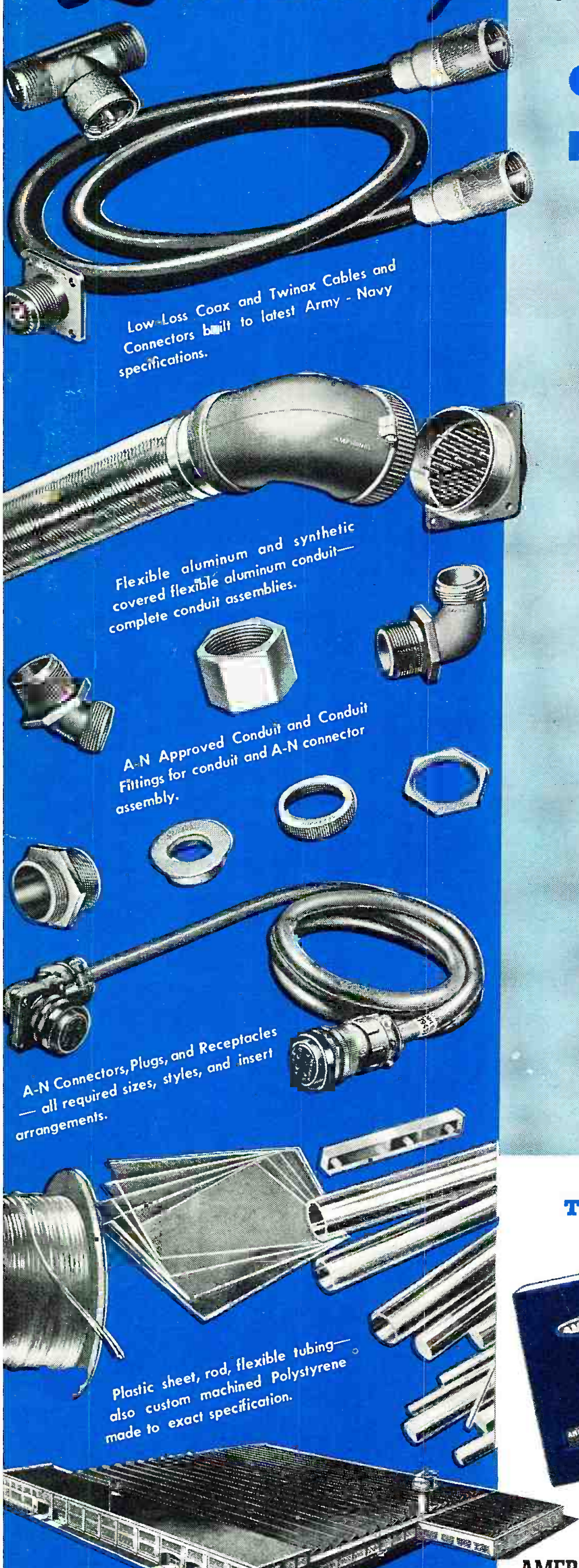
RADIO NEWS

JANUARY
1944
25c
In Canada 30c

Leadership in the Production of

CONNECTORS · CABLES and PLASTICS for ELECTRONICS



• Wide experience in the field . . . close collaboration with the industry's leading engineers... adequate production facilities . . . explain Amphenol's leadership in the manufacture of Army-Navy Type Connectors, Conduit, and Conduit Fittings, Low-Loss Cable and Connectors, and Plastics for electronic applications. Amphenol A-N products are precision engineered to give lasting dependable operation. The greatly increased production facilities at the Amphenol plant expedite the handling of orders quickly and efficiently. Depend upon Amphenol quality, workmanship, and service!

THE LEADERSHIP CATALOG OF THE INDUSTRY

With complete specifications of all Amphenol Products, technical data, charts, and helpful information — a guide book of electrical equipment used in aircraft, radio, shipbuilding industries. Send your request on company letterhead.

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IN CANADA · AMPHENOL LIMITED · TORONTO

J. E. SMITH, President
National Radio Institute
(Our 30th year)

I WILL SEND A SAMPLE LESSON FREE to PROVE I can Train You at Home in Spare Time to BE A RADIO TECHNICIAN

I Trained These Men

$200 A MONTH IN OWN BUSINESS

"For several years I have been in business for myself making around $200 a month. Business has steadily increased. I have N.R.I. to thank for my start in this field." ARLIE J. FROEHNER, 300 W. Texas Ave., Goose Creek, Texas.

$5 to $10 Week in Spare Time

"I am engaged in spare time Radio work. I average from $5 to $10 a week. I often wished that I had enrolled sooner. All this extra money sure does come in handy." THEODORE K. DuBREE, Horsham, Pa.

1st Lieutenant in Signal Corps

"I cannot divulge any information as to my type of work but I can say that N.R.I. training is coming in mighty handy these days." RICHARD W. ANDERSON. (Address omitted for military reasons.)

More Radio Technicians and Operators Now Make $50 a Week Than Ever Before

I will send you a sample Lesson, "Getting Acquainted with Receiver Servicing," to show you how practical it is to train for Radio at home in spare time. It's a valuable lesson. Study it—keep it—use it—without obligation! Tells how "Superhet" Circuits work, gives hints on Receiver Servicing, Locating Defects, Repair of Loudspeaker, I. F. Transformer, Gang Tuning Condenser, etc. 31 illustrations. And with this Lesson I'll send my 64-page illustrated book, "Win Rich Rewards in Radio." It describes many fascinating jobs Radio offers, explains how N.R.I. trains you at home for good pay in Radio! Get both FREE by mailing coupon!

