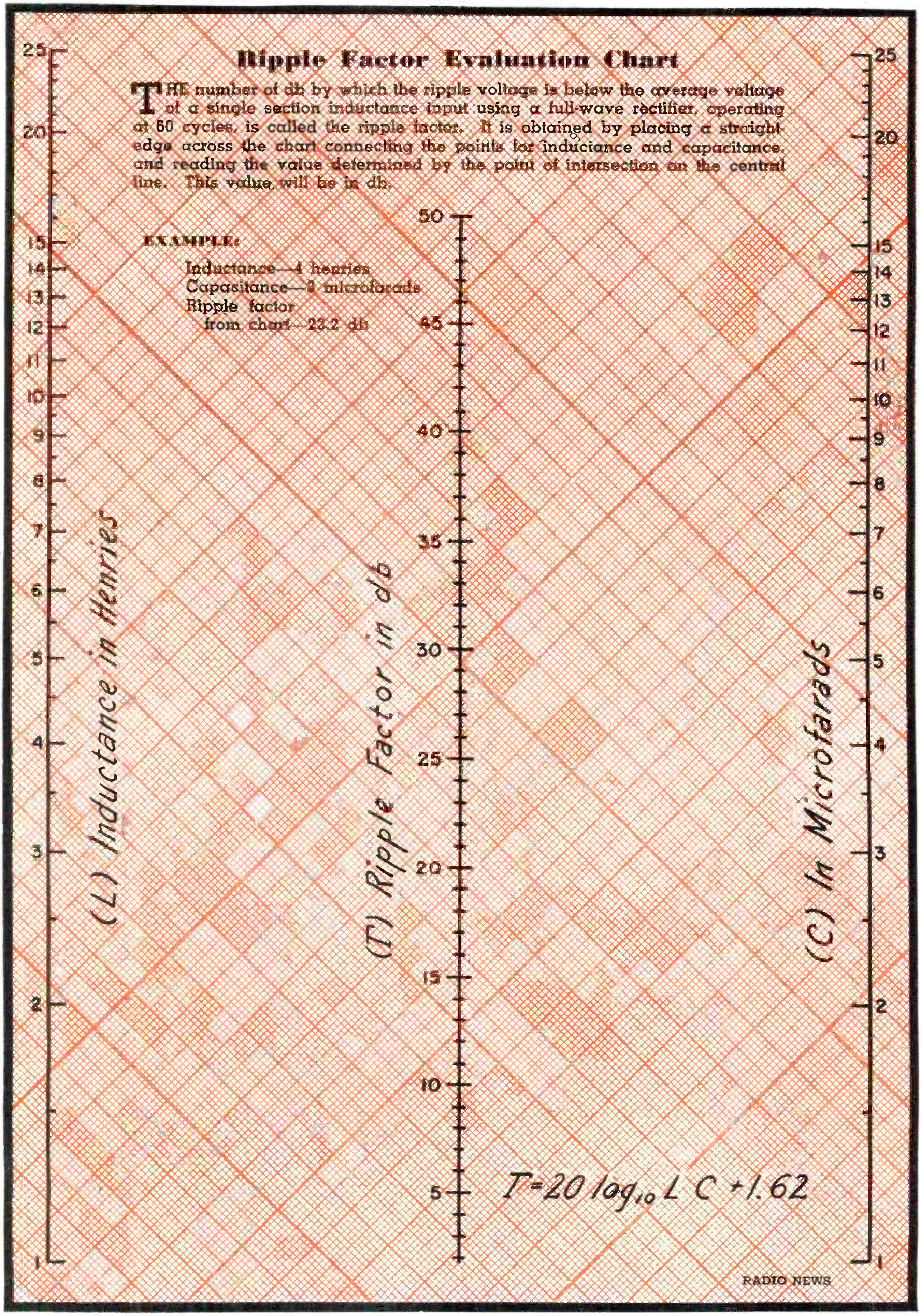


Ripple Factor Evaluation Chart

THE number of db by which the ripple voltage is below the average voltage of a single section inductance input using a full-wave rectifier, operating at 60 cycles, is called the ripple factor. It is obtained by placing a straightedge across the chart connecting the points for inductance and capacitance, and reading the value determined by the point of intersection on the central line. This value will be in db.

EXAMPLE:

Inductance—4 henries
Capacitance—2 microfarads
Ripple factor
from chart—23.2 db



Low-Distortion Audio Oscillators

Summary of many special types of oscillators which produce the unusually pure waveforms necessary in present-day laboratory tests.

By RUFUS P. TURNER
Consulting Eng., RADIO NEWS

MANY electronic laboratory and field tests require an audio oscillator having a low value of distortion percentage. These tests are generally made at 60, 100, 400, 500, or 1000 cycles per second and include (1) a-c bridge measurements of all kinds, (2) amplifier and network distortion and gain tests, (3) measurements on wave filters and other frequency-selective a-f circuits, (4) determination of dynamic tube characteristics, and (5) sundry operations involving close timing. An unusually pure waveform is required in each case.

Several sine-wave oscillators are available for discriminating audio-frequency tests. Aside from the well-known beat-frequency arrangement (involving two r-f oscillators in combination), low-distortion oscillators of the following types have been developed: (a) special tuning forks, (b) fork-controlled tubes, (c) filtered-output, self-excited oscillators, (d) resistance-capacitance-tuned circuits, and (e) crystal-controlled multivibrator-amplifier combinations. The b and e types, when provided with close temperature control, are frequently the basis of primary and secondary audio-frequency standards.

In this article, it is aimed to digest the practical information, now large in amount, which is available on characteristics and typical operation of low-distortion oscillators in the above groups. This data has been formerly available separately for individual types of oscillators, and few, if any, reviews of the entire art have been presented.

Electromechanical Oscillators

Audio frequencies are tones. For this reason, it is natural that tuning forks and vibrating reeds should have been the earliest source of audio test signals. The so-called "microphone hummer" (see Fig. 1) is such a rudimentary signal generator. In one type of hummer (Fig. 3A), vibrations of the electrically vibrated reed are conveyed to a carbon microphone button. Corresponding variations in button resistance then convert simple direct currents from the battery into a pulsating direct current of reed frequency, and these are converted into alternating current by the output transformer. In another type of hum-

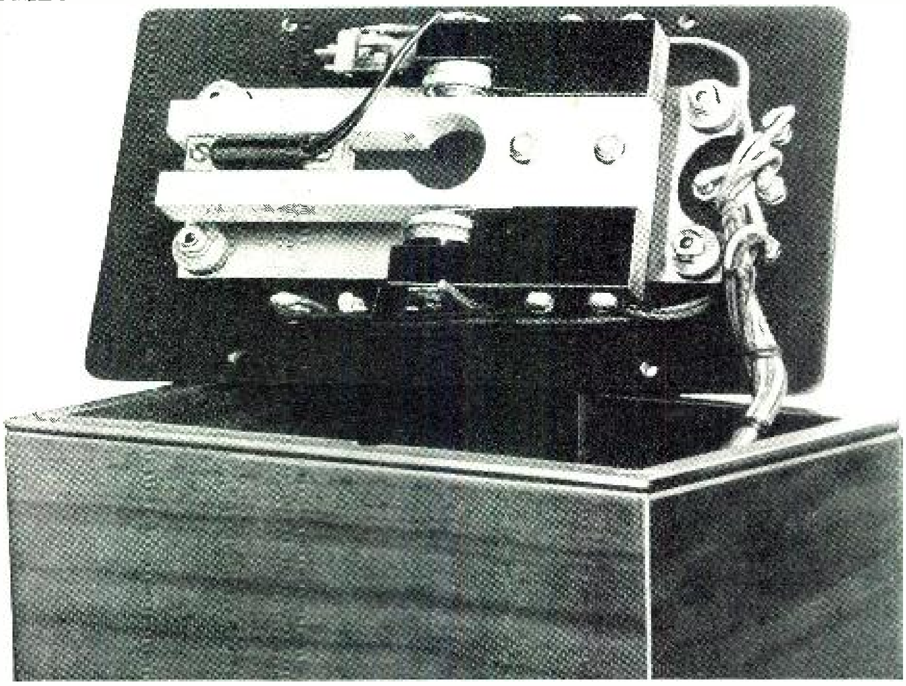


Fig. 1. Rudimentary type signal generator, technically termed "microphone hummer."

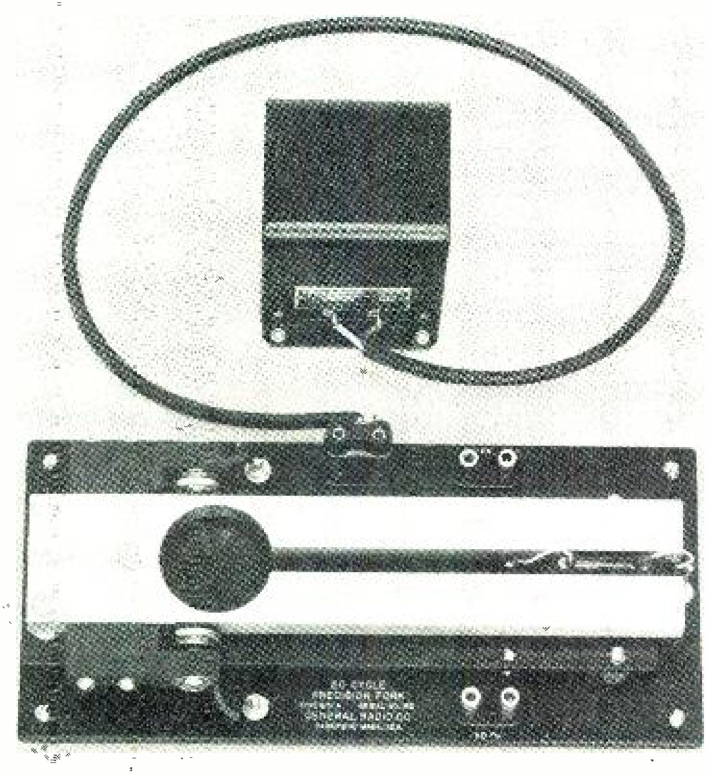


Fig. 2. Precision fork, supplied for specified single frequencies between 40 and 200 cycles.

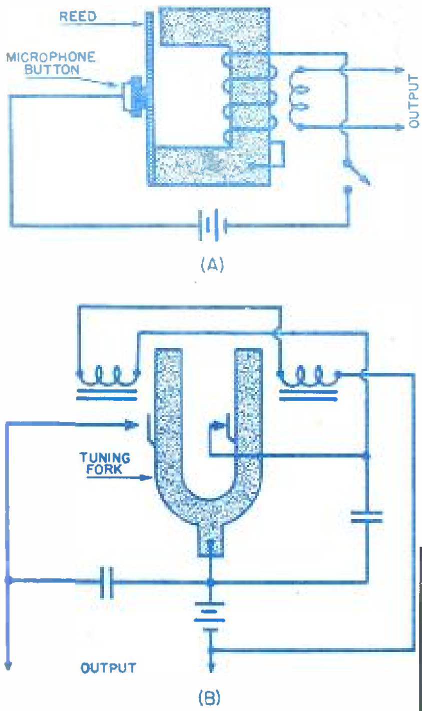


Fig. 3. Circuits of two distinct types of oscillators. (A) Pressure on button microphone used to produce a pure waveform; (B) Vibrations of tuning fork tines make and break circuit to produce oscillations.

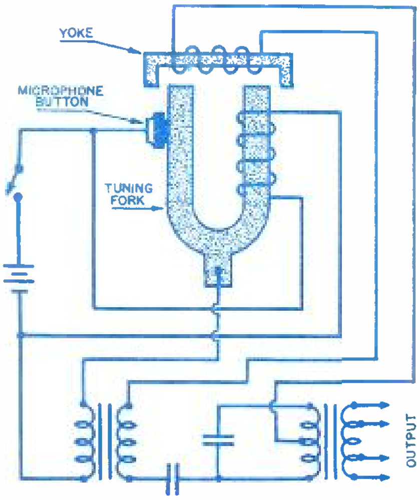


Fig. 4. A more elaborate method of obtaining a pure waveform.

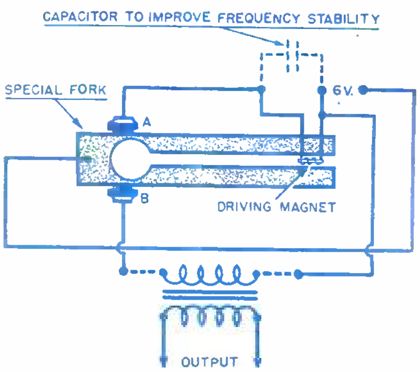


Fig. 5. Circuit arrangement of precision fork oscillator shown in Fig. 2.

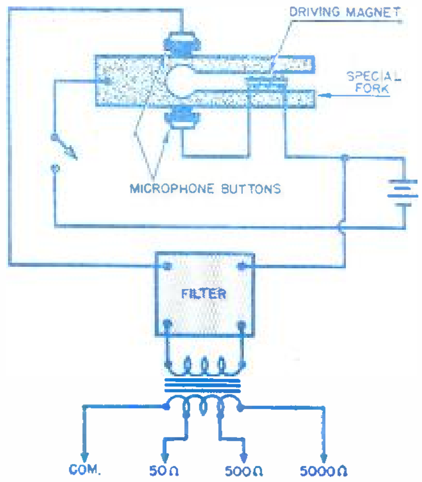


Fig. 6. Internal arrangement of fork type oscillator shown in Fig. 1.

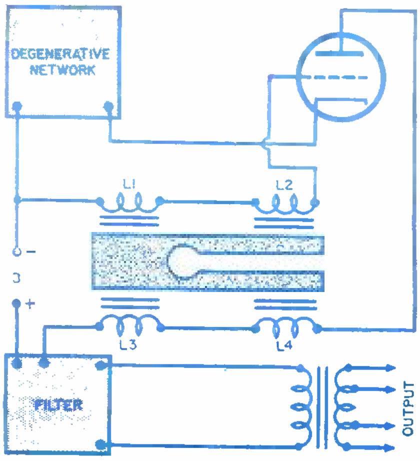


Fig. 7. Employing a tuned fork and vacuum tube to produce oscillations.

mer (Fig. 3B), vibrations of tuning fork tines make and break the circuit.

Simple hummers were employed widely at one time to supply signals for bridge operation and general test purposes. But reed and fork design, damping effect of microphone buttons, and several related factors contributed to high distortion and instability so that the hummer has been superseded almost entirely by improved tuning fork units of special design. Output of the new units is somewhat lower than that afforded by the hummer, but waveform purity is much higher. Typical circuits of the newer units are given in Figs. 4, 5, and 6 with photographs of improved tuning fork oscillators being shown in Figs. 1 and 2.

In Fig. 4, the fork is driven by one coil, which is wound about a tine but not in contact with it, while exciting another coil magnetically coupled. The single microphone button sustains the vibration. This arrangement provides low-distortion output.

Fig. 2 illustrates a precision fork which is supplied for specified single frequencies between 40 and 200 cycles. The circuit arrangement of this oscillator is shown in Fig. 5.

The fork itself is of special design, being fabricated of low-temperature-coefficient stainless steel alloy, and has its microphone buttons mounted below each tine near the heel of the fork to minimize damping action. Separate buttons (A and B) are employed for driving and output, respectively.

The precision fork is adjusted at a stated temperature with 0.005% of its rated frequency and measured to 0.001%. Under normal room temperature variations, the frequency stability which may be expected is better than 100 parts per million; the negative frequency-temperature coefficient less than 10 parts per million per degree F. Frequency-voltage coefficient does not exceed 50 parts per million per volt change with this type. Output of the precision fork (delivered by the output transformer shown in Fig. 2) is 50 volts when the driving-battery voltage is 6.

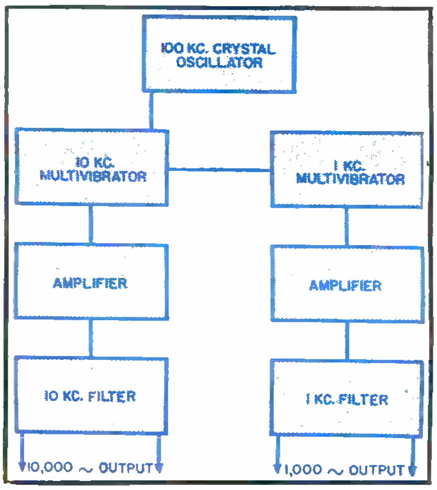
Aside from the ordinary applications of such audio oscillators, the precision fork is employed in rating operations on timepieces, synchronization of facsimile transmitters, and as audio-frequency standards.

Fig. 1 shows the internal arrangement of another fork type oscillator. The schematic is given in Fig. 6. This fork is driven by an electromagnet mounted between its tines, as in the previously-described oscillator. Separate microphone buttons, supplied by a common battery, are provided for driving and output.

In this oscillator, waveform purity is obtained by means of a built-in filter in the output circuit. Total harmonic distortion is 1% for a battery voltage of 4½, and 1½% for 6 volts. The instrument is supplied for any single frequency between 300 and 1000 cycles. Power output of the unit shown is 30 milliwatts for 6-volt drive.

Temperature-frequency coefficient for this type of unit is negative and 70 parts per million per degree F.; voltage-frequency coefficient does not ex-

Fig. 8. An arrangement for obtaining low-distortion signals.



ceed 100 parts per million per volt. The oscillator frequency is adjusted within ½% of its rated value and measured to 1/10%.

The specially-designed tuning fork may be employed also to maintain the oscillation and to control the frequency of a vacuum-tube circuit. A controlled single-frequency tube oscillator is thus obtained, and is equivalent to the crystal-controlled oscillator employed at radio frequencies. Fig. 7 illustrates such a *vacuum-tube fork.*

No microphone buttons are needed in this type of oscillator, as will be seen by examining Fig. 7. The driving coils, L1 and L2, and the pickup coils, L3 and L4, are wound upon permanent magnets placed close to opposite tines of the fork. Accordingly, there is no mechanical restraint upon vibration of the fork. One set of coils is connected in the triode-grid circuit; the other set in the plate circuit.

The harmonic distortion inherent in this oscillator is very low because of tube linearity and the method of fork coupling; nevertheless, further reduction is effected by inserting a filter in the output circuit. Total distortion in the output signal is less than ½%. Frequency-temperature coefficient is negative and approximately 80 parts per million per degree F. The vacuum-tube fork is supplied for 400- and 1000-cycle operation, and is adjusted at 77° F. within plus or minus 0.01% of rated frequency. Power output of such instruments is approximately 50 milliwatts to a matched load.

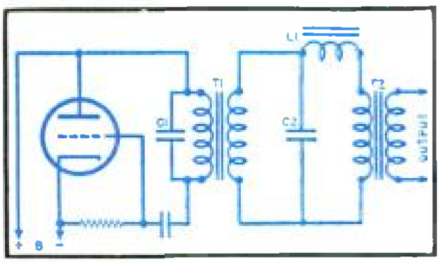


Fig. 9. Single-tube shunt-fed Hartley oscillator with low-pass filter.

Stability of the fork-type oscillator may be improved still further by the addition of precise temperature control. The entire oscillator (when tubes and other components are included) are mounted with the fork in the stabilized oven. Fig. 10 shows an oven-mounted precision fork.

The clock, seen on the front panel of this instrument, is propelled by a synchronous motor driven by the alternating voltage output of the oscillator, and provides an excellent means for checking frequency deviation. The clock will keep correct time (as checked against standard time signals) if the fork frequency remains constant. Frequency deviation over any interval between periodic checks may be calculated simply from the difference between the clock indication and true time. The temperature-controlled fork thus becomes a simple primary standard of audio frequency.

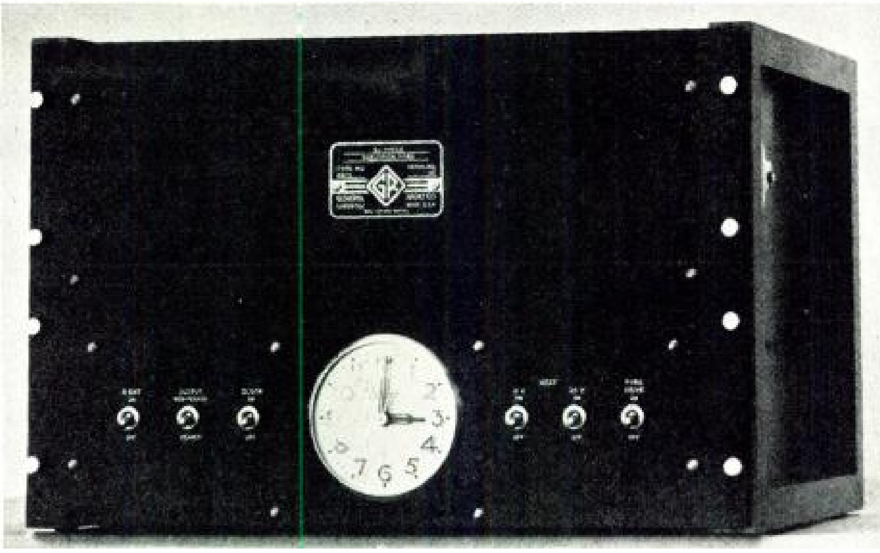


Fig. 10. Oven-mounted precision fork. Clock is propelled by synchronous motor driven by the output of the oscillator and used in checking frequency deviations.

Filtered V. T. Oscillator

Any self-excited vacuum-tube audio oscillator, in which frequency is determined by tank-circuit components or resistance-capacitance networks, may be provided with an output filter to reduce distortion. This is a simple, but effective, means of improving output-signal waveform. A single-tube, shunt-fed Hartley oscillator with low-pass filter is shown in Fig. 9.

In this version, frequency is determined by the primary winding of transformer T1 and the shunting capacitor, C1. If the primary inductance is known, the frequency may be calculated in terms of the shunt capacitance:

$$f = \frac{1}{6.28\sqrt{LC}} \text{ cycles} \ldots\ldots\ldots\ldots (1)$$

where L is the primary inductance (henries) and C, the shunting capacitance (farads).

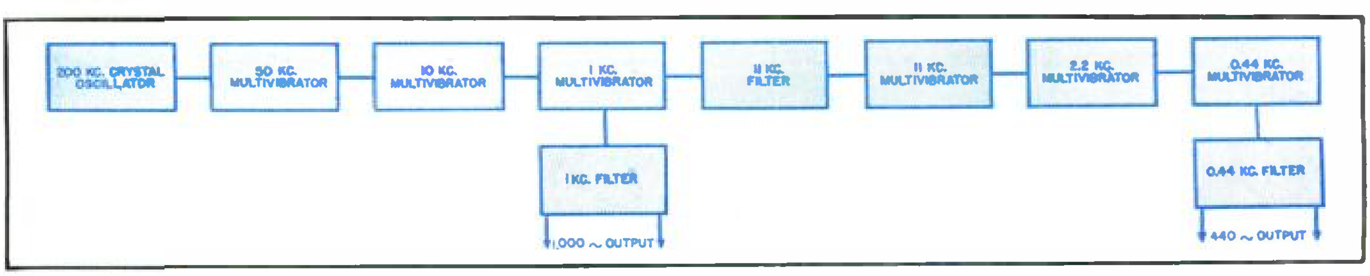
Output voltage delivered by the secondary of T1 is modified by the low-pass filter (L1-C2) and delivered to the output transformer, T2. A single filter section is shown. However, several sections may be combined for greater attenuation of harmonics. The filter is designed for maximum cutoff at the second harmonic of the oscillator frequency. It accordingly will permit the fundamental to pass through to the output circuit with little attenuation; but because of its low-pass characteristic, will effectively block the harmonics. Chart I lists L and C values for common test-oscillator frequencies. The values given are for second-harmonic cutoff in each case, and assumed 500-ohm termination. Ratings are in common units—henries and microfarads.

While the shunt-fed Hartley circuit is indicated in Fig. 9, any other audio-oscillator arrangement might be employed with equal success. For instance, an electron-coupled circuit or resistance-capacitance-tuned arrangement might be used. Likewise, a push-pull version of any common oscillator circuit might be enlisted for increased second-harmonic reduction. Harmonic content in the output voltage of self-excited audio oscillators has been reduced by filtration to such an extent that these instruments are employed frequently in routine distortion checking in broadcast and telephone work.

The principle of degeneration has been utilized very ingeniously for the

(*Continued on page* 70)

Fig. 11. Method of obtaining precise 440 c.p.s. signals, used to modulate standard frequency transmissions from station WWV.



About to take to the air over the Post Broadcasting System at the Army Air Forces Training Command Radio Station, Sioux Falls, S. D.

SIOUX FALLS

By Cpl. PHILIP MINOFF

Unique public address system constructed by the AAFTTC, at Sioux Falls. Programs are also sent via telephone lines for broadcasting over local radio stations.

IT'S a long stone's throw from 50th Street and Sixth Avenue, but the Army Air Forces Training Command Radio School at Sioux Falls, S. D., has a Radio City all its own.

There is nothing about the appearance of the Post Broadcasting System Building to suggest page-boys, Krispie-Krunchie salesmen or soap operas, but the unpretentious structure houses a technical setup that is strictly "big time."

Visitors to the studio are invariably impressed with the layout's professional appearance. Veteran radio people agree it rivals any well-operated commercial studio of equal size.

The Radio School itself trains radio operator-mechanics for jobs in aerial combat crews. The course is a rugged one, calling for intense concentration in the studying of code and radio theory.

Because of the gruelling nature of the work, mental relaxation is of the utmost importance. By bringing programs of news, comedy and drama to students at all hours of the day, the Post Broadcasting System fulfills an unusually worthy function.

The "PBS," as it is known to soldiers, is primarily a huge public address system which has been adapted for distributing programs to KSOO and KELO in Sioux Falls through telephone lines.

To take a look at the technical setup of the system—the control room contains the main console which measures 50 by 90 by 40 inches. In this console are two Stromberg-Carlson pre-amplifiers, two RCA 16-inch transcription turntables with an RCA recording unit which facilitates recording and play-back at 78 revolutions per minute or 33⅓, and a monitor amplifier. There is a recording amplifier with meters to indicate volume level of both recordings and programs going over the air.

Patch cords make it possible to pick programs from either of the two pre-amplifiers, office of the Commanding Officer, Colonel O. L. Rogers, both post theaters, the Service Club, Chapel and sports arena. Then, of course, any program KSOO or KELO, Sioux Falls stations broadcast, including NBC and Blue network shows, may be "piped in" to the studio.

Four steel cabinets house twenty 25-watt Stromberg-Carlson dual channel amplifiers. These feed programs to 36 giant loudspeakers distributed in centralized street locations of each squadron and the radio school area. In addition, each mess hall is equipped with four 12-inch Stromberg-Carlson speakers, so the soldiers may have music while they dine.

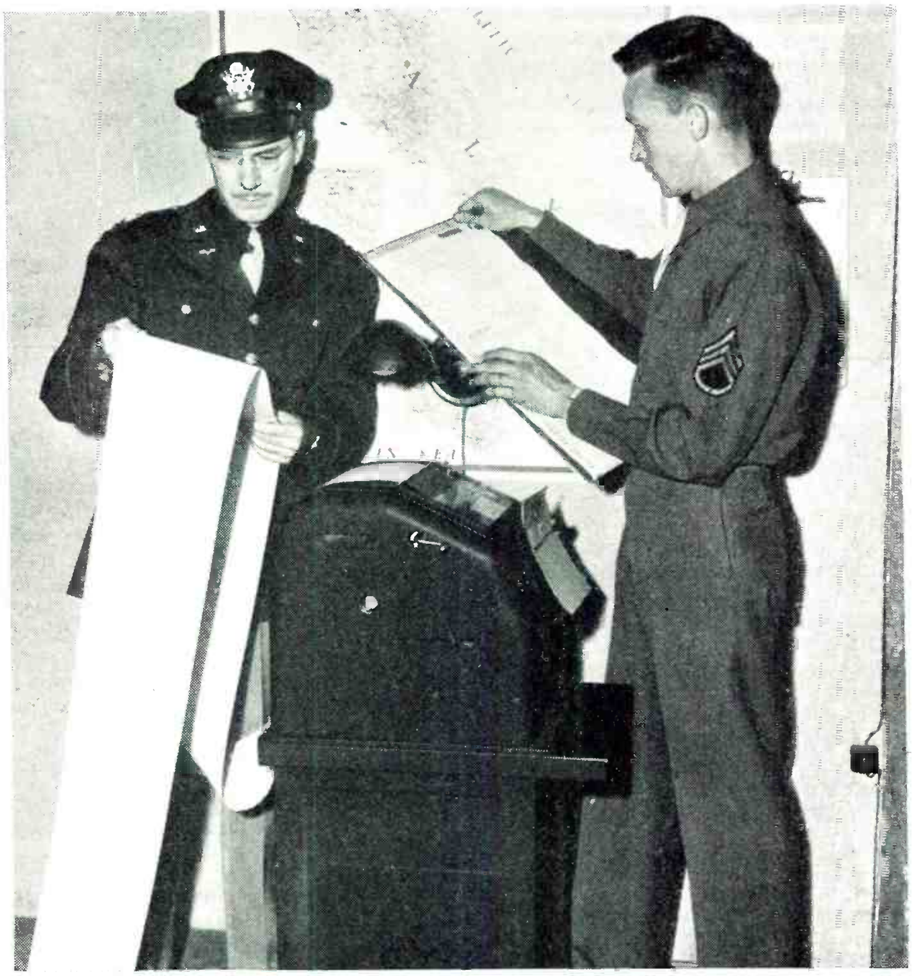
Switch panels facilitate feeding any group of amplifiers to either of three input channels and also feeding any speaker or group of speakers any one of three available programs simultaneously. Each set of speakers may be controlled independently.

The three-program distribution works something like this—just suppose it's late in the evening and time for members of one squadron to leave their class rooms. These students march snappily out of the buildings and back to their squadron with the aid of appropriate military music. At the opposite side of the Post, soldiers with leisure time lounge about their barracks and enjoy Fred Waring's music, while still other GI's spring into action in preparation for chow as the bugle sounds "Mess Call."

The studio consists of the main studio, control room, chief's office and general office. All rooms are thoroughly sound-proofed to eliminate outside noises. The main 20 by 40-foot studio boasts a piano with a solo-vox attachment, music stands for an orchestra, a host of microphones, announcer's table and monitoring speaker.

One of the most appealing aspects of the PBS is its "GI" personality. The system, from start to finish, is a result of the ingenuity and work of soldiers. But the men responsible for the whole thing are hardly tyros in the radio business. Nearly every man connected with the system was engaged in some aspect of the radio industry before entering the Army.

Capt. Myron J. Bennett, youthful, energetic officer-in-charge, has been in the broadcasting field since 1927 and was manager of the Southwest Broadcasting System. At one time he was connected with NBC's Special Events Division. He also taught radio administration at the University of North Dakota. Three years prior to entering the Armed Forces, Capt. Bennett originated and produced the "M. J. B." show, which received the No. 1 Hooper Rating for the most popular locally-produced radio program in St. Louis.



Associated Press teletype furnishes world-wide news for the Post Broadcasting system.

BROADCASTING SYSTEM

Working with Capt. Bennett has been capable Sgt. Edward M. Scribner, of Schoharies, N. Y., who created quite a name for himself 13 years ago by designing the equipment for the nation's first outdoor-talkie theater in Scoharies.

Aided by only two assistants and continually handicapped by long delays in obtaining vital materials, Sgt. Scribner, who designed and installed the system, worked long hours and gave up much of his free time in order that the PBS could be completed as quickly as possible.

Cpl. Roger O. Wolf, non-commissioned officer-in-charge of broadcasting and announcers, was connected

(*Continued on page* 104)

Radio students erecting wire network for PBS.

Designer at control console in main studio.

TECHNICAL BOOK & BULLETIN REVIEW

"ILLUSTRATED TECHNICAL DICTIONARY" edited by Maxim Newmark, published by *The Philosophical Library,* New York. 352 pages. Price $5.00.

In this new book, edited by Mr. Newmark, is a wealth of technical information on many subjects including definitions of current terms in the applied sciences, the graphic and industrial arts as well as those commonly used in the mechanical trades.

The text is profusely illustrated with line drawings of the subjects defined and this illustrative material, coupled with clear and concise definitions, makes this book a valuable addition to the scientific library of any student or engineer.

Mr. Newmark has included in this dictionary an extensive appendix in which he includes standard technical abbreviations, units of weights and measure, temperature interconversion tables, chemical element tables, and geometrical shop data. The inclusion of this material in one text is unusual and obviates the search for this pertinent information when the occasion for its use arises.

"PLASTICS IN THE RADIO INDUSTRY" by E. G. Couzens and W. G. Wearmouth, published by *Electronic Engineering,* London, England. 57 pages. Price 2/6.

An interesting all-over picture of the progress in plastics being made at the present time in Great Britain is presented in this monograph.

While the American scientist is prone to consider the plastic field as a native monopoly, it is surprising to find that vast strides have been made in the utilization of this synthetic in other countries. New methods of heating and curing are described by Mr. Couzens and Dr. Wearmouth as well as the physical and electrical properties of each type of plastic material.

Comprehensive charts and graphs, showing the various characteristics, are presented, enabling the reader to determine at a glance the comparative values of a certain plastic for a given task.

To persons interested in plastics and plastic applications, this book will prove extremely valuable reading material.

"BELOVED SCIENTIST" by David O. Woodbury, published by *McGraw-Hill Book Company,* New York. 351 pages. Price $3.50.

In the pages of this biography, the early days of electricity and electrical development are relived in the life of Elihu Thomson, the Beloved Scientist. A contemporary of Edison and Marconi, Dr. Thomson's associa-

(*Continued on page* 129)

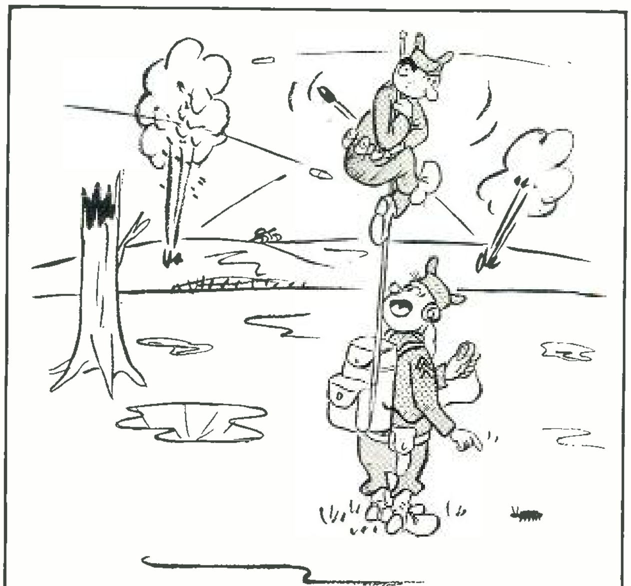
By CARL COLEMAN

THE world has never seen such a high production achievement as has been accomplished by the United States, during the past two and one-half years, in its task of supplying the equipment with which to win the present war. The construction of merchant ships during this period has kept pace with other materials essential in our fight against the Axis, construction being cut successively from months and weeks until finally only a matter of days are required for the construction of a complete vessel. This record performance of production has pulled our chestnuts out of the fire twice during the past thirty years as the United States has been called upon to fight in great wars, both of which have been dependent to a large extent upon marine transportation. Each time, during these two wars, success has been achieved by a nearly super-human effort and with a needless loss of life and unnecessarily high cost to our government. To avoid such cost in men, materials and money in the future the United States must adopt a maritime policy to continue at the end of the present war to remain the world's greatest maritime nation and likewise maintain the strength of the U. S. Navy.

Various indications during the past few months have pointed to our government's thoughts along the above lines and to the fact that the United States is becoming more merchant-marine minded. Late February saw the conclusion of a series of week-long conferences in Washington, at which time the War Shipping Administration made a decision to maintain a twenty-four hour watch by the radio officers aboard American flag ships in order to obtain the greatest possible use of radio communication aboard vessels in the prosecution of the war. Vice President Harry A. Morgan, of the American Communication Association, inquiring of Captain Edward Macauley, WSA Deputy Administrator, as to the actual date when the new policy will be placed in effect, was told: "As soon as practical operations will permit, which you may take to mean immediately." Under the understanding reached between union officials and the War Shipping Administration officials, the Division of Maritime Labor Relations will set an interim wage scale, to apply to the three commercial radio operators to be carried on each ship, subject to final negotiations with the steamship companies.

SAM ROSENBERG and L. Clark have taken out Liberty assignments from the East Coast. O. Haffer had a short stay ashore recently while his ship underwent a minor overhauling. K. Allstad went out on a new tanker assignment. D. Philip and A. Radcliff are both out on new freighters. F. Gaffney is now aboard a nice C-2 vessel. Harry Morgan of ACA in New York sends along a good bit of news, for which we express many thanks, and advises that an old friend of his, Frank A. Barnard, located him recently through a recent item in QTC. Frank is now with American Airlines as a flight radio officer

(*Cont'd on page* 84)



"Come down here, what would the captain say if he knew you were afraid of a little caterpillar?"

G.I. Radio Servicing

By WALTER FERNALD

Aviation Eng., USAAF

The problems of a G.I. radio technician in servicing radio receivers, using available parts.

WHAT really prompted the author to write this article was the fact that many radio technicians throughout the country persist in telling their customers that they (the radio technicians) cannot repair the customer's set due to lack of parts and tubes.

The author having once been a radio-technician himself, has the peculiar habit of most radiomen, that of visiting radio shops in his immediate locality and talking a little shop with the man behind the bench. This peculiar habit, when practiced now and then, tends to offset that so-called homesickness for the old trade and perks up the morale no end.

On several visits to neighboring radio shops, their stock in trade was carefully looked over. Just a quick glance here and there around the parts shelves was evidence enough to convince the author that a large percentage of the home front could be assured of some sort of radio reception even though it be only of the local variety.

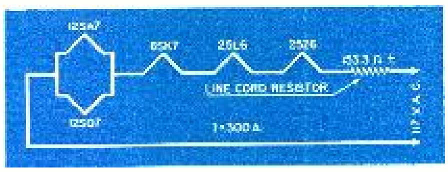
True, there was no over-abundance of tubes or parts in sight, yet the amount and types available seemed sufficient to keep the shop going for quite awhile, not taking into consideration all the junk sets available for spare parts. Putting two and two together the author finally decided to give the readers of *Radio News,* and especially the radio technicians, an insight on what we in the Army have to contend with while trying to effect repairs on our own personal sets (not G.I.).

Citing himself as an example, the author, a radio operator in the Army and a former radio technician in civilian life, is preyed upon daily for advice and assistance concerning the small matter of a radio that will not play or one that makes funny noises and still another that plays now and then. Wanting to help the boys, and keep up the morale, the answer to their queries is usually "sure I'll take a look at it and see what I can do, just bring it around when you get a chance."

The term "see what I can do" usually winds up into a nasty repair job. There is the case of a hard-bitten 1st Sgt. at the reception center. The author opened his mouth once too often and wound up behind the proverbial "eight ball"; a repair job on a 30-watt P.A. system that the 1st Sgt. used to a great advantage by scaring the daylights out of all the rookies with his gruff and extremely loud voice.

After a quick check on the amplifier, using the old standby, the finger method, the trouble was finally traced to the output stage. Nothing serious, just a burnt-out secondary on the output transformer and a quick replacement job if taken to a radio shop. If, what a big word. If some dumb sergeant had not plugged the voice coil line into the 110 v. a.c. wall socket, thus causing the burnout, the author would have been doing KP that day.

With the tools available, a 2" screw driver, a pair of kleins, a 300-watt soldering iron and a piece of solder about 3" long plus a roll of No. 20 enameled wire snatched from the local signal unit, the author set to work. The transformer underwent a dismantling operation and the burnt-out secondary



Replacement filament circuit for faulty 12SK7, 35Z5, and 50L6 tubes.

was removed. A new secondary was wound on the remaining core and the necessary taps were brought out on the proper side of the core and tagged accordingly.

After a great deal of cussing and a few dented fingers the laminations were restored to their original resting place, the transformer remounted in the amplifier and the necessary connections made. A flip of the power switch and lo and behold, once more the gruff voice of the 1st Sgt. echoed throughout the area. The system sounded good and the author's KP and guard duty days were over at the reception center; that is for about a week anyway.