Big Demand Now for Well-Trained Radio Technicians, Operators

There's a big shortage today of capable Radio Technicians and Operators. Fixing Radios pays better now than for years. With new Radios out of production, fixing old sets, which were formerly traded in, adds greatly to the normal number of servicing jobs.

Broadcasting Stations, Aviation and Police Radio, and other Radio branches are scrambling for Operators and Technicians. Radio Manufacturers, now working on Government orders for Radio equipment, employ trained men. The Government, too, needs hundreds of competent civilian and enlisted Radio men and women. You may never see a time again when it will be so easy to get started in this fascinating field.

Many Beginners Soon Make $5, $10 a Week EXTRA in Spare Time

The moment you enroll for my Course I start sending you EXTRA MONEY JOB SHEETS that show how to earn EXTRA money fixing Radios. Many make $5, $10 a week EXTRA in spare time while still learning. I send you SIX big kits of real Radio parts. You LEARN Radio fundamentals from my lessons—PRACTICE what you learn by building typical circuits like those illustrated on this page—PROVE what you learn by interesting tests on the circuits you build.

Be Ready to Cash in on Good Pay Jobs Coming in Television, Electronics

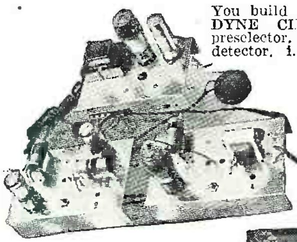
Think of the **NEW** jobs that Television, Frequency Modulation, Electronics, and other Radio developments will open after the war! You have a real opportunity. I will train you to be ready to cash in when Victory releases these amazing wartime Radio developments for peacetime uses!

But the opportunity the war has given beginners to get started in the fascinating field of Radio may never be repeated. So take the first step at once. Get my FREE Lesson and 64-page, illustrated book. No obligation—no salesman will call. Just mail the coupon in an envelope or paste it on a penny postal. Get started today on the road to better pay! —J. E. SMITH, President, Dept. 4AR, National Radio Institute, Washington 9, D. C.

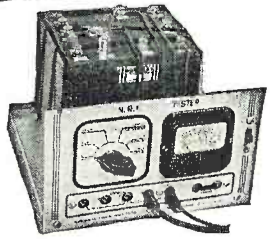
TRAINING MEN FOR VITAL RADIO JOBS

You Build These and Many Other Radio Circuits With Kits I Supply!

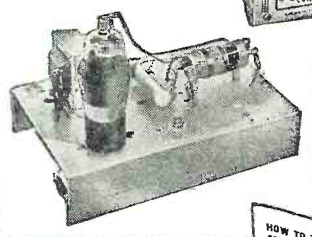
By the time you've conducted 60 sets of Experiments with Radio Parts I supply—have made hundreds of measurements and adjustments—you'll have had valuable PRACTICAL experience.



You build this SUPERHETERODYNE CIRCUIT containing a preselector, oscillator-mixer-first detector, i.f. stage, diode-detector-a.v.c. stage and audio stage. It will bring in local and distant stations. Get the thrill of learning at home evenings in spare time while you put the set through fascinating tests!



You Build this MEASURING INSTRUMENT yourself early in the Course, useful for practical Radio work on neighborhood Radios to pick up EXTRA spare time money. It is a vacuum tube multimeter, measures A.C., D.C., and R.F. volts, D.C. currents, Resistance, Receiver Output.



Building this A. M. SIGNAL GENERATOR will give you valuable experience. Provides amplitude-modulated signals for test and experimental purposes.


Extra Pay in Army, Navy, Too

Men likely to go into military service, soldiers, sailors, marines, should mail the Coupon Now! Learning Radio helps Service men get extra rank, extra prestige, more interesting duties, MUCH HIGHER PAY. Also prepares for good Radio jobs after service ends. Over 1,700 Service men now enrolled.

GOOD FOR BOTH 64 PAGE BOOK SAMPLE LESSON **FREE**

Mr. J. E. SMITH, President, Dept. 4AR
NATIONAL RADIO INSTITUTE, Washington 9, D. C.

Mail me FREE, without obligation, your Sample Lesson and 64-page book, "Win Rich Rewards in Radio." (No Salesman will call. Please write plainly.)

Name.. Age........

Address ....

City.................................... State...........4FR

JANUARY, 1944

RADIO NEWS

"Reg. U. S. Pat. Off."

Vol. 31, No. 1

CONTENTS

DEPARTMENTS

FEATURES

COVER PHOTO—BY RUDY ARNOLD

One of the specially-trained men who operate the sound locator, or "ears." His helmet and stethoscope-like attachments give him a weird appearance. All sound locator soldiers must have binaural hearing; be able, that is, to accurately trace the origin of sounds. This photo was taken somewhere on the east coast of the Anti-Aircraft Artillery Command, Eastern Defense Command.

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Member of the Audit Bureau of Circulations

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FOR THE *Record*

BY THE EDITOR

THE American radio serviceman still finds himself unable to purchase essential tubes which are sorely needed to keep the millions of sets in American homes in operating condition. As we all know, there are several types which are particularly hard to obtain. There just aren't any!