During that week, at least a dozen more sets were repaired and with the same tools as previously mentioned, plus a considerable amount of ingenuity.

"Go west young man" seemed to be the theme song at reception center and after a two-day train ride through the arid wastes of lower New Mexico and Arizona your author was dropped right into the lap of sunny California, sunny is the correct word, too.

Basic training was the order of the day and no time was wasted in getting started either. Basic training utilizes all 24 hours of one's time per day and that famous saying "on your free time" is the bunk.

Thoughts of radio were defintely dismissed from one's mind because it took all of the space available up there to cram in the subjects taught during basic training.

Graduation day found the author in fine condition and, with a 36-hour pass in one hand and not much money in the other, the town of Los Angeles was given a quick 30-hour inspection. 36 hours is not much time so all of it was well spent.

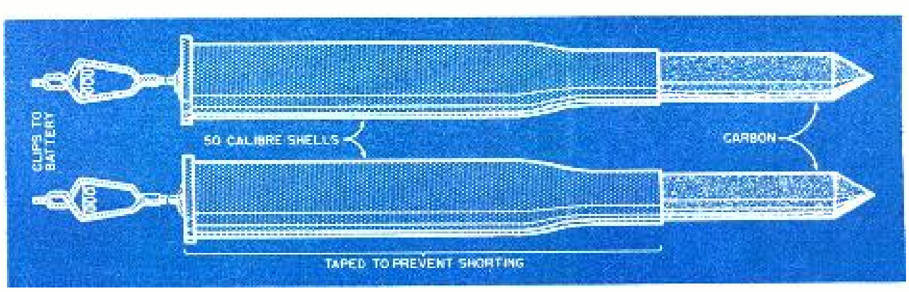
The holiday over (which incidentally included visits to quite a few jobbers and a lot of window shopping and wishing) this serious business of war had to be attended to so everyone in the outfit settled down to the daily routine of being a soldier.

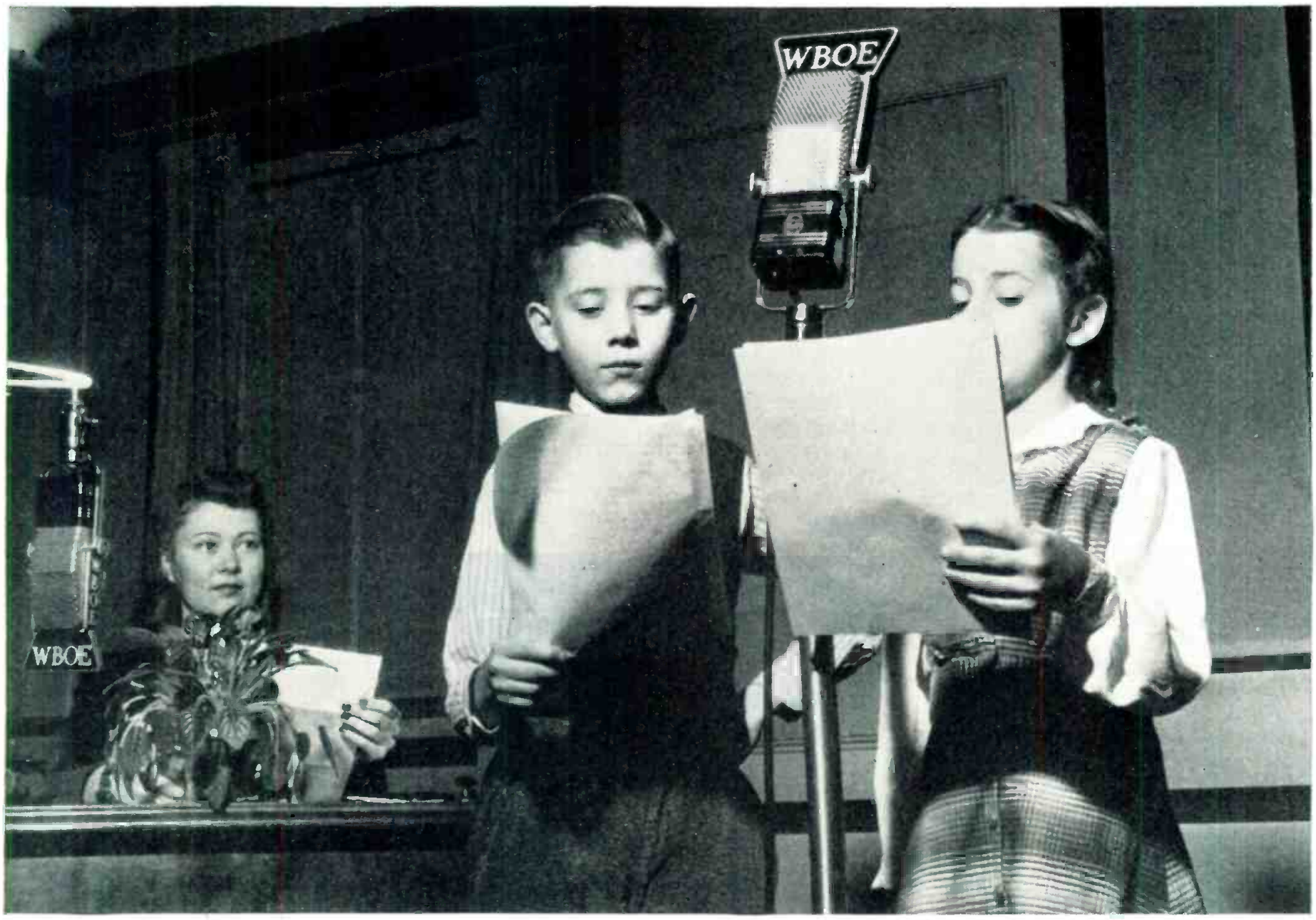
During the author's stay of over five months in California, quite a few sets were put back in playing condition. Some of the jobs involved a bit of redesigning of the set undergoing repairs and such items as bad capacitors and noisy volume controls were easy. Enough capacitors were salvaged from a discarded set and utilized no end. Noisy volume controls were given a shot of good old lead pencil plus a little vaseline and they performed as well as ever.

Many a burnt-out antenna coil was rewound, not to mention the open i-f coils and shorted transformers that popped up every now and then. A lot of the sets had been subjected to the so-called screw driver maniacs who delight in turning those little screws mounted in the i-f, r-f, and oscillator trimmers until the threads were very nearly stripped. Try lining up the i.f.'s on a superhet sometime without benefit of a signal gen-

(*Continued on page* 78)

Substitute soldering iron made up of two carbon electrodes mounted in 50-caliber shells.





Grade school pupils participate in one of the regularly scheduled FM broadcasts sponsored by the Board of Education.

EDUCATIONAL FM BROADCASTS

By RAYMOND NATHAN

Frequency allocation problems for postwar educational broadcasts, including operating and constructional costs.

Safety programs may be carried to all classrooms simultaneously by FM radio.

TRIPLING of the FM channels allocated for use by educational institutions has been asked of the FCC by John W. Studebaker, U. S. Commissioner of Education.

His request reflects the determination among advocates of educational radio to hold their own in the reshuffle of frequency assignments which FCC Chairman Fly declares is inevitable after the war.

Probable attitude of the FCC toward Studebaker's request was foreshadowed in a recent talk by Fly. He told educators that "if their plans are ready and they can show both the real use to which educational frequencies are being put and the proposed use for which plans have been fully laid, the necessary frequencies will no doubt remain available."

Fly warned, however, that "if lethargy prevails, and others seeking to expand their own services are able to show that the channels reserved for educational stations are going to waste, then it will be difficult or impossible to continue the reservation of unused frequencies."

Acting on Fly's warning, leaders in the educational radio field are earnestly trying to interest school authorities in making postwar plans now, and they are having considerable success.

Eleven states have asked the U. S. Office of Education to help them prepare state-wide FM broadcasting plans. Newark has applied to the

Students in the lower grades participate in "quiz" programs which stimulate interest in classroom subjects.

FCC for a channel. Atlanta has approved funds for FM broadcasting by the schools.

School interest in FM radio broadcasting was growing before the war halted production of receivers and other equipment. Five educational licenses were issued: Cleveland, New York, Chicago, San Francisco, and the University of Illinois. Of these, Cleveland and Chicago have gone farthest in actual broadcasting. New York and San Francisco are just getting started, and Illinois is using its station for training purposes.

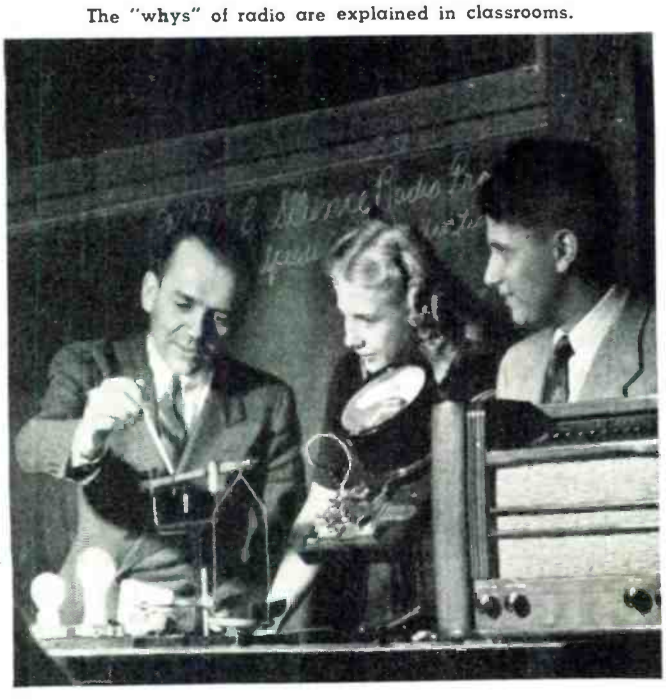
A total of five is not as small as it sounds, since only 45 commercial FM stations actually came into operation. Educators believe that the speed and efficiency achieved by wartime training programs through use of films, recordings, and other novel devices will stimulate the schools to wider use of radio, and they see FM as ideal for the purpose.

Says James F. Macandrew, radio

(*Continued on page* 112)

Older students receive valuable radio experience.

The "whys" of radio are explained in classrooms.



THEORY AND APPLICATION OF U.H.F.

By MILTON S. KIVER

Part 5. Basic theory and applications of transmission lines operating at the ultra-high frequencies.

IN THE last article the conventional theory of transmission lines at the broadcast frequencies was discussed. It was seen that when the transmission line is loaded with an impedance equal in value to the characteristic impedance, all the power sent down the line was absorbed and maximum power transfer was accomplished. This is very desirable, for example, in feeding energy from a transmitter to an antenna located some distance away. The transmission line that is the connecting link between the two is carefully designed so that all input and output impedances are matched as nearly as possible.

There are very many cases, however, where it is not desirable to terminate a transmission line in its characteristic impedance, but rather to go to the extreme conditions of placing a direct short on the end of the line or else leaving it entirely open. The line is then mismatched and it is these conditions that will be considered to see why they are important. In order to simplify the discussion and at the same time take the conditions usually encountered in practice, only transmission lines that are ¼ and ½ wave lengths long will be discussed.

It will be recalled that the voltage and current values along a matched transmission line vary smoothly from one end of this line to the other. To determine the voltage and current distribution for a mismatched condition, let there be connected an alternating-current generator to one end of a quarter wave line and let the other end be left open or what is equivalent, terminated in an infinite impedance. Any signal sent out from the generator will hit this open end and bounce back, so to speak, just as a sound wave hitting a stone wall is sent back or reflected. This reflected wave will travel away from the open end of the line and cause interference with the waves coming from the generator. The result is a standing wave which will have values that vary from point to point, all zero values being called nodes and all maximum points being referred to as loops. Quite logically, the current at the open end of the line will be zero since here the line is open and no current can pass from one line to the other. The standing waves of current and voltage are due to the combined effect of the wave going toward the open end and the wave which is reflected back. Where they cancel each other are the nodal points and where they reinforce each other the result is a maximum or loop. In between, the reinforcement or cancellation is only partial and so intermediate values are obtained. Fig. 1 is an illustration of the relative phase of the reflected and incident waves. Here, both are shown separately, but any meter used to measure the value of current or voltage on the line will read the resultant of these two. And since it is the resultant that is important, only this one shall be used hereafter on all diagrams depicting standing waves on transmission lines.

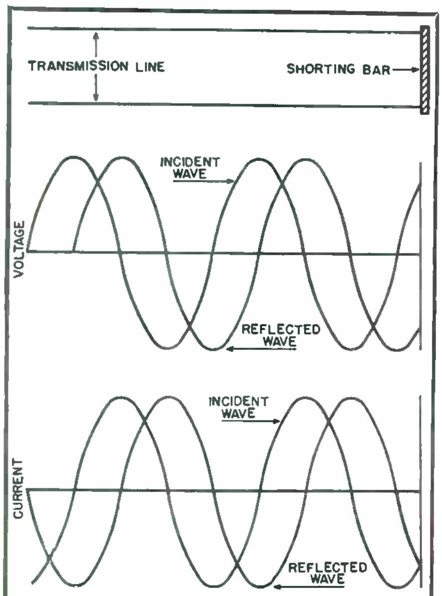


Fig. 1. The incident and reflected waves on a short-circuited transmission line.

Now, whereas the current is zero at the end, the voltage here is a maximum, a result of the voltage drop across the infinite impedance. The voltage distribution will also vary in a sinusoidal manner, but the voltage maxima will always occur when the current is zero and, hence, the waves as depicted pictorially will be displaced, as shown in Fig. 2. Using the ratio of voltage to current for the impedance, which is Ohm's law, it is possible to determine this impedance at any point along the transmission line. At the current nodal points the value of the impedance will be very high since

$$\frac{\text{large voltage}}{\text{small current}} = \text{large impedance.}$$

At the current maxima points the opposite situation will occur and the impedance will be low. In general, then, the value of the impedance along the line will tend to vary as the voltage, being high when the voltage is maximum and low when the voltage is a minimum.

It should be emphasized again that the only time standing waves will occur on a line will be for a mismatch between terminating impedance and line impedance. It is only under this condition that any energy will be reflected, since with a perfect match all the energy would be absorbed as soon as it reached the load. Incidentally, it might be mentioned at this

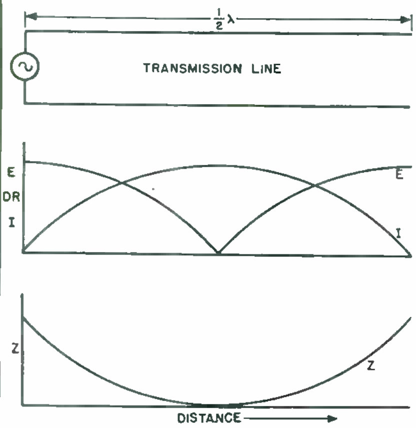


Fig. 2. Relative values of voltage, current, and impedance on a half-wave, open-ended transmission line.

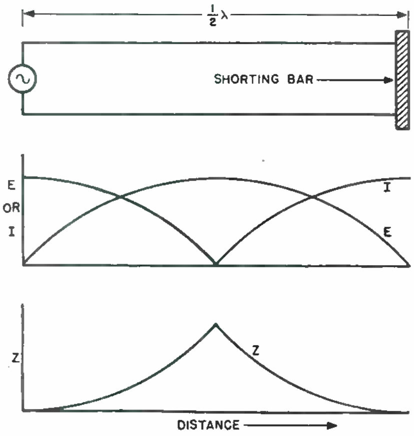


Fig. 3. Relative values of voltage, current, and impedance on a half-wave, short-circuited transmission line.

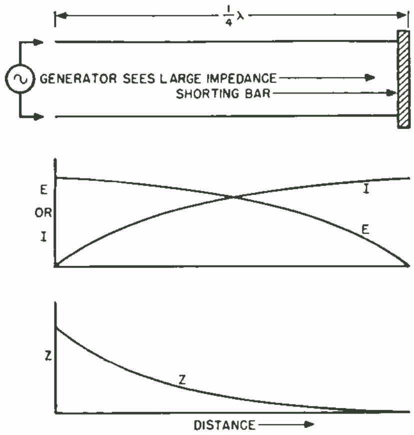


Fig. 4. Relative values of voltage, current, and impedance on a quarter-wave, short-circuited transmission line.

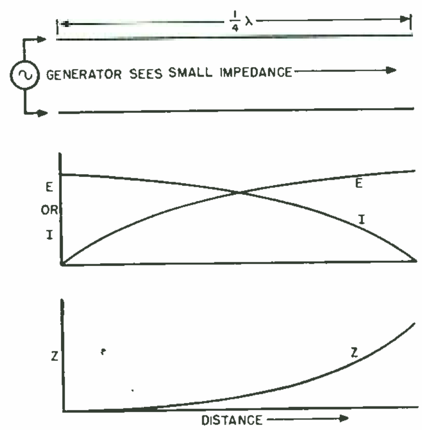


Fig. 5. Relative values of voltage, current, and impedance on a quarter-wave, open-ended transmission line.

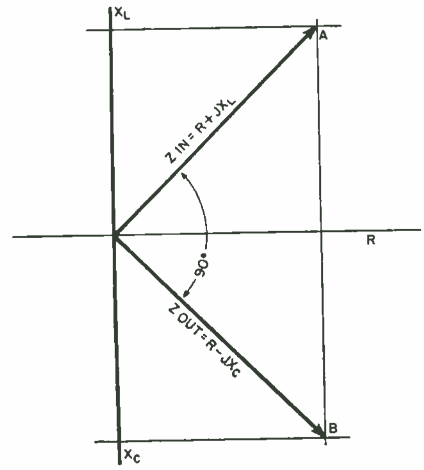


Fig. 6. Illustrating graphically that a quarter-wave transmission line automatically introduces a 90° phase shift.

time that when amateurs wish to determine the amount of mismatch on lines they want to match up perfectly, they use the ratio of maximum to minimum voltage as found on the line. Suppose this ratio turns out to be 6 to 1. This means that the voltage as measured at the voltage maximum points is six times greater than the minimum voltage measured at the nodal points. The minimum voltage, theoretically, should be zero but actually it is some small value. This ratio then will indicate that the load impedance is either six times larger or one-sixth as large as the line impedance. To determine which of the above holds, it is necessary to measure the voltage across the load, a maximum voltage indicating the load is six times greater than the line impedance and a minimum indicating that the load impedance is too low. This generalization becomes more inaccurate as the reactive component of the load becomes larger.

If instead of having the end of the short transmission line open, it is now short-circuited, the voltage and current standing waves formed along the line will be much different than the previous open case and similarly the impedance at various points will be changed. Fig. 3 shows the relationships in detail and by comparing the Figs. 2 and 3 these differences will be immediately discernible.

Now that the general differences between an open-ended and a short-circuited line have been noted, it is time to bring out the practical applications that are derived from these two conditions. To use a transmission line as a resonant circuit, use is made of the standing waves to produce, at the input, either a high impedance or a low impedance depending upon whether a parallel or a series resonant effect is desired. To show this graphically, start with Fig. 4 where a quarter wave section has been shorted at one end. By drawing the voltage and current distribution along the line and from them the impedance values, it can be seen that when one end is shorted, the input will present a high resistive impedance to anything connected to it. The reason the impedance is resistive is due to the fact that the line is tuned and the quarter wave line is now equivalent to a parallel tuned circuit. And as is true with ordinary coil and condenser resonant circuits, this high value is obtained at only one frequency, the high impedance falling off on either side of the resonant frequency.

For the open-ended quarter wave line, the conditions depicted in Fig. 5 are obtained. Now it is seen that with the far end open, the input end of the line will appear as a very small impedance and since this quarter wave line is adjusted for one frequency, its impedance will be resistive in nature just as a series tuned circuit. From the preceding explanation, it can be seen that the quarter wave transmission line makes a load appear opposite to what it is—as for example, short-circuiting the load end will make the input end show a high impedance. This is called load inversion or impedance transformation and is one of the most important properties of these quarter wave lines.

For a very practical example, refer back to part one of this series and locate the high-frequency oscillators that used quarter wave Lecher wire systems for tuning purposes. A Lecher wire system is nothing more than a two wire transmission line and its action is explained by the above discussion. Naturally as the frequency is changed, the length of the Lecher wire tuning system would have to be altered since a quarter wave line length at one frequency is different from the length at some other frequency. For 5 meters the length would be five divided by four while for 1 meter it would be one divided by four. In practice the actual length is not changed by cutting off any excess wire but rather by moving the short back and forth until the resonant point is found.

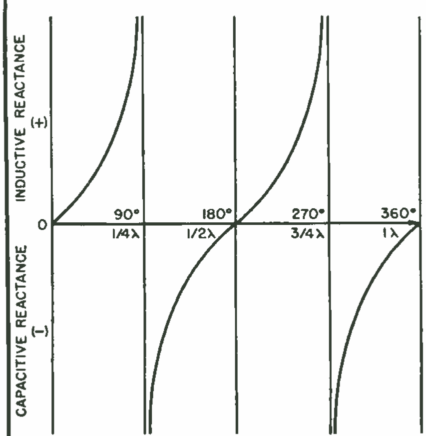


Fig. 7. Input impedance of a short-circuited transmission line at various points along the line.

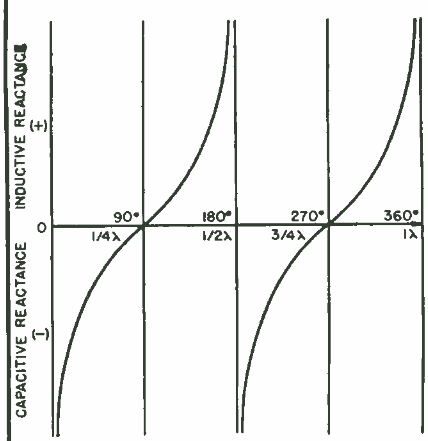


Fig. 8. Input impedance of an open-ended transmission line at various points along the line.

A second property of a quarter wave line involves its use in circuits where a 90° phase shift is desired such as the Doherty modulating system. To start off, it can be shown that if Z_{in} is the impedance looking into a quarter wave line and Z_{out} is the impedance connected across the opposite ends of

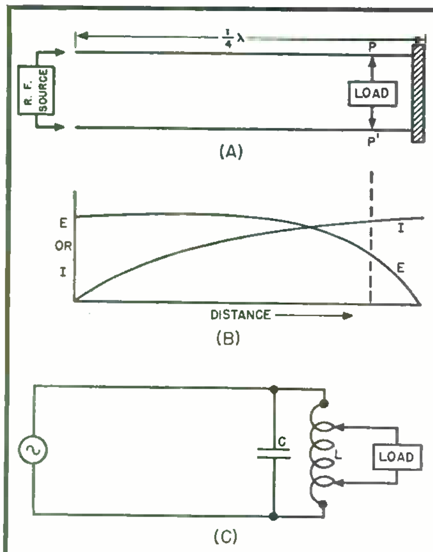


Fig. 9. Voltage stepdown from a quarter-wave transmission line. (A) Load connection. (B) Voltage and current relationship. (C) Equivalent circuit at the low frequencies.

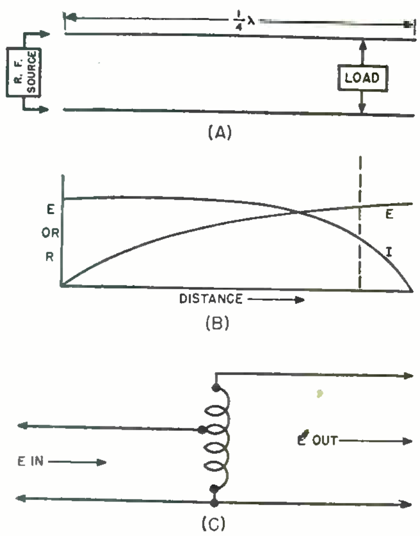


Fig. 10. Voltage stepup from a quarter-wave transmission line. (A) Load connection. (B) Voltage and current relationship. (C) Equivalent circuit at the low frequencies.

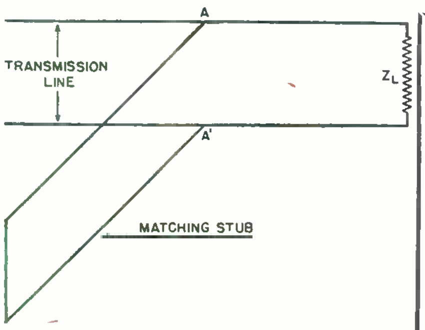


Fig. 11. Use of matching stub to neutralize the reactance of load Z_L.

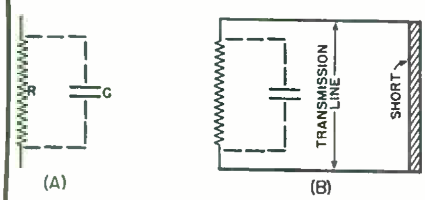


Fig. 12. Method of neutralizing capacitive reactance of a resistor at U.H.F.

the line, then these two quantities are connected by the formula

$$Z_{in} = \frac{Z_k^2}{Z_{out}}$$

where Z_k is the characteristic impedance of the line and is, of course, a constant. Since in the ultra-high frequency case Z_k is usually a resistance, what the above formula means is that Z_{in} times Z_{out} must result in a resistance and this can only be true if the two impedances are conjugates of each other. By conjugates is meant that if Z_{in} is $R + jX_l$ (a resistance plus an inductance) then Z_{out} will have to be $R - jX_c$ (a resistance plus a capacitance). These two quantities multiplied together will give a pure resistance. Another way of saying the same as above is to state that the quarter wave line produces a 90° phase shift. To understand this refer to Fig. 6. Line A will represent the vector quantity $R + jX_l$. This will be Z_{in}. Line B will represent $R - jX_c$ and will be Z_{out}. The angle between these two lines is 90° (as shown). Hence, if a network is needed that will produce a 90° phase shift, a quarter wave line will do nicely. Thus, quarter wave lines not only change the magnitude of an impedance, they also change the character of the impedance.

Another use to which the above inverting property can be put involves the very practical application encountered by amateurs when they want to match a 600 ohm line from the transmitter output to a 72 ohm dipole antenna. Using the above formula and substituting for Z_{in} 600 ohms and 72 ohms for Z_{out}, the following result is obtained:

$$600 = \frac{Z_k^2}{72}$$

$$Z_k = \sqrt{600 \times 72}$$

or

$$Z_k = 208 \text{ ohms.}$$

Thus it is necessary to get a line whose characteristic impedance is 208 ohms and when placed between the 600 and 72 ohm impedances, this line will effect a match.

Hence, to summarize the three important properties of a quarter wave line—

1. The line can act as a resonant circuit, either series or parallel tuned.
2. Due to its inverting properties, there is obtained a 90° phase shift.
3. Also due to its property of inversion it can match two impedances that differ widely in value.

The next step in the development is concerned with the half wave transmission line, its properties and uses and wherein it differs from the quarter wave line just mentioned. No trouble should be encountered if the half wave transmission line is simply regarded as two quarter wave lines joined together. Since it was found in the above discussion that one quarter wave line inverts the load, two joined together will only bring it back to its original form by another inversion. By referring back to Fig. 2, it can be seen that the same conditions prevail at both ends of the line, thus demonstrating what has been stated above. A half wave line short circuited at one end will appear as a very low impedance at the other end and likewise if the one end is left open, the other end will appear as a high impedance. Thus, there is a one to one impedance transformer action here and such a unit finds practical application in circuits where it is necessary to isolate the radio frequencies from the power supply but still allow passage of direct current. For a specific example, refer to Chapter One where the high frequency currents in the filament circuit are kept from the filament power supply by means of these half wave lines. The isolating effect is obtained with a short-circuited half wave line. In this way the point where the direct current enters the high frequency system from the power supply acts as a short-circuit only for the ultra-highs and they can be considered as being by-passed just as with by-pass condensers.

Up to this point the entire emphasis has been on either quarter wave or half wave lengths of transmission lines. The next possible question that might be posed would inquire as to the effects obtained when lengths of line between a quarter wave and a half wave length are used, or even lengths less than a quarter wave. In order to tie these in with the material that has been presented, it would probably be best to delve a bit into the mathematical equations connected with transmission lines. It is quite logical that the input impedance of a transmission line will vary as the length of the line is changed since by this process more or less resistances, inductances and capacitances are brought into the circuit. Of interest is the equation that expresses the relationship between the input impedance Z_{in} and the length of line used. For a short-circuited line the relationship turns out to be

$$Z_{in} = Z_k \tan \theta.$$

where Z_k is, as usual, the characteristic impedance of the line and as mentioned previously is a constant. The angle θ requires a little more explanation since it might not, at first, be obvious that the length of a transmission line may be measured either in feet or in degrees, the two being equivalent. To show this, consider a line that is 2 feet and at a certain frequency has one complete standing wave on it. A complete wave has

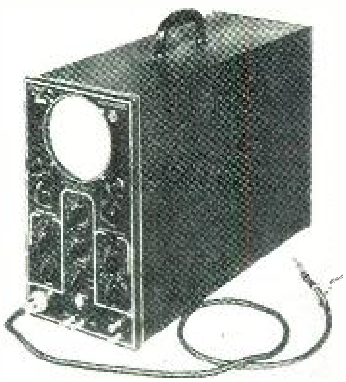
(*Continued on page* 106)

WHAT'S NEW IN RADIO

New products for military and civilian use.

CR OSCILLOSCOPE

A new 5" oscilloscope which is particularly adaptable to the study and measurement of intermediate frequency phenomena, such as wave forms and transients up to 1 mega-



cycle, is now being manufactured by the *Reiner Electronics Company*.

This particular unit, known as the Model 550-A reproduces square wave signals from 40 cycles per second to 50 kc. per second and the vertical amplifier has a sine wave frequency response of 500 kc. per second, plus or minus 1 db.

The oscilloscope is equipped with a detachable coaxial cable with an input capacity of 8 μμfd. This low capacity minimizes detuning or excessive loading of the circuit under test. A special compensated 4 step attenuator permits observation of voltages up to 175 volts, with a variable gain control on the second stage providing continuous variation of gain which change in the frequency characteristic.

For information regarding this oscilloscope and other test equipment, write the *Reiner Electronics Co.*, 152 West 25th Street, New York, 1, New York.

COMBINATION RECORDER

A new and complete portable combination recorder, radio and public address system has been announced by the *Radiotone Division* of *The Robinson Houchin Optical Company*.

This unit is designed primarily for installation in war plants where such combined facilities are necessary to carry music, announcements and alarms to all parts of the factory and office. Radiotone may also be used as a paging system within the plant.

This unit may be so connected as to record conferences, correspondence and other verbal instructions or material of which a permanent record must be kept. One of the features contributing to the performance of Radiotone is its Duo-chromatic Equalizer which permits the focussing of any program, voice or music to any quality and fidelity of tone desired.

The Radiotone requires no special studio facilities and the unit may be operated by inexperienced personnel.

A catalog No. P-120 describing this equipment is available upon request to *Radiotone Division* of *The Robinson Houchin Optical Company*, 79 Thurman Avenue, Cleveland, 6, Ohio.

FLUXED SOLDER

A new type of fluxed wire solder, which contains flux in longitudinal grooves on the surface rather than in the conventional core, has just been placed on the market.

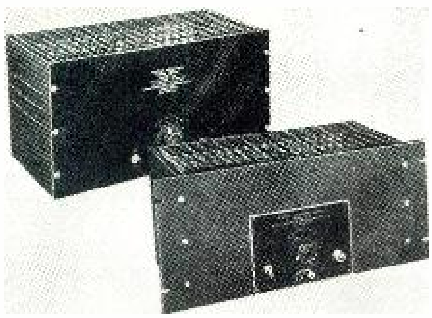
This design overcomes completely an inherent disadvantage of regular cored solders which supply flux and solder to the surface simultaneously. Since in this new product, "Fluxrite," the flux is on the outside of the solder, it liquefies and flows through the work before the solder melts. This insures a thorough and complete fluxing and results in stronger solder joints.

The new product comes in the same diameters as regular cored solder. It is available in two compositions from *National Lead Company*, Room 1815, 111 Broadway, New York, 6, N. Y.

POWER SUPPLIES

Two new power supplies with an unusually low noise level, known as the 1100 and 1110 models, are two items in a new line by *Communications Measurements Laboratory*.

The models are identical in operation and differ only in the construction. The Model 1100 is a table model for laboratory use while the 1110 is designed for rack mounting. A high-gain two stage control circuit is used to insure low noise level and secure better regulation. The high-voltage output can be shifted through a range

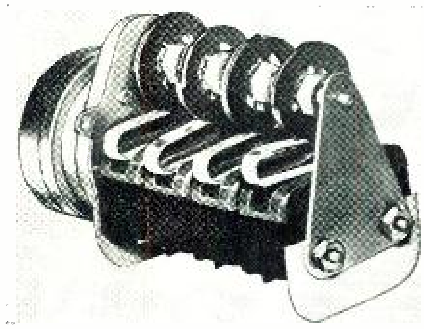


of 225 to 325 volts by means of a potentiometer control. The maximum current drain is 200 milliamperes from 225 to 300 volts and 180 milliamperes from 300 to 325 volts. Under these conditions the sum of all a-c components present in the output is less than 5 millivolts. The primary of the power transformer is tapped for use at 105, 115 and 125 volts on a 50-60 cycle source. An unregulated heater supply winding of 6.3 volts at 5 amperes is furnished.

A bulletin giving complete details of this series is available from *Communications Measurements Laboratory*, 116 Greenwich Street, New York, New York.

HAYDON TIMERS

A new line of continuous running repeat-cycle type timers for either a-c or d-c operation has been an-



nounced by the *Haydon Manufacturing Company*.

The timers are available with from one through eight switches as required. These units may be used to advantage where control of unattended equipment is desirable. The timing cycles may be adjusted to the speed desired including ranges from 8 or more RPM to one cycle per month. In certain instances, where a longer time lapse is desired, the mechanism may be adjusted for one cycle per six months.

The unit is available on various commercial a-c voltages and frequencies as well as for d-c applications.

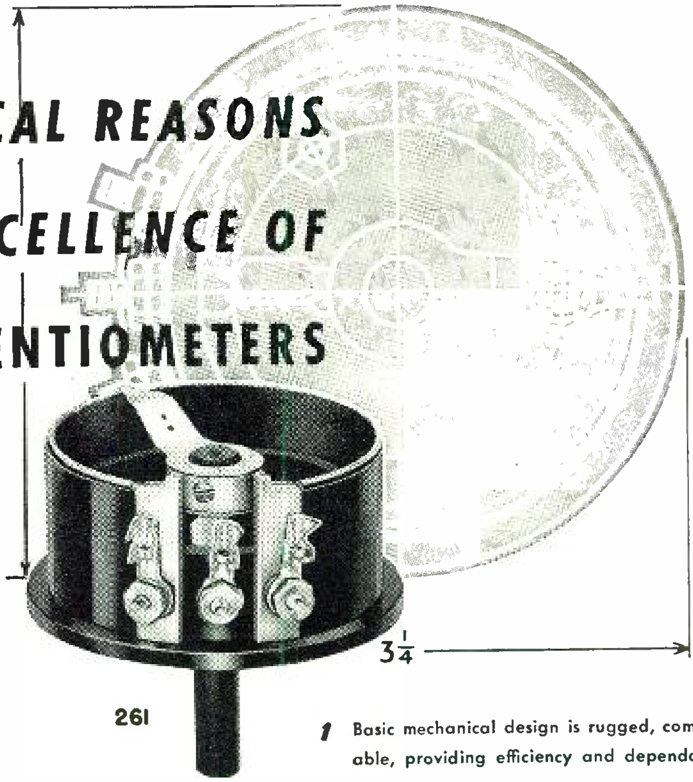
The line of timers is described in catalog No. 112 which is available on request from *Haydon Manufacturing Company*, Box 52, Forestville, Conn.

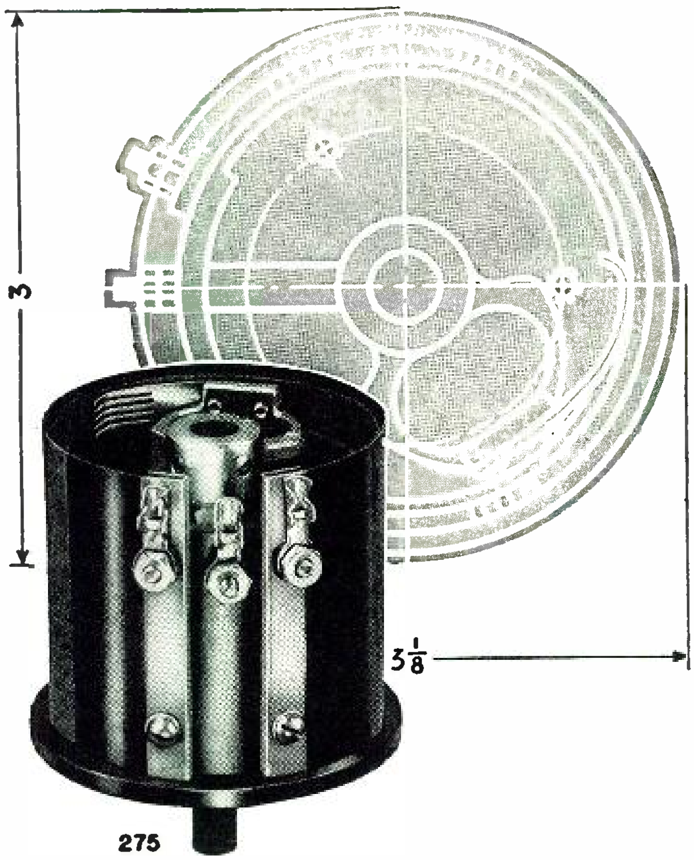
WELDING ELECTRODE

An offset spot welding electrode which can be cooled at the tips has been announced by the manufacturer, *Frostrode Products*.

Of particular value in the fabrication of aircraft sub-assemblies, this electrode is useful in welding "hard-to-reach" positions such as welds adjacent to flanges. The cooling liquid enters the offset electrode below the

9 MORE LOGICAL REASONS FOR THE EXCELLENCE OF DeJUR POTENTIOMETERS





1 Basic mechanical design is rugged, compact and easily adaptable, providing efficiency and dependability.

2 Difficult applications in *power* and *high frequency* circuits are met with ease. Resistance winding elements are permanently close, smooth, and free from shorted out or irregular turns.

3 Excellent control as variable resistors in filament and plate supply control units, and in tube voltage and circuit elements.

4 Resistance element for *heavy duty* and *heavy watt* designs are specially wound to set up better radiation conditions in the component elements.

5 A close tolerance held on full resistance value for regular production units.

6 Controlled resistance wire quality from ingot to final drawing of wire sizes; resistance element is externally protected against damage.

7 Internal multiple fingers contact arm design, and reduces extraneous noises; assures a smooth operating rotation.

8 Terminal and mounting holes easily re-located for special applications; terminals are heavily tinned for adaptability in subsequent circuit hook-up.

9 Electrical power ratings and the mechanical characteristics are in accordance with National Electrical Manufacturers' Association standards.

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NEW YORK PLANT: 99 Hudson Street, New York 13, N.Y. • **CANADIAN SALES OFFICE:** 560 King Street West, Toronto knee and flows through the coolant guide into the finned and replaceable "Frostcap" which forms the electrode's tip.

The function of the coolant guide is to direct the coolant to the tip of the electrode. A controlled flow of the cooling medium is circulated through the finned cap and then back through the flutes which have been machined into the outer diameter of the coolant guide.

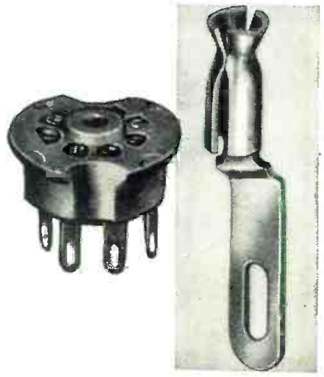
The offset electrode is adaptable to any standard electrode holder and is available with either a ⅝", ¾" or ⅞" O.D. replaceable "Frostcap."

Detailed information may be obtained from *Frostrode Products,* 19002 John R Street, Detroit, 3, Michigan.