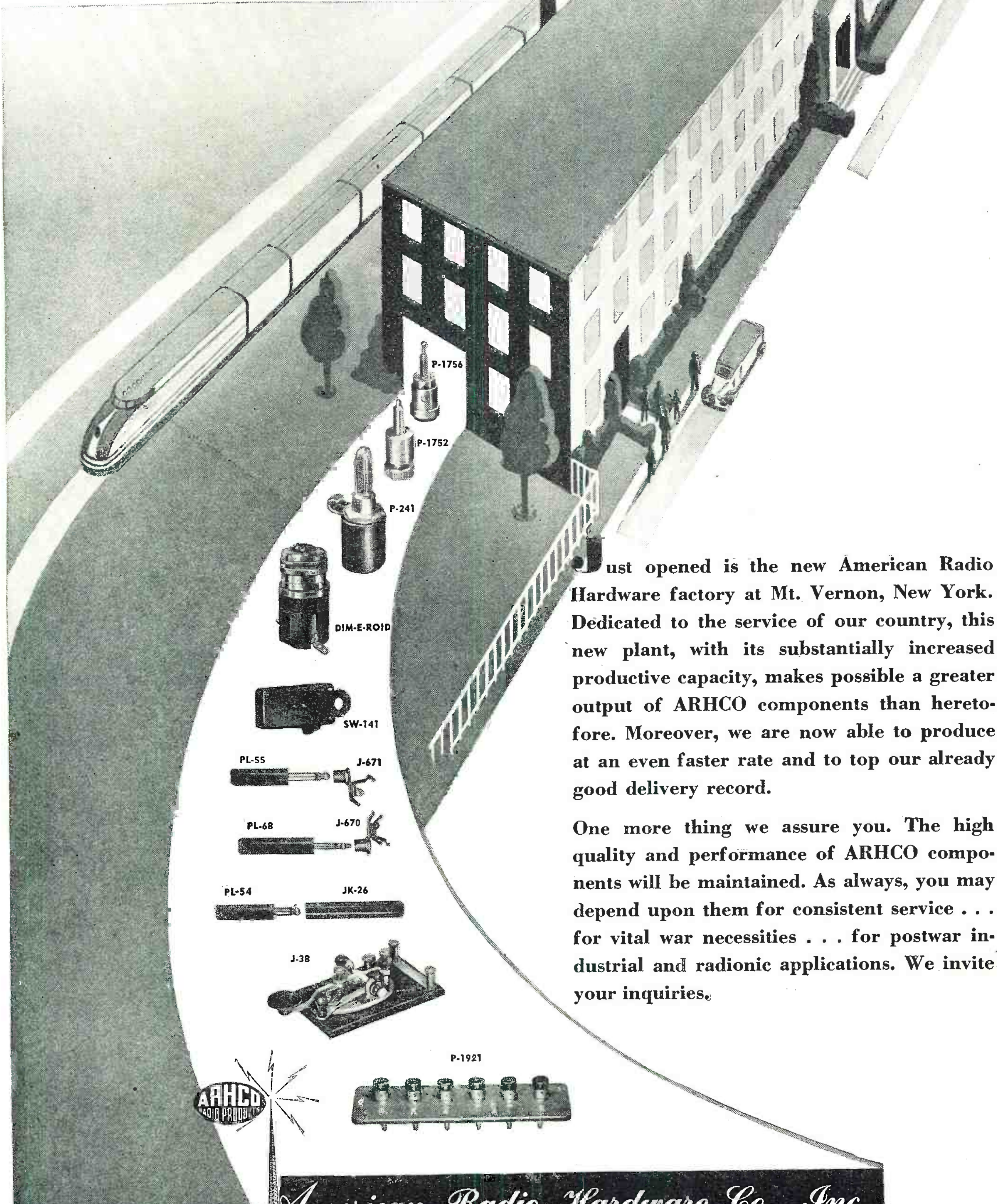
It is with this considerable alarm that we find that Lend-Lease has supplied thousands and thousands of tubes for replacement purposes to the British government. We find that these tubes, known in Britain as "valves," are being sold to British servicemen in order to keep civilian receivers in operation. There has been considerable ballyhoo appearing in various British trade papers together with many advertisements offering "American lease-lend radio valves" for immediate delivery to owners of radio receivers requiring valve replacements. Dozens of American made types are listed. Even the 50L6 which is a rarity in this country is to be found throughout these various listings. The radio servicemen in this country would certainly like to know why they did not get a supply of popular replacement tubes at the time when these huge shipments were sent abroad. Is it not just as important for the American listener to be informed as it is for those residing in the British Empire? We think it is! What can be done to straighten out this bottle-neck is up to Washington.

WE SUGGESTED, in our December editorial, that steps be taken to keep American made communications equipment on foreign shores after the peace has been won. We have presented this idea to several executives in Washington and find them to be entirely in favor with such a proposal.

We feel that if various countries were permitted to order used equipment on Lend-Lease that it could be scheduled for delivery *after the war*. A certain number of units of, let us say, the SCR 299 could be set aside

(*Continued on page* 105)

OUR NEW PLANT
steps up ARHCO production



Just opened is the new American Radio Hardware factory at Mt. Vernon, New York. Dedicated to the service of our country, this new plant, with its substantially increased productive capacity, makes possible a greater output of ARHCO components than heretofore. Moreover, we are now able to produce at an even faster rate and to top our already good delivery record.

One more thing we assure you. The high quality and performance of ARHCO components will be maintained. As always, you may depend upon them for consistent service . . . for vital war necessities . . . for postwar industrial and radionic applications. We invite your inquiries.