MINIATURE SOCKET

A miniature tube socket, designed and developed at the Signal Corps Laboratories is now being manufactured by *Hugh H. Eby, Inc.*

The socket, which was designed to



give long service life under rigorous conditions, meets the required specifications and withstands the humidity cycle, immersion shock, vibration and thermal shock tests.

The socket includes an especially designed beryllium copper contact which is silver plated. This contact is said to give higher electrical conductivity and low contact resistance between the socket and the tube pin.

This socket is available in two types, the low loss type with Navy grade G steatite casting tested in accordance with ASTM D 150-42T standards, and the general purpose type with mica filled plastic casting, tested by the same standard.

Samples and prices will be sent upon request to *Hugh H. Eby, Inc.,* 18 West Chelten Avenue, Philadelphia, 44, Pa.

IGNITION CABLE

A new high-tension ignition cable, tested in accordance with Army Air Forces specifications for use on air-

craft engine ignition systems, has been announced by *General Electric.*

This sheath-type cable is made of a new synthetic, Neoprene, and has high

(*Continued on page* 110)

SPRAGUE TRADING POST

A FREE Buy-Exchange-Sell Service for Radio Men

Important Notice!

We discourage offers to buy or sell anything beyond the O.P.A. ceiling prices, and will not knowingly accept such ads for the Sprague Trading Post.

OHMMETER WANTED—Any kind, new or used. Have tubes to swap for it. Ted Schoblocher, 2987 Salmon St., Philadelphia, Pa.

WANTED — Good late model voltohmmeter, also a tube tester or combination. Stanley Klucznik, Conrath, Wisc.

WANTED — Hickok oscillograph RF05; signal generator #188X; AC-DC multitester #202; Sprague de luxe Telohmike; RCA-Rider Chanalyst 162C; Supreme tube tester 589P; complete set Rider's manuals. H. J. Swanson, Box 207, Red Lodge, Montana.

TUBES FOR SALE — Or will trade for condenser analyzer: 2-31; 1-6A4; 1-6A6; 3-2A7; 3-32; 10-6L6; 9-6H6; 4-6Q7; 12-6J5; 2-49; 1-55; 1-53; 2-56; 2-485; 1-483; 6-31; 2-38; 2-6SA7; 3-6B8; 3-01A; 2-1F6; 1-2B7; 2-6A6; 3-12Z3; 2-6F7; 1-1E7; 1-1A4; 2-1A6; 3-6Q7. What have you? Radio Elec. Appliance Co., 111 E. Main St., Lancaster, Ohio.

FOR SALE—Two 954 and two 956 acorn tubes. Frank Dane, 3852 Eagle St., San Diego 3, Calif.

CLOSING OUT my business. Have many tubes to sell, but will sell entire stock only. 1R5; 1A5GT; 1A7GT; 1LH4; 6R7; 1H5GT; 1N5GT; and hundreds of others. M. Thurman, 897 Bryant Ave., Bronx, New York, N. Y.

WANTED—Refrigerator repair equipment, tools, gauges, cylinders, etc. Emerick J. Sepic, 2510 Harrison Ave., Eureka, Calif.

FOR SALE—Clough-Brengle oscilloscope model CRA and frequency modulator #111 in good condition. Also Bogen DX70 binaural control P.A. system with mike & speakers. Ralph A. Lebo, R #2, Jonestown, Pa.

TUBES WANTED—Want ten or more each: 12SA7; 12SK7; 12SQ7; 35 or 50L6; 1A7; 1A5; 35Z5; 25Z5; 25L6. Cash. Al Robertson, 2328 So. Robinson St., Oklahoma City, Okla.

WANTED—Used low-reading d-c voltmeter (0-3 or 0-5). Cash. Describe fully. Richard Cernigliaro, 585 Washington St., Brighton, Mass.

WANTED—A 100 to 200 microamp. meter and a 955 tube for a V-T-V-M. Ethan Wright, Box 393, Ignacio, Colo.

URGENTLY NEEDED — A good V-O-M and tube tester. Cash. Describe. E. C. Webber, 1408 Stewart Ave. S.E., Roanoke, Va.

FOR SALE — 600-w R-F amplifier with power supply & modulator. Incl. 2 TW-75; 2 TZ-40; 2 866 tubes, coils for 40, 20, 10 meters, compl. on std. rack. Cpl. Jas. Fahnestock, Hq. & Hq. Group III (C D), Ft. Eustis, Va.

WANTED—Multitester & a #432A Readrite tube tester. Theo. R. Showacre, 618 Grantley St., Baltimore 29, Md.

FOR SALE—20-watt 6L6 phono amplifier complete with 6 tubes, $30 cash. Write for details. Want 12" PM 15-watt (or greater) speaker, automatic record changer, 1 oz. crystal pickup, V-O-M. Robert Greenough, 65 Blossom St., Leominster, Mass.

SWAP OR SELL — Used tubes in good condition: 01A; 26; 45; 47; 24A; 80; WD11; 99; 27; 25Z6GT/G. Sell or swap for parts or tubes. Will also buy damaged sets, AC or DC. New Osborne, 502 Crestview Rd., Columbus 2, Ohio.

WANTED—Small AC-DC radios, transformers of all kinds; Superior 1240 or similar tube checker; 12A8, 12SA7, 12K7, 7A8, and other tube types, wireless phono oscillators, or what have you? Have scarce tubes for trade. Saml. Bruce, 1186 Lexington Ave., New York 28, N. Y.

WANTED—Good used tube tester, also all types of tubes. What have you? Mervyn Stagg, 480 Valley Pl., Englewood, N. J.

EQUIPMENT FOR SALE — 38 Weston, Triplett, Supreme and Jewell meters of many different types; Janette rotary converter with filter, practically new; 8 Racon giant speaker units; 10 Racon 3½' horns; 4 Universal d.b. carbon mikes; 10-watt Webster amplifier; 20 amplifiers ranging from 10 to 100-watts output; Shure crystal mike; floor and desk stands; relays; jack switches, pilot light brackets; seven conductor cable, and many other needed items. Write for list. Geo. Gimera, 14 Brook St., Bradford, Penna.

WANTED—Vols. 7 and 9 Rider's manuals; also capacity meter such as Solar in A-1 condition. D. M. Decker, Deckerville, Mich.

FOR SALE—RCP tube tester #307 with 5 locktal adapters and 6H6 tube, $30; Rider's vols. 1, 3, 4, 5—$20; 3 WE 242A tubes with sockets, $6; 1 WE 212D tube def; 0-2 AC amp. Jewell 3"; 0-5 DC volts, Weston 2"; 0-15 DC amp. Jewell 2½"; 0-7½ AC volts, Jewell, 3" 0-15 DC volts Jewell, 3"; 0-5 DC ma. Readrite, 2"; 0-50 DC volts, Readrite, 2"; 0-200 DC ma. Weston 2½"; 0-300 DC ma. Weston, 2½"; Weston #506 type SIF2. All instruments perfect. $25 for the lot. E. Just, R.D. #3, Paterson, N. J.

FOR SALE—Kellogg radio tubes #401, $2.35 ea. #403, $2.50 ea. R. Eberlen, 6021 N. Wolcott Ave., Chicago 26, Ill.

SELL OR TRADE—Thordarson 6935-7551; UTC PA-428; photographic electronic timer, Stromberg-Carlson broadcast & weather band receiver, relays, Sky Buddy. Carl Hart, Wyomissing, Pa.

FOR SALE—Dayrad tube tester Series 27. Good as new. Sam M. Olson, Box 13, Regent, N. D.

WANTED—Jackson or what have you in good signal generator? Leonard Langeness, Box 376, Anoka, Minn.

WANTED—Multimeter, tube tester, sig. generator, and A-B pack batteries or what have you? Robt. E. True, Box 30, Madison, Ala.

FOR SALE — Reconditioned RCA ACR-175 4-band receiver, compl. with speaker (less crystal). Tubes all new. S/Sgt. O. Schlegel, 857th Signal Service Co., AAFAFS, Altus, Okla.

WANTED FOR CASH — Condenser analyzer or set analyzer and tube tester. Joseph Budnik, 13 Linden St., Spencer, Mass.

FOR SALE—32-V Delco plant, batteries, vacuum cleaner, flat iron, and toaster, all for 32 volts. J. E. Thompson, 1440 West 47th St., Chicago 9, Ill.

WANTED—Echophone EC-1. Cpl. J. P. Hummel, Hq. & Hq. Co. (Prov.), Lint Hill Farms Station, Warrenton, Va.

WILL TRADE — One Weston 0-1 mill. Weston milliammeter, also 0-2-6-8 AC voltometer; Weston both model #301, also following tubes: 6N6; 6N7; 6B5; 6C5; 6A8; 48; 6AC5; 6J5; 6H6; 25A7; 6A4; 6B7; 6B5; 1B5; 1H5; 6S7; 37; 6C8; 1F7; 1C7; 55; 6AE7; 85; 1A7 and many other 6-V tubes. Want Precision #910 series model 912P or Simpson multitester or what have you? Louis Wolanin, 5415 S. Tripp Ave., Chicago 32, Ill.

FOR SALE—12" speakers, 600 ohm field, $4.25, new. BN8Q speakers, Operadio, $4.50, slightly used. Tubes: 7C6, 7C5, 7B5, 7B6, 36, 37, 38, 56, 57, 2A5, etc. Write for list. Smoky Radio Service & Repairs, Rush City, Minn.

WANTED—Record player or radio-phone comb. Will trade V-O-M, AC-DC, Triplett #666-H. Meter in excellent condition. Will pay difference, or all cash. J. J. Smith, 2312 S. Fern St., Arlington, Va.

WANTED — Two Utah or Jensen P-M speakers, 7 lb. or larger magnets; also phono motors & crystal arm pickups. Cash. R. B. Thackeray, Box 266, Melvin, Ill.

WANTED—Meissner signal booster; also Hallicrafter SX-28, SX-32, SX-23, SX-25, or SX-24. Have for sale 2 wireless inter-office Crosley Chatterboxes, list $50. Also Stromberg - Carlson phonomixer - changer with permanent stylus, list $75. Both new. Also have Underwood deluxe port. typewriter with built-in tripod stand. $62 —like new. Michael J. Blackwell, % Marine Hospital, Memphis 5, Tenn.

FOR SALE—Portable Hickok tube tester, #467, $25. C. F. Rogers, 1405 Washington St. N.E., Minneapolis, Minn.

FOR SALE — $100 worth of used radio parts suitable for repair work, $25. D.C. to A.C. motor generator, 110V, $25. #2525 RCA oscillator, $25. Kimbark Elec. Appliance Co., 1309 E. 53rd St., Chicago, Ill.

WANTED—Test instruments of all kinds, also meters, filament transformers, portable recorders, parts, tubes, etc. F. A. Cabon, 1504 La-Baig Ave., Los Angeles 28, Calif.

WANTED FOR CASH—Rider's manuals VII to XIII. State price. Hartley Grisham, 700 So. Buchanan, Marion, Ill.

WANTED—Late model AC or battery signal generator; also RCA voltohmyst, Jr. Chas. R. Bestard, Alton, N. Y.

FOR SALE — Omnigraph international code instructor with inst. book. OKay condition. Will key many circuits. $10. L. C. Chapman, R. 1, Columbus, Miss.

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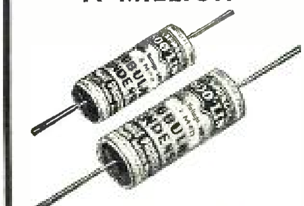

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When there's a by-pass capacitor job to do, do it with famous Sprague TC Tubulars — and forget it. They will not let you down!

We'll appreciate it if you ask for them by name.

WANTED for overseas use: Model 3 or 4 Echophone, or Hallicratters S-29. Lt. J. A. Geitgsell, 874th Bomb Sqdn., Army Air Base, Great Bend, Kans.

FOR SALE — Janette rotary converter CA20, new, in original case. 32V DC to 110V AC, 7 amps. DC, 1 amp. AC. 3600 r.p.m. $25. Another ditto, only used, $12. H. D. Morton, % Wm. G. Brown Co., Gloucester, Mass.

TUBES FOR SALE—1A5, 1C6, 1E7, 1F7, 1H4, 1H6, 1LB4, 1LH4, 1R5, 1S4, 1S5, 1T4, 2A3, 2A5, 2A6, 2A7, 3A8, 3Q4, 3Q5, 3S4, 5U4, 5X4, 5Y3, 6A3, 6AD6, 6B4, 6C5, 6C8, 6F6, 6F7, 6F8, 6J5, 6J7, 6K7, 6L6, 6N6, 6P5, 6SJ7, 6SQ7, 6V6, 7A5, 7A6, 7A7, 7A8, 7B5, 7B6, 7B7, 7C5, 7C6, 7C7, 7F7, 7J7, 7Q7, 7H7, 7V7, 12A6, 12B8, 12J5, 12K7, 12SF5, 12SQ7, 25A6, 25L6, 25Z6, 26, 27, 31, 35Z4, 36, 39/44, 43, 45, 55, 56, 57, 70A7XXD, XXL, XXFM. All new in sealed cartons. 25% off list. Radio Service Shop, Hudson, Wisc.

WANTED—Phono pickup arms and motors, also tubes such as 50L6, 35Z5, 12 and 6 series. Must be good. Victor D. Letourneau, Jr., 179 Main St., Holyoke, Mass.

FOR SALE—John Meck tube tester, tests up to latest loctals, $20. Also 75-watt Thordarson amplifier, like new, output meter, 3-mike and 2-phono outputs. Original price $145, first $100 takes it. Have new factory-boxed tubes to trade for other types. Write for list. Longer Radio & Sound Co., Danville, Ill.

WANTED—RCA Jr. velocity mike; 55-C Unidyne mike; or Amperite Studio velocity mike; also a 33⅓—78, 16" turntable. Engel Radio Service, 430 N. Bancroft, Indianapolis 1, Ind.

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KOOLOHM RESISTORS

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Radio Oscillators

(*Continued from page* 27)

This method tells if the oscillator is working, since no sound will be heard if the correct adjustments have not been made.

If a more sensitive detector is desired, a triode detector (Fig. 3) followed by as many stages of a-f amplification as desired can be used.

Signal Tracing

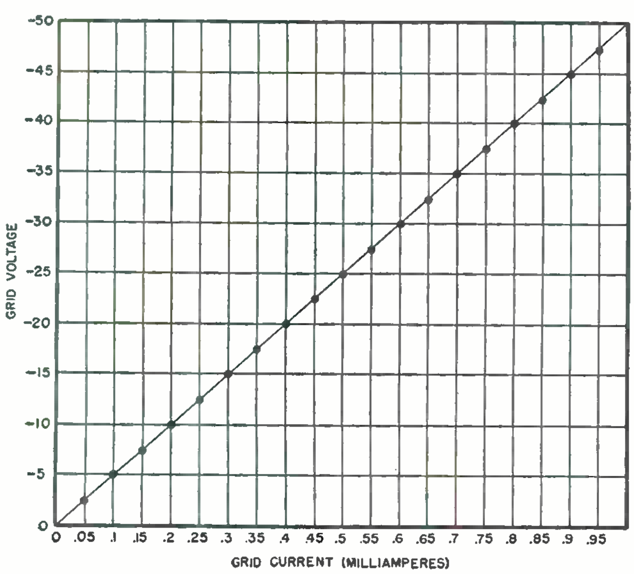
Since the introduction of signal tracers, it has been much easier to tell if an oscillator is working and if so, at what frequency. Most signal tracers have special probes which may be connected to a tuned circuit without changing its resonant frequency appreciably. A signal tracer has a dial which is frequency calibrated like a receiver, so that by connecting the probe to the oscillator tube and tuning the tracer, it is possible to find at what frequency the oscillator is working. Usually some type of output indicator such as an electron-ray tube or a meter is used.

To operate, connect the probe of the signal tracer to the tuned circuit of the oscillator (Fig. 4) and tune the dial of the tracer to give maximum indication on the "eye," or meter, as the case may be. Read the oscillator frequency directly from the signal-tracing instrument dial.

Testing for Oscillator Failure

Many methods of testing to see if an oscillator is oscillating may be used. No method to date has been described to tell why an oscillator does not oscillate. It is the purpose of this article to describe a method whereby every component part and function of the oscillator circuit may be tested. The instruments used are the RCA Chanalyst, Jr., Voltohmyst, and r-f oscillator. Other equipment may be used just as well, but the ones mentioned are used because of the familiarity of these instruments.

Fig. 12. Grid voltage vs. grid current with 50,000-ohm grid leak.



Tuned Circuits

In connection with the oscillator testing it may not be out of place to review tuned circuits and their behavior. In order for a circuit to resonate at a certain frequency, the inductive and capacitive reactances must be equal at that frequency. Since inductive reactance is positive while capacitive reactance is negative, the two will cancel at resonance, leaving only the resistance in the circuit. Since X_L equals X_c (Fig. 7), and they are of opposite signs, they will cancel, leaving only R to limit the flow of current in the circuit. The amount of current that will flow, therefore, will be the voltage divided by the resistance, or 1/10 ampere. This same current flows through the inductance and condenser since they form a series circuit. If the voltage is measured across L, it will be found to equal current times reactance, or 1/10 times 100, giving 10 volts. This seems strange, since the generator voltage is only 1 volt; however, it is a fact.

At any frequency other than resonance X_L will not equal X_c; hence, will not cancel and the circuit impedance will be a combination of resistance and inductance or capacity, depending on whether the frequency is above or below the resonant frequency of the coil.

Parallel Resonance

Unlike series resonance, which offers minimum impedance to the flow of current, parallel resonant circuits offer maximum impedance. The impedance of a parallel resonant circuit is equal to $2\pi fL$ times Q. The term Q is a figure of merit for a coil and is equal to $\frac{X_L}{R}$. For most purposes the higher the Q, the better the coil. Since Q is equal to $\frac{2\pi fL}{R}$, then the tuned circuit impedance becomes $\frac{(2\pi fL)^2}{R}$.

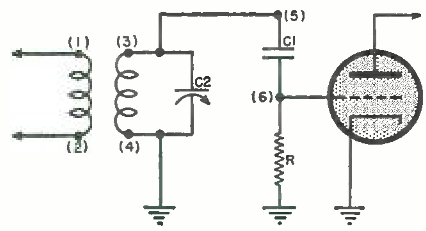


FIG. 13

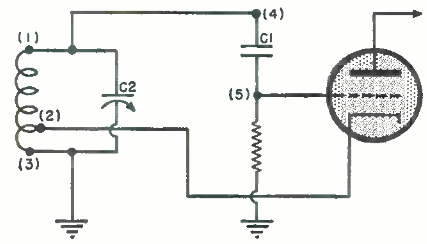


FIG. 14

A tuned circuit gives a voltage step-up, as was shown in the series resonant circuit where the voltage across the condenser or coil was greater than the generator voltage. If the turns ratio of the transformer, shown in Fig. 8, were 1:1, then the voltage induced into the secondary will approximate that across the primary. Once the voltage is induced into the secondary, the circuit resembles the series resonant circuit shown in Fig. 7.

A voltage of 1 volt represented by the generator G (Fig. 9) is in series with the R, C and L in the circuit. The voltage is usually taken from across the variable condenser and is equal to the voltage induced by transformer action times the Q of the coil. If the Q of a certain coil were 50, the E × Q would be 1 volt times 50, or a voltage of 50 volts developed across the tuned circuit.

In a case where the coil resistance is high, the condenser has leakage resistance, or the coil has absorbed moisture, the Q of the coil will be lowered and the voltage stepup of the circuit likewise lowered.

Causes of Oscillator Failure

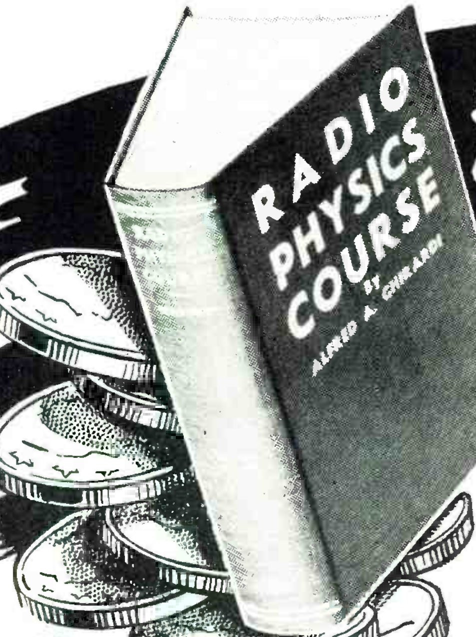
Referring to Fig. 1, it is obvious that any tube defects, short circuits in C1, C2, C3, C4, or open circuits in R1, R2 or L_1, will cause oscillator failure. Servicemen are familiar with methods of testing for these defects and little time need be spent here in reviewing them.

After all of the component parts have been tested and found to be all right it may be found that the circuit will still fail to oscillate.

Tuned Circuit Impedance

As stated previously, the impedance of a tuned circuit is $X_L \times Q$. *From this it may be seen that anything that affects the impedance of the circuit will also affect the amount of voltage across the circuit.*

Suppose that an r-f voltage of 10 volts were fed into the circuit at point 1 as shown in Fig. 10. If, as an example, this causes enough current to flow through the tube to produce 1 volt at point 2, and if the Q of the coil were 15, then the voltage of 1 volt from point 2 to ground would produce from 10 to 15 volts from point 1 to ground. This circuit would then oscillate since enough voltage would be fed back to the grid to supply its own energy. If something should occur to lower the Q of the coil to about 8, then the cir-



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cuit could not oscillate since it would not feed enough voltage to the grid of the tube to produce sustained oscillations. Anything affecting the Q of the circuit would also affect the impedance of the circuit; therefore, a method of testing the tuned circuit impedance would also tell the merit or condition of the circuit.

Checking Impedance

A resonant circuit behaves as a pure resistance since the reactances cancel. However, ohmmeters will not check this impedance and costly bridges are usually required. With a Chanalyst and a test oscillator it is possible to determine the impedance.

Connect the equipment as shown in Fig. 6. Set the Chanalyst for maximum sensitivity and the test oscillator for maximum output. Connect the vacuum-tube voltmeter section of the Chanalyst to read the rectified d.c. output of the r.f.-i.f. channel. (It is even better to use a Voltohmyst, Jr. for this, since the voltage variations may be read easier.)

Procedure

The circuits under test are supposedly those of a broadcast-frequency set.

1. Set the test oscillator to around 1100 kc.
2. Connect the Chanalyst probe to point 1.
3. Tune the Chanalyst for maximum meter indication. If the eye overlaps considerably, reduce the gain of the Chanalyst or output of the oscillator to prevent overload.
4. Connect Chanalyst to point 2.
5. Adjust C1 for maximum indication on the meter. *Do not change any controls on the Chanalyst or oscillator* except to change scales on the VTVM if necessary.
6. Return probe to point 1. Read and record voltage.
7. Read and record voltage at point 2.
8. Subtract voltage at point 2 from the voltage at point 1.
9. Difference in voltage divided by voltage at point 2 is proportional to resistance of R divided by impedance of circuit.

Example:

Suppose voltage at point 1 equals -4 volts.

Suppose voltage at point 2 equals -2 volts.

-4 volts less -2 volts equals -2 volts.

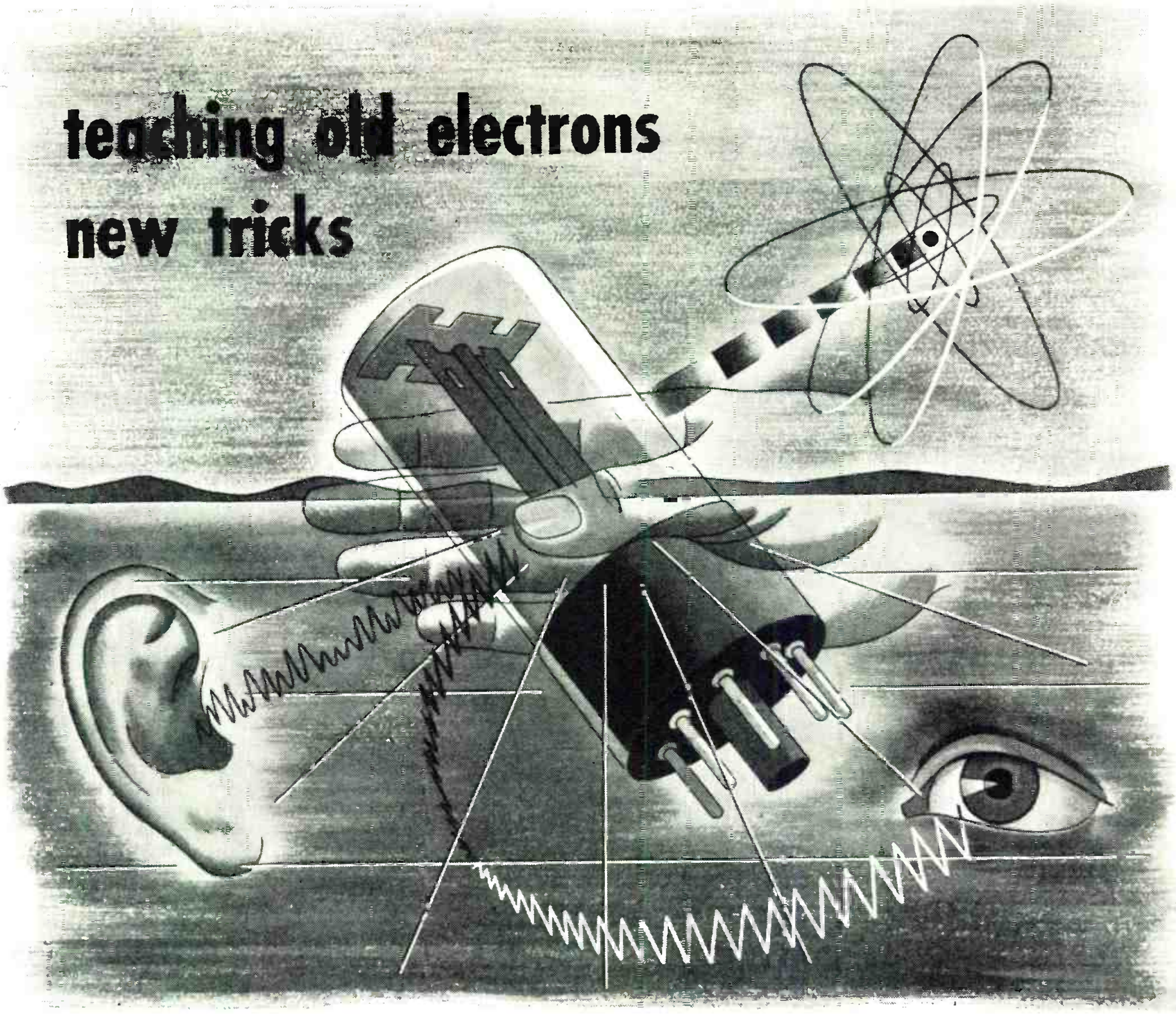
Assume R to be 5,000 ohms.

$$\frac{2}{2} = \frac{5000}{Z}$$

Therefore, Z equals 5,000 ohms, impedance of tuned circuit.

It has been found by experimentation that 5,000 ohms is a suitable value for R, when making these measurements.

Another method, which is more easily applied since it requires no calculation, is to make R variable. Tune the circuit to resonance as before, and



Electrons have always been with us, since the beginning of time. But it was not until the development of radio that they were disciplined and put to work.

Now that the science of electronics has become better understood, these electrons have been taught a lot of new tricks. They have been trained to reproduce images as well as sound, to perform miracles of control in military equipment and industrial machinery. Long hours of research and development have been applied to making electronics a useful force in the fight for Victory.

Delco Radio has worked closely with Army and Navy engineers to help put this relatively new science on a fighting basis. In its laboratories, technical principles have been explored and exploited; in its engineering departments, designs have been evolved to apply these principles; and on its production lines, complete equipment is being manufactured with all the accuracy and know-how gained through Delco Radio's extensive experience as a large manufacturer of precision radio instruments.

This background of knowledge will continue to serve a useful function in days to come. It holds a promise of important improvements in peacetime radios, and significant developments in new electronic products.

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adjust R until the voltage at point 1 is exactly twice that at point 2. Measure the resistance of the variable resistor and the resistance of the circuit will be equal to the resistance of the control. (It is necessary that the resistor be carbon and non-inductive.)

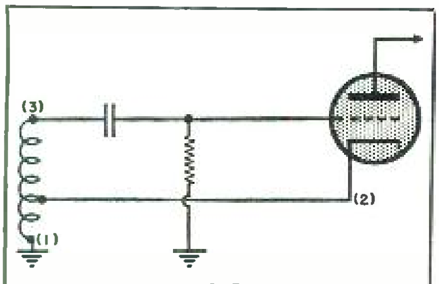


FIG. 15

Reasons for Low-Tuned Circuit Impedance

Fig. 11 is used to illustrate some of the causes of low impedance. One cause is the change in the resistance of R. At radio frequencies, R is effectively in parallel with the tuned circuit. From one of the simplest rules in radio we know that when two resistances are placed in parallel the total resistance will be less than the value of the lowest resistance. Therefore, the impedance from grid of the tube to ground can never be greater than the value of R. If R decreases in value it will lower the impedance of the circuit when measured as described in the preceding paragraphs.

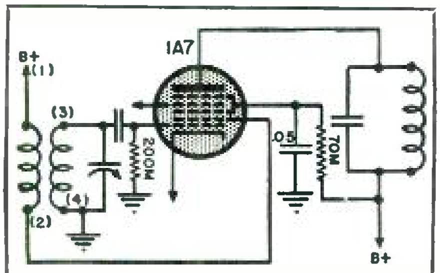


FIG. 16

Another cause of low circuit impedance is dirt or burrs on the variable condenser. This makes the condenser leaky and is equivalent to connecting a resistor in parallel with the condenser. This has the same effect as reducing the value of R.

Coil trouble causing low impedance may be due to shorted turns or the coil form or insulation absorbing moisture. In either case, it is difficult, and sometimes impossible, to locate such faults by means of the volt-ohm-milliammeter.

Steps to Isolate Defective Part Causing Oscillator Failure

1. Determine that the oscillator is not working by one of the methods described above.

2. Test tube in a good tube tester. Often an emission tester will not show up a bad oscillator tube; for this a truly dynamic tester is necessary. If

(*Continued on page* 83)

Manufacturers' Literature

Readers are asked to write directly to the manufacturer for the literature. By mentioning RADIO NEWS, the issue and page, and enclosing the proper amount, when indicated, delay will be prevented.

JOB SURVEY

An increased interest in the field of electronics as a postwar opportunity for employment is responsible for a new booklet entitled "Occupations in Electronics" recently published.

Many persons interested in establishing themselves in positions with a stable future have inquired about the many phases of this industry. In an effort to supply authentic and up-to-date information on the subject, Mr. Forrest H. Kirkpatrick of Bethany College and Mr. John E. Crawford of RCA have compiled this booklet.

Questions regarding the nature of the work, the abilities and training required, earnings, methods of entrance and advancement are answered while data on geographical distribution of employment pertinent to the subject are given.

A copy of this booklet is available from the *Occupational Index, Inc.,* New York University, New York, 3, N. Y. upon receipt of 25 cents in cash.

LAFAYETTE CATALOG

The 1944 edition of the *Lafayette Radio Corporation's* yearly catalog is now available for distribution.

New developments in radio and electronics are covered both from the military and civilian standpoints. In the 104 pages of this catalog, over 50,000 items are illustrated including a complete line of public address systems and communications equipment.

A greatly expanded list of new "Victory line parts," especially prepared for factory and assembly use, advance notice of 1944 books on radio and electronics, postal and shipping data are also included.

Information regarding the WPB order L265 and its specific application to dealers is discussed and explained. Copies may be obtained by writing to *Lafayette Radio Corporation,* at either 901 W. Jackson Boulevard, Chicago, 7, Illinois, or to their office in Atlanta, Georgia, which is located at 265 Peachtree Street, and asking for Catalog 94.

DILECTENE

An announcement of a new insulating material has been made by the *Continental-Diamond Fibre Company* in a four-page booklet entitled "Dilectene."

The material is a pure-aniline-formaldehyde synthetic resin and its properties and applications are discussed in this leaflet. The manufacturers of Dilectene illustrate by picture and example the flexibility of this material.

Because of the shortage of standard insulating materials, the announcement of this product is of interest to manufacturers of products requiring insulating material.

The descriptive folder, DN-42, is available upon application to *Continental-Diamond Fibre Company,* Newark, Delaware.

SPRAGUE CAPACITORS

A folder announcing immediate deliveries on various Army and Navy type bathtub condensers, oil-filled, oil-impregnated can-type capacitors and various mica condensers has been released by *Sprague Products Company.*

The "bathtube" type metal rectangular units are available in a wide variety of single and dual capacities and in voltages from 50 to 1750 d.c. Tolerances on this condenser ranges from minus 20% to plus 30%. The oil-filled, oil-impregnated can-type units are available in capacities from 1.0 to 17 μfd. with a wide range of a.c. and d.c. voltages.

This folder is available upon request. Address *Sprague Products Company,* North Adams, Mass., and request "Immediate Delivery" booklet, Form XI.

THY-MO-TROL DRIVE

The Thy-mo-trol, *G. E.'s* pioneer electronic drive for providing and controlling adjustable-voltage power from a-c lines, thus making possible the utilization of the inherent advantages of d-c motors, is described in an attractive new 40-page bulletin recently issued by the *General Electric Company.*

The bulletin, well illustrated throughout, is divided into two parts. The first part explains the unique Thy-mo-trol drive in considerable detail, describes its functions, and lists its advantages. This section also lists many Thy-mo-trol applications and describes some of them. Typical applications listed include: installations on grinders, turret lathes, drill presses, conveyors, and form-and-thread milling machines; and to machines for testing tachometers, magnetos, propeller governors, and the tensile strength of various materials.

The second part of the publication is devoted to a complete, easily understood, technical explanation of the Thy-mo-trol drive's operation.

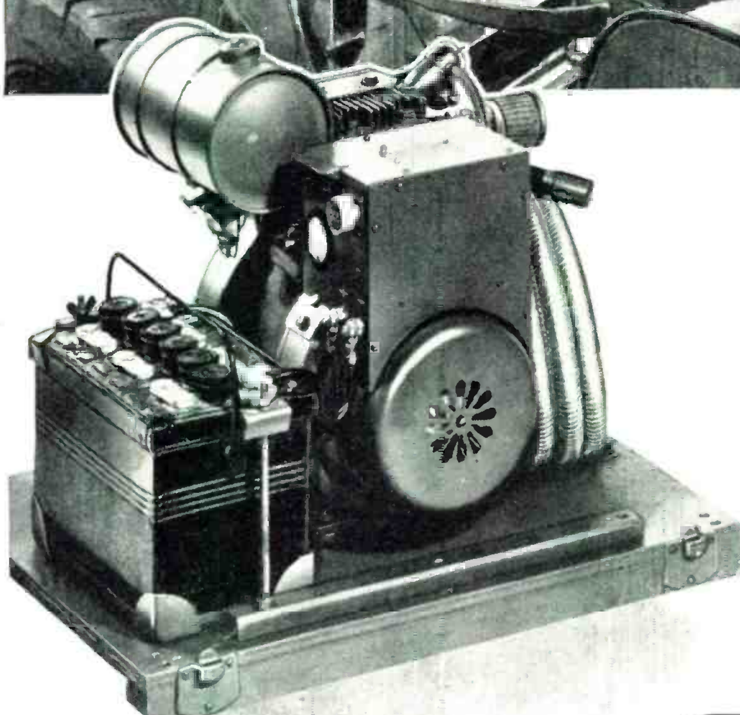
Copies of this bulletin may be had by addressing all requests for Bulletin GEA-4025 to the *General Electric Company,* Schenectady, New York.

TUBE CATALOG

A new and up-to-date catalog of the electronic tubes manufactured by the *Continental Electric Company,* is

(*Continued on page* 96)

Dependable Power..



Probably the most important single factor in modern warfare is complete, dependable communications. Dependable communications require a dependable power supply. Pincor is proud of its part in furnishing portable gasoline-driven and other electrical power supply units to the fighting front as well as to the home front.

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Radio in War Theater
(*Continued from page* 23)

tion-guiding equipment. Floating airports situated each few hundred miles across an ocean might, in fact, act as a magnet to bring to safe harbor small, short-ranged pleasure aircraft, and then send them off again to the next floating gas and repair station.

Britain still prefers to fly her bombers manually, but with the aid of many radios. Mr. Oliver Lyttelton, Minister of Production, commented recently on the increase in manufacture of war equipment. In the course of his speech, Mr. Lyttelton said:

"We are also planning further increase in certain types of naval vessels and the numerous scientific instruments and other devices used in war at sea. Then we also have to plan for a greater production of radio equipment. When I tell you that some of our Lancaster bombers now carry 12 radio sets, you will appreciate how great is the demand for radio."

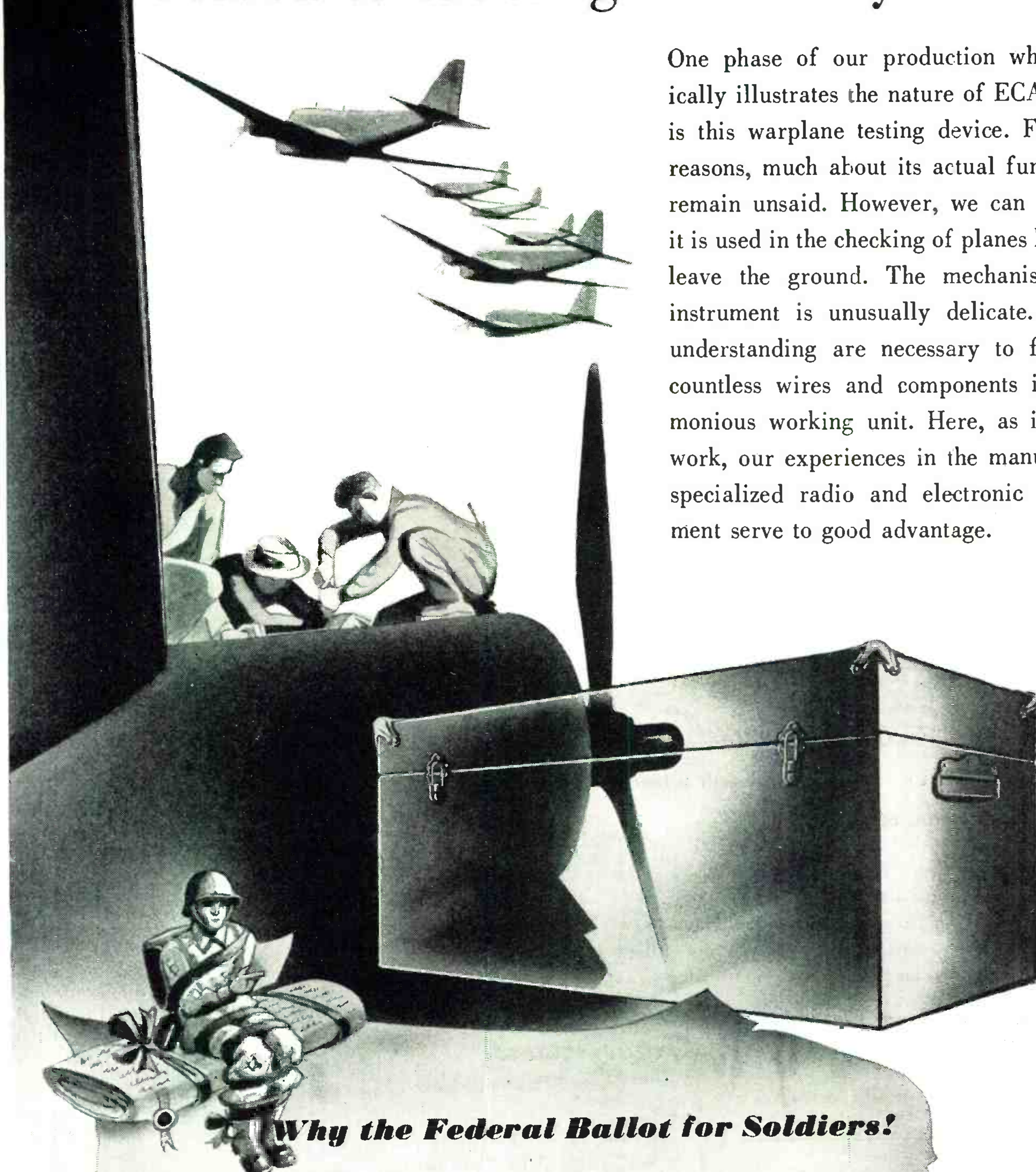
Generally speaking, Allied military radio for ground use has been standardized. The British have adopted certain types of American transmitters and receivers as being more efficient for particular requirements, but in most instances, they have utilized equipment of their own manufacture. They have developed a loud-speaker system, similar to the United States Army's public address unit, for direction of beach assault parties and troop activities on a large scale.

A portable radio set similar to our own Signal Corps walkie-talkie also is used for invasion purposes but is more apt to be found taking a part in the communications network between troops based in England. It is possible to use this short-range equipment here, since military installations are not so widely separated as in the United States. As for the Signal Corps handie-talkie, it is still a source of great interest to the British, but our ally has no counterpart in design or adaptability.

Another American development, a modification of the SCR-299 mobile transmitter and receiver, which demonstrated its flexibility in the North African campaign, is said to be a "miniature domestic broadcasting studio." This equipment is self-sustaining from a power standpoint, and with special antennas and other attachments, the range has been increased so that broadcasts may be transmitted distances hitherto considered impossible for such portable equipment. The necessary additions to the SCR-299 have been designed so that they may be mass-produced in kit form and included as regulation equipment for the transmitter.

Two more radio developments now being used exclusively by our Army may have a bearing on civilian radio after the war.

Geared to exacting laboratory standards



One phase of our production which graphically illustrates the nature of ECA standards is this warplane testing device. For obvious reasons, much about its actual function must remain unsaid. However, we can reveal that it is used in the checking of planes before they leave the ground. The mechanism of this instrument is unusually delicate. Skill and understanding are necessary to fashion the countless wires and components into a harmonious working unit. Here, as in all ECA work, our experiences in the manufacture of specialized radio and electronic test equipment serve to good advantage.

Why the Federal Ballot for Soldiers!

At ECA, we earnestly cooperate with every phase of the war program. We are also conscious of another responsibility to our soldiers, that is, the preservation of their rights. As this is being written, legislation permitting soldiers to vote is under consideration. The Federal Ballot is unconstitutional, it violates states' rights—so some men say. To us, the argument for the Federal Ballot is quite clear. If the government has the power to go into any state and select a man for service, then it should have the equal power to make certain that he can take advantage of his *constitutional* right to vote—in the easiest possible manner. Back the President, the War Department and all others who support the Federal Ballot. There is no red tape wrapped around a bullet. It should not be wrapped around a ballot.

eca

ELECTRONIC CORP. OF AMERICA

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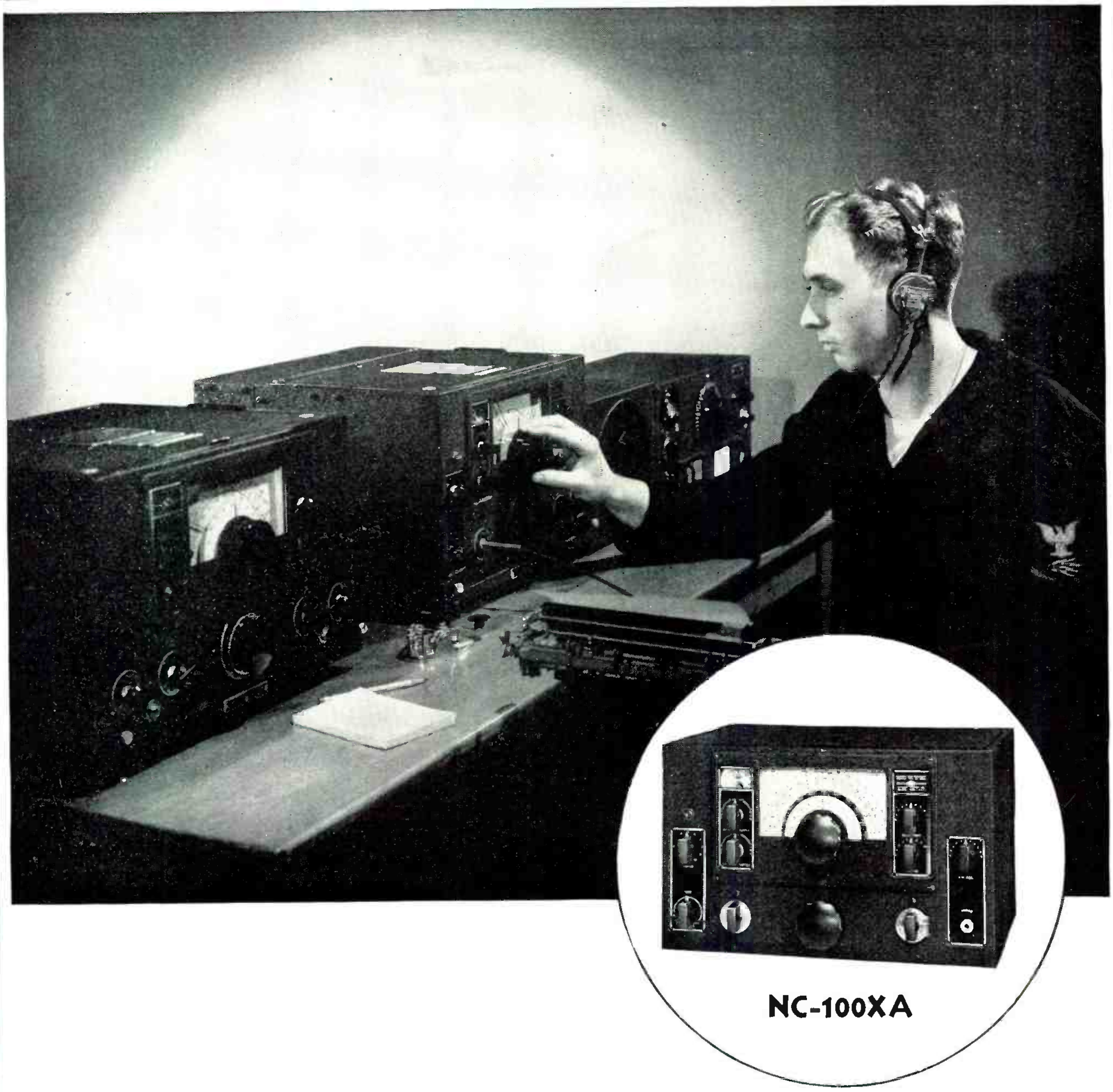
The first concerns the special 50-watt transmitters, which were designed and produced especially for the American Forces Network, operated by the Radio Branch of the Services of Supply Special Service section in the European Theater of Operations. Through this network, transcribed American musical, news, and theatrical programs are broadcast to United States troops scattered throughout the United Kingdom. Broadcasts are sent out to soldiers with the aid of British Broadcasting Corporation facilities and Signal Corps installation and maintenance personnel. A shipment of several hundred receivers from the United States will soon increase the listening audience. The network is under the direction of Lt. Colonel Charles H. Gurney, former owner of WNAX, Yankton, S. D., and his assistant, Captain J. H. Hayes, former New York network executive.

The other innovation came to the attention of radio listeners in the United States, who tuned in on August 18 to an NBC broadcast of a bomber mission over LeBourget, France. This not only was the first radio broadcast of a Flying Fortress in actual combat, but was the result of a most unique experiment. The voices of the bomber crew, as heard by the listeners, were recorded on a magnetic wire recorder device which may prove of tremendous tactical value to our armies in the future. Similar in appearance, and somewhat in construction, to a small portable radio receiver, this apparatus picked up the speech from the plane's intercommunication system through the aid of throat microphones worn by the crew and a lip microphone worn by the observer-commentator, underneath their oxygen masks. Magnetic wire recording is accomplished by passing a carbon steel wire through a magnetic field. On the Fortress, several hours of conversation were recorded on the small rolls of wire. These were later edited and transcribed for the broadcast. There was no outside interference or noise reproduced on the recorder, thus giving the factual report clarity which would have been impossible to obtain by any other method.

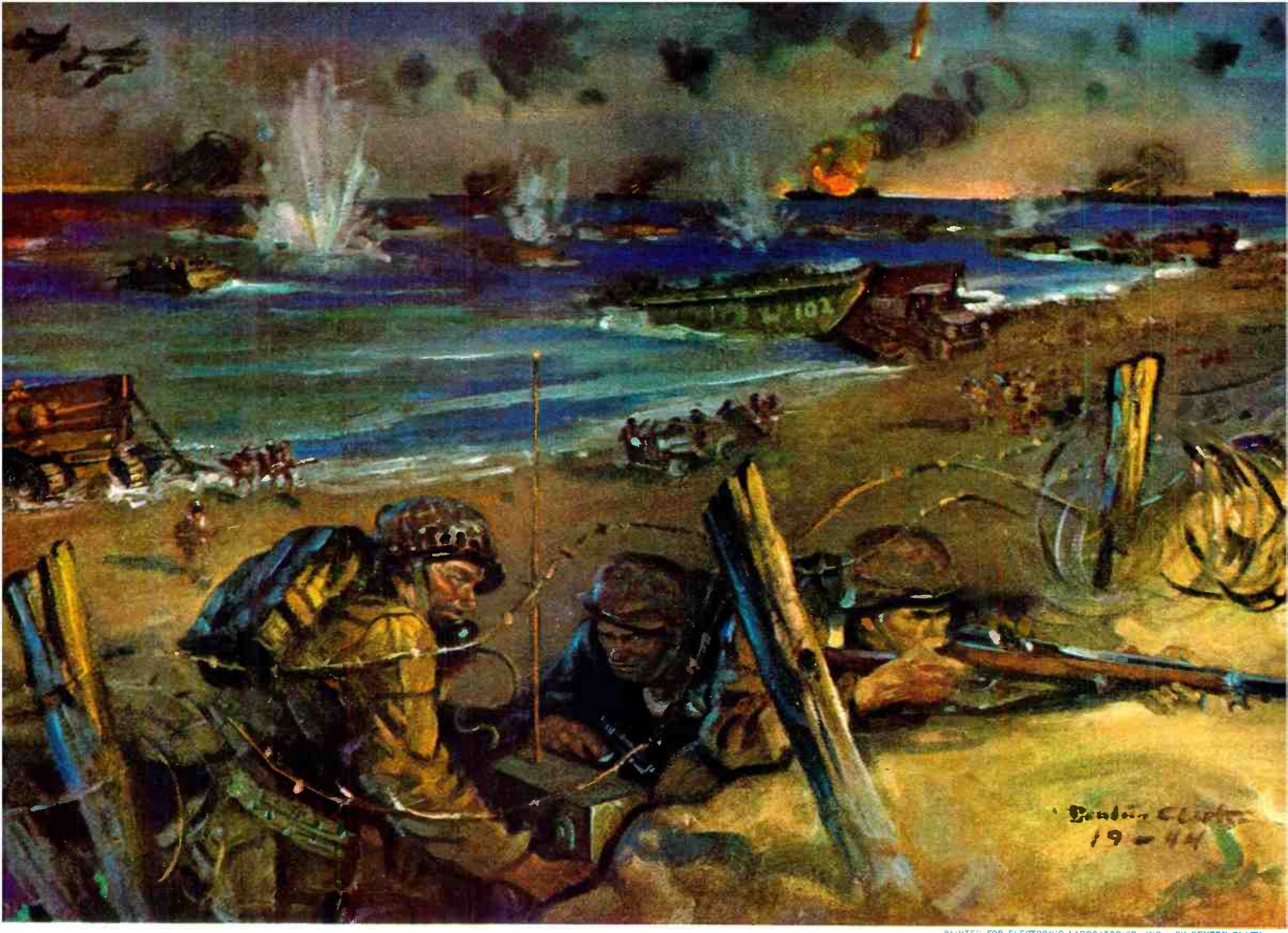
Quite naturally, British, and it may be assumed, American, radio engineers already are drawing up plans for postwar civilian radios. The British engineers, however, have had a problem to face which has not yet become acute in America. Here, after four years of drastically reduced production of civilian receivers, England finds herself short of radio listeners. Statistics show that of the country's 8,600,000 licensed sets, approximately ten per cent are not in use. Half of this ten per cent is accounted for by sets awaiting repair, and the other half by those short of spare parts. At the British government's request, the radio experts have rushed through specifications for a utility radio set. These sets, considered a wartime



NC-100XA

The NC-100XA has gone to war. Under the pressure of the emergency following Pearl Harbor, many stock receivers of the NC-100 series went into action, and served brilliantly. Since then growing experience has led to a long series of minor changes and improvements, culminating in the superb receiver shown in the photograph above. We cannot show what is inside the cabinet until after the war, but a glance at the front panel will make any amateur recognize an old friend. It is stripped for action and in battle dress, but it is still the old reliable NC-100XA. And like its amateur prototype, this new Navy model is winning an impressive reputation for brilliant performance and absolute reliability.

NATIONAL COMPANY, INC., MALDEN, MASS.



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"Beach 3 Calling Fire Control 3

... *pinned down by pillbox on right flank!*"

★ Landing parties must depend on supporting fire from ships off shore until their own artillery can get into action. By radio communication the Navy's fire is brought instantly to bear on enemy strong points holding up the advance.

When the Marines carry out the tough landing operations for which they are noted, Walkie-Talkies are among the first ashore. *They must get the messages through!* For unfailing power, many depend on *E·L* Vibrator Power Supplies.

Wherever reliability is a "must," *E·L* Vibrator Power Supplies are also proving their other advantages of light weight, small size and high efficiency. They are products of the most extensive research in vibrator power supplies and circuits ever known.

That research has extended the scope and usefulness of vibrator type power supplies beyond all previous conception. Certainly, in the electronic era of peace to come *E·L* Power Supplies will contribute new advances and economies wherever electric current must be changed in voltage, frequency or type.

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Power Supply using rechargeable, non-spill storage battery for operation of Walkie-Talkie radio equipment. Input Voltage: 4 Volts D.C.; Output: Numerous Voltages, supplying plate and filament requirements of the equipment. Width, 3½"; Length, 6½"; Height, 4⅜".

necessity because of the important war messages that are broadcast, soon may somewhat relieve the situation.

But besides solving the present receiver shortage, British engineers have in mind postwar two-way radios for use in private automobiles, aircraft and boats, and they say a modification of the American handie-talkie certainly would be a boon to sportsmen tracking game, or even to mother calling Johnny home for dinner from a baseball game in Jones' vacant lot.

Automobile radios may be compact sets no larger than the clock on the dashboard, and by the same token, personal receivers the size of a pocket watch might be carried just as casually as a time-piece by listeners, who then would find no reason to interrupt appointments to rush home to catch the latest chapter of "The Lone Ranger." Miniature, rechargeable batteries will furnish power for these pocket-size sets.

These ideas all are concerned solely with radio as we know it now. The British are well advanced in the study of frequency modulation, which would bring static-free programs to long-suffering listeners. The experts here realize that ordinary stations would have to be converted before frequency-modulation transmission would be possible, and, of course, when they consider converting present transmitters, television comes in for a good share of thought.

It is generally admitted that America, because of the competitive nature of our radio system, has developed far beyond the British in production of radio entertainment. We Americans went through a "radio era." There may never be a "radio era" in England. All that we have learned in the entertainment field may be incorporated by the British when television is launched, as it will be, after the war. Let it not be assumed, then, that England must go through all the experimenting, and sometimes bungling, that we did in order to catch up with us on voice radio, before television can become practical here. Indeed, it is quite apparent that England will be right up with us after the war in adding sight to the miracle of radio.

There is every reason to assume that the great radio inventions described above and others which cannot be described now, will be put to civilian use after the war.

Those who cried, "The war will set us back a hundred years in science," certainly could not have referred to the science of radio. If anything can be termed a "beneficial" outcome of the war, then the progress made in radio comes under that heading. Under the pressure of immediate need to stop the enemy, radio technicians accomplished the unbelievable, for in the new surge of might to overpower him, these men have done what all of us, a short five years ago, would have considered impossible.

—30—

Audio Oscillators

(*Continued from page 43*)

reduction of distortion in certain oscillators which, in type, are essentially audio amplifiers with sufficient feedback to make them oscillate. In such circuits, two types of feedback are actually applied — *regenerative* for oscillation, and *degenerative* for the reduction of distortion. Such an arrangement is shown in Fig. 13, and is attributed to H. H. Scott.

The principle of the Scott oscillator is illustrated by the block diagram in Fig. 13. Section B in this diagram is an audio amplifier with flat response. This amplifier is provided with regeneration through the block section C,

Low-Pass Filter Data

(Values Are For Cut-off At 2nd Harmonic)

OSC. FREQ. (cycles)	L1 (henries)	C2 (μfds.)
60	1.33	5.55
100	0.796	3.18
250	0.318	1.27
400	0.199	0.796
500	0.159	0.637
1000	0.0795	0.3185
2000	0.0398	0.159

Chart I.

and degeneration through block section A.

The basic circuit of the oscillator is shown in Fig. 13B. The amplifier is seen to be a direct-coupled circuit provided with cathode output coupling. The degenerative network is interposed between the plate and cathode circuits of the second tube and the grid circuit of the first tube, and is comprised by C1, C2, C3, R1, R2, and R3.

The degenerative network consists of resistors and capacitors arranged in a parallel-T circuit (shown within the dashed lines in Fig. 13B). The nature of this circuit is such that the network may be adjusted to null, that is, to zero transmisison, at one frequency. In this respect, the parallel-T circuit is equivalent to a bridge. The network accordingly will transmit degenerative feedback voltage to the amplifier input on all frequencies except the null point. Inverse feedback will thus render the amplifier inoperative on all frequencies except the one to which the network is set.

In the degenerative network, R1=R2=2R3, and C1=C2=½C3. The null frequency is equal to 1/(6.28 RC). By ganging variable resistors for the R1, R2, and R3 positions, the instrument may be made continuously variable in frequency.

Regenerative feedback (through Section C) occurs at *all* frequencies. However, the regenerative voltage is unable to excite the amplifier input since it is bucked by the degenerative feedback (through Section A), except at the null frequency. As a result, oscillation of the system takes place only at the null frequency and high attenuation of all other frequencies (including hum and harmonics) obtained.

The Scott oscillator offers the advantage of simplified resistance-capacitance tuning, together with absence of transformers and inductors, except the output coupling transformer. Degenerative action renders the amplifier a sharp band-pass circuit which eliminates all harmonics, subfundamentals, stray feedback, hum, and noise. Total harmonic distortion with this type of oscillator is under 0.1% when proper adjustments are made.

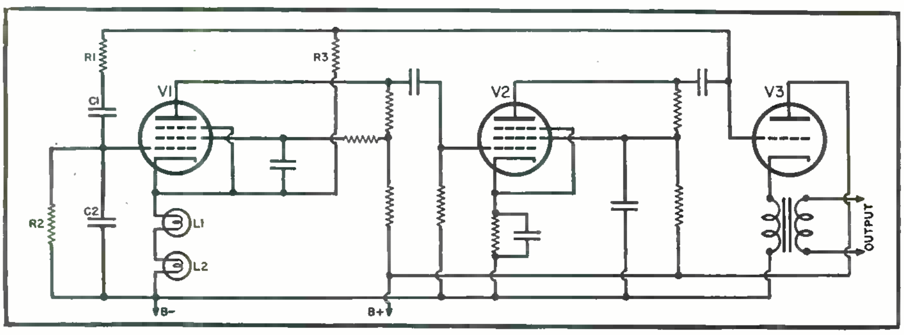
Another degenerative-amplifier type of low-distortion oscillator is illustrated by Fig. 12. This unit operates on a somewhat different principle, although it also is a resistance-capacitance-tuned arrangement.

Here we have an amplifier in which the frequency-responsive circuit is a Wien bridge arrangement with R1, R2, C1, and C2 as the determining elements.

Sine-wave characteristics in the output a-f voltage are obtained by regulating the amplifier gain automatically in such a way that operation is always at class-A level for low distortion.

This automatic operation may be explained in the following manner: The entire system may be regarded as a three-stage audio amplifier of good frequency characteristics. Feedback voltages are transmitted from the grid of the last tube, V3, over the line to resistor R3. Feedback voltages are then divided at this point, a portion passing through to the frequency-determining network (R1-R2-C1-C2) and the remainder passing through the pair of tungsten-filament lamps (L1 and L2) in the cathode circuit of V1.

Fig. 12.



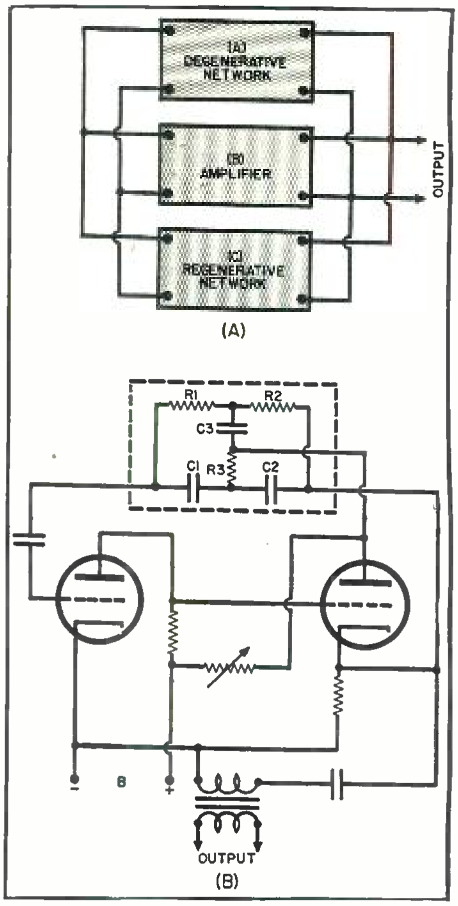


Fig. 13.

The voltage at the R-C network sets up the regeneration necessary for oscillation; that across the lamps sets up a degenerative voltage necessary to maintain constant the strength of oscillation.

By keeping the network capacitances equal on each side of the grid of V_1, and likewise keeping R1 equal to R2, the oscillation frequency becomes equal to $1/(6.28\ R_1C_1)$.

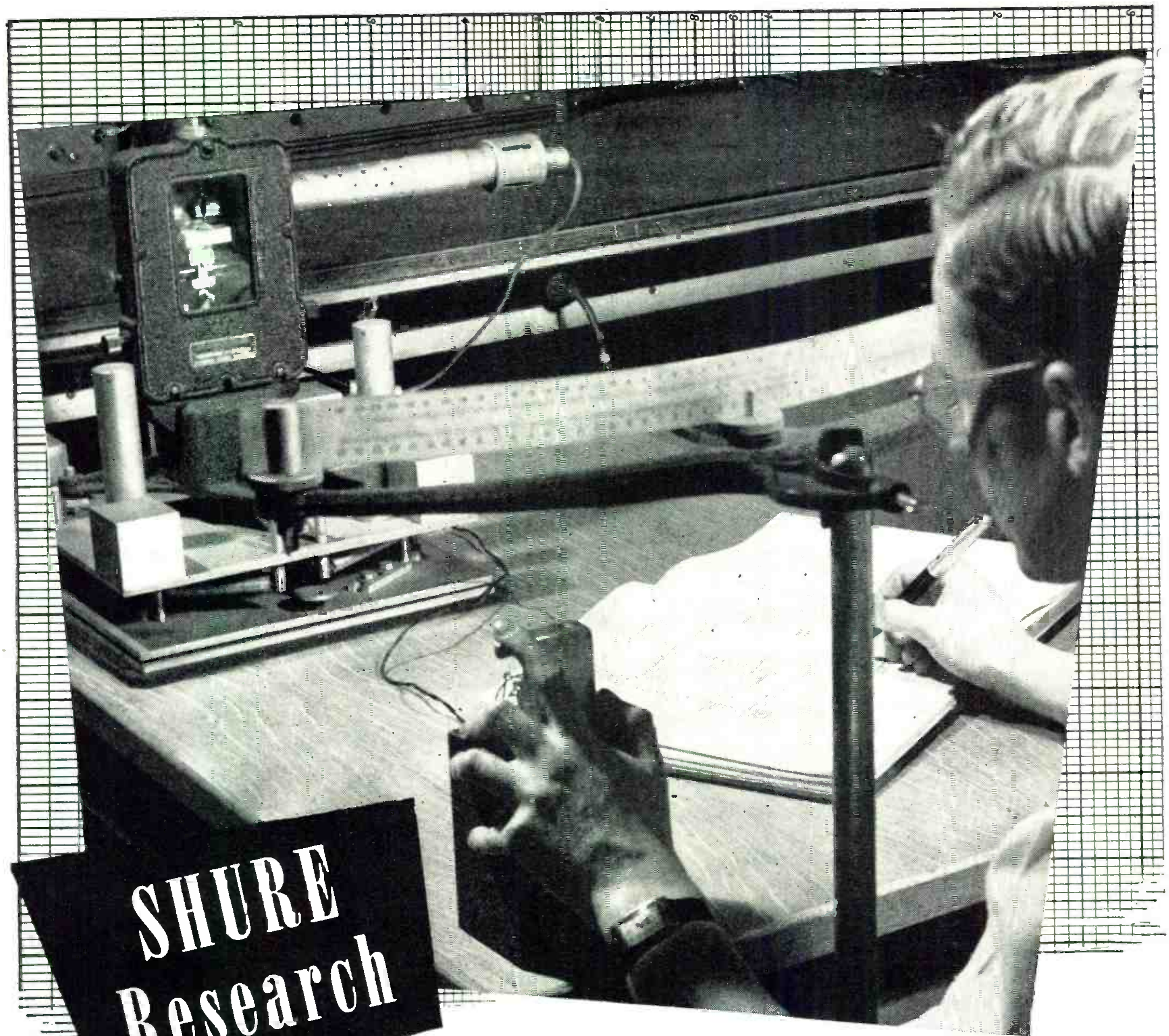
The two lamps in the V1 cathode circuit act together as an automatic degeneration resistor by virtue of the positive voltage-resistance characteristic of their tungsten filaments: As the strength of oscillation increases and the plate current of V1 rises, the total cathode current also increases. However, increased current through the lamps raises their resistance, reducing the gain of the first stage. Thus, automatic gain control is obtained through this degenerative effect and the entire amplifier is held down to the level required for sine-wave output. R3 is chosen in value such that there will always be the proper ratio of regeneration to degeneration to insure this type of operation.

Total harmonic distortion in the signal-voltage output of this type of oscillator is of the order of 1% or lower when proper adjustments are made.

Filtered Multivibrator

The multivibrator, controlled by a crystal oscillator and provided with amplified and filtered output circuit,

(*Continued on page* 122)



Radio Telephone Transmitter

(*Continued from page* 30)

is wound with 85 turns of 10/41 Litz, no spacing between turns or at tap-point, upon a 2¼" outside diameter bakelite tube having 3/16" thick wall. Here power is on the order of a few watts, and 10/41 Litz is adequate. In L_2, L_3 and L_4 some 50 watts of low-frequency r.f. flows at relatively high currents. This makes a large surface area upon the wires comprising L_2, L_3, and L_4 essential. This requirement is satisfied by 3/16/48 Litz for each of the three large diameter r-f inductors. L_2, 4" in diameter, is wound 55 turns, the lower 9 turns spaced ⅝" away from the upper 46 turns to provide a space upon the supporting bakelite tube in which to mount the spring bearings carrying the rotatable antenna coupling coil L_3. This coupling coil is wound with a total of 13 turns, separated into two 6½ turn sections spaced ⅜" apart upon a 3½" diameter rotor grooved to allow the wire to lie flush with its outside diameter to permit easy 180° rotation within, and tight coupling to, L_2.

L_4 is the antenna loading variometer. It has a 180° rotatable rotor similar to that in L_2, but connected in series with the outer 4" diameter winding. The outer winding of L_4 has 75 turns of 3/16/48 Litz, with ⅝" spacing between its first 20 turns and its remaining 55 turns, the rotor bearings being located in this space. L_4 is tapped at the 20th, 35th, 50th, 65th and 75th (end) turn. The inner winding is wound with 33 turns, spaced as in L_3. The taps come out to banana jacks in such manner that by shifting a plug from jack to jack anywhere from a basic 33 up to a total of 108 turns may be included in the series antenna circuit. Rotation of the rotor reduces the inductance of the basic 33 turns to almost nothing effectively, as well as providing for vernier adjustment of inductance within the variations made possible by the major plug-and-jack taps.

This type of antenna circuit is peculiar to most low and medium-frequency transmitters, though seldom found in amateur high frequency transmitters, for example. It is made necessary by the extremely long physical lengths needed to yield quarter- or half-wave antennas. Such lengths are unwieldy and difficult to erect in usually available space. It, therefore, most frequently occurs that a low-frequency antenna will consist of a single-wire leadin, the combination usually being considerably less than an electrical quarter-wave in length. Operation of such antennas is usually as a quarter-wave, current-fed radiator. This necessitates some means of loading up the too-short antenna until it "looks" like a quarter-wave to the transmitter if efficient power transfer and final amplifier loading is to be effected. The high-currents pres-

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ent under quarter-wave, current-fed conditions explain in some measure the large surface area required in the inductor windings, and in interconnection wiring.

The variable antenna coupling accomplishes two desirable results. It allows the final amplifier to be loaded up to optimum efficiency yet permits establishing coupling sufficiently below "critical" to obviate the "double-humped" tuning curve usual to over-coupled tuned circuits, a condition resulting in extreme tuning difficulty since tuning of one circuit reacts upon tuning of the second, and so a satisfactory match between antenna and final amplifier is most difficult to obtain. Tuning is effected by resonating the final amplifier to the operating frequency as set up by the oscillator in conjunction with a suitable heterodyne frequency, but with antenna coupling at minimum. Antenna coupling is then increased and the antenna circuit tuned by variation of L_1 for proper plate current-indicated loading of the final r-f amplifier. This operation involves some juggling of antenna tuning and coupling in order to produce a pure resistive antenna load as seen by the amplifier plate circuit, and as evidenced by the absence of changes in antenna tuning, causing changes in amplifier plate tuning for maximum power output. The basic technique is that of tuning any vacuum-tube transmitter, except for the over-coupled, double-humped condition possible when antenna coupling may be increased to a point bringing this deleterious and confusing reaction into being. Its possibility is usually avoided, as in this equipment, by making the antenna coupling adjustment such that over-coupling is a condition almost impossible to realize in practice.

It is hoped that the rather unusual physical construction embodied in this particular transmitter may prove a source of helpful suggestion both to other engineers, and more particularly to amateurs dreaming of post-V-day ham transmitter construction—in which metal working with other than drill and file is always a difficult problem. Examination of Fig. 1 will reveal the multiplicity of counter-sunk flat-head screws used to fasten all components to the back of the single panel. Touched up with black lacquer matching the panel finish after assembly, they present no unsightly appearance. The panel for this pretuned, fixed frequency transmitter is notably free of knobs and dials—yet all except rough antenna tuning is done upon its front face. At upper left is the ceramic antenna feed-through insulator, with along the top center, the antenna current thermo-ammeter at the left and the 0-1 milliammeter used for all tuning and checking tests at the right. The knob between these two meters is a 5-position, 2-circuit rotary switch which shifts the basic milliammeter movement from oscillator cathode current with range established at 100 ma.

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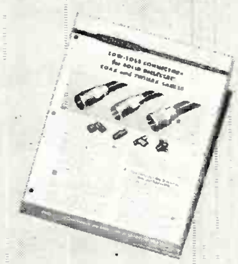

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full-scale by shunt resistor R_2, on through the amplifier grid, amplifier cathode and modulator cathode circuits to its final position in which, with a 1-megohm multiplier resistor R_{22}, it serves as 1000-volt full-scale voltmeter to check total plate voltage. The shunt resistors R_6, R_8 and R_{19} are individually hand-wound in terms of the particular type of meter employed to give amplifier grid current range of 25 ma. and amplifier and modulator plate and screen current ranges of 500 ma. full scale. It is respectfully suggested that the use of the fifth switch position to provide a means of checking plate voltage is a good guard against trouble, for power-supply trouble, for example, will almost invariably show up some variation from normal in plate supply voltage, either an increase in the presence of an open circuit or component, or a decrease in the event of a short-circuited or leaky component or circuit.

All tuning is done by insulated shaft extensions consisting of ¾" diameter polystyrene rods slotted in their flat front ends and brought through clearance holes in the panel in such a manner that they are flush therewith and can be turned only by a large coin. This discourages unauthorized tampering with tuning, yet makes it accessible upon the front panel for quick resetting to a new frequency should the need arise. These tuning controls are neither calibrated nor equipped with graduated scales, since there is no need therefor. All tuning is accomplished as previously outlined, by first setting the oscillator frequency with a heterodyne wavemeter, then resonating the three remaining adjustments by observation of the single switchable milliammeter.

Turning to the rear of the panel, the power supply is arranged horizontally across the bottom of the panel from plate transformer at right, through filament transformers and two filter reactors. A 3/16" thick bakelite panel mounted upon the unused rear holes in the transformer cases by means of four spacer tubes, screws, lock-washers and nuts carries the a-c input receptacle, remote control terminals, on-off and time-delay relays and the two 4-μfd. 600-volt oil-impregnated filter capacitors, the latter upon a small metal angle plate. This panel is mounted far enough away from the transformer terminal boards to insure adequate insulating separation, and also to permit test probes to be inserted to contact the transformer terminals directly, as in routine test and check-up.

On what might be termed the next upper horizontal line are mounted the two 866 rectifier tubes at the right of Fig. 2, while well to the left are the modulator components-modulation transformer, two 807 tubes, 6SN7GT a-f tube, microphone transformer, and, between modulator tubes, the small angle-mounted wax-impregnated bakelite terminal board on which all a-f resistors and capacitors are mounted.

At the extreme top left of Fig. 2 are the oscillator circuit components. At top is the terminal board carrying all oscillator fixed resistors and capacitors; below this the 6V6 oscillator tube, oscillator inductor and oscillator 520 μfd. tuning capacitor. To the right of the oscillator section are the paralleled 807 r-f amplifier tubes, the amplifier plate inductor with its tuning capacitor below it, and the antenna loading variometer at the right. These three inductor assemblies have been carefully disposed in such a position within the actual physical assembly as to provide zero deleterious interaction between their fields. Because of the proximity of metallic objects the fields are not as they would be in free air, but are somewhat distorted. Hence the non-symmetrical spacing and positioning illustrated becomes necessary to reduce interaction between inductor fields to a necessary minimum.

Fig. 3 illustrates the polystyrene studs used to space and insulate the inductors back from the panel, as well as the considerable separation of the inductors away from the steel panel. This substantially one-half diameter spacing between inductor ends and peripheries away from the steel panel is substantially duplicated in their spacing away from the ends and back of the steel cabinet.

Such, then, is one example of a modern medium-powered 440- to 660-kcs. radio telephone transmitter rather hurriedly designed and assembled from mostly standard commercial component parts, the design worked out for maximum simplicity and ease of servicing, yet with the handicaps of many less-than-military-specification parts largely overcome by operating all well below manufacturers' rating, and with design and finish in terms of corrosion, vibration, temperature and humidity resistance at close indeed to the most rigorous of military specifications. It is hoped that its single panel, no-chassis type of construction may give rise to profitable thought on the part of amateur constructors looking avidly forward to V-Day resumption of amateur activities.

—30—

G.I. Radio Servicing

(*Continued from page* 47)

erator. It, too, causes no end of headaches sometimes. The old standby, the transmitter, was usually the last resort in the tougher cases, especially when no signal could be detected in the speaker.

Twenty watts of carrier four or five feet away usually did the trick and after a preliminary balancing, a weak signal from any broadcast station was tuned in and the set lined up from there on. Knowing the frequencies of the stations tuned in on the set, a fairly accurate balancing job can be ac-

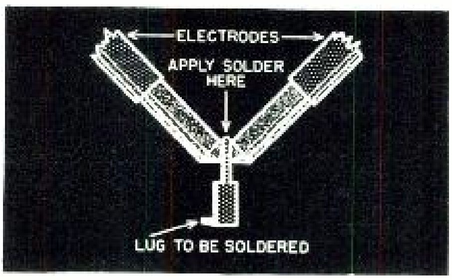

Fig. 3. Method of applying carbon electrode type soldering iron.

complished in practically no time at all.

After lining up the i.f.'s a station, preferably around 1400 or 1500 kc., is tuned in on the set and the oscillator trimmer set correctly to correspond with the frequency of the incoming signal. A check is made with a signal at around 600 kc. and if necessary the low frequency padder adjusted. Back to 1400 kc. again and then the r-f adjustment. Repeat this operation three or four times until each station comes in on the nose. In between repeats on the above operations the i-f trimmers are usually given another final adjustment just to make sure. After the fancy bit of alignment described above, the set undergoing repairs performed very satisfactorily.

One set in particular would have been very easy to repair had the tubes been available. The set, a Crosley 52TE, had three bad tubes, a 12SK7, 50L6 and a 35Z5. After considerable scouting among the local radio shops without success, the project was almost given up as hopeless. As a last resort another scouting party was formed and sent out among the barracks with instructions to return with anything containing tubes. After a most thorough canvass a small RCA was unearthed from one of the men's barracks bags and brought in as a donation to the cause. This set, incidentally, had fallen from an upper bunk into a G.I. can filled with hot water. It not being customary to give radios a bath, this one in particular objected very much and did not take it so well. It was quite a mess, but being interested primarily in tubes at the moment, the balance of the set was forgotten.

Luck was with us that day. A 25L6, 25Z6 and a 6SK7 were salvaged along with the combination line cord resistor. The 35Z5 socket connections in the Crosley were rewired in order to conform with the 25Z5 socket connections and the remaining 12.6-volt tubes were wired with filaments in parallel, as illustrated in Fig. 1. This change was necessary inasmuch as the 12.6-volt tubes draw .150-amps. filament current and the remaining 6.3-volt tubes draw .300-amps. filament current.

The total voltage drop across the tube filaments amounted to 68.9 volts and using 115 volts as a basis for line voltage, the drop across the line cord resistor would amount to 46.1 volts provided the correct resistance was available. The total drop across the

Motorola Radio "HANDIE-TALKIE" fights with CARLSON'S RAIDERS in GUNG HO!

The great story of Lt. Col. Evans Carlson and his Marine Corps raid on Jap-held Makin Island can now be seen in Walter Wanger's exciting Universal war movie. It's a four-star picture!

You'll see Motorola Radio's famous Handie-Talkie at work in battles against the Jap that add greater glory to our fighting leathernecks. The picture takes its title from the Marine battle cry, "GUNG HO," which in Chinese means "work together". That's a good slogan for everyone on the home front too!

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filaments of the tubes used in the RCA exclusive of the line cord resistor also amounted to 68.9 volts, so it was therefore obvious that the salvaged line cord resistor from the RCA could be used satisfactorily.

After completion of the necessary changes, the set was tested and it performed like a new one. Incidentally, quite a few parts were salvaged from the discarded RCA and a lot more sets put back in playing condition using those salvaged parts.

Ohm's law has been put to use constantly by the author inasmuch as tube replacements were many and varied, and identical replacements out of the question. The tools used for practically all the repair jcbs here consisted of an 8" screw driver, a G.I. knife, a small 10c screw driver, a pair of lineman's kleins and last, but not least, the acme of soldering irons. This ultra-modern model of soldering iron consisted of two carbon electrodes mounted firmly in 50 caliber cartridge cases. Two leads with battery clips attached as illustrated in Fig. 2 constituted the balance of the gadget.

With 6-volts d.c. as a source of power, the gadget does a good job of soldering after one gets used to it. Just apply both electrodes to the part to be soldered, as illustrated in Fig. 3. After a sufficient amount of heat is generated, apply the solder, letting it flow freely around the connection.

After a bit of experience with the soldering iron described herein anyone can become very proficient at the art of soldering with most any type of iron available. The gadget is also very useful for effecting repairs where current other than that obtainable from a storage battery is not available.

A point well worth mentioning at this time is the fact that a total expenditure of approximately $5.00 was all that was necessary for parts needed for repairs during the past five months. The absence of test equipment is another important point to bring out at this time. Any form of test equipment was taboo inasmuch as the availability of said equipment was impossible. Practical experience, ingenuity, and a lot of good common sense, plus the small amount of tools previously described, summed up the total amount of test equipment on hand.