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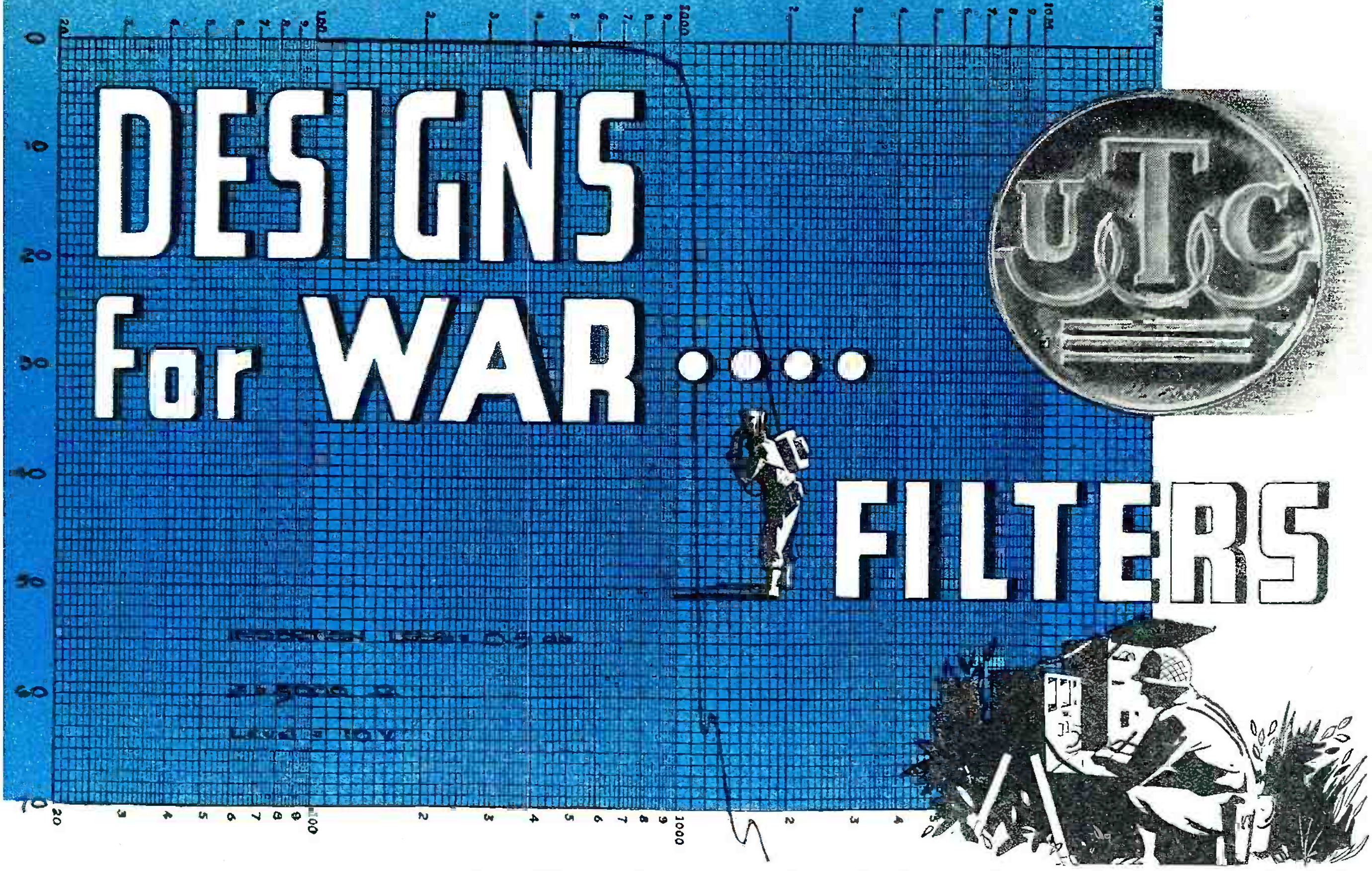
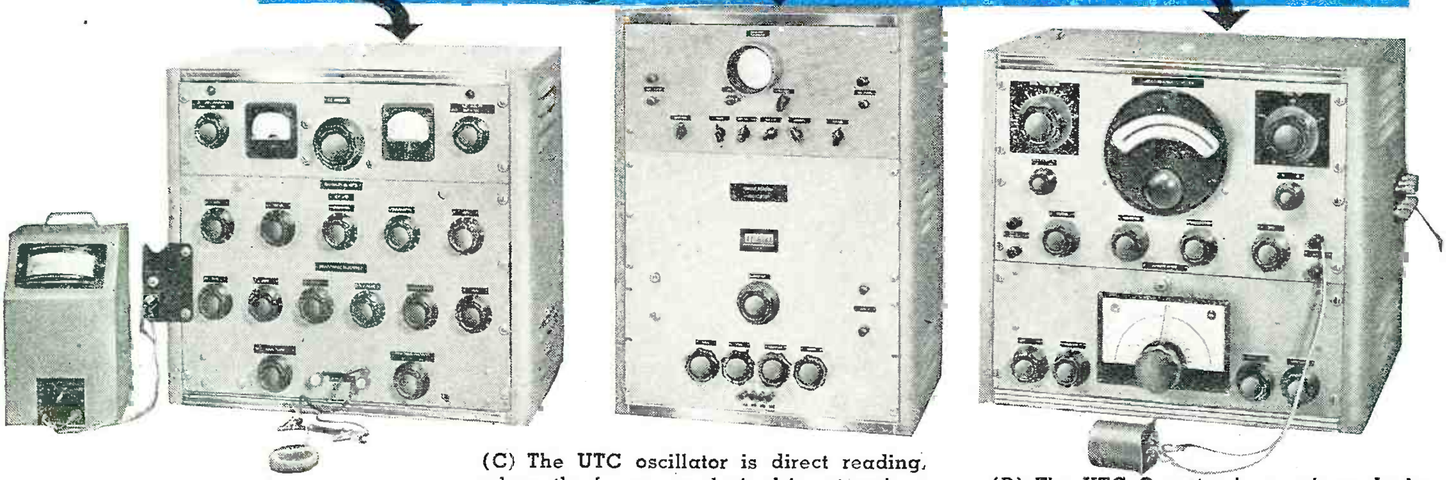
MANUFACTURERS OF SHORT WAVE • TELEVISION • RADIO • SOUND EQUIPMENT

DESIGNS For WAR.... FILTERS



(A) Filter performance is dependent upon three major factors, basic design . . . Q of coil and capacitor elements . . . and precision of adjustment. The superiority of UTC products in this field has been effected through many years of research and development on core materials and measuring apparatus. We illustrate below a typical filter formula and some of the UTC apparatus used to determine quantitative and qualitative values:

$$\frac{(LC\pi^2 f\infty - 1)\left(\frac{1}{Q} + 1 - \left(\frac{f\infty}{f}\right)^2\right)}{\frac{1}{Q^2} + \left(1 - \left(\frac{f\infty}{f}\right)^2\right)^2} = U_m \text{ (ATTENUATION CONSTANT)}$$



(B) The UTC inductance bridge is capable of four digit accuracy and covers a range from extremely low values to over 100 Hys. The effective resistance and inductance values are direct reading, eliminating the possibility of error in conversion.

(C) The UTC oscillator is direct reading, where the frequency desired is set as in a four digit decade box, and is accurate within 1 cycle at 1,000 cycles. The range is 10 cycles to 100 kc. Accuracy of this type is essential with filters having sharp attenuation characteristics. This instrument is augmented by a UTC harmonic analyzer for the output measuring device.

(D) The UTC Q meter is a unique device which has helped considerably in the development of the special core materials used in our filters. It is also of importance in maintaining uniform quality in our production coils. The Q is read directly and covers the entire range of possible Q factors over the entire audio frequency band.

UNITED TRANSFORMER CO.

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NAVY
FIRST . . .
Hallicrafters has the honor of being the 1st exclusive radio manufacturer to receive the Army-Navy Production Award for the 3rd time!
BUY MORE BONDS!
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The World's Largest Exclusive Manufacturer of Short Wave Radio Communications Equipment

Spot Radio News

IN DEFENSE AND INDUSTRY

by **LEWIS WINNER**
RADIO NEWS Washington Correspondent

Presenting latest information on the Radio Industry.

THE "TRAFFIC COP" OF THE AIRWAYS . . . radio . . . has again been extolled, this time at an air transport meeting of the Institute of Aeronautical Sciences. The praising remarks were made by A. M. Burden, special aviation assistant to the Secretary of Commerce. He said that in the tremendous postwar expansion of civil aviation, radio will play an extremely vital role, particularly as a "traffic cop."

In describing the growth of aircraft movements, Mr. Burden predicted that postwar traffic would be approximately five times that now being handled. He cited how the many manually-performed operations in an airway traffic-control center must be replaced by automatic radio means, to avoid delays and minimize accidents. The human element, he said, introduces problems in the possibility of error, speed of handling of messages and other manual faults.

"Air traffic in the future will be routed around congested corners through the facilities of u-h-f radio range assistance," explained Mr. Burden. "These ranges will be arranged to provide direct routes, closely approximating great-circle routes, between large terminals, thus bypassing the points of congestion. The terminals en route, will be linked to a through airway by the radio range. Locations will be spotted so that aircraft standing by will not interfere with the through traffic," he explained.

"With such an arrangement, trunk and feeder-line airways for not only transcontinental but intra-continental traffic will be possible," explained Mr. Burden.

Looks as if radio is scheduled to have quite a busy time in the air!

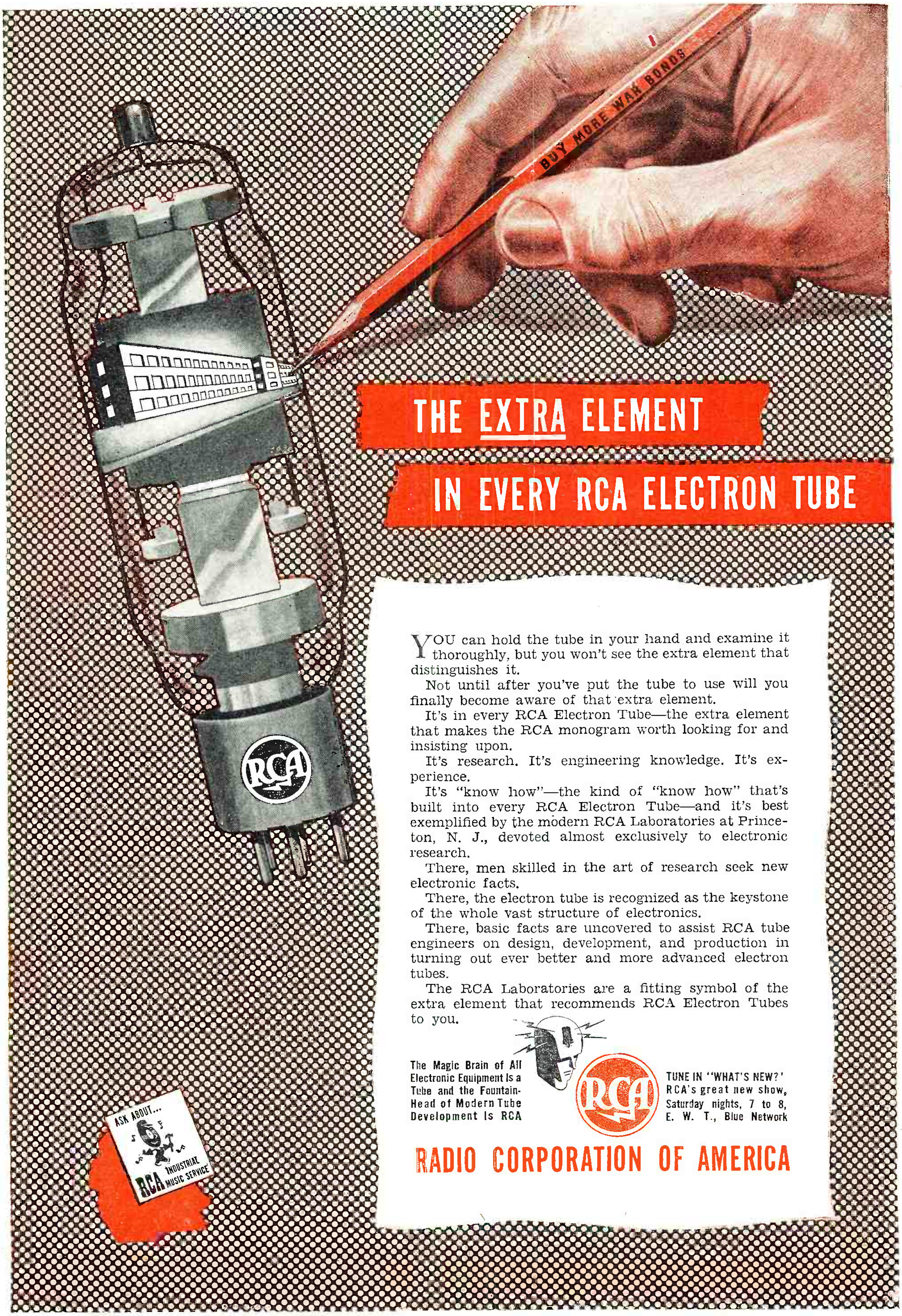
THE FIRST OF THE YEAR will see the inauguration of two commercial networks in Canada. They will be known as the Transcanada and Dominion networks. The Transcanada network will include most of the stations in the CBC national network from Vancouver (CBR) to Sydney, N. S. (CJCB). The Dominion network will link Victoria, B. C. (CJVI) to Sherbrooke, Quebec (CHLT). The Toronto station, CJBC, will be the key station for the Dominion network, and its power will be increased from 1000 to 5000 watts, as soon as it is possible to install new equipment.