In the Army, one usually learns to do a great many things with practically no assistance from tools and equipment. At some later date when the shells are whining overhead and the bombs start falling and a near miss wrecks the receiver or transmitter, then the author will thank his lucky stars for that experience gained from repairs on sets without the use of elaborate equipment and an abundant supply of tools.

In closing the author would like the following brief message conveyed to all the radio servicemen throughout the country. The greater percentage of you radio servicemen are doing a swell job on the home front; some of you are not. Most of you charge your customers a fair price for your services; that is only in fairness to you and you deserve a fair price for the work you do. Some of you charge beyond reason, far beyond the limit of the service you render to your customers. Most of you do good work and keep your customers satisfied. Some of you are sloppy in your work and your customers are always dissatisfied. It all boils down into two categories: technicians and tinkerers.

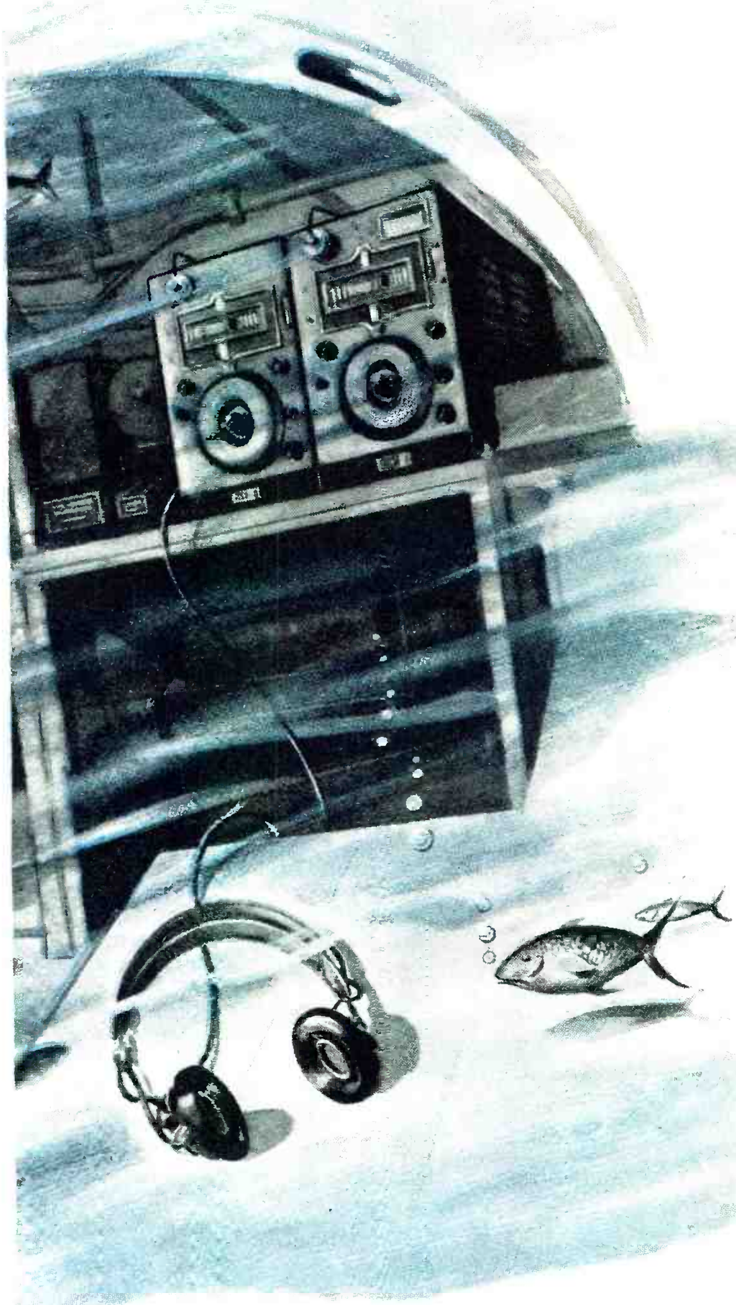
The technician knows his radio; the tinkerer tries to make people believe he knows it. Are you a technician or a tinkerer? If you are a tinkerer it is about time you awakened and crawled out of your cradle and learned to walk. If you are a technician there is always room for improvement. To both technicians and tinkerers remember this one important thing, your customers and not you will decide whether or not you stay in business when this war is over and the peace is won. So take a tip from one who knows from experience, keep your customers happy and you keep your business and vice-versa.

Note: The tools mentioned in this article are not representative of those used in the Army in the line of duty. Any type of tool or equipment is available but for repairs on G.I. equipment only and not for personal use.

-30-

3 MONTHS IN DAVY JONES' LOCKER

—*And this radio still worked!*



For three months, a radio receiver and transmitter lay at the bottom of the sea. It was part of the equipment of a plane that had accidentally plunged into the ocean during a test.

After three months under water, the radio was brought up and tested. What was found may seem unbelievable, yet it's a matter of record. After the sea water had been drained out, the radio set still worked perfectly.

Unfortunate as the attendant circumstances of this "case history" may be, they afford concrete proof of the invaluable properties and qualities of General Ceramics and Steatite Insulators used in this set.

The fact that Steatite is absolutely impervious to moisture and has no cold flow properties are among the reasons why Steatite is specified by the U. S. Army and Navy.

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We're just little people

We're not brass hats.
We're not big shots.
We're just plain folks . . . but
We're the folks who made this country!
And we're the folks who will save it!

Save it from *two* things it's *got* to be saved from now. The first thing is the Enemy. The second's something that doesn't look very dangerous, but is. It's the danger of Prices Getting Out of Hand.

Here we are this year—after we've paid our taxes—with 131 billion bucks in our pockets. But only 93 billion dollars' worth of goods to buy. That leaves 38 *extra* billion dollars.

Sure, the easy thing to do is to take that 38 billion and start running around buying things we don't need, bidding against each other . . . forcing prices up and up!

Then people want higher wages. Then prices go up some more—and again wages go up. So do prices again.

And then where are we!

But us little guys—us workers, us farmers, us businessmen—are not going to take the easy way out.

We're not going to buy a single, solitary thing that we can get along without.

We're not going to ask higher wages for our work, or higher prices for the things we sell.

We'll pay our taxes willingly, without griping . . . no matter *how much* in taxes our country needs.

We'll pay off all our debts now, and make no new ones.

We'll *never* pay a cent above ceiling prices. And we'll buy rationed goods only by exchanging stamps.

We'll build up a savings account, and take out adequate life insurance.

We'll buy War Bonds until it pinches the daylights out of our pocketbooks.

Heaven knows, these sacrifices are chicken feed, compared to the ones our sons are making.

Use it up . . . Wear it out.
Make it do . . . Or do without.

HELP US KEEP PRICES DOWN

A United States War message prepared by the War Advertising Council; approved by the Office of War Information; and contributed by the Magazine Publishers of America.

Radio Oscillators
(*Continued from page 62*)

possible, try substituting a new tube.

3. Make a routine check of tube voltages d-c resistance of oscillator coil and grid leak resistor.

4. Check tuned circuit impedance as described previously.

5. If the tuned circuit impedance is low, disconnect the variable condenser and test with a high resistance ohmmeter. If it is leaky, clean the insulation with carbon tetrachloride and burn out any burrs with high voltage. Blow dust from between the plates with compressed air.

6. Reconnect condenser and recheck impedance. If high, the set is likely to be all right. If not, the trouble is probably in the coil.

7. To test the coil itself, refer to Fig. 13.

A. If the circuit of Fig. 13 is used, disconnect point 5 and connect a test oscillator across points 1 and 2.

B. Connect Chanalyst across points 1 and 2. Read the voltage on the VTVM.

C. Connect the Chanalyst to points 3 and 4. Tune the variable condenser to obtain resonance. If the voltage here is very little more or if it is less than at points 1 and 2 then the coil is at fault.

D. If there is a good voltage step-up then the coil may be all right even though it has a low impedance. The rest of the circuit should be carefully tested.

E. Reconnect point 5 and connect the test oscillator between points 4 and 5. With the Chanalyst read the voltage at point 5. Next, measure the voltage at point 6. The voltage readings should be approximately the same. If it is considerably less at point 6 than at point 5 it indicates an open C1 or a short between point 6 and ground.

F. After tests have been made and any trouble remedied; disconnect point 3 and 5 and connect osc. to point 5. Read the voltage at point 3. If the voltage at 3 is as great or greater than at point 5 then the set will oscillate when reconnected.

8. If the circuit is as shown in Fig. 14, proceed as above, except points 3 and 2 now act as the primary circuit in place of points 1 and 2 in Fig. 13.

Tuned Circuit Impedance Data

PHILCO MODEL 40-90—A-C impedance of circuit at resonance
1100 kc. ....35,000 ohms
1700 kc. ....45,000 ohms

RCA MODEL 94 BT—Oscillator coil secondary impedance
1100 kc. ....20,000 ohms
Antenna coil impedance
600 kc. .... 20,000 ohms
1500 kc. ....120,000 ohms

TRUETONE MODEL D-731—Oscillator coil impedance
1100 kc. ....22,500 ohms
1700 kc. ....43,300 ohms
Antenna coil impedance
600 kc. ....15,800 ohms
1500 kc. ....15,000 ohms

EMERSON AC-DC SET (See Fig. 15)—Oscillator coil impedance
1100 kc. ....11,000 ohms

Notes:

In the Philco circuit shown in Fig. 16 the signal generator was connected between points 1 and 2. The Chanalyst was connected to the same points and the vacuum-tube voltmeter was connected to read the output of the Chanalyst. With the generator set for maximum output and the Chanalyst for maximum sensitivity, the vacuum-tube meter read 3 volts. When the circuit was tuned to resonance, 16.5 volts was developed between points 3 and 4. The voltage stepup of this circuit is then 5.5.

In the Emerson diagram in Fig. 15, if an r-f voltage of .7 were applied to points 1 and 2, there would be 13 volts developed between points 1 and 3.

By a systematic approach to oscillator testing, even the worst cases can be solved. However, a good set of test equipment is necessary to simplify the test procedure.

If this system of testing gains recognition it may be that in the future the manufacturers will include in their service data such items as coil impedance, voltage stepup, etc., to simplify the serviceman's problems.

Testing of i-f coils, whose d-c resistance may check correctly, but which have low gain when used in a circuit, is also possible. For example, a 455-kc. i-f transformer was checked and its impedance at resonance measured 764,600 ohms. A coil having shorted turns or which had absorbed moisture would show considerably less impedance due to circuit losses.

—30—

QTC

(*Continued from page* 46)

and was formerly employed by Petroleum Navigation Co.

WELL, at last some good news has been received regarding an old wage dispute. ACA announced recently that the National War Labor Board had finally handed down a Directive Order in its two and one-half year old wage dispute with eight major tankship companies. The ruling of the Board provides for the payment of over $14,000 to some seventy of ACA's men in retroactive wages. The order also requires the eight companies to adjust wages from $170 to $178.25 per month, which was payable retroactive to March 1, 1942.

PROBABLY many are not aware that radiomen have already been given high honors for their deeds during the present war. Last fall, Richmond, California, saw the launching of the S. S. Lawrence Gianella, first Liberty ship to be named in honor of a radio officer of the U. S. Merchant Marine. Gianella was also awarded the President's Distinguished Service Medal posthumously; he was the fourth radio officer to receive the medal.

PHIL KENNEDY was in at an East Coast port recently aboard a Liberty. Al Murray has taken out a tanker as has G. Brady. C. Amato has gone into the Signal Corps. J. Williams is out on a new cargo vessel job. E. Waters and R. Hopeland are both out on new freighter assignments. M. Gordon is ashore awaiting a berth.

HARRY A. MORGAN, Vice President of the American Communications Association Marine Department, announced recently that arrangements have been made to have legislation introduced in this session of Congress which will legally establish Merchant Marine Radio Officers as licensed officers aboard ship. Morgan stated that "Radio Officers have enjoyed the title by virtue of agreements held with 141 steamship companies on the east, west and gulf coasts by the ACA for several years; however, all Radio Officers desire to have Congress legalize their status through the

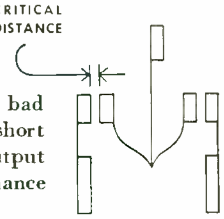
Precision Production Means Careful Inspection, Too

Common Errors in Attempted Vibrator Repairs

If you are thinking about tearing that vibrator out of the can and "working" on it, beware! Remember that individual parts of the vibrator mechanism are selected to operate with each other—adjusted to give maximum voltage output for the longest life. When contacts wear to the point of failure, attempts to bend or rework springs and arms can never return the vibrator to efficient operation.

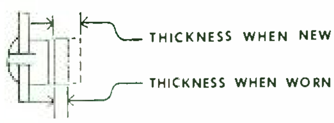
1

SPACING



If too close, arcing and bad wave result in noise and short life. If too wide, low output voltage and poor performance can be expected.

2



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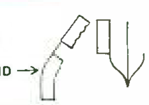
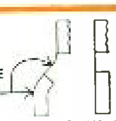


ATTEMPTED REPAIRS BY BENDING REDUCE CONTACT AREA

4



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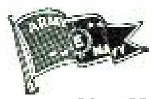

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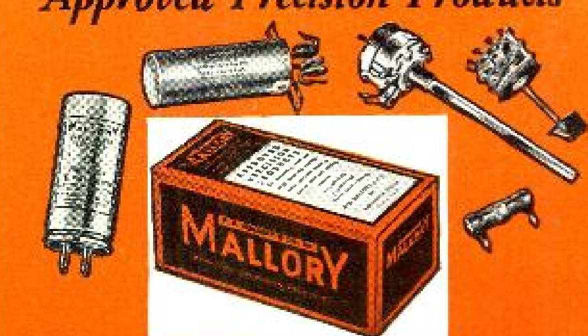


proper legislation. By this," Morgan continued, "we do not mean 'staff officer' status, rather, we mean the same status as provided by Congress for the other duly licensed officers." It is expected that ACA will receive the full support of all radio officers toward having such a bill introduced before the House of Representatives. Morgan pointed out that this would be the third time that the ACA has had such legislation introduced for this purpose and that he is hopeful of success, but that it would depend upon the efforts of every individual radio officer to get behind and help push the bill through, saying that "We may very well expect opposition to our proposal from certain quarters, however, the American people are cognizant of the heroism of radio officers in war and in peace—the devotion of the American radio officer to his duty, oft times, giving his life, as the record will show, that others may survive disasters."

WAR Shipping Administration's new regulations requiring three operators on all vessels will require many more radio officers than are at the present time available. Despite the fact that in the early part of 1944 there were large numbers of men ashore waiting for berths, the new demands will far offset the number of men on hand. The Maritime school at Gallups Island is still turning out radio ops but these likewise will not be enough to fill future demands, as each new vessel requires three operators in addition to putting extra men on the present ships. The total required will be several hundred, in addition to those already available. If you are ashore and available, your services are needed in the merchant marine . . . ex-marine operators, old timers from way-back-when are urged to return to the merchant marine as radio operators will be required to maintain the additional ships and watches specified under these new regulations.

ACA marine department held its 7th National Marine Department Conference in Kansas City, Missouri, during late March. Hope to have some dope from this meeting next issue regarding airways men, which was an important topic at the meeting. 73.

—30—

Practical Radio Course

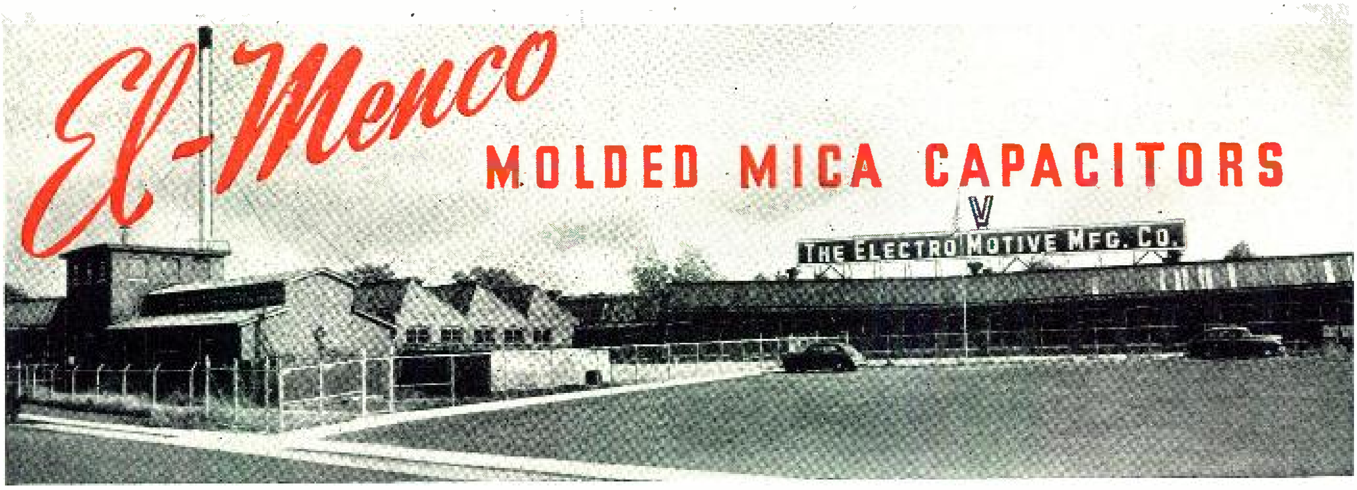
(*Continued from page* 39)

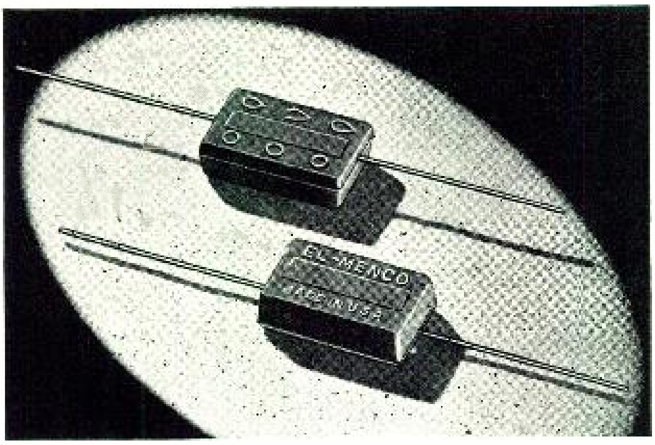
This is wave-form (harmonic) distortion. Since the harmonics due to this distortion, when fed back, are in phase-opposition to the input signal, the action is to reduce the harmonic components in the output signal, and consequently the harmonic distortion. Hence, only the plate circuit waveform (harmonic) type of distortion is reduced by this method of degeneration, and for the expected reduction to result, the ideal conditions of resistive load must exist. Frequency distortion is *not* reduced by it.

Another disadvantage is that variations in frequency response due to the output transformer or coupling network, as well as to variations in load impedance caused by the non-linear impedance characteristic of the speaker, do *not* affect the feedback voltage, since their distortion components appear *beyond* the plate circuit. Hence, they are not corrected by this method of feedback.

In some types of amplifier circuits, notably resistance-coupled *voltage* amplifiers, frequency distortion and discrimination due to the plate coupling network is negligible over the operating range and in such cases cathode degeneration can be used to provide a simple and effective method of reducing the only other important distortion—that due to nonlinear operation of the tube. However, since in *power* amplifiers the frequency distortion and discrimination in the plate coupling network is usually of serious importance—especially at or near maximum power output—cathode degeneration is seldom used in them.

Another important characteristic of cathode degeneration is that it *increases* (unlike plate degeneration) the apparent plate resistance of the output tube. This is so because an *increase* in plate voltage increases the plate current, causing the degenerative voltage drop across the cathode bias resistor to *increase*. In this case, however, increased feedback voltage means a more *negative* grid, which





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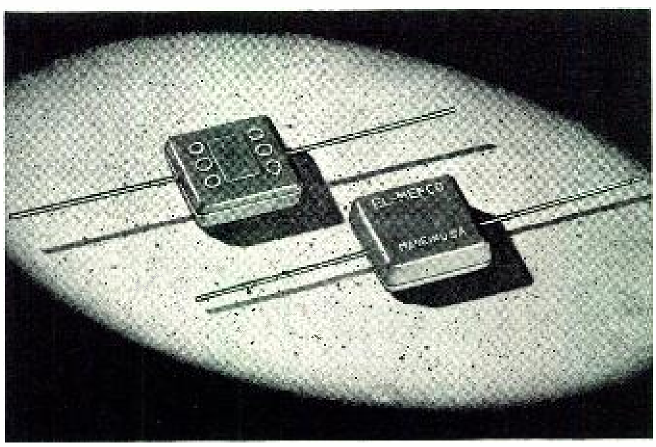

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tends to *reduce* the plate current. Thus a larger increase of plate voltage is necessary with cathode feedback to produce the same change in plate current that is necessary without the feedback. Obviously the apparent plate resistance R_p of the tube is therefore effectively *increased* by the feedback. We have learned previously that increase in plate resistance of the output tube means less damping of the speaker by the tube, with the result that transients and hang-over effects at the resonant frequency of the speaker are accentuated (among other things). The practical effect of this on a power amplifier driving a loudspeaker is illustrated by the output characteristic labeled "with constant-current degeneration" in Fig. 3.

A further disadvantage is the obvious one that since the cathode resistor is part of the load circuit, some of the audio signal power is dissipated in it (in proportion to its relation to the total load). Hence the power output is somewhat reduced. In single-tube operation, cathode degeneration will reduce the plate circuit (harmonic) distortion of a beam power tube to approximately one-half its normal value, while the required grid input signal will be *doubled* and the output power reduced about 10 per cent by the signal power loss in the cathode resistor. Also, since a certain definite value of bias resistor is required to bias the tube correctly, this arrangement does not allow the amount of feedback to be readily regulated.

Of course hum is reduced, and the gain stability is increased, making it independent of supply-voltage variations and tube gain. Cathode regeneration has, of course, the advantage of simplicity and low cost (an actual saving of the cost of the usual cathode bias condenser).

The foregoing disadvantages listed should not be taken as a condemnation of all circuits degenerated in this manner, as there are applications where the use of the load in the cathode circuits is desirable and beneficial. For example, the removal of the by-pass condenser will not cause the amplifier to oscillate; hence, cathode-resistor by-pass condensers can be removed from several voltage amplifier stages with consequent improvement in stability and decrease in distortion. Also, because of the higher effective plate resistance of the tube, less filtering is required in the plate circuit for a given hum level. However, such applications usually do not include those where *output* stages of amplifiers feeding loudspeaker loads are concerned (*power* amplifiers).

The possibilities of designing cathode degeneration for frequency discrimination should be mentioned. If the cathode resistor is by-passed by the proper low value of capacitance, the high frequencies will not be degenerated as much as the low frequencies. This makes the inverse feedback *frequency-selective*. This may be a useful design feature where low-frequency accentuation is desired and the attendant increase in harmonics is not objectionable. It may be combined with capacitance-coupled constant-voltage feedback specially designed to produce just the opposite characteristic, that is, the low frequencies are not degenerated to the same extent as the high frequencies. A combination "bass" and "treble" tone control results.

Constant-Voltage Inverse Feedback

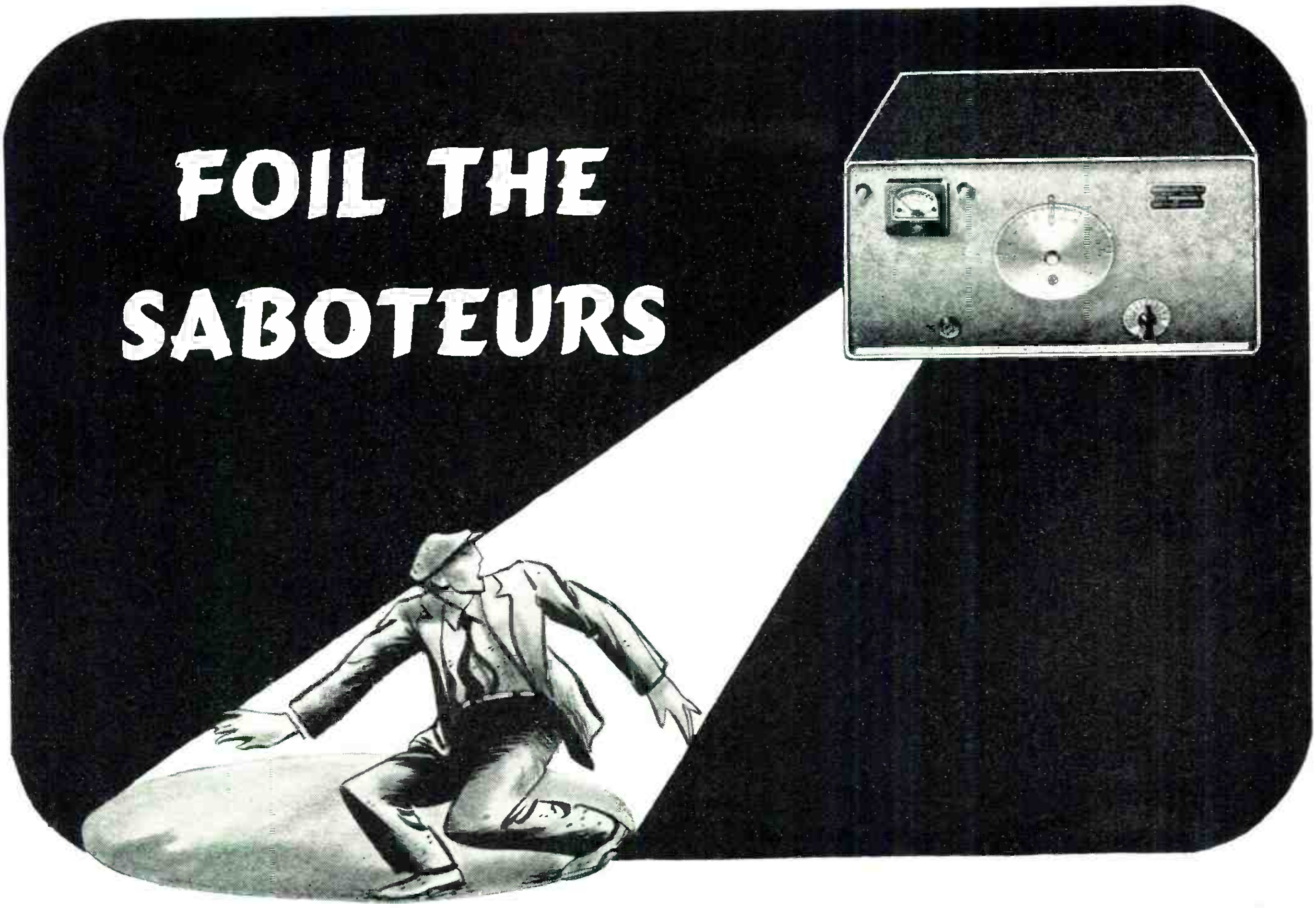
In the constant-voltage system of inverse feedback the feedback voltage is made proportional to the output signal *voltage*. This output signal voltage may be that developed across a plate-circuit resistor, that across the primary of an output transformer, or that across the voice-coil winding of an output transformer (see Fig. 2). In this system of degeneration, any variations in frequency response and load impedance will appear as components of the feedback voltage, and therefore are corrected. The feedback also has the effect of lowering the apparent plate resistance of the tube, as explained previously in Part 21 (March issue) of this series, so that in the case of a pentode or beam-power tube, the advantages of a triode are approached without losing the benefits of the high-power sensitivity and power-output capabilities of the pentode and beam-power types.

The practical effects of this upon loud speaker damping are illustrated in Fig 3. Moreover, due to the reduction in distortion obtained, the addition of a satisfactory degree of feedback (around 10 to 12 db) increases the *undistorted* power output that can be obtained from a given tube type.

With constant-voltage feedback, then, all of the advantages of constant-current feedback, plus the additional benefit of improved frequency response, are obtained. These make it the most frequently used type of inverse feedback arrangement especially when applied to the power amplifier stage.

Methods of Obtaining the Feedback Voltage

In the constant-voltage system of inverse-feedback, the feedback voltage may be obtained from the output circuit in several ways as indicated in Fig. 2. At (A) it is taken from the plate of the tube, the flow of direct current being prevented by an isolating capacitor C_F of sufficiently large capacitance value to prevent frequency discrimination over the working band of frequencies (unless such frequency discrimination is especially desired). Since the plate voltage *decreases* when the grid voltage *increases* due to the signal, this arrangement provides the correct phase for inverse feedback. When the feedback voltage is obtained from the primary



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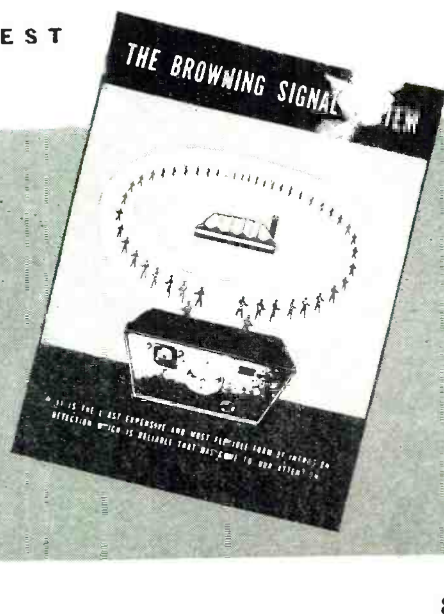

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of the output transformer in this way, the feedback tends to maintain a constant voltage across the primary, and the voltage across the voice coil falls, due to leakage reactance in the output transformer. However, since the primary connection does not introduce a phase shift in the feedback circuit, the feedback voltage should be obtained from the primary of the output transformer when good stability is necessary.

One disadvantage of this arrangement lies in the fact that with it the distortion and frequency response of the output transformer have little or no effect on the feedback voltage. Consequently, the circuit compensates only for frequency discrimination due to the tube itself and tube distortion. It does not counteract the falling off at the high frequencies due to the leakage reactance of the output transformer.

At (B) the feedback voltage is taken from the secondary (voice coil circuit) of the output transformer, but of course this requires that the load impedance be high enough to develop the required feedback voltage. When taken from the secondary the feedback voltage acts to counteract frequency and also amplitude distortion due to the output transformer. In addition, when the signal voltage across the voice coil rises above or falls below a certain value, the regulating action of the circuit compensates for abnormal output voltages. But this connection is not as good as the first one for stability. The leakage reactance of primary and secondary of the output transformer shift the phase of the voltage across the secondary at high or low frequencies, which tends to make the circuit oscillate. Thus, obtaining feedback from the secondary of the output transformer improves frequency response and increases the tendency toward oscillation. However, this is not usually serious.

Series and Parallel-feed Constant-Voltage Feedback Circuits

There are two general types of constant-voltage inverse feedback circuits, *series*-feed and *parallel*-feed. In the series-feed type, a portion of the output voltage is applied in *series* with the input signal; in the parallel-feed type a portion of the output voltage is applied in *parallel* with it. The parallel-feed type of inverse feedback circuit is often more simple and more economical than the series-feed type. However, as we shall see, there are several factors which limit the extent to which it can be employed.

Practical Consideration When Applying Inverse Feedback to Conventional Amplifier Circuits

Inverse feedback from output to input may be effected over a number of different paths, as shown in Fig. 4. A variety of circuit arrangements have been developed for applying feedback in these different ways in various types of amplifiers. The particular feedback arrangement employed in any case depends upon the type of amplifier circuit involved, the elements contained within the feedback loop, and the results it is desired to accomplish.

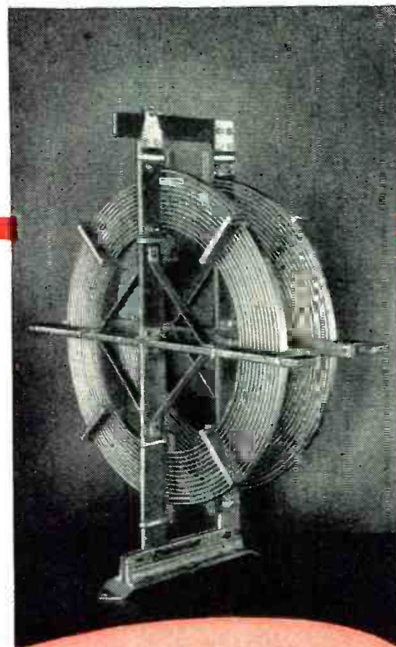
Contrary to a widespread misconception, degenerative feedback may be applied effectively to all types of tubes (whether they be of triode, tetrode, pentode or beam-power design) operated as either Class A, AB_1, AB_2, or B amplifiers. However, it is used most often in connection with pentode and beam-power type power amplifier tubes where the load on the tube is a loudspeaker, because it tends to minimize many of the inherent undesirable operating characteristics of such tubes (such as high plate resistance, large third-harmonic distortion, etc.). Furthermore, it is much less useful with power triodes than with the other tube types, for the gain of the former is already low, and cannot well be further reduced by the application of degeneration. At present, the chief advantage of inverse feedback in audio amplifiers is to give a pentode or beam-power tube a performance which approaches that of a triode as regards quality of reproduction.

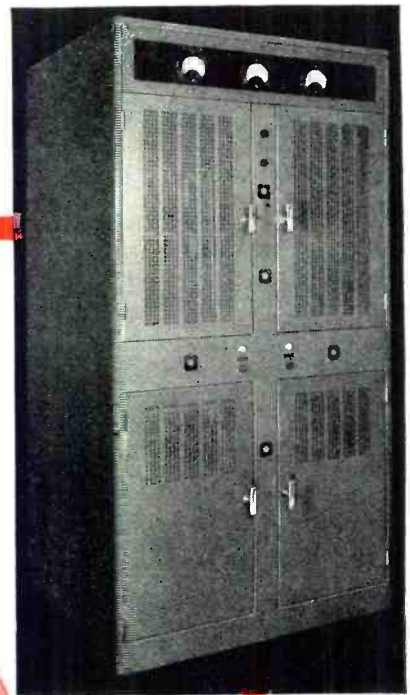
Furthermore, inverse feedback is applicable to either single tube or push-pull amplifier stages and may be employed so as to include one, two, or more stages of amplification. Since the distortion and other undesirable effects that degeneration is intended to correct occur mainly in the power amplifier stage, that stage is usually included in the feedback circuit. In other words, the feedback voltage is obtained at the *output* of the amplifier and fed back an appropriate number of stages, always in such a manner as to be suitably out of phase over the operating frequency range with the signal voltage existing at the point in the amplifier to which it is returned.

Before applying negative feedback to an amplifier circuit the things it is to accomplish must be decided upon, for this will determine at once whether constant-current or constant-voltage feedback (or both) is to be used. The former is readily and cheaply achieved by leaving off the by-pass condenser across the grid-bias resistor in the cathode lead (Fig. 1). While this reduces the amplitude distortion, it will actually *increase* the frequency distortion when the load consists of a loudspeaker, for it has the effect of *increasing* the apparent plate resistance of the tube. It also has the disadvantages of causing a signal power loss in the bias resistor and of not allowing the amount of feedback to be readily regulated.

On the other hand, constant-voltage feedback *decreases* the apparent plate resistance and will therefore reduce *both* forms of distortion in pentode and beam-power stages (see Fig. 3).

Furthermore, in applying negative feedback to a circuit it is necessary to make sure that the phase relation





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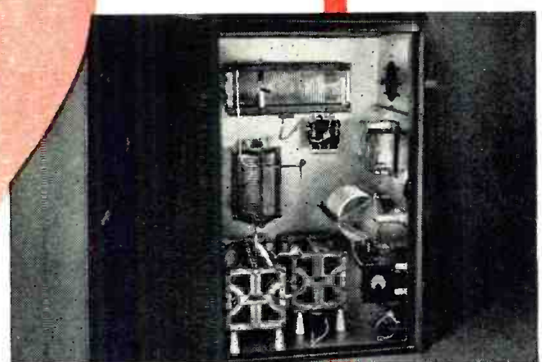

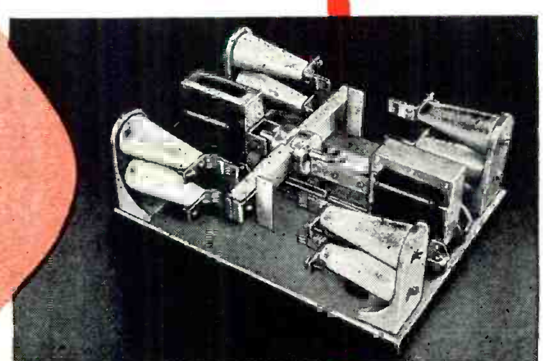

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E. F. JOHNSON COMPANY • WASECA • MINNESOTA between the feedback voltage and the input signal voltage at the point where the feedback is introduced is correct —and that it will remain so over the operating-frequency range. Then, too, such things as whether the feedback circuit itself is to have no frequency discrimination, or whether it is to provide also high-frequency or low-frequency (or both) tone control, etc., must be known.

What has been said here previously about oscillation caused by inverse feedback must also be kept in mind. It is generally possible to use feedback over two stages without running into serious oscillation difficulties, but it is somewhat dangerous over three, especially when some of the stages are transformer-coupled, because the large phase shifts in the transformers can cause oscillation at the high or low-frequency ends.

—30—

Radiomen in Iceland

(*Continued from page* 37)

before it can penetrate the field in full force. This is offered as the reason for peculiar effects caused in distant parts of the world by the lights, the signal being reflected back and a double signal effect given. That portion of the signal being received at the listening post in the center of this field will therefore be weak and tend to have a peculiar sound. A description of this sound would probably be a rapid fading, so fast it will actually modulate the signal as though an audio frequency is causing variation. Substantiating this fact, and connecting the "enemy," is the action of the northern lights as they shoot across the sky in great speeds, changing directions and colorings. The intensity of the light with reflections and harmonics of variation give the color.

Number two of the defects is that the incoming signal is overridden by an alien signal which does not seem to have any definite frequency. This has been attributed to a high or stratospheric light, whereas the other effect is the result of lowhanging lights. In both cases, of course, the lights emit harmonics that are strong enough to interfere in the radio frequencies (not very-high frequencies).

Of the two types of northern lights that for elementary purposes are classified as "low ceiling" and "high ceiling," you may always observe one of them, but seldom both of them at the same time.

In well over a year of observation, I have seen the combination twice. There is, however, a freak cloud effect that may cause a "reflect" from the stratosphere type light.

On this particular night I was looking at the "reflect." It must have been near midnight. I went inside the hut to hook up an extension for my headset in order to see and hear at the same time, what reaction my radio set had to interpret—and the set did bear out what I saw.

The more I looked at this "reflect," the more realistic a shape it took as that of an "angry dragon, writhing its luminous body about the fleeing clouds as if swallowing or absorbing radio waves." The body of this dragon acted in the same manner as gas that flickers in a neon tube when it is lighted. The radio receiver responds to the effect of this "flicker." Its disappearance was as dramatic as its appearance.

The "reflect" type of northern light seems to be attracted to radio towers. It is the worse enemy we have encountered here so far, and is also the most effective. Here is a reason why the "cw" operator must be good, and above all have patience—the effect lasts from a few seconds to as long a time as seventy-two hours.

The stratosphere type of northern light is not as effective as its reflect—it does not seek out radio towers and does not move about the sky, staying fixed at a certain position, usually northeast of the North Star. It is really a most pleasant sight, among the many to be noted in Iceland where even the aforementioned star displays unusual brilliance and reveals itself in swiftly changing hues of silver, amber, purple and green, all in perfect timing over a two hour period.

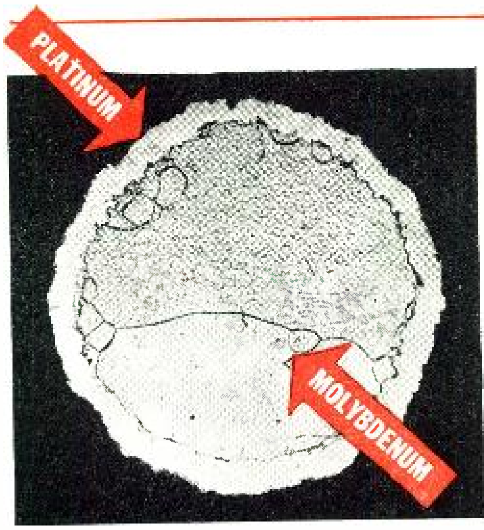
One advantage the "cw" operator has here in Iceland, is that he can forecast his weather conditions, that is, by listening in the earphones and tuning in that certain station for oscillation adjustment. The faraway station must have high fidelity of tone and stability of signal; the operator must be "born," that is, he must have a sharp ear in order that he may make his decision comparing the readability of the signal strength and pitch and the behavior of oscillations.