The Transcanada network will begin operation with about seventeen hours of sustaining and commercial programs, while the Dominion network will be on the air every night from 8 to 11 p.m.

Speaking of network inaugurations, the Mutual Broadcasting System celebrated one in October, for the system was nine years old then. In 1934, there were but four stations in the system. Today there are 211 with outlets in Canada, Hawaii and in Mexico through the 36-station Radio Mil chain. To president Miller McClintock, the Mutual system is deeply indebted for this growth. His ability to originate and pioneer has brought Mutual to the top rungs of popularity among the listeners of this continent.

THE STORY OF THE AMAZING GROWTH of radio is effectively told in a 261-page market data handbook just released by the National Association of Broadcasters. In a year-by-year series of records compiled by the NAB Department of Research, we find that in 1922, there were only 60,000 sets for 60,000 radio families. Now, there are 30,800.000 radio families who own 59,850,000 receivers, including home, auto and portable types. The term "radio family," incidentally, was employed by the U.S. Census in its work of 1940, saying that . . . "the term radio family or dwelling unit was enumerated as having a radio if it contained a usable radio set or one only temporarily out of repair." Three types of areas were included in the survey. These were the urban, rural non-farm and rural farm. According to the Census definitions . . . "the urban area is made up, in general, of cities and other incorporated places having 2500 inhabitants or more, and all territory outside of these areas, is classified as rural." In the rural non-farm category we find those homes located outside of the boundaries of urban places. The rural farm units represent about 99% of all farm units. There are a few states with farms located in urban places. These were included in the urban area portion of the survey.

Broadcast advertising is sold on the basis of the 30,800,000 families and not


BUY MORE WAR BONDS
THE EXTRA ELEMENT
IN EVERY RCA ELECTRON TUBE
YOU can hold the tube in your hand and examine it thoroughly, but you won't see the extra element that distinguishes it.
Not until after you've put the tube to use will you finally become aware of that extra element.
It's in every RCA Electron Tube—the extra element that makes the RCA monogram worth looking for and insisting upon.
It's research. It's engineering knowledge. It's experience.
It's "know how"—the kind of "know how" that's built into every RCA Electron Tube—and it's best exemplified by the modern RCA Laboratories at Princeton, N. J., devoted almost exclusively to electronic research.
There, men skilled in the art of research seek new electronic facts.
There, the electron tube is recognized as the keystone of the whole vast structure of electronics.
There, basic facts are uncovered to assist RCA tube engineers on design, development, and production in turning out ever better and more advanced electron tubes.
The RCA Laboratories are a fitting symbol of the extra element that recommends RCA Electron Tubes to you.
The Magic Brain of All Electronic Equipment Is a Tube and the Fountain-Head of Modern Tube Development Is RCA
RCA
TUNE IN "WHAT'S NEW?" RCA's great new show, Saturday nights, 7 to 8, E. W. T., Blue Network
RADIO CORPORATION OF AMERICA
ASK ABOUT... RCA INDUSTRIAL MUSIC SERVICE
RCA

the 59,850,000 radio sets, says the report. For radio use in the home is the preponderance of radio listening. That is why it is used as the sales base, explains the report. In addition, there are the listening posts in autos, institutions and places of business, which must be added to the overall audience possibilities of radio.

The survey covers the 48 states and the District of Columbia, and lists the counties, with their non-radio and radio families, with percentages of radio families cited for each county.

This invaluable survey has already become the "bible" of the industry and will undoubtedly retain that position for a long, long time to come. Our congratulations to the men and women of NAB for their exhaustive work in the preparation of this volume.

LONDONERS WILL SOON BE LISTENING-IN on American made receivers. For some 8000 were recently received over there, through the facilities of the lend-lease program. And according to reports from the British Isles, this is but the first of the shipments, with several more to follow soon.

Most of the receivers, which are of the 110-volt variety, will have to be converted to 200 to 250-volt operation, that being the power used on the Isles.

The president of the Board of Trade issued the announcement that the American receivers had arrived.

EXTENSIVE PROGRESS HAS BEEN made by the recently formed RTPB (Radio Technical Planning Board). Government interest and cooperation has been keen. A few weeks ago a special meeting was called by FCC chairman Fly. It brought together members of the FCC, and Army and Navy communication officials, as well as most of the chairmen and vice-chairmen of the thirteen RTPB panels.

The studies that the FCC are conducting to determine the possibility of long distance skywave interference in the present FM and television bands were disclosed at the meeting.

The problem of allocation was discussed at length. If, said some of those present, no change in allocation of frequencies for television is made, and large numbers of sets are sold under the present commercial standards, the effect would be to freeze the service without giving the public the benefit of wartime developments.

Other problems that will be studied by the various governmental and industrial panels were also analyzed. These included . . . (1)—major changes which may be required with respect to standard broadcasting, FM broadcasting. television, aviation, police and emergency services, international point-to-point, maritime and government; (2)—changes to be made in the FCC present standards of good engineering practices and other technical rules; (3)—possibilities of using frequencies above 300 megacycles.

Among the government officials who attended this meeting were . . . Commander Franz O. Willenbucher, Navy Department; Lt. Commander Paul Segal, Navy Department; J. H. Dellinger, National Bureau of Standards; Lt. Commander Paul D. Miles, Navy Department; Capt. E. M. Webster, Coast Guard; L. H. Simson, CAA; Lt. Col. A. G. Simson, Signal Corps; John S. Timmons, WPB; FCC Commissioners T. A. Craven, C. J. Durr, Paul A. Walker, Ray C. Wakefield and Chairman James L. Fly; FCC staff members including chief engineer E. K. Jett, general counsel Charles Denny, P. F. Siling, Rosel Hyde, Dr. L. P. Wheeler, George Sterling, William H. Bauer, George Adair, George Turner, James P. Veatch, Harry Plotkin and William N. Krebs.

Among the members of the RTPB in attendance were . . . Dr. W. R. G. Baker, (RTPB chairman), vice president, General Electric; Dr. Alfred N. Goldsmith, (chairman, panel 1, Spectrum Utilization) and Dr. R. H. Manson, Stromberg Carlson Company, (vice chairman, panel 1); Dr. C. B. Jolliffe, RCA, (chairman, panel 2, frequency allocation) and F. M. Ryan, American Tel. and Tel., (vice chairman, panel 2); R. M. Wise, Sylvania, (chairman, panel 3, high frequency generation) and H. F. Argento, Raytheon, (vice chairman, panel 3); Howard S. Frazier, NAB, (chairman, panel 4, standard broadcasting) and Burgess Dempster, Crosley, (vice chairman, panel 4); E. F. Gustafson, Zenith, (chairman, panel 5, vhf broadcasting) and C. M. Jansky, Jansky & Bailey, (vice chairman, panel 5); D. B. Smith, Philco, (chairman, panel 6, television); J. V. L. Hogan (chairman, panel 7, facsimile) and C. J. Young, RCA, (vice chairman); Haraden Pratt, Mackay Radio, (chairman, panel 8, radio communication); E. W. Engstrom, RCA Labs, (chairman, panel 9, relay systems) and Dr. Ralph Brown, Bell Telephone Labs, (vice chairman, panel 9); C. V. Aggers, Westinghouse, (chairman, panel 12, industrial, scientific and medical equipment) and H. B. Marvin, General Electric, (vice chairman, panel 12); Professor D. E. Noble, Galvin, (chairman, panel 13, police and emergency services) and Frank Walker, Michigan State Police (vice chairman, panel 13).

An interview with Dr. Baker further revealed the speed with which the RTPB intends to operate.

"For," said he, "it is possible that the television and FM study may be completed within 6 months!"

THE EFFECTIVE USE OF LIGHT BEAMS for voice transmission by the Germans, has just been disclosed by the British authorities. Apparatus captured during the Battle of Alamein and tested in the laboratories of the Royal Corps of Signals in the Middle East reveals that the Germans used a system of modulating the beam. The equipment consisted of a transmission-

reception unit that resembled a pair of binoculars. Here were located the modulator, color filters, transmitting and receiving lens, photocell and amplifier. In addition there was also a built-in telescope and a tripod on which the equipment was mounted. Amplifiers for transmission and receiving were housed in a box, with batteries and carried separately.

To eliminate possibility of interception, infra-red light was used. White or red light was used too, by simply switching filters. With the aid of a sharp lens, it was possible to direct a beam six yards wide at a mile and thirty miles wide at five miles. Since the system depends upon line-of-sight, elevated positions for the instrument were necessary. And these positions had to be high enough to avoid interruption by passing vehicles.

Tests showed that an average range of five miles was possible, with a corresponding decrease in travel during rain or fog. Audio response ranged from about four to 5000 cycles. To minimize low frequency flutter due to hot air currents rising in the optical path, attenuation at 300 cps. and below was found to be very high.

The telescope served two uses with this equipment. First it aided in aligning the station to the receiving or transmission terminals. In addition it served as a *visual* monitoring device to check modulation action.

According to the British military authorities, this equipment has been in use by the Germans for some eight years. It represented quite a foolproof medium of transmission.

PLANS TO AVOID SURPLUS DUMPING of radio equipment are now being made by the Radio and Radar Division of WPB. The foreign markets, particularly South America, will undoubtedly be able to absorb a good portion of the transmitting and receiving equipment, according to a WPB official. Civilian aircraft will also serve as a source for the military-designed aircraft communications equipment, plans indicate. In addition, a large part of the equipment not in use or in reserve would be undoubtedly retained in the services for months and perhaps years after the war. Thus, says WPB, surplus stock will, to a great extent, be kept within government bounds, the remainder to be released for specific purposes and in accordance with planning consistent with industrial needs.