Referring again to the North Star and the rest of the larger stars here, they can be seen in plain daylight like flakes of snow, just as visibly as in the night time. The rainbow has another unusual appearance here. It will appear at almost any time of of the day. It can be seen fully in its complete arc from one point of the arc to the other with no distortion in its color effect whatsoever.

It seems to me that all of these changes that occur here to celestial bodies are due to the locality of the island, remembering that this part of the world touches the North Arctic Circle.

Many years ago Iceland suffered a volcanic eruption. Previous to that eruption, vegetation flourished in abundance. This eruption left an upper layer of iron and other metallic substances in such large quantities that today the island is practically left without any vegetation; all that is left is a vast naked plateau with its valleys, ridges, lakes and streams.

U-H-F Tube Stability



Photomicrograph of cross-section of platinum-clad molybdenum wire, enlarged 255 diameters, developed by RCA to provide better grids for u h f tubes. The sample, taken from a tube after operating 1,000 hours at full rating, shows how the platinum sheath still protects the molybdenum core. The core shows the crystalline structure characteristic of "moly" wire which has been operated at high temperature.

Operator making photomicrograph of grid wire. Photomicrographs are one of the methods which RCA engineers use in their continuous search for better tube performance for the ultimate user.

PERFORMANCE STABILITY in a tube is something you normally expect and take for granted today.

But in ultra-high-frequency tubes, stability becomes a problem.

For example, a few years ago instability in an experimental u h f tube was traced to grid emission. RCA engineers knew that platinum on the grid would reduce grid emission to negligible amounts, but the problem was how to apply the platinum successfully.

The method first tried—platinum plating—did not fill the bill. There was too much uncertainty in the plating process, and the best efforts of our engineers in trying all kinds of baths, concocting new ones, developing quick test procedures, failed to solve the problem. More tests. More months. "Try other metals . . . try sandwiching nickel between platinum . . . try drawing it cold, then hot, instead of swaging it."

At last they had it: *a drawn platinum-clad molybdenum* grid-wire — the "moly" base for strength and heat conductivity, but sheathed in platinum to prevent grid emission. This combination worked so well that RCA's process was immediately made available to the entire industry, at the suggestion of the Services and the War Production Board.

Next time you look at an RCA-829-A, RCA-829-B, or an RCA-832-A, notice the very fine grid wires inside — wires that measure only a few thousandths of an inch in diameter. Then, think of the technical skill and "know how" required: first, to draw the original ¼-inch rod, including platinum sheath, down to so small a diameter and, at the same time, maintain a layer of protective platinum only a few ten-thousandths of an inch thick on it, then to fashion it into grids, and finally to assemble the grid inside a tube to deliver what you expect as a matter of course—*stable operating performance* throughout the life of the tube.

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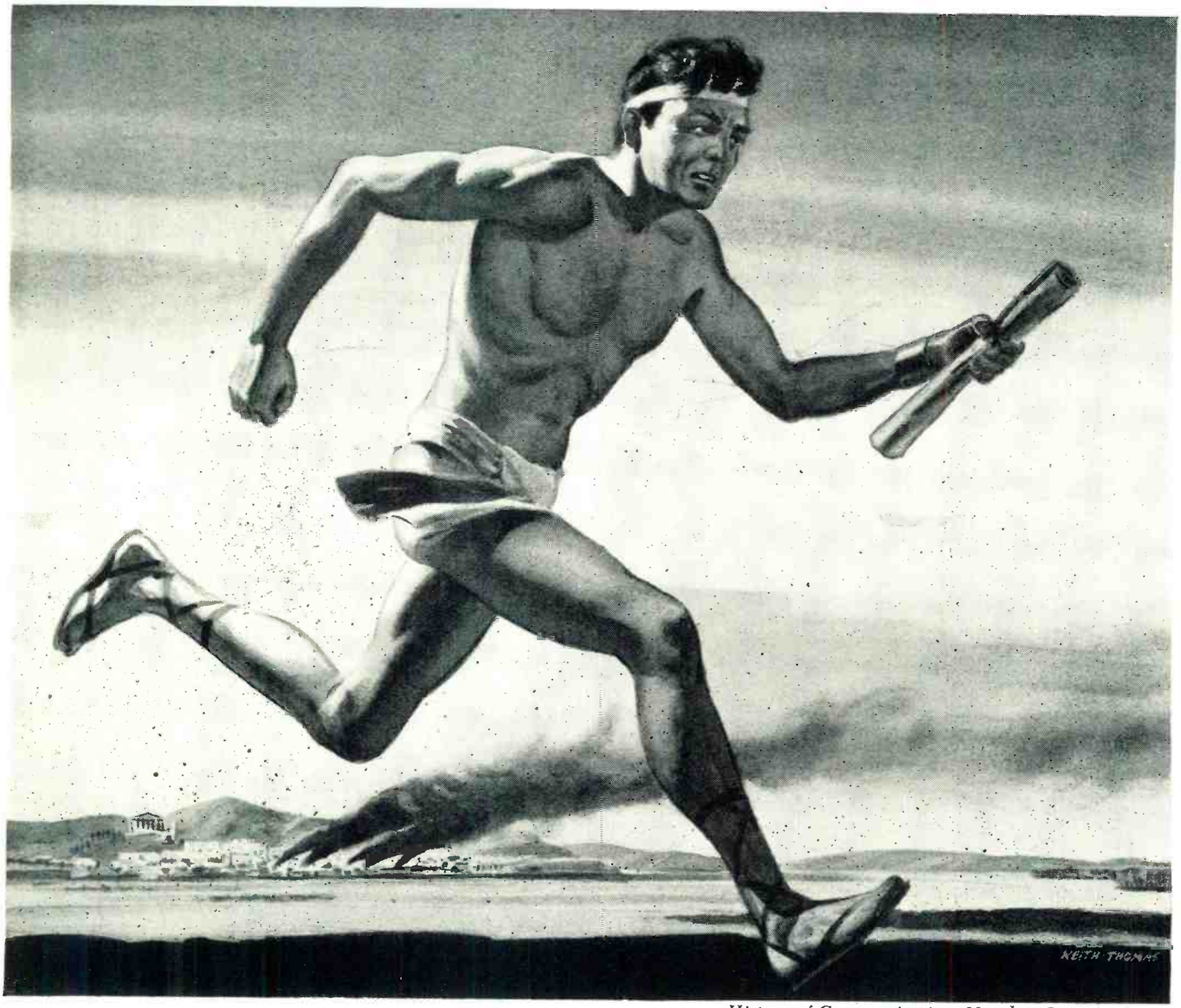

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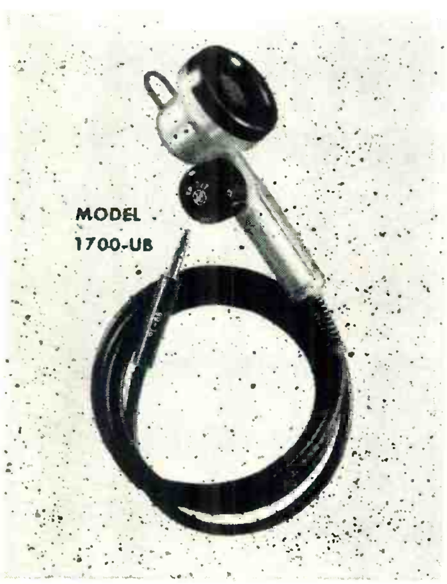

One of the first known channels of message carrying was by runner, and annals of Grecian and Phoenician history describe the nimble lads who firmly grasped rolls of parchment and sped hither and yon. Clad in typical running gear of the period, they covered amazing distances with almost incredible speed. That was the forerunner of today's modern communications where scientific electronic devices are "getting the message through" on every war front. Universal Microphone Co. is proud of the part it plays in manufacturing microphones and voice communication components for all arms of the United States Armed Forces, and for the United Nations as well. Other drawings in the series will portray the development of communications down through civilization and the ages to the modern era of applied electronics.

< Model 1700-UB, illustrated at left, is but one of several military type microphones now available to priority users through local radio jobbers.

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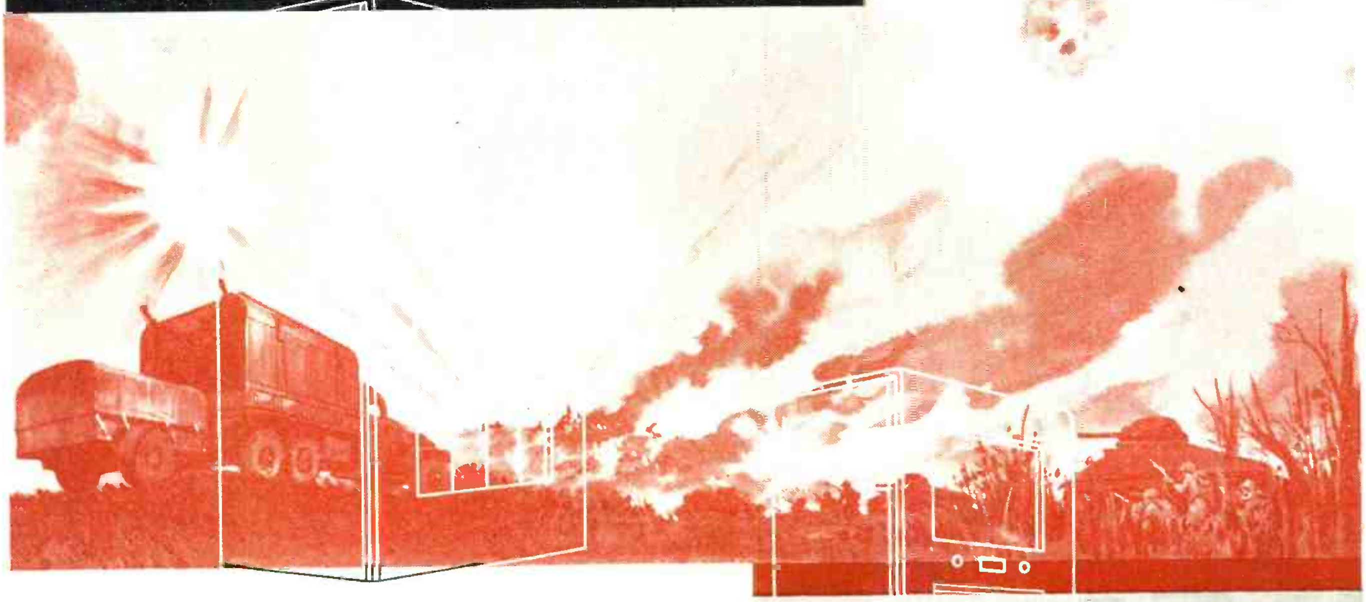

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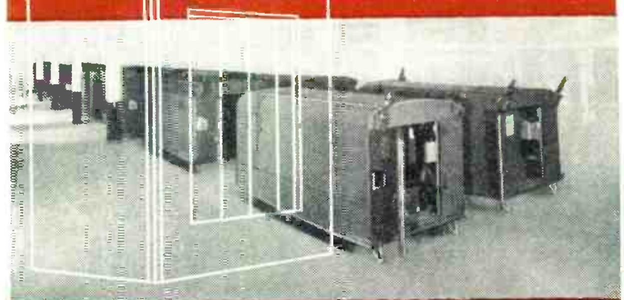

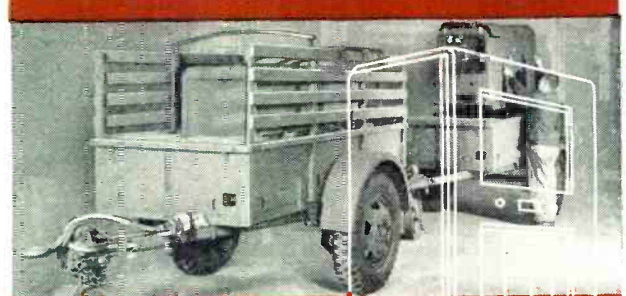

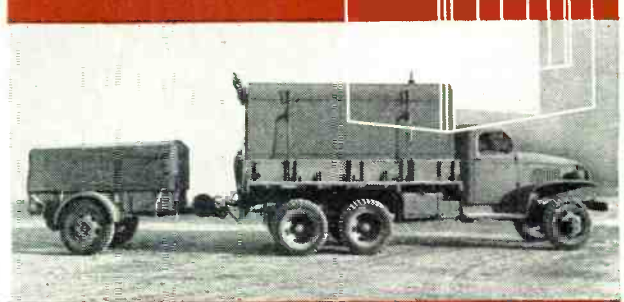

War's demands for better weapons have added mightily to the progress of radio. Here at Detrola we are in the forefront of it. Detrola engineers are giving their knowledge and experience to the perfection of new and finer electronic equipment. Detrola production workers are learning and employing new short cuts in the mass manufacture of quality products. Our work today is providing us with ideas for a great variety of postwar radio-electronic devices . . . and new ability to translate them into products of finest quality. *Every War Bond You Buy Helps Bring Victory Closer. Buy Another Today.*

DETROLA RADIO

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Who can tell? Maybe Iceland previous to that eruption was the ideal place for radio reception. Perhaps this large layer of iron and its other metallic components and the locality of the island, so near to the magnetic North Pole and the northern light effect, help to make Iceland the nightmare of the "cw" operator.

While the topic discussed herein is not entirely scientific nor a conclusive answer to a long bothering type of interference, these observations are passed on in the event they be of interest to those who follow the waves in comparative calm and uninterrupted leisure.

Of course, to those whose idea of our climatic conditions is one of expectation and doubt as to just what the actuality is, the various celestial performances more than outdo any concept. That they provide unknown and difficult problems in addition for the ordinary radio operator is also well to note.

—30—

Mfrs.' Lit.

(*Continued from page* 62)

now available for general distribution.

Complete information and technical data on phototubes, rectifier tubes, and thyratrons, is included in handy and easy-to-use form for ready reference.

While tube delivery is on a priority basis at the present time, this catalog gives information on tube characteristics which may be utilized by the non-priority user.

This catalog is available without charge. Requests should be addressed to *Continental Electric Company,* Geneva, Illinois. Specify catalog No. RS.

ELECTRONIC CONTROL

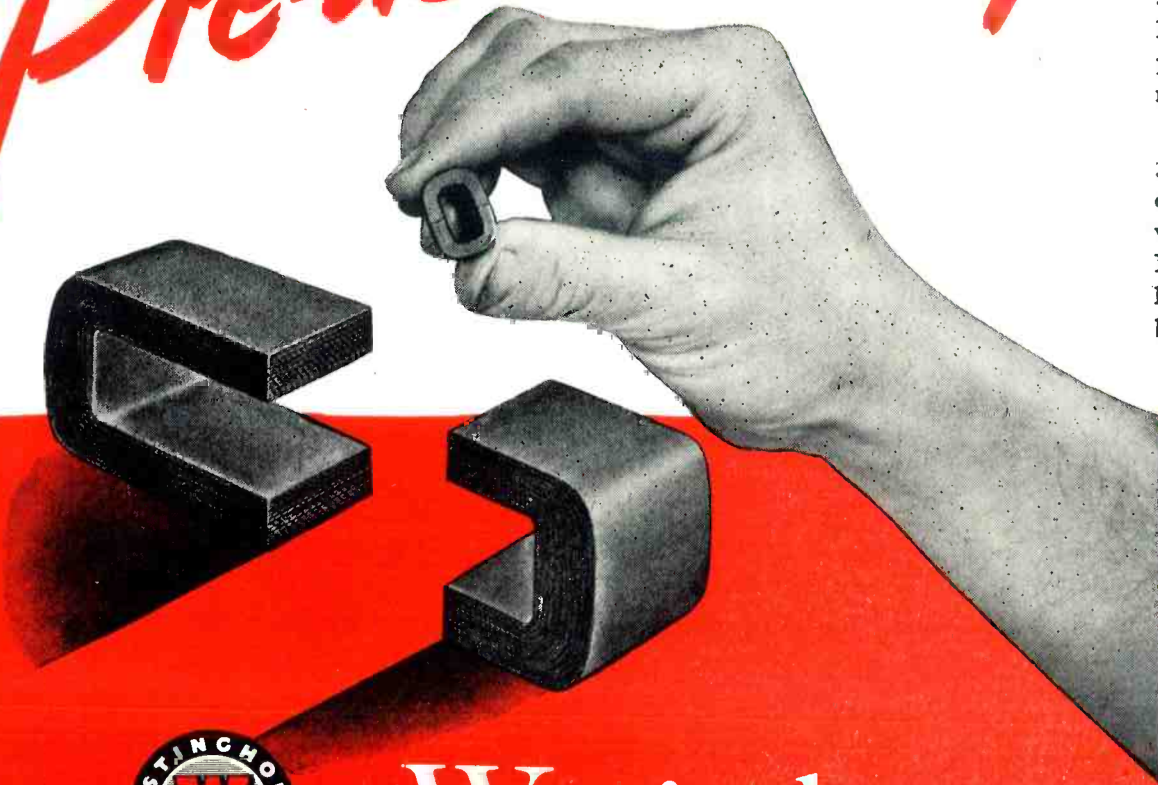
The fundamentals and the various applications of electronic control are interestingly described in a new 12-page bulletin (GEA-4126) recently issued by the *General Electric Company.*

Well illustrated, the publication explains in clear, simplified language the fundamental principles of electronic tubes and their operation, describes the construction of the well known thyratron tube, and lists the functions of eight of the more widely used industrial-type tubes.

The publication also describes and illustrates many practical applications of electronic control, including rectification, resistance welding, timing, and processing operations, as well as photoelectric installations involving counting, sorting, weighing, measuring, registering, illumination, and the control of cement kiln temperatures. Many of these applications have been in successful operation for a decade or more.

Also listed in the publication are the various advantages afforded by the use of electronic control, such as flexibility, precise control, reduced main-

it's Pre-assembled!



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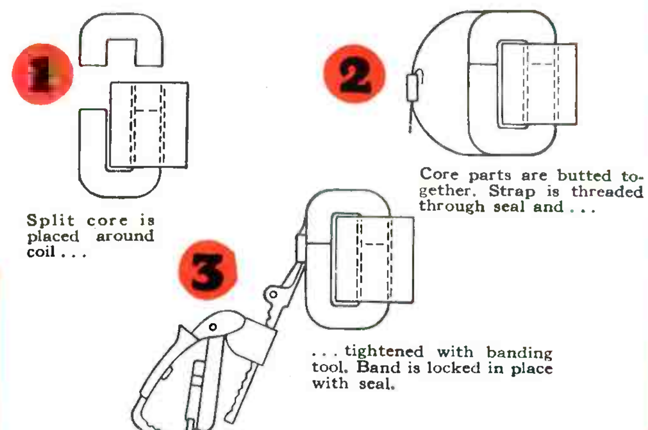

Banding Straps, Seals and Tools available from Westinghouse. See Page 9 of B-3223-A.

Westinghouse

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Copies of this bulletin are available by writing to the *General Electric Company,* Schenectady, New York.

SOLDERLESS WIRING

A 72-page sectionalized catalog of AMP Solderless Wiring devices has just been published by the *Aircraft-Marine Products Inc.*

This reference manual includes complete illustrated data on the company's line of solderless insulation support terminals, standard and flag type terminals, connectors, lighting contacts and other devices.

AMP hand tools and installation presses are described and illustrated and complete working instructions for setting up crimping dies are included.

Data, specification and dimensional charts, Army, Navy and commercial wire sizes are given for every item listed in the catalog.

For a copy of this catalog, write on company letterhead to *Aircraft-Marine Products, Inc.,* 1591 N. Fourth Street, Harrisburg, Pa., and request Catalog SD-1.

PROCEDURE MANUAL

A new manual of operational procedure has been published by *Electronic Specialty Company.* Prepared in conjunction with the Civil Air Patrol, this manual furnishes necessary data for aircraft radiotelephone communication.

Because of the scope of the CAP program it was found necessary to set up some form of standardization in the transmitting and receiving of radiotelephone communications and this booklet is the result of this standardization program.

Practical examples of the correct procedure for transmitting and receiving messages are given, as well as a brief review of standard forms used in transmitting. The phonetic alphabet and the chart for giving time signals is included.

Distribution of this manual is made free of charge to all members of the Civil Air Patrol by the *Electronics Specialty Company,* 3456 Glendale Boulevard, Los Angeles, 26, California.

CAPACITOR CATALOG

A new and complete catalog covering the El Menco line of capacitors has been issued by the *Electro Motive Manufacturing Company.*

These mica capacitors cover a wide range of characteristics to fill every engineering need. The units are available in special "custom made" types which are made to fit individual specifications. These units are pre-wired at the factory to insure easy and rapid assembly on the production line.

Complete data is given to facilitate quick location of the capacitor for the job. Copies of the catalog are available from the *Electro Motive Manufacturing Co.,* Willimantic, Conn.

—30—

UHF vs. Microwaves

(*Continued from page* 25)

30,000,000,000 and 300,000,000,000 cycles . . . or 30,000,000 and 300,000,000 kilocycles . . . or 30,000 and 300,000 megacycles. Although this represents only 9 millimeters or nine-thousandths of a meter wave length difference, it corresponds to 270,000,000 kilocycles of future frequency allocation. At this time it is impossible to realize how it will ever be necessary to need so much frequency space. This is even more true if we pause long enough to remember that it still is considered to be a ground-wave proposition with the same frequency spectrum available all over again for every other horizon of distance.

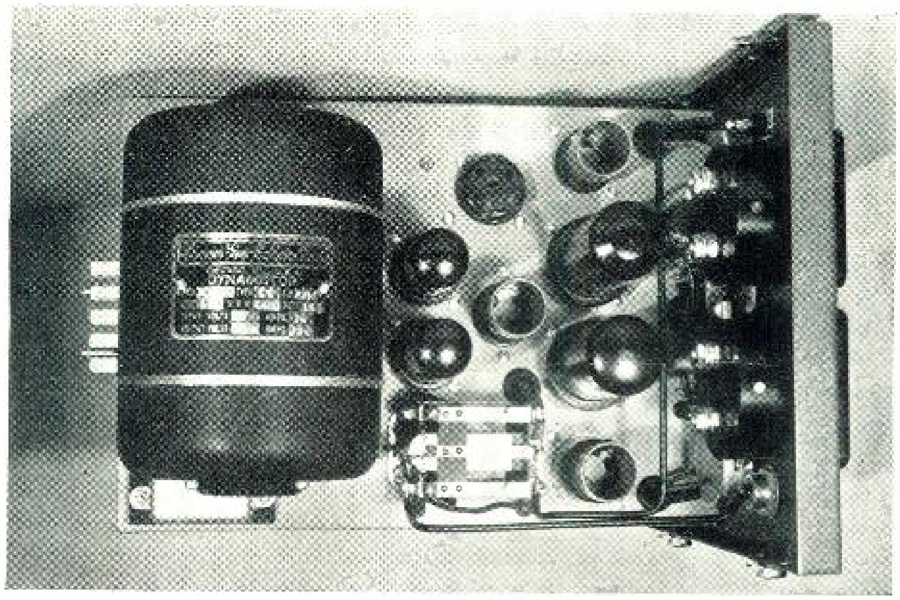
In view of the foregoing, the problem of frequency utilization during the future becomes one of equipment development. Enough is already known and accomplished to say that is definitely solvable. The experiences of the past can very well serve in goodly part as the criterion of the experiences to be encountered during the future in this regard. This is to say that to use these higher frequencies, new equipment will loom up which will work efficiently only on such or even higher frequencies and be entirely unsuitable for lower frequencies.

This will result in the eventual abandonment of the very long wave lengths with their limited number of kilocycles of frequency space. As we leave the old and enter the new spectrums of radio, many past conceptions of radio must be radically revised. Prewar textbooks and instructional material will have to be scrapped or extensively revised. In trying to make prewar equipment and techniques function on the microwave band, it will be found that parts including their associated electrical phenomena will not do the expected or the desired. As new developments emerge for microwave utilization, it usually will be impossible to get any benefit from them on the lower frequencies but to get increasingly better results in the higher frequency direction. The result will be to lure radio enthusiasts ever higher-frequencyward to leave behind forever the lower frequencies or longer wave lengths.

Many qualified and resourceful men with courage and vision are virtually straining at their leashes to develop this vast field after the termination of hostilities. Any developments and opportunities they create cannot help but be beneficial to innumerable others. Each development and application becomes too vast an undertaking for one man. He must seek help, facilities and capital, thereby enabling many others to participate and find useful employment.

While the equipment utilized on ultra-high frequencies thus far has been described in many publications, this is not an opportune time to reveal the methods employable in the high-frequency end of the microwave band. In part, it is still a job for the laboratories of our great universities and commercial companies as well as that enormous reservoir of ideas . . . the postwar radio amateur. Nothing can do more to stimulate centimeter and eventually millimeter microwave communication as will the American "Ham," operating with the approval of his friendly and understanding government. No amount of capital and available scientific personnel can compare with him. The American radio amateur fraternity prewar represented some 50,000, which may increase postwar to over a quarter of a million. They will delve into both communications and electronics. These amateurs are in a position to make major contributions to the art because of their number, wide geographical distribution, unselfish interest, ingenuity, resourcefulness and tendency to do things the "hard way" or in their own way. They are not "hidebound" by too much conventional knowledge and methods. As a result they are in a better position to stumble on revolutionary ideas and discover new phenomena, even though they may not know the rhyme or reason motivating their efforts. For them the old adage "fools wander where angels fear to tread" is particularly true. No more prolific source of microwave development could be had.

However we actually need all groups of thought and activity. We need both theory and practical experience . . . we need the physicist, engineer, amateur and the layman . . . to get any job done regardless of the field. In reality the amateur frequently has within his ranks many professionals. A professional can be classed as an amateur if he further engages in his field as a hobby or in spare time participation along lines of approach different from his compensatory employment.



Neat, compact, and inexpensive ultra-high-frequency AM transmitter, which will become obsolete and later replaced with FM operation. Microwave equipment will be approximately the same size and cost, but will house both transmitter and receiver and require one-fifth of the power input.

Both ultra-high frequencies and microwaves are not at this stage of the art suitable for much further than horizon distances except by the addition of relaying stations. These need not be manual but can be simple, unattended automatic stations. The minimum ranges in miles may be reliably computed by multiplying the square root of the total antenna heights in feet by the coefficient 1.225 for the curvature of the earth. The total antenna heights necessary for this computation are computed as follows . . . figures indicated are only for typical illustration. . . .

1. *Height of land above surrounding terrain or sea level at transmitting point* .... *125 feet*
2. *Height of transmitting antenna above ground*.. *65 feet*
3. *Height of land above surrounding terrain or sea level at receiving point* .... *20 feet*
4. *Height of receiving antenna above ground*.... *15 feet*

Total antenna heights..*225 feet*

The square root of 225 when multiplied by the earth's curvature coefficient 1.225 equals 18.375 miles for the above illustration. It makes little or no difference, so far as minimum range is concerned, whether any one or more of these four antenna computations are more or less than shown. It is the total of all four heights that we are interested in. Whether one point is 10 feet and the other is 90 feet . . . or whether it is 36 feet and the other 64 feet, makes no difference so long as it totals 100 feet. Either way it is equally effective in clearing the curvature of the earth and extending the horizon.

The writer has proved this formula to be the minimum that can be expected time after time. For example, while flying in the State of Maine's Fish and Game Plane over Belgrade Lakes, Maine, he tried to communicate with Wells, Maine 99 miles air line distance to the State Police on 39,900 kilocycles. Communications could not be effected until the earth's curvature and horizon was cleared. This did not occur until an elevation

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This new star which adorns our "E" pennant marks the *third* time WESTON has been *first* in this highly specialized field to receive each successive war citation. Weston Electrical Instrument Corporation, Newark 5, New Jersey.

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of 6,200 feet was obtained, after which continuous contact was maintained for all levels above that. This also reached every police car on the highways 2-way. It was definitely a function of height and horizon. It was not a function of power or ideal installation as less than ten-watts power on amplitude modulation was used and the plane installation was "haywire" and hastily installed. On much higher frequencies, comparable with microwaves having zero elevation other than the mere height of the equipment itself resting on the ground, he has communicated six miles over water and four miles over land repeatedly. It was not the limit of the range.

These ranges are substantially increased by the presence of moisture or improved ground conductivity or wave path which can be a variety of factors. Some of these factors may even conduct it around or over an obstacle in the line of sight regardless of size or nature of its composition. These factors serving to increase the minimum range are:

1. *Rain*
2. *Snow*
3. *Ice*
4. *Mud*
5. *Swamp*
6. *Marsh*
7. *Railroad track of endless length*
8. *Adjacent landlines*
9. *Conducting minerals in the earth*
10. *Metallic structures nearby that are well grounded*
11. *Lakes*
12. *Oceans, including bays, inlets and coves*
13. *Canyons and contours behaving like wave guides*
14. *Other conditions permitting reflections or conditions that are frequently unexplainable.*

If the range is ever found to be less than computation given, such as a very localized deadspot, a reason should be forthcoming. The cause may be due to some metallic or conducting object in that spot or near that spot which resonates at the frequency employed, tending to cancel out radiation in some direction or area. The writer discovered a deadspot of 2 feet one night while riding in a police radio car at Hyannisport, Massachusetts, on Cape Cod. The car was moved backwards and forwards to carefully study this. Returning in the daytime the effect was found to be caused by a 6 foot grounded metallic pipe used to protect a power line from chafing as it emerged from underground at a summer estate and went up an electric light pole. This was almost identical to the length of the grounded fishpole used on the police car for 39,900 kilocycles. On another occasion at South Dartmouth, Massachusetts, the police asked the writer to explain another deadspot. It was on a lonely road in sparse forest with the deadspot existing at certain angles, with respect to a certain large oak tree, about 2 feet in diameter. Nothing appeared unusual about the ground or the tree which was identical to many other trees in the area. It was an unimportant area and the full cause was not determined although the writer was sorely tempted to saw the tree down to examine its interior. It was too laborious a job and involved trespassing to do it, so it has been left unsolved.

It is admitted that long waves or low frequencies have a great advantage in being able to use sky waves and even ground waves to work further in one jump without resort to relay stations. But it is equally true that longer wave lengths cannot begin to compare with ultra-high frequencies or microwaves, particularly the latter, in any of the following:

1. *Ability to accommodate enough stations.*
2. *Amount of frequency spectrum.*
3. *Ability to let each station have enough room to operate with maximum efficiency.*
4. *Freedom from static and interference.*
5. *Ability to use the same channel several times without interferences at any time.*
6. *Freedom from lightning.*
7. *Consistent and uniform performance.*
8. *Ability to operate on very low power with only minor reduction of performance.*
9. *Ability to get the maximum benefit of frequency modulation particularly as regards the deviation ratio.*
10. *Ability to function with directional beamed or focussed antennas or in conjunction with wave guides without becoming prohibitive in size.*
11. *Ability to be unheard and prevent wastage of power in undesired areas and directions regardless of angle of elevation or azimuth.*

As compared to ultra-high frequencies, a microwave requires more careful attention in respect to interelectrode capacitances and abnormal impedances resulting from the high frequencies involved. It is ordinarily unable to pass through or around objects in its direct path of any considerable size because its wave length is so short and transmissions are usually beamed to occupy only a narrow sector. Solutions are conceivable. In fact most of microwave limitations are expected to be its more important advantages in connection with future developments. Nature had a very good reason for everything it created for us to unearth.

A very interesting consideration is the transit time between elements within a vacuum tube. This begins to become important as the frequencies increase . . . particularly in the microwave band where the frequency involved is several billion cycles per second. During the time required for passage over the tiny distance from the filament or cathode to the grid or anode within a vacuum tube despite the speed of electron travel, it is enough to reach the next element with changed phase or polarization conditions. There will be a considerable change in the point of the cycle from starting point to destination element. This causes it to be influenced differently by the amplitude and polarization of the charge on that element.

The reactance of a condenser at such frequencies becomes small and a condenser may behave like a conductor. Ordinary insulation material acts as a virtual conductor or leakage path. Good designing requires that microwave frequencies be confined to a very limited part of the equipment with operations shifted at the earliest opportunity in the circuit design to a lower intermediate frequency.

Many interesting phenomena begin to occur in the microwave region. For

example, diathermy effects may be noted when a hand is placed in front of the antenna if frequency is sufficiently high and very high power is employed. Those who were foolish enough to believe that exposure to microwave radiation would produce sterilization are parents of fine children. Other mistaken notions have arisen such as a claim that it might produce soft X-ray burns. The writer once was troubled with a skin rash resembling poison ivy. Doctors tried to associate it with microwave work. All treatments failed until a doctor diagnosed it as a mild case of scabies and treated it for same. The rash trouble disappeared promptly. Under all practical conditions, diathermy or X-ray effects are absent. Such effects will be deliberately developed in the fields of medicine and industrial heating. Radio's greatest benefit to mankind is yet to come in the field of medicine but it will be on frequencies and with powers much higher than what will ever be required for microwave communication. Microwaves are still tremendously remote in frequency from the X-ray spectrum even though it is approaching frequencies where its thermal effect can be felt. But that is true only if developments are directed deliberately in that direction.

The time is approaching when we in the radio fraternity shall migrate from both long and short waves towards the microwave band. There lies unlimited space and opportunity for all of us to perform miracles without number of great value to all mankind. The writer sincerely hopes that thousands of men comprising some of the backbone of radio will join in post-war microwave development.

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Sioux Falls PBS

(Continued from page 45)

with the Production Department of WABC's Network Operations Division in New York.

Another Gothamite on the staff is Cpl. Edgar H. Kobak, former member of the Traffic and Script-writing Departments of NBC's International Division in New York. Cpl. Kobak is the son of Edgar Kobak, executive vice-president of the Blue Network.

Others who keep the PBS going 16 hours a day are Staff Sgt. Burt M. Cloud, non-commissioned officer in charge of administration; Staff Sgt. Jesse V. Faulkner, engineer; Cpl. Robert S. McCarl, announcer and engineer; and Cpl. Victor M. Turner and Pfc's Max E. Pierce and James P. Pund, broadcast technicians.

The management of Stations KSOO and KELO, NBC outlets in Sioux Falls, which have cooperated wholeheartedly with the PBS since its inception, is enthusiastic about the local Army setup.

"The Post Broadcasting System," says Morton Henkin, vice president and manager of both stations, "is a complete broadcast service except that it transmits programs by wire instead of by wireless.

"No objection, of course, is raised by NBC artists and program producers, because the broadcast service is conducted exclusively for Army personnel.

"I understand it has been proved that students who are given periods to listen to radio programs during actual classroom instruction learn code much faster than do students who do not have access to such facilities."

With the radio school on two shifts, the soldiers who operate this PBS get up early and retire late.

It's tough on GI's who heartily desire to murder the bugler at this station. The "Man with the Horn" is a recording in the control room which gets the day off to a perfect (?) beginning with reveille and winds up military proceedings with taps.

The primary original reason for PBS was a means of affording a period of rest from the tiring job of listening to code for several hours.

Each shift of classes in code receives a special program of music and news each day, "piped" directly through headsets in class rooms. These programs cover 10 minutes and include musical transcriptions, news bulletins and special announcements. Needless to say, these newscasts help keep the soldiers informed on what's going on in the world.

On Sundays, these 10-minute periods are utilized by chaplains of every faith for religious talks.

Often interesting personalities, both civilian and military, visit the Post and transcriptions are made of interviews with the visitors. If of sufficient interest to students, these interviews are rebroadcast to classes at appropriate times.

The 55-piece Post band is featured in a concert once each week and the 20-piece Post orchestra also has 30 minutes on the air every week. Practically every squadron has its own orchestra and these also stage half-hour musical and variety shows.

Thrice each week, at noon, a program of luncheon music originates from the studio featuring talented soldier singers and instrumentalists—aired especially for men in the mess halls. On alternating days, the noon hour is turned over to novelty shows, which spotlight short humorous skits and popular music.

Each Sunday a religious program is put on from one of the three Post Chapels. These consist of organ music, vocal solos, choral works and short sermons by chaplains.

Outstanding network shows such as Bob Hope, The Telephone Hour, and Glenn Miller's Army Air Forces Training Command band are "piped in" each week. For the men who miss these shows, the programs are transcribed and rebroadcast. In addition, all important national and world events such as Cordell Hull's address

to Congress and presidential talks, as well as sports such as World Series and football games, are broadcast in their entirety.

Through remote facilities most important intra-post sports are broadcast direct from the scene to the entire Post. Station breaks include time signals, weather reports and uniform of the day. News is supplied by an Associated Press teletype which operates 24 hours a day in the studio. All important news flashes are reported immediately to the military personnel.

Thus, while on or off duty, the student can always have the best in entertainment or latest news, thanks to PBS.

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U.H.F. Course

(*Continued from page* 52)

360° and so, for this one particular frequency, 360° is equal to 2 feet of this line. One foot would allow only a half wave to be put on the line again at this frequency, and now there is only 180°. The words "at one frequency" are important because as pointed out previously, the amount of line needed to resonate at one value of frequency is different than that required at any other frequency. It is analogous to an ordinary tuning coil and condenser which will resonate at one frequency, but must be changed before it will respond to any other frequency, (except, perhaps, a harmonic).

The plot of the above equation in Fig. 7 shows that when the length of line used is less than ¼ wave length, or 90°, that the value of Z_{in} is positive (above the zero line) and so shows inductive properties. For values of θ between 90° and 180° the value of Z_{in} is negative and so a capacitive effect is obtained. The remaining length will give rise to either inductance or capacitance depending on whether Z_{in} is positive or negative. At exactly 90°, 180°, 270° and 360° the line is neither capacitive nor inductive but acts as either a series or parallel tuned circuit depending on the angular length involved. If the above seems strange, remember that in ordinary coil and condenser tuned circuits, whenever you tune above the resonant frequency the combination has a capacitive reactance while if the circuit is tuned below resonance, an inductive effect is obtained. And since a transmission line is a tuned circuit, it is only natural to expect the same behavior.

For the open-circuited line the equation differs from the above and is given by

$$Z_{in} = Z_k \cot \theta.$$

The same interpretation should be given to this set of curves as in the previous case. (Fig. 8)

Not only can a transmission line act as an inductance, capacitance or

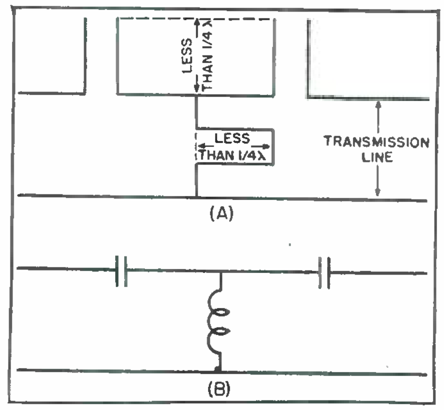

Fig. 13. (A) A U.H.F. high-pass filter using short length of transmission lines. (B) Equivalent circuit at the low frequencies.

resonant circuit, but it is also used as either a step-up or step-down transformer, depending again on the type of load across the end of the line. For example, take a line that is an odd number of quarter wavelengths long and draw the voltage and current distributions all along the line. This has been done in Fig. 9 on a short-ended

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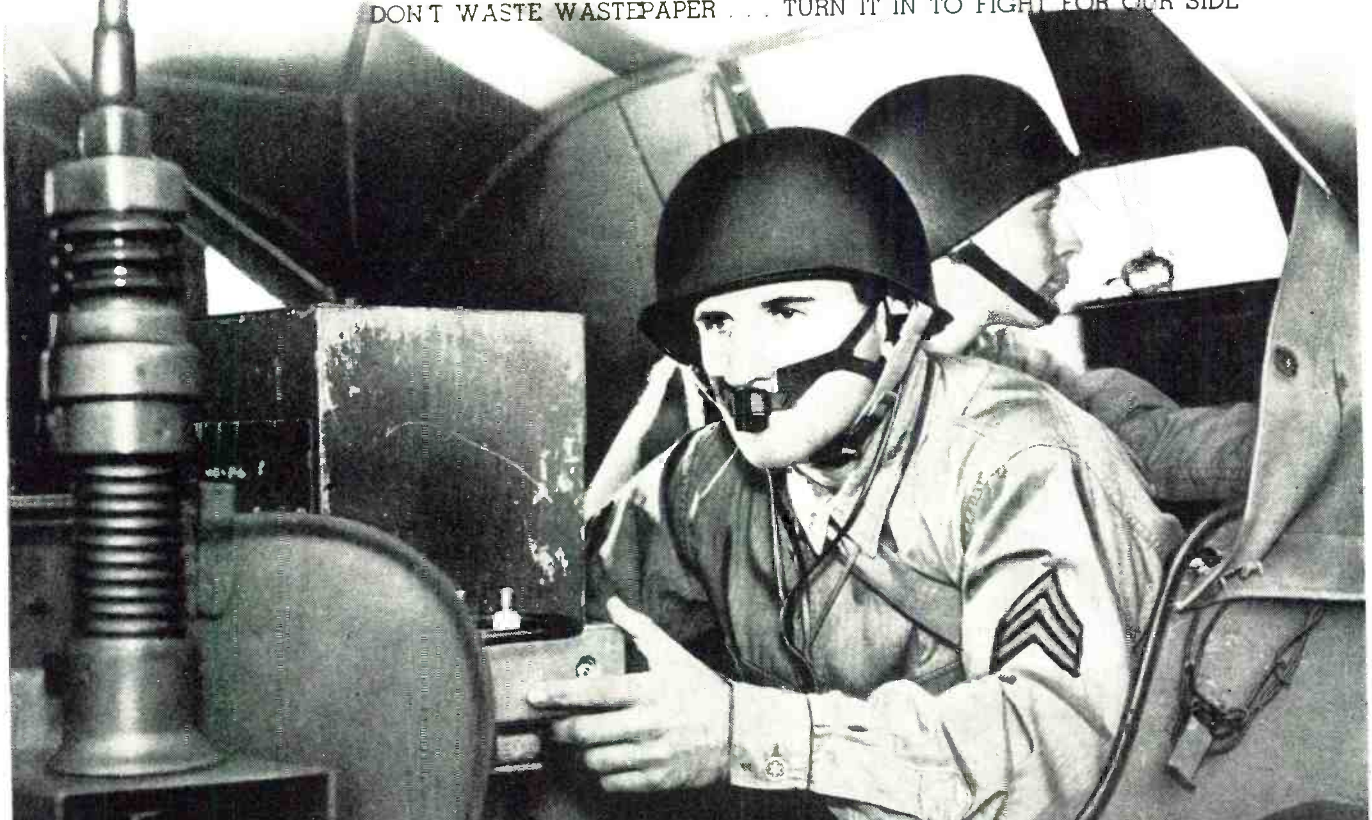

Electro-Voice MICROPHONES

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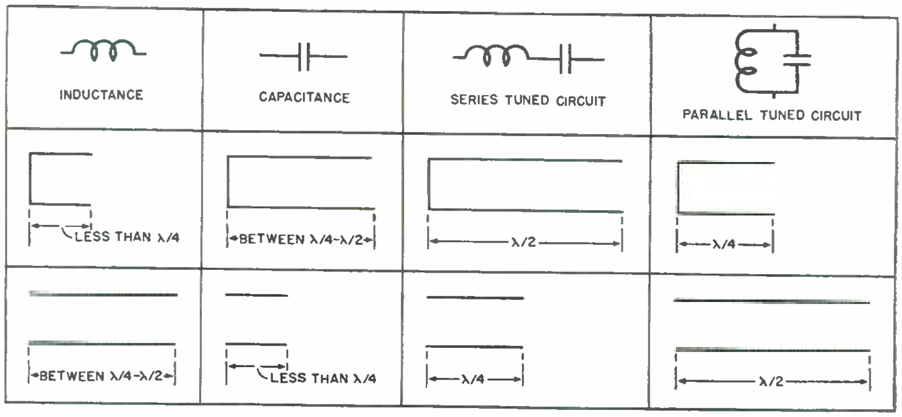


Fig. 14. Compiled summary of the properties of transmission lines that are up to one-half wave length long.

quarter wave line. Now if at some point like P-P[1] a resistive load is connected across the line, it will be subjected to a voltage that is less than the voltage across the input of the line. And as is true in all step down transformers, if the voltage is stepped down, the current will be increased in like proportion. Fig 9C shows the similarity of the transmission line to the ordinary tuned circuit. For voltage step-up purposes an open-ended line can be used that is also any number of odd quarter wave lengths long and connected as shown in Fig. 10. The load that is shunted across the line should not contain too much reactance nor should its impedance be too low, as either case will disrupt the conditions as shown in the preceding diagrams and result in voltage and current distributions that will vary with each case.

Now that the fundamental ideas of transmission lines have been discussed it is possible to investigate some of their applications where more than one property comes into use. An excellent example would be a quarter or half wave matching stub such as that so widely used by amateurs on short wave antennas. To facilitate the explanation, refer to Fig. 11 where a transmission line and a matching stub are shown connected together at points A-A[1]. The load at the end of the transmission line, Z_L, may be any impedance and in amateur work is usually the antenna. The point of this entire arrangement is to help couple the transmission line to the load and to have both impedances match as closely as possible for maximum power transfer. In most applications at the high frequencies, the characteristic impedance of the transmission line can be represented by a pure resistance while that of the load may not be. It is the purpose of the matching stub to cancel any reactive component in Z_L and thus have Z_L appear as a resistance to any generator feeding the transmission line. If the distance from the load to the points A-A[1] is properly adjusted, the resistive component of the load will match Z_o and so a perfect match will be accomplished. Usually this is a quarter wave length but this is only an approximate rule and may not always give best results.

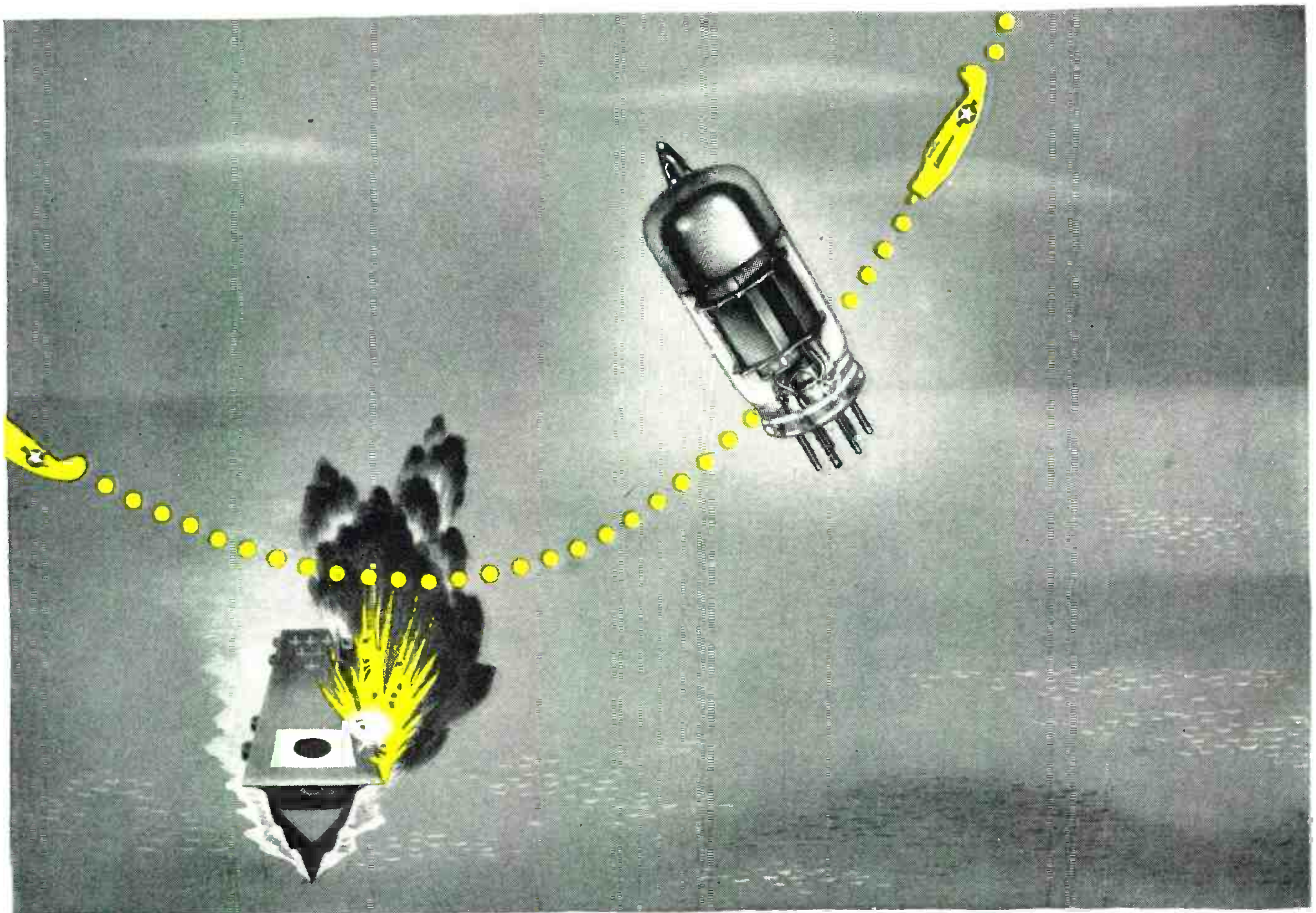
To adjust the length of the matching stub (which is also near ¼ wavelength) one end is short circuited and the shorting bar is moved until standing waves on the transmission line disappear. When this happens the reactive component of Z_L has been neutralized and the load presents an impedance matching that of the transmission line. Sometimes amateurs use a half wave matching stub in which case the end is not short-circuited but left open and the length cut off until the line is adjusted.

Another variation of the above principle is illustrated in Fig. 12 where the capacitance that usually develops across a resistance at the ultra-high frequencies is neutralized by adding a short amount of transmission line, long enough to present an inductive reactance at the resistor and thus neutralize this capacitive reactance. The same idea is frequently made use of to do away with some of the effects of inter-electrode capacitance, an ever present trouble at the ultra-highs.

Perhaps it has occurred to some readers that since resonant lines can take the place of coils and condensers, such systems may be used to act as high pass, low pass and band pass filters. Such use has already been suggested and a high pass filter is shown. The conventional low frequency circuit is shown in Fig. 13B and comparison of the two will aid in again bringing out the equivalent circuits developed at the beginning of this article. Many other arrangements will probably occur to the reader and it would help considerably if these were put on paper and practised. It might be mentioned that all of the preceding material will also apply to concentric cable as well as to parallel wire systems.

In conclusion it was thought that a consolidated summary in pictorial form of the various properties of the transmission line would be of great help in correlating all of the important facts, and so was included as Fig. 14.

(To be continued)



They know their G's

What is this menace to flying men and their equipment which our scientists call "G's"? And why are N. U. engineers who design tubes for airborne radio and electronic devices taking so much pains these days, to *know* their "G's"?

In a mild form, most of us have felt "G's" at work on a roller-coaster, when we take the turns and hit the dips. However, in high speed flight, with its shifting, twisting, turning, about-face maneuvers—"G's" *really* shake your insides. Think of a dive bomber pilot as he pulls out of a high vertical power dive. That's when "G's" can become dangerously high. And when there are *too many* "G's"—look out!

Research into the effects of "G's" on the delicate, indeed flimsy filaments and other parts of tubes, has enabled N. U. engineers to provide our armed forces with tubes individually tested to withstand many more "G's" than a pilot or a plane ever has survived. For such battle-tested N. U. Tubes there will be many post-war uses, with profit opportunities for service engineers. *Count on* National Union.

NATIONAL UNION RADIO CORPORATION, NEWARK, N. J.
Factories: Newark and Maplewood, N. J., Lansdale and Robesonia, Pa.

NATIONAL UNION
RADIO AND ELECTRONIC TUBES

Transmitting, Cathode Ray, Receiving, Special Purpose Tubes • Condensers • Volume Controls • Photo Electric Cells • Panel Lamps • Flashlight Bulbs

What's New

(*Continued from page 56*)

heat, moisture and oil resistance and can withstand the effects of an electrical discharge at low atmospheric pressures.

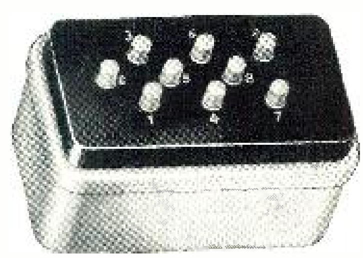
The conductor of this cable is flexible. It consists of Monel wires twisted together and covered with an insulation of low-capacitance rubber compound reinforced by a braid of glass yarn for added tensile strength and ruggedness. An over-all thin coating of transparent wax aids in handling and installation.

Additional data on this cable is available from the Wire and Cable Division of *General Electric Company*, Bridgeport, Conn.

RECTIFIERS

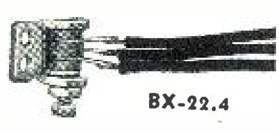
Copper oxide rectifiers equipped with gold contacts for adaptable mounting are being offered by *Bradley Laboratories, Inc.* Presoldered lead wires and other arrangements to prevent overheating are innovations in these rectifiers.

The BX-100 a center tap, full wave rectifier is completely enclosed in bakelite and rectifies high-frequency current, operating in special circuits up to 8 megacycles. The BX-22.3 is a double bridge rectifier with unusual temperature and temperature-current



BX-22.3

BX-100



BX-22.4

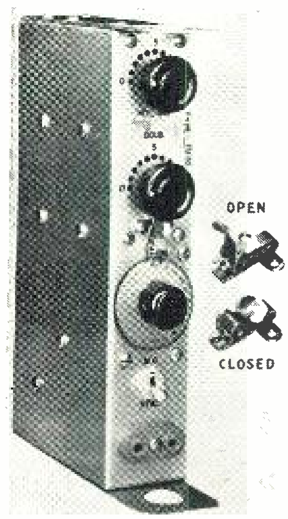
characteristics. Conservative ratings show low forward resistance combined with high leakage resistance.

Full information on these, and other rectifiers, may be obtained from *Bradley Laboratories, Inc.*, 82 Meadow Street, New Haven, 10, Conn.

DIAL LOCK AND TUNING INDICATOR

A tuning-dial lock, originally engineered and manufactured for use as a tuning control for the frequency-tuning unit of the famous Hallicrafters SCR-299 mobile unit, is now available to other manufacturers.

This product of *The Radio Craftsman*, 1341 S. Michigan Ave., Chicago, Ill., performs a dual function—(1) a dial lock that will accommodate a wide range of dial thicknesses—(2) a precision tuning indicator that maintains a fixed position on the dial simply by snapping the lock. Thus, speedier tuning is achieved over the ordinary set-screw type of dial lock.



Production problems are cut to a minimum as this dial lock is a metal stamping and is not affected by the prevailing scarcity of screw machine parts. The finished product is nickle-plated brass.

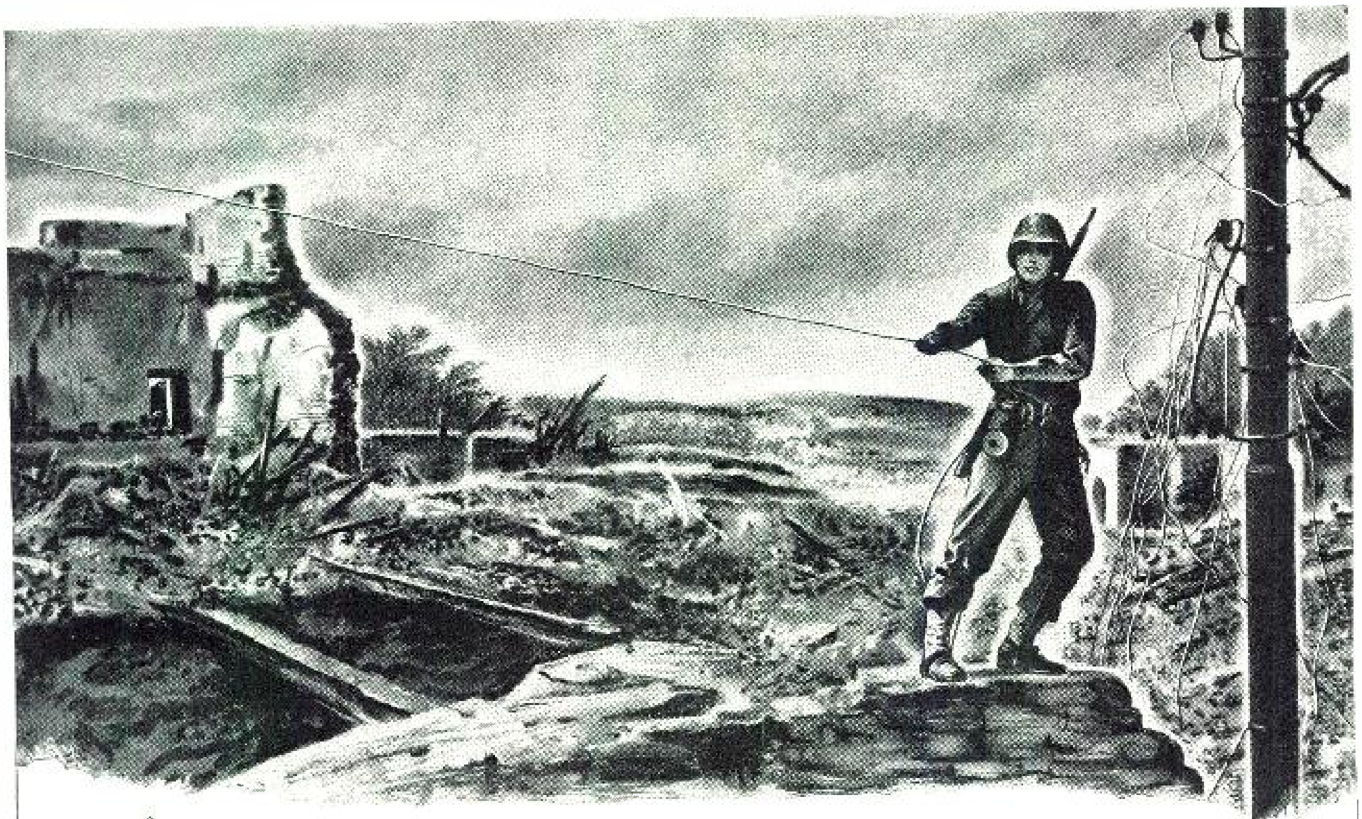
—30—

Speaker Measurements

(*Continued from page 34*)

sort are particularly important in listening tests, where it has been found essential to make observations at different points in the room in order to form valid judgments of loud speaker performance.

The last group of curves, illustrated in Fig. 9, shows the influence of loud speaker position on the low frequency efficiency as indicated by array measurements. The positions shown are commonly employed and were studied because of their practical aspects. Curve 1 is for the case of the speaker in a floor corner position; curve 2 is for location on the floor against an end wall at its center; while curve 3 is for a speaker centrally mounted on an end wall. Only the portion of the response curves below 1,000 cycles is shown, because from the theory it is known that the influence of position on response through restriction of the solid angle of radiation is effective only in the region below about 800 cycles. The graphical mean of the curves for each individual position was drawn and these are shown superimposed in the lower group of curves. For interest and to aid in evaluating the amount of improvement introduced by the various speaker positions, the outdoor axial response is also shown. The corner position is definitely to be preferred, with an efficiency approximately 5 db higher than for the wall position. Position 2 (wall and floor intersection) is the next best with a gain of the order of 3 db. All three positions are definitely better in the extreme low frequency region than the outdoor response. —30—



WHERE THE GOING IS TOUGHEST is where the men of the U. S. Signal Corps do business

Behind the front, at the front — yes, and ahead of the front lines, they are laying wire, directing artillery fire, spotting enemy movements and putting their superb technical training into practice with calmness and efficiency in the thick of battle. They don't get as many headlines as they deserve, but they rate and get the thanks of every soldier, from General to buck private.

Many of our own men, now in the service, have been assigned to Signal Corps duty, and are frequently using the very equipment they once helped to build. Their experience in our plant is being put to good use at fighting fronts all around the world. Signal Corps training will in turn make them all the more valuable to us when they return. Thus, important forward strides in communications engineered by the Signal Corps, manufactured by the communications industry, and put to the acid test by superbly trained technicians will be available to serve you in the postwar world.

CONNECTICUT TELEPHONE & ELECTRIC DIVISION,

Great American Industries, Inc.

MERIDEN CONNECTICUT

AFTER THE WAR . . . *Advanced*

- TELEPHONIC SYSTEMS
- SIGNALLING EQUIPMENT
- ELECTRONIC DEVICES
- HOSPITAL & SCHOOL COMMUNICATIONS AND SIGNALLING SYSTEMS
- ELECTRICAL EQUIPMENT
- IGNITION SYSTEMS

Oscillations Simplified

(*Continued from page* 35)

electrons start this equalizing process, they constitute a flow of current which is *opposite* in direction to the initial impulse. Thus a negative-going pulse will be induced in L_g, and the pulse of voltage on the grid will round the hump of point 1 and head for point 2 (Fig. 2). A condition will now exist at point 3 similar to that at point 1, and identical proceedings will occur except in the opposite direction, and the voltage will round this peak and head for point 5. The circuit has now started to oscillate, but oscillations have yet to build up to full working strength. The next problem is to determine where this building-up process is to end, and what will be obtained when it has ended.

At this juncture it is necessary to look into the grid condenser C and resistor R_c. Fig. 2 shows that the grid voltage is being driven slightly positive for part of each cycle, due to the previously mentioned fly-wheel effect. We immediately remember that whenever a grid is positive (with respect to its cathode) grid current will flow, due to rectification within the tube. As this current flows from grid to ground, through R_c, a d-c voltage is developed across the resistor, negative at the grid side. This small negative voltage is stored, in part, in the condenser C, and remains stored during the entire first cycle, since R_c prevents it from leaking off entirely by the time the next cycle occurs. The appearance of the next cycle again causes grid current to flow, developing more negative grid voltage, which is added to that already stored in the condenser. Successive cycles increase the charge on C, until point X (Fig. 2) is finally reached, at which time there is no further increase. (Note that the condenser reaches this point via a sloping line, which is the charging curve of a condenser.) There is no further increase because C and R_c have been so chosen that any further negative voltage will not charge the condenser but will leak off through R_c before the next cycle occurs. This point X is made to be around twice cut-off for the tube—the grid voltage at which oscillators and class C amplifiers operate most efficiently. Oscillations will now occur continuously around the operating point X, and at a frequency determined by the constants L_o and C_o. The energy required to overcome circuit losses and sustain oscillation is of course supplied by the tube and its power supply.

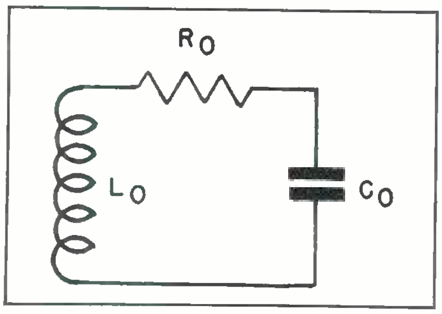


Fig. 3.

This same approach can be applied to oscillators which do not rely on inductive coupling for oscillation energy. If the grid and plate coils are not inductively coupled, a circuit can be made to oscillate by feeding energy from the plate circuit to the grid circuit by means of the plate-to-grid capacity of the tube. In this case, the initial impulse of voltage resulting from applying the plate supply is capacitively coupled to the grid instead of being inductively coupled, and the ensuing process is the same as described above.

—30—

FM Broadcasts

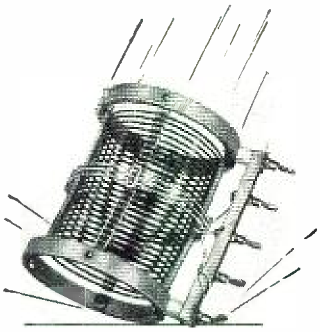
(*Continued from page* 49)

director of the New York Board of Education: "There can be no argument about the superiority of FM over AM in educational broadcasting. The static-free feature of FM along with its high fidelity is more important in school broadcasting than in ordinary commercial radio. School listening is invariably group listening in a large room. Noisy, distorted reception leads to quick fatigue and loss of attention. ... One of New York City's best known high schools is so located that its principal reported that radio programs were a complete waste of time. Man-made static was so bad that not even the 50-kw. network stations could be heard with any degree of satisfaction. As a test and with a temporary installation, an FM receiver brought in all the 1-kw. FM stations in the area with perfect clarity."

Anticipating a spurt in school use of FM, educational leaders feel the present five channels allocated for this purpose are inadequate, and they are mobilizing the same sort of support which helped win those five back in 1938. At that time, more than 300 school officials supported Commissioner Studebaker's plea to the FFC. As a result, education was given the 42,000-43,000-megacycle band, while the 35 channels up to 50,000 were reserved for commercial FM.

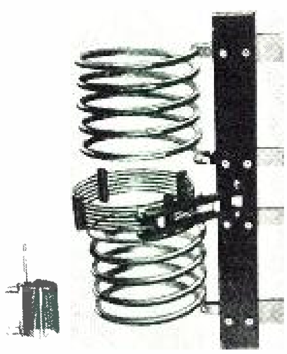
Educators point out that in any one area only every other channel may be used. In the New York area, for example, FM stations at Newark, Elizabeth, and New York City would use up education's megacycle.

As a partial solution, they advocate allocation of educational channels on the basis of state-wide networks, with special channels for beam relay facilities. In this way they hope to avoid situations where a few wealthy cities might have FM stations, while large rural areas of the state might be denied service. Transmission of pro-

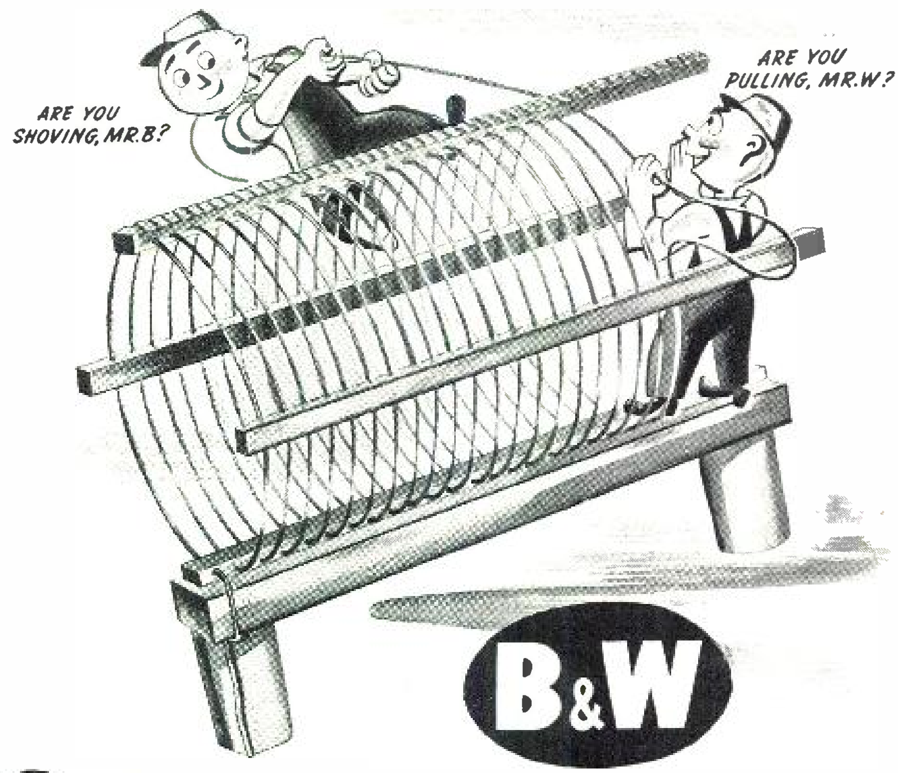


Dropped 35 feet to a cement sidewalk, this B & W Air Inductor was immediately put back in perfect operating condition without tools of any kind. Actually, the only damage was a bent "banana" plug, and a cracked support bar.

This indent feature illustrates the versatility of B & W "Air Wound" design. Every turn of the wire is indented on alternating sides of the coil. This means that the windings on both sides of the turn you want to tap are indented out of the way. No matter how small the wire, or how close it is wound, taps can easily be made *anywhere on the inductor.*



"Air Wound" construction is just as desirable for mammoth inductors as it is for small ones. Here you see a B & W No. 1591 Air Inductor, only 2" in diameter by 3" long, in a size comparison with a B & W high-power (10 KW.) coil.



Why WIND COILS ON "AIR"?

"Air Wound" Inductors—pioneered and perfected by B & W—hold many advantages for many applications:

- *They weigh much less. Conventional winding forms are eliminated.*
- *They are readily adaptable to almost any mounting arrangement.*
- *They are far less likely to be damaged if dropped. There is little about them to break—and, even if bent completely out of shape, they can easily be repaired.*
- *They can be protected for rough service with bumper rings —still at a minimum of weight.*
- *They offer greater design adaptability in such valuable features as indented turns which make it easy to tap any turn on a small coil.*
- *They have exceptionally low dielectric loss.*
- *They are wound to uniform pitch.*
- *They lend themselves readily to mechanical and electrical revisions in the circuit.*

. . . For other uses B & W offers a variety of ceramic and phenolic form coils. Whatever your coil problem, come to coil headquarters!

BARKER & WILLIAMSON

235 FAIRFIELD AVENUE
UPPER DARBY, PA.

grams from an originating station by ultra-high beams instead of over wires, they say, has not only proved workable, but doubles fidelity, making possible reception of virtually the entire range of musical instruments.

Advocates of education by radio have made a careful study of the equipment and cost problems involved, and are making available to school authorities detailed information designed to take the mystery out of FM radio broadcasting. Using a familiar comparison, they state that an FM station would cost no more than two classrooms, at most. Estimating the cost of a 250-watt transmitter with necessary equipment at about $7,000, they say that enough transmitters to assure service to all schools in any but our very largest states could be installed for $100,000 to $200,000. Ohio, for example, would be served by 20 transmitters. For the service possible, they declare, this would be a small item in the average state education budget. Here is how they break down costs:

A 250-watt transmitter, about $4,500. This would provide ample powerage for most local school systems, and possibly county-wide coverage where the terrain is not too hilly. Cost might range up to $9,000 for a 1-kilowatt transmitter.

Antenna, from $300 to $3,000, depending on location. The electrical radiations in FM transmission tend to move in a straight path. Hence, the higher the source of the broadcasting signal, the farther it will reach. The schools are therefore advised to get an option now on use of a high hill or hall building to avoid the expense of erecting a tall antenna tower.

Studios, $200 to $2,000, for construction and acoustic treatment of at least one studio plus a control room separated by a double glass window. This figure is very flexible, of course, depending on what there is to start with.

Studio equipment, from $1,000 to $3,000. This would include, at pre-war prices, a speech-input unit, $500 to $1,500; microphones, $175 to $500; cables and stands, $50 to $200; and transcription turn tables, $350 to $800. The possibility of reducing these costs by constructing some items in the school shop or laboratory is indicated, but not recommended.

As for the cost of receiving equipment, educators are warned that it will cost slightly more than AM, but it is pointed out that much of the radio receiving equipment now in the schools will probably need extensive repairs or replacement by the war's end, anyhow. Pre-war FM table models cost $50 to $80, and combination AM-FM consoles from $140 to $650, and not more than 10 to 15% reduction is anticipated.

However, where schools are already equipped with program distribution systems, all that will be necessary in order to convert them from FM reception will be to replace the present AM tuner with an FM tuner. If only FM reception is desired, the cost of such a tuner will be about $55. If both FM and AM receptions are wanted, the cost of a combination tuner will be somewhere between $100 to $150. The actual service charge, for either type, for making the installation will probably be somewhere between $8 and $15.

Moreover, an FM tuner can be connected to almost any make of standard sound-film projector or auditorium public-address system to provide FM reception for auditorium audiences.

"While a number of loud speakers may be employed with a single receiver of proper design without the use of additional amplifying equipment, it is believed desirable," says George Adair, assistant chief engineer of the FCC, "to use some form of amplifier in schools where a considerable number of loud speakers are needed in order not to sacrifice high fidelity and adequate volume. A system of this type would be much more inexpensive than one where separate receiving sets are used in the individual rooms. This arrangement would have the added advantage of enabling such schools to have, by the simple addition of a microphone, a public address system for communications to the individual rooms. However, in schools where additional wiring proved burdensome, either by reason of cost or decorative standpoint, individual classroom receivers may be used."

Adair has this to say about depreciation: "Depreciation of most low-powered broadcast equipment is considered to be approximately 10% to 15% per annum; equipment used in noncommercial educational broadcasting will, however, probably be used less per year and over a longer time, permitting a smaller figure to be used for depreciation. Ten percent should be a safe value. Depreciation of any required building construction can probably be considered at approximately 3 to 5% per annum.

Maintenance costs of equipment used in noncommercial educational broadcasting, probably in use only a limited number of hours per day, should be very low and should not exceed the depreciation figures. The tubes and other components of the low-powered transmitters used in this service are relatively inexpensive and long lived. FM transmitters, operating at constant efficiencies and not subject to higher voltages during modulation peaks, should be less subject to breakdown and tube troubles. Maintenance of studio and transmitting equipment should not exceed $500 to $1,000 per year at the average station."

Minimum operating costs are foreseen through the use of members of the teaching staff and student body. Since engineers for an educational station need hold only a second class license, it should not be too difficult to find a qualified "ham" among the students or for a science teacher to obtain a license. Production and man-

agement personnel, with the exception of a competent director, should be available from the same sources.

What sort of relationships with the commercial broadcasters will result if the schools expand their FM operations? No real conflict is foreseen. As one educator puts it, "The schools have never felt at home on commercial radio stations, and the latter will probably feel relieved of the responsibility for providing educational programs."

The education by radio advocates sum up by saying that when there could be only 800 stations, each had to be all things to all men, but when FM multiplies the potential to 4,000, there is room for specialization.

They conclude, in the words of Commissioner Studebaker, that "the day is not far distant when the slender shaft of a radio transmitter tower will be as familiar to the school scene as a flag pole."

—30—

Spot News

(*Continued from page* 14)

the entire amount produced went to railroads for use by trainmen.

Approximately half as many flashlight batteries were shipped in 1943 as in 1940, and many of these did not reach the retail market. War plants, public utilities, and other users, whose requirements had increased as a result of the war, received a much greater share than what they had received in 1940.

Generally speaking, WPB now provides enough material to permit production at the capacity of the dry battery industry. But even the expanded capacity of the industry is not large enough to meet all the many war demands and all the usual civilian demands as well.

All military operations, on land and sea and in the air, require enormous quantities of dry batteries. If batteries are not immediately available for the family radio, it is because batteries are needed for walkie-talkies, bazookas, signal lights, or other war equipment.

REPRESENTATIVES OF THE NEWSPAPER AND RADIO Advisory Committees of the Domestic Branch of the OWI and the War Advertising Council have recently completed a two-day session called by Elmer Davis, Director of OWI, to review a special demand on the Overseas Branch of the OWI. There is a vital need for 450 men for important and urgent missions overseas, in view of impending military operations.

Many of the 450 men, which include 60 radio engineers, will be sent abroad. Others will replace OWI men in America who are urgently needed abroad. The great majority of the men will go abroad within the new few months.

The qualifications for the necessary 60 radio engineers have been stated as: "All types of qualified radio engineers can be used for the erection and repair of transmitters, recording, studio and operation work. Men with five to ten years of experience in this field can be employed for overseas duty. They should be at least 26 years old, preferably older. Men who are physically fit and of even temperament will be accepted. These men will be sent overseas as rapidly as they can be cleared, as training in this country is not essential. Men experienced in sending and receiving radiophotos, or interested in this subject, are badly needed."

The committee has been assured that the State and War Departments have not only endorsed the recruiting program, but have called upon OWI for its fulfillment. It offers a chance for radiomen to be of vital service to the country.

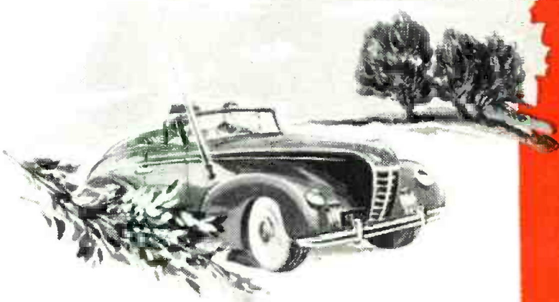
MR. A. H. HARDWICK has recently joined the executive staff of International Resistance Co. Mr. Hardwick is well known throughout the radio and electronic fields, having been directly associated in the resistor industry for the past 16 years with Hardwick, Hindle, Inc., of Newark, N. J., whose presidency he relinquished to assume his new duties.

LARRY F. HARDY has been elected vice president in charge of the Home Radio Division of Philco Corporation, it was recently announced by John Ballantyne, president. Mr. Hardy, who has been connected with the Company since 1932, will be in charge of Philco's entire home radio business, including radio-phonographs, consoles, table models, and small sets.

THERE IS A SEXTET OF WOMEN war workers—all grandmothers—at the United Electronics Company, Newark, whose ages total more than 300 years. With children and grandchildren either in the Armed Forces or busy at war work, they have signed up as their own contributions to the war effort.

Mrs. Susan Raab has her only grandchild on a subchaser and a favorite nephew in the Army Air Corps. Mrs. Martha Cooper's husband served in the Spanish-American War, and her children are all in war production work. Another grandmother, Mrs. Emma Kirby, has been with the company a year and her son is also in war work.

With three daughters and three grandchildren, as well as six nephews, in the service, Mrs. Mary Davin is also doing her part in war industry. Mrs. Rose Ostrinsky has four grandchildren. One son-in-law is going into



Yesterday *and* TODAY

WARD ANTENNAS

The year before Pearl Harbor, WARD PRODUCTS CORPORATION manufactured and sold *better than 90%* of all aerials used by leading manufacturers of automobiles, radios and portable radios. That commanding position was made possible by superior designing ability, manufacturing knowledge and production efficiency.

That expertness of antenna manufacturing is today being totally applied to the war effort . . . and in wartime, as in peacetime, WARD is the leading manufacturer of antennas. The name WARD is found on aerials used on command cars, tanks, planes—on communication units of all kinds—on battle fronts all over the world. . . . The knowledge that is being gained from this wartime effort will mean new and improved products in peacetime. If the use or specifying of antennas is included in your post-war planning, look to WARD!

THE WARD PRODUCTS CORPORATION, 1523 E. 45TH STREET, CLEVELAND, OHIO

service and another is a welding foreman. Mrs. Margaretta Thompson has five grandchildren and a husband war worker in another plant.

SEVERAL ARMY-NAVY "E" AWARDS have been made recently, including the White Star award, for continued service.

For the second time, the award for meritorious services on the production front has been earned by Henry L. Crowley Company, Inc., of West Orange, N. J. It was among the first companies to receive the Army-Navy "E" to which is now added the White Star.

In a dual ceremony at Bridgeport, Conn., two divisions of the Bryant Electric Company were awarded "E" flags for their achievements in war production. The two divisions were the Wiring Device Division and the Plastic Division.

Also in recognition of its continued meritorious services on the production front, The United Electronics Co., Newark, transmitting tube manufacturers, has been named to receive the White Star for its Army-Navy "E" pennant, which was awarded last August.

A fourth renewal of the award has been granted to P. R. Mallory Co., Inc., Indianapolis, Ind., manufacturers of electronic and metallurgical products. Mallory, too, was among the first plants to receive the original "E".

A second company who has received the fourth renewal of the "E" award is the Storage Battery Division of Philco Corporation, Trenton, N. J. This division is furnishing batteries for the operation of many types of vital war equipment.

HOW LABOR AND MANAGEMENT UNITED in joint action to obtain higher wage rates and recruit war workers was told by Leonard J. Shapiro, general counsel of the Belmont Radio Corporation of Chicago, when he spoke at the annual convention of the United Electrical, Radio and Machine Workers' Union (CIO) in New York on February 26.

Mr. Shapiro is secretary of the Radar-Radio Industries of Chicago, a cooperative group of 52 manufacturers of electronic equipment which has the support of the labor organizations.

AMONG OTHER MEMBERS OF CARLSON'S RAIDERS who came to Chicago during the week of February 26 for the premiere of the new moving picture, "Gung Ho!", was Steve Fremarek, a former Hallicrafters employee.

Steve left Hallicrafters over three years ago to join the Marine Corps and went through many of the early campaigns in the South Pacific. He was one of the thirty survivors of the raid on Makin Island when eighty of Carlson's Raiders landed from a submarine, and was also with the first landing party on Guadalcanal, where he was wounded.

Adorning his uniform are five ribbons and four stars—one for each major battle in which he fought. Of the five hundred men who went over with Steve, only sixty-nine have returned.

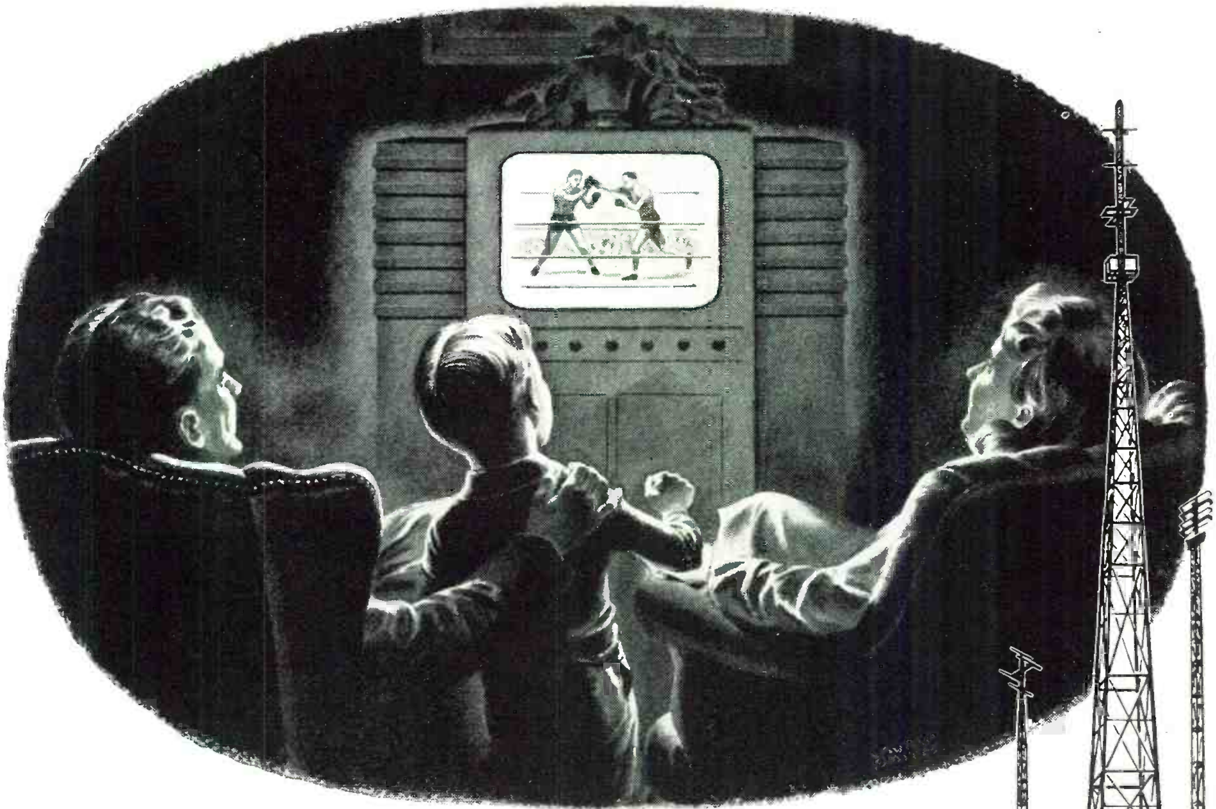
The above picture shows Bill Halligan presenting Steve with a new radio on the occasion of his recent visit to the Hallicrafters Company.

A BUREAU OF BROADCAST MEASUREMENT incorporated within the Association of Canadian Advertisers and the Canadian Association of Advertising Agencies will soon be in full operation in Canada. The decision to provide for such a service was made at the recent Canadian broadcasting convention which was held in Quebec. Although at this writing only independent broadcasters have agreed to participate in this venture, it is expected that the Canadian Broadcasting Corporation will also utilize the services of this bureau.

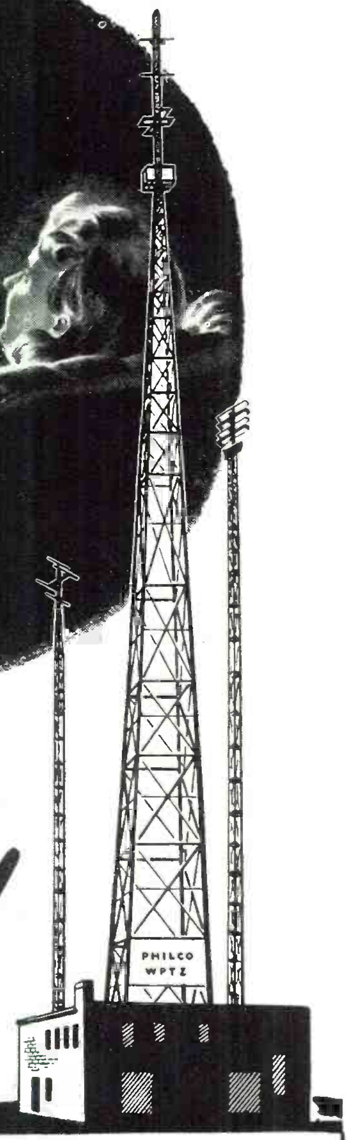
Analyses of listener interest will probably follow the analysis procedure adopted by the Columbia Broadcasting System. In this system selected families in the country and in the city, in different income brackets, are surveyed. Questions asked include how often they listen, stations listened to, and when the listening is done. Resultant information is plotted on a coverage map.

Another pertinent subject covered at this annual meeting of the Canadian Association of Broadcasters was FM. Paul Chamberlain of General Electric discussed FM and its effect on Canada. He pointed out that there are great opportunities in Canada for setting up an FM allocation plan. With such an extended plan, he said, it will be possible to completely realize all its advantages.

He cited the recommendations made by General Electric to the three major networks in the United States. He said that there are four types of stations that could use FM most effectively. These are: (1) stations in the marginal income or loss group; (2) low power stations operating in the crowded AM channels from 1,000 kc. up; (3) stations sharing time, stations sharing channels, and stations limited to power that is insufficient for good nighttime coverage (by changing to FM almost all of these stations could become full power stations with adequate power for both day and night coverage of their primary service areas, he explained); and (4) stations that for local reasons



PHILCO, THE LEADER ... AND TELEVISION!



Much is being said today in the public and trade press about Television, the "billion dollar industry" of the future. Where will Philco, the industry leader, stand when Television is here for you to sell?

Since 1928, for sixteen years, Philco engineers have devoted millions of dollars to research in the field of television. More than any other research group, they have been responsible for constant improvement in the clarity, sharpness and detail of the television picture. Their pioneer contributions have helped to bring television to maturity, ready for rapid expansion after the war.

In this and many other directions, Philco has been in the forefront of the developments that make television a bright hope for the future to appliance dealers. And when it is ready to sell in your community, you can depend on Philco to fulfill the obligations of leadership.

PHILCO TELEVISION STATION WPTZ

Since 1933, Philco has owned and operated its own television station in Philadelphia, sending out studio programs and sports events direct from the scene. It has also rebroadcast programs from New York, establishing the technique upon which future television chains can be built. All this has been a rich laboratory of experience through which Philco engineers will help to make television, some day, a nationwide service.

PHILCO

CORPORATION

have problems of poor reception in one or more communities which lie just inside their normal service area.

Low powered FM satellite stations automatically operated by a master high powered FM installation were suggested. These stations would pick up the signals from the master station and rebroadcast them on another FM channel or on the same channel. Such satellite stations may be installed at any point within the service area to bolster signal strength where poor reception problems present themselves.

FROM THE WPB COMES A FORECAST on anticipated civilian production that reveals many important trends. Unfortunately, radio is not included among the products that may soon be produced in the civilian program. However, in the list citing the qualifications for production, it appears as if there may be many affiliated radio components that will be on the production schedule soon. In the requirement schedule prepared by WPB, four qualifications are listed. These are; (1) articles using comparatively small quantities of manpower and materials; (2) those not interfering with war production; (3) those not requiring extensive conversion of facilities; and (4) those which would contribute more time and energy to war workers for their jobs.

On the civilian goods list we find dry cell batteries. The 1943 rate of production will be maintained this year. And this rate was a fairly substantial one, for the dry battery industry produced 3,750,000 radio battery packs as compared with 3,500,000 produced in 1940. A forty per cent production increase on hearing aid batteries also appeared on the production schedules in 1943. Actually, the increase in production of cells for these batteries was greater than forty per cent since hearing aid batteries today call for many more cells. Practically all of the radio battery packs produced in 1943 went to rural areas. The same distribution procedure will be followed this year. And incidentally, in view of the increased listening habits of the farmers, even this extended production will not be sufficient. The urbanites will again have to wait their turn for battery packs, what few may be available.

RADIO RELAYS will probably become one of the most important link mediums in the postwar era. Some months ago we mentioned that many engineers favored this point-to-point link system, not only as an emergency system but also as a standardized method for both broadcasting and telephone use, particularly on long-line work. Several weeks ago a two-million dollar program calling for the installation of this type of link system between New York, Boston and intermediate points, was announced by the American Telephone and Telegraph Company.

The new project proposes to use microwaves which will be beamed from stations approximately thirty miles apart. The proposed system has undergone long extensive experimentation, for just before the war radiotelephone service, operating in the two to three meter spectrum, was established across Chesapeake Bay between Norfolk and Cape Charles. A service was also established across Massachusetts Bay between Boston and Provincetown, and between the mainland and Smith and Tangier Islands in Chesapeake Bay.

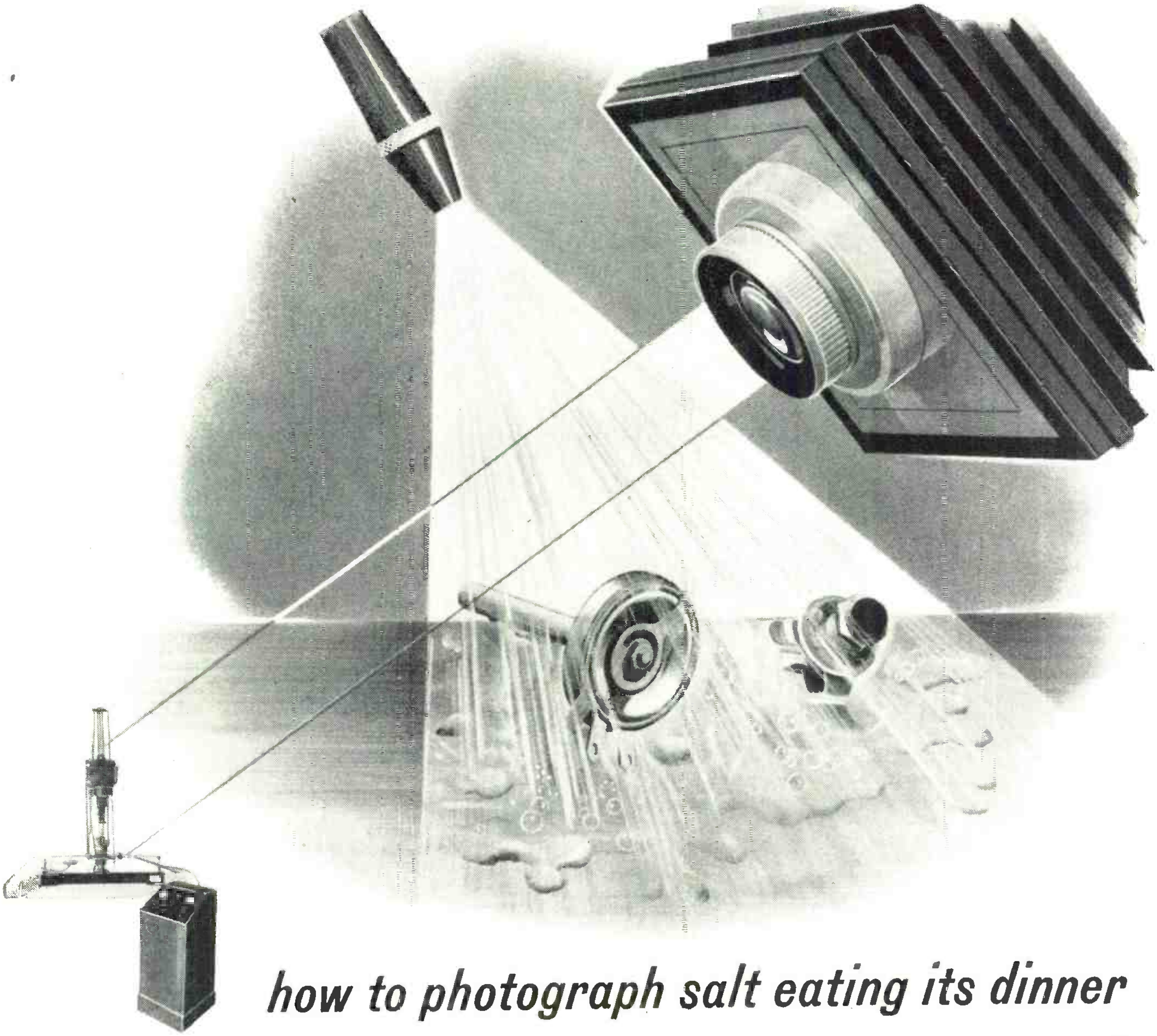
According to A T & T engineers, relative costs represent only one of the factors to be determined. Others include the relative quality of transmission, flexibility under actual operating conditions, and dependability.

Watch these radio relay links grow!

AN HISTORIC FM APPLICATION has been filed with the FCC. The applicants are Major Edwin H. Armstrong, famous for his many FM inventions, C. M. Jansky, Jr., and Stuart L. Bailey, of the Washington consulting engineering firm of Jansky and Bailey. The application calls for the installation of a 50,000-watt FM transmitter to serve Washington, D. C. and a surrounding twenty-thousand square-mile area. The station, which will be located near Olney, Maryland, some twenty miles from Washington, will be under the jurisdiction of the FM Development Foundation, with Armstrong, Jansky and Bailey as directors.

THE RECENT CHICAGO MEETING of RTPB Panel Thirteen, covering portable, mobile and emergency service communications, disclosed the wide scope of problems facing this panel. Within this panel are eight subcommittees, devoted to police radio, fire radio, forest fire and conservation, power utilities radio, transit utilities radio, highway systems radio, railroads, and general engineering. Professor D. E. Noble, who is chairman of this panel, also acted as chairman at this conference. He cited that "private" radio communications such as mobile services for doctors and private ambulance services, as well as private car services, would probably become an important type of communication for this panel to consider.

William N. Krebs of the FCC appeared at this conference and discussed frequency allocations. He admitted that there was congestion below 30 megacycles. However, he said that this situation was brought about by military requirements. Demands for these frequencies after the war will probably be made by the aircraft and merchant fleet, as well as international broadcasting facilities. Mr. Krebs stated that he believed that frequencies above 100 megacycles would be desirable in certain instances for consideration by Panel Thirteen. In regard to the numerous channels required by tele-



how to photograph salt eating its dinner

Salt, from the sea and air, has a tremendous appetite for many metals—eating them away unless they're protected. The exact effect of its gluttony and the success of the means used in preventing this costly damage are measured accurately by Utah's salt-spray test. One of the stages in Utah's *complete* circuit of radio and electronic tests.

Immediately after the parts have been subjected to the salt spray, microphotographs are taken and developed in the especially equipped Utah dark room. Thus, it is possible to make a microscopic inspection of the actual condition of the metal *before* other atmospheric changes take effect. Since metal surfaces exposed to salt-spray tests change rapidly *after tests are completed*, it is necessary and possible, by this photographic method, to determine and *accurately* record corrosion in metals.

As a result of this and other Utah tests, efficient performance of Utah parts is assured under any and all conditions normally encountered—the failures due to inadequate, inaccurate testing are avoided. ★ ★ ★

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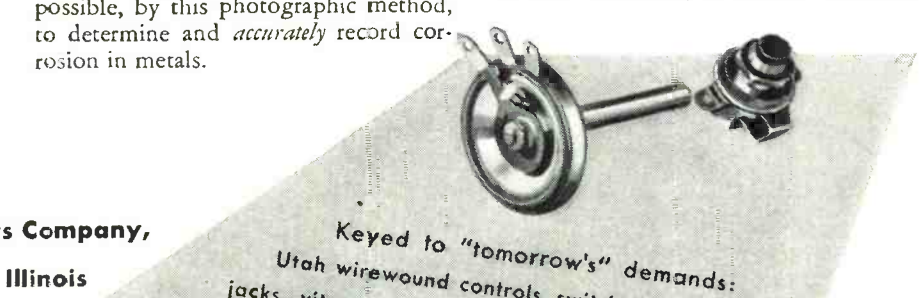

utah Radio Products Company,
824 Orleans Street, Chicago 10, Illinois

vision and FM in the 30 to 150 megacycle band, he said that there was only one solution, and that was a fair compromise. The problem of diathermy interference was also projected. Frank Walker, president of the Association of Police Communication Officers and associated with the State Police radio system of Michigan, asked if this form of interference was being studied by Panel Two, the frequency allocation panel. He was told it was, and that all memoranda from any committee concerning the subject could be directed to that panel. Incidentally, the diathermy interference problem was under FCC fire about a year ago but doctors and patients showed that such interference was beyond their control. They claimed that the appartus was an important health aid and should not be sacrificed because of the interference, which they implied might be curbed by design changes. After several hectic sessions, the issue was pigeon-holed. It now appears to be returning—and with gusto!

A DOZEN WOMEN specially trained as studio operators under the supervision of the engineering department of the National Association of Broadcasters have been offered to stations as a solution to the manpower problem. The four major networks provided the lecturers and studios, while the facilities of a radio school were used for supervision and training coordination. In addition to actual operating experience at the control consoles at the network studios, the girls were instructed in the basic principles of acoustics, care and use of microphones, purpose and functions of studio control equipment, various types of program material, use of the volume indicator, mixing and fading, operating procedure, remote pickup operation, operation of low powered broadcast transmitters, recording, etc.

Personals . . .

Ernest W. Heilmann is now head of the radio and miscellaneous unit of the Consumer Durable Goods Branch. . . . **Dr. P. M. Deeley**, formerly of Cornell-Dubilier is now with the Radio and Radar division in charge of quartz crystals and capacitors . . . Another well known radio figure now serving in the Radio and Radar branch, **Peter Jensen** of loud speaker and needle fame, is in charge of relays, microphones, and speaker units . . . An Industrial Sound Equipment Industry Advisory Committee recently formed has as it members: **David Bogan**, David Bogen, Inc.; **Ed Cahill**, RCA; **A. F. Gibson**, Stromberg Carlson; **Henry G. Kobick**, Webster Electric Co.; **Carl Langevin**, Langevin and Co.; **John Meck**, Meck Industries; **R. M. Gray**, Rauland Corporation; and **H. N. Willets**, Western Electric Company . . . **Dr. Orra S. Duffendack**, professor of physics at the University of Michigan has been appointed director of research for the North American Philips Company . . . **Henry C. Bonfig**, formerly of RCA, is now with Zenith as vice president in charge of the household radio sales division . . . Marconi Memorial Medals of Achievement have been won by **T. R. McElroy**, president of the McElroy Manufacturing Corporation, **E. A. Nicholas**, president of Farnsworth Television, **William J. Halligan** president of Hallicrafters and **Ludwig Arnson**, Radio Receptor president. Presentations were made at the recent Veteran Wireless Operators' Association dinner in New York. To **General Henry Harley Arnold**, Commanding General of the Army Air Forces went the Marconi Memorial Commemorative Medal. The award was accepted for the General by **Brigadier General H. M. McClelland**, Air Forces Communications Officer. NBC carried the presentation ceremonies . . . **Errol H. Locke** has been elected president of General Radio Company, to succeed **Melville Eastham** who continues as chief engineer in charge of research and development . . . **Paul J. Pfohl**, western manager of RCA's tube division has become sales manager of the Muter Company . . . **J. Kelly Johnson** is now executive engineer at the Hammarlund Manufacturing Company. He was formerly with the Navy as production chief of the electronics division.

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Audio Oscillators

(*Continued from page* 70)

offers an interesting and successful source of highly-precise low-distortion audio-frequency voltage. An arrangement for obtaining low-distortion signals in this manner is shown in functional block diagram in Fig. 8.

The 100-kc. crystal oscillator controls a 10-kc. multivibrator, a portion of the output voltage of which is employed to synchronize a 1-kc. multivibrator. The first multivibrator also feeds a signal output circuit embracing a low-distortion amplifier and 10-kc. filter. Likewise, the second multivibrator feeds an output circuit comprised by a low-distortion amplifier and 1-kc. filter. This arrangement effectively divides the frequency of the crystal oscillator; the first time by ten, and the second time by 100.

By this arrangement, two low-distortion audio-frequency signals having the same stability and accuracy of the controlling oscillator may be obtained. The arrangement shown in the diagram is not the limit of the scheme. Frequency division may be carried out still further by addition of more multivibrator-amplifier-filter sections. Thus, 500, 100, and 50 cycles might be obtained in addition to the 10,000- and 1000-cycle signals already provided. Likewise, the system is not restricted to 100-kc. crystal operation.

If the crystal oscillator frequency is referred periodically to some standard, such as WWV transmissions, the arrangement shown in Fig. 8 becomes a reliable secondary standard of audio frequency. And if the crystal oscillator is temperature controlled very precisely, a synchronous clock may be driven by one of the multivibrator-amplifier output voltages (1000 or 50 cycles) and its indications referred to standard time signals to check oscillator frequency drift. The clock will keep correct time if the oscillator frequency remains constant. If, on the other hand, the oscillator drifts, the amount of deviation between check periods may be calculated from the clock frequency and the difference between indicated and true time.

The precise audio frequency of 440 cycles per second, used to modulate standard-frequency transmissions from the National Bureau of Standards station WWV, is obtained in the manner just described. The arrangement of stages for this purpose is shown in Fig. 11.

A precisely-operated 200-kc. crystal oscillator with close temperature and voltage control is the heart of this system. The oscillator controls a 50-kc. multivibrator, which in turn controls a 10-kc. multivibrator, and the latter in turn a 1-kc. multivibrator. 1000-cycle output voltage is supplied by the latter stage through a 1-kc. amplifier and filter. The 1-kc. multivibrator also controls a multivibrator

(*Continued on page* 128)

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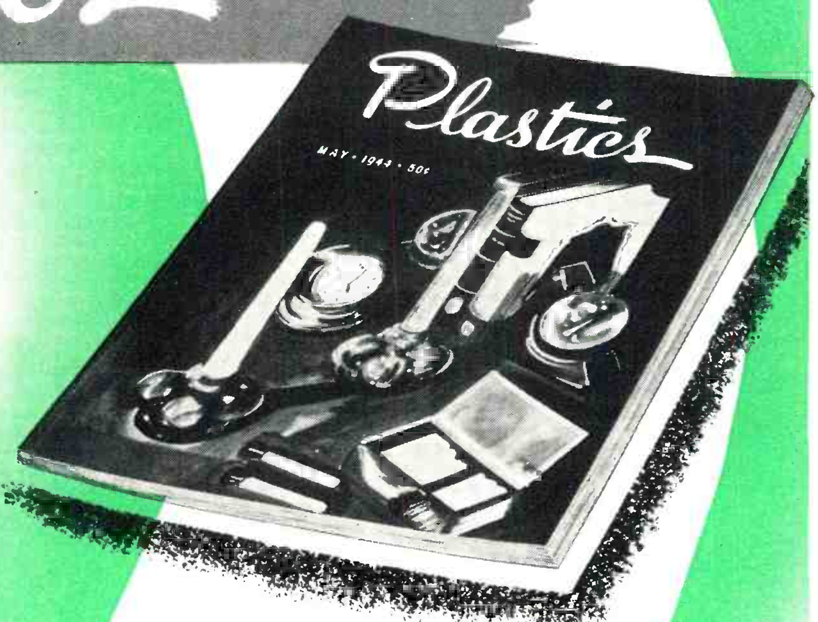
Announces

Plastics 1944



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Designed to anticipate the rapid developments in this rapidly growing industry, PLASTICS will cover authoritatively and completely the diversified interests of this ultra-modern field. This magazine is dedicated to the advancement and exploitation of the use of plastics through the visual merchandising of their applications and properties to all actual and potential users. PLASTICS brings to manufacturers the feel, sight and understanding of plastics in terms of their own products and facilities.

No effort is being spared to place before key executives the most complete accurate reporting possible. They will consistently see the news foreshadowed in PLASTICS before it makes the headlines elsewhere. PLASTICS circulation is limited to business executives only. The subscription price: one year $5.00, two years $8.00.

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You work with real radio equipment and materials which we furnish. During your National course you build experimental units, check circuits—get real practice with tools and parts. *You learn by doing and in a short time you are ready* for your first job in radio.

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Radio is only one of the courses you receive when you become a National Student. Electronics is brand new and open to every trained radio man. After this war it will produce new marvels that will be needed and used in every home. General Electric, Westinghouse and all great manufacturers have many new electronic inventions ready to market. National men, because of their knowledge and training, will be among the first to cash in. Television is a *big new opportunity.* National men will have the "know how" to merit jobs in this great industry.

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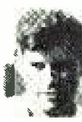

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"I got a job with International Telephone & Radio Co. in their laboratory developing new Radio equipment. It's a good salary job."—Douglas Nielsen, Jamaica, N. Y.

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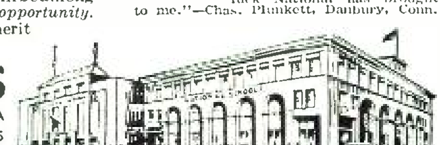

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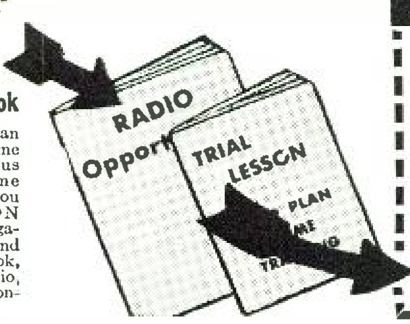

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Our laboratories in Newark, N. J., offer ideal working conditions. We prefer that you have a degree in electrical engineering, physics, chemistry or mathematics—your experience, however, may be sufficient.

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OPPORTUNITY TODAY, FOR POSTWAR

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- *Ability to do experimental work on small electro-mechanical devices. Familiarity with mass production practices preferred.*

Position is with fast growing company now engaged in war work but with an 18 year peacetime record in electronics and electro-acoustics.

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Radio, Electrical and Mechanical Design Engineers, Draftsmen and Technicians for war and post-war design work.

Engineering degree, or, actual design experience in Communication Radio, Broadcast Receivers, Television and other Electronic Fields is required.

Write giving full details, education, experience, draft status and salary desired. Essential workers need release statement and U.S.E.S. consent. All inquiries confidential.

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with college education and five years practical experience in construction and layout work. Experienced in design and layout of services. State salary and draft status.

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At least two years' design and development experience with Radio Communications Equipment manufacturer on items subsequently satisfactorily produced in quantity. Knowledge and experience in two-way mobile equipment, low power transmitters, receivers, and control equipment essential. Permanent position. West Coast Manufacturer. Will pay expenses to coast for interview if qualifications satisfactory. Write giving complete past experience, employment record, salary received, and technical references.

BOX NO. 338 **c/o RADIO NEWS**

"This section is designed to help the radio industry obtain trained, experienced, technical men to facilitate vital war production. Before applying for any of these positions consult your local United States Employment Service office to determine War Manpower Commission regulations concerning the changing of jobs. If you are already employed in war work at your highest skill, stick to your present job."

(*Continued from page* 122)

on 11 kc. through an 11-kc. filter. The 11-kc. multivibrator controls a 2.2-kc. multivibrator, and the latter a 0.44-kc. multivibrator. The last multivibrator supplies 440-cycle output voltage through an amplifier and filter. By this time, the original crystal frequency has been divided more than 400 times.

The crystal-controlled scheme has been employed not only as a source of standard audio frequencies, but also for a number of other important scientific purposes, including precise time-telling. This system is the basis of the highly-accurate *quartz clock*, which is in effect a primary frequency standard. A suitable low-frequency output voltage propels the clock which, when a fine crystal oscillator is precisely controlled (with respect to temperature, operating voltages, atmospheric pressure, humidity, etc.), keeps remarkably accurate time.

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AACS Station

(*Continued from page* 31)

jects at the same time and make sense doing it.

With so many airplanes in the air, separate frequencies must be assigned, else everyone would be talking on the same line. This means a separate radio receiver in the AACS station must be working continuously for every frequency.

To "talk back" to the airplane, the AACS airways operators have remote control of especially designed transmitters located several miles from the field where the antennas will not be a hazard to flying. The transmitters have sufficient power to work airplanes hundreds of miles away.

Pilots of inbound flights often want to know the weather conditions of the base long before arrival. This is especially true on days or nights when the weather is acting up or unsettled. At odd times some item of an airplane's multitude of equipment may go haywire and the crew may need advice from the Base Engineer's office. On a freight run, the pilot may want to ask for a quick unloading in order to maintain schedule.

For these and many other things the AACS airways operators must keep constant listening watch, alert to give the service wanted without delay. More often than not, it is impossible to know in advance what an Army airplane will ask for. Radio operators must think fast and act fast.

Flying today is no longer a matter of landing and taking off; it is a matter of control. It is necessary to know where every Army airplane is every minute, especially if the pilot is flying "blind" on instruments and can't see outside the cockpit. This requires radioing repeated position reports to make sure two airplanes on instruments are not in the same place in the air at the same time. The handling of these contacts is another job of heavy responsibility for the AACS radio operator.

The operators at Scott Field, which, incidentally, is the Army Air Forces Training Command radio school, are members of the Army Airways Communications System, now a world-wide organization, operating aeronautical radio and wire facilities along all of the military airways.

Military airways can be said to consist of the air space through which military airplanes travel between Army air bases. To fly safely along such airways, three elements are necessary: (1) Communications, (2) Weather information, (3) Control.

These elements are an inseparable trio. AACS stations provide the coordination of these elements. Without weather information, the planes cannot fly the routes; without control, chaos results; and without communications there is neither weather information nor control. To do this, the Army Airways Communications System operates a total of 593,000 miles of radio and wire circuit, miles enough to go around the world 25 times.

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Book Review

(*Continued from page 46*)

tion with the great scientific minds of the early age of electricity gives a clear picture of the backgrounds that produced much of the electrical equipment being used today.

The book is written in an extremely sympathetic manner, as Mr. Woodbury both knew and loved the charming simplicity of the great man who made so many contributions to the age of electricity. At times, Mr. Woodbury tends to lose his perspective of the problem as a whole and pictures Dr. Thomson as a misunderstood genius whose inventions were being surpassed by other workers in the field, due to Dr. Thomson's inability to grasp the importance of filing applications for patents.

Except for this tendency to minimize the work of Dr. Thomson's contemporaries, the book presents a lively and interesting picture of the age of invention in the middle and late nineteenth century. For those particularly interested in the beginnings of electricity and scientific research, this book will be a welcome addition to their libraries.

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Page Numbers	Credits
22	British Official Photo (War Office)
23	British Official Photo (Admiralty)
31, 44, 45	AAF Training Command
36 (top)	Acme
36 (bottom), 37 (top and bottom)	U. S. Signal Corps
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FOR SALE: P.A. System with thirty watt Bogen Amplifier, twelve inch Jensen Speakers, RCA Mike. Gen. Ind. Recorder and Playback. All or part. Schmidt Radio, Goodthunder, Minn.

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WANTED: Phono motor and turn table 60 cycle 110 volt 78 R.P.M., also communications receiver, any make or model. State price, etc. Ted E. Matzen, 523 E. 3rd St., Anaconda, Mont.

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ULTRA-HIGH-FREQUENCY *Capacitors*

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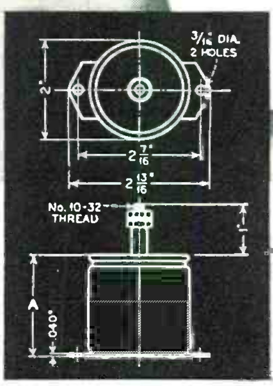
Losses are extremely low due to highly refined sulphur dielectric used. Corona losses are avoided by the unique design and construction, grounded case, and insulated terminal.

When your requirements reach up into the higher operating frequencies, just bear in mind these two Aerovox U-H-F capacitors.

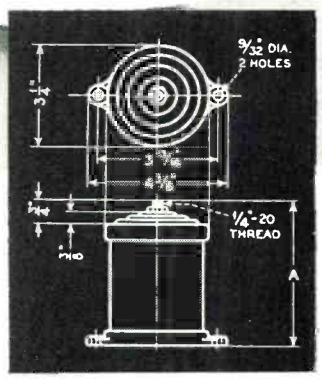
● **WRITE FOR LITERATURE**



Type 1860 (see photo and above drawing) has suitably plated brass terminal mounted in mica insulating plate. Dimension A is from 2 to 3½"

10,000 test volts eff. .00001, .000025 and .00005 mfd.; 5000 v., .00005 mfd.

Catalog lists maximum current in amperes at operating frequencies from 1000 KC. to 75 MC. max., for both types.



Type 1865 (no photo, but see drawing above) differs in the use of cast-aluminum case and steatite insulator to support terminal and withstand higher voltages. Dimension A is from 2-11/16 to 6-11/16".

• • •

Tolerance for both types, plus/minus 10% standard. Available in closer tolerances. Minimum tolerance, plus/minus 2 mmf.

AEROVOX *Capacitors*

INDIVIDUALLY TESTED

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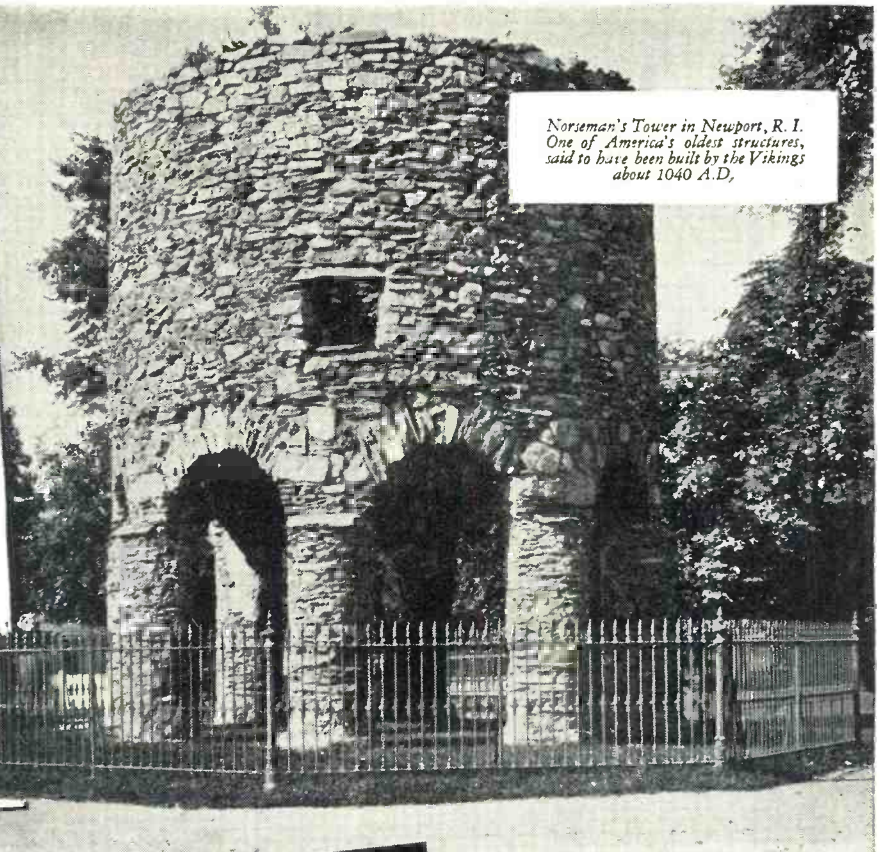
Stalwart *against* Time

THE REPUTATION of Tobe Capacitors for *long life* rests on a record of practically no "returns". Ratings are always conservative. Constant research . . . manufacturing skill born of long, specialized experience . . . frequent, rigid inspections—these are the "secrets" of Tobe's ability to master difficult specifications, like those of the new American War Standards. The "DP" Molded Paper Condenser shown below is an example. It is made of high grade Kraft tissue paper and aluminum foil—mineral oil impregnated and molded in low-loss Bakelite. Leads are tin copper wire. Whatever *your* condenser problems, Tobe engineers will gladly work with you. Inquiries and requests for samples will receive prompt attention.



Norseman's Tower in Newport, R. I. One of America's oldest structures, said to have been built by the Vikings about 1040 A.D.

LONG LIFE ASSURED

SPECIFICATIONS "DP" MOLDED PAPER CONDENSERS

CAPACITANCE ....001 to .04 MFD
WORKING VOLTAGE ....*See chart at right*
Flash test 3 times rated DC working voltage
SHUNT RESISTANCE At 185°F— 1000 megohms or greater
At 72°F—50000 megohms or greater
WORKING TEMPERATURE RANGE Minus 50° F to plus 185° F
OPERATING FREQUENCY RANGE..Upper limit 40 megacycles
Q at one megacycle—average 20
POWER FACTOR............At 1000 cycles .004 to .006
DIMENSIONS.................13/16" x 13/16" x 19/64"

Capacity in MMFD.	DC Working Voltage Rating	TOBE & AMERICAN WAR STANDARDS DESIGNATIONS "A" Characteristic	"B"
1000	600—1500	CN35A102	CN35B102
1500	600—1500	CN35A152	CN35B152
2000	600—1500	CN35A202	CN35B202
2500	600—1250	CN35A252	CN35B252
3000	600—1000	CN35A302	CN35B302
4000	600—1000	CN35A402	CN35B402
5000	600— 800	CN35A502	CN35B502
6000	600— 800	CN35A602	CN35B602
7000	500— 700	CN35A702	CN35B702
8000	500— 700	CN35A802	CN35B802
10000	400— 600	CN35A103	CN35B103
20000	200— 300	CN35A203	CN35B203
30000	50— 150	CN35A303	CN35B303
40000	50— 100	CN35A403	CN35B403

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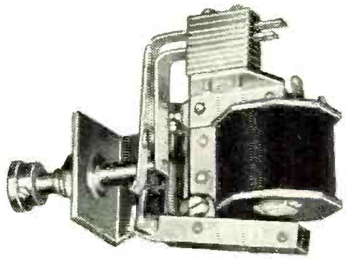
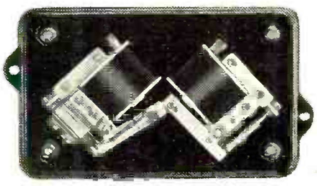
Series 90 Interlock Relay locks mechanically from an electrical impulse and unlatches or resets from another such impulse. Combinations up to DPDT available with 12½ amp. contacts rated at 110 v., 60 cycles, non-inductive load. Coil resistances up to 10,000 ohms. For AC or DC operation.

Series L-500 Overload Relay, manual reset, protects DC circuits against abnormal current surges where current conditions are constant. Contacts can take severe overloads undamaged, cannot be reset during overload. Rated for 1500 watts on 110 v., 60 cycle, non-inductive AC.



Series L-500—Overload Relay
Ask for Bulletin R-5



Series 90—Interlock Relay
Ask for Bulletin 21

Consult Guardian wherever a tube is used—*however*—Relays by Guardian are NOT limited to tube applications but may be used wherever automatic control is desired for making, breaking, or changing the characteristics of electrical circuits.

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