THE ANNUAL MEETING OF ENGINEERS in Rochester this year posed some interesting trends . . . and they were good ones, too! This year's session lasted two days, as against the one-day affair of last year. This year, a variety of engineering papers were presented, whereas last year, no engineering papers were read at all. Papers prepared covered a new type of capacitor and tube, as well as data on i-f systems and ceramics.

The new capacitor described was a vacuum type. George Floyd of General Electric presented the paper on the new component that is being made in capacities ranging from 25 to 100 μμfd with peak voltages of from 7,500 to 16,000. The units are unusually small. For instance, a 50-μμfd capacitor is only 3 5/16 inches in length. A variable capacitor of that capacity with a high breakdown voltage would be considerably larger. The units, incidentally, were designed especially for aircraft work.

A coaxial cylinder enclosed within a glass envelope, that is sealed with an edge-type seal, and fernico end cups, constitutes one of the types of vacuum capacitors. Fernico is an alloy of iron, nickel and cobalt. According to Mr. Floyd, the 50-μμfd capacitor has a temperature rise of only 40° C when operated at 6 megacycles.

The operation of tubes from a 28-volt source of supply in aircraft was discussed by Walter Jones of Sylvania. These tubes use but 28 volts for filament and plate. They are double-beam power types, with two-beam amplifier units in one envelope. The control grid and plate of each section, are brought out to separate pins. There is a common terminal for the cathodes and the screen grids. The heaters are connected in series internally, but the cathodes are not tied to either heater terminal. Although the voltage from the aircraft source may vary from 27 to 32 volts, the power output variation will be but 3%, according to Mr. Jones.

"The two sections of the tube may be connected separately, in parallel or push-pull. The higher power output rating of the tube makes it suitable as a power supply," said Mr. Jones.

He showed that power outputs up to 725 milliwatts at medium voltages of 50 to 250 could be obtained, by rectifying and filtering the voltage developed across a coil coupled to a tank circuit of the tube as a self-excited oscillator, with only 28 volts supply. Both pentode and low mu triodes can be used to drive this 28-volt tube.

In a paper on the design of FM intermediate frequency transformers, William H. Parker of Stromberg Carlson showed that higher values, than are now being used, are more desirable for intermediate frequencies, particularly, if the present waveband is to be widened. He recommended that an 8.2 megacycle intermediate frequency channel be used for lower priced FM receivers, while a channel of 16 megacycles for the intermediate frequency be used for the higher priced receivers.

A discussion by R. B. Gray, a physicist of Erie Resistor, on ceramics, revealed that ceramics which have constants of just over a thousand at room temperatures can be greatly increased in dielectric constant, converting them into semi-conductors, so that they have a polarized layer.

"This results in a very greatly increased capacity and dissipation factor at low frequencies. Rochelle salt,

TRIBUTE FROM *Motorola Radio*

o the Men of the U. S. Army Signal Corps

It is no secret that our armed forces have the finest communications equipment in the world. What is even more important is the fact that this equipment—"the eyes and ears" of our fighting men—is in the hands of that even finer product of American Democracy . . . the men of the U. S. Army Signal Corps. *To them from Motorola Radio—a speedy Victory and a quick safe return!*

AFTER THE WAR . . . For the Signal Corps, Motorola Electronic Engineers pioneered in the development of the famous Guidon Set, the new Walkie-Talkie and the highly effective Handie Talkie—portable two-way communications systems. When Victory signals resumption of Civilian Radio production Motorola Engineers will add to their impressive list of "Firsts" in the development and production of Special Electronic devices and 2-Way F-M Communications Equipment.

Expect Big Things from Motorola—*THEY'RE IN THE MAKING!*

For the continued development and production of Radio Communications and other special Electronic equipment for our Armed Forces, the Motorola organization has been awarded two stars for their Army-Navy "E" Flag. Motorola is proud of the part it has been privileged to play in the speeding of Victory.

ARMY E NAVY

Motorola RADIO
FOR HOME & CAR
GALVIN MFG. CORPORATION • CHICAGO, ILLINOIS

with the high dielectric constant of 800, is now topped by many ceramics," explained Mr. Gray.

Incidentally, the captured enemy communications equipment displayed in Washington, during the "Back The Attack" exhibition, was also on display in Rochester. Italian, German and Japanese receiving and transmitting apparatus and accessories were shown. According to Captain Herr of the Signal Corps, the equipment will now be sent on a tour throughout the Nation.

Conference officials opined that perhaps next year, the meeting will cover the prewar three-day schedule. Let's hope it does!

WHEN FORECASTS EMANATE FROM THE desk of one of the top-flight executives of the industry, we are prone to listen with deep concern. It is thus with keen interest that a prediction on the future of FM by W. R. David of General Electric is presented. He says that the potential market of FM receivers in the immediate postwar period is approximately 12,500,000, not including second receivers and car sets.

"This," he said, "is based on the assumption that one out of four in the FM service areas, where there are some 50,000,000 people, will buy an FM receiver. To serve this tremendous market, there will be at least 500 FM stations, five years after the war," he also predicted. This does not mean that the public will not have suitable FM transmission units serving them before that time. There will be a progressive increase to that many stations.

"The growth of FM has been quite phenomenal," said Mr. David. "In 1938, there was but one station, the Armstrong station in Alpine, New Jersey. Today, notwithstanding wartime difficulties, there are some 50 stations, of which 40 are commercial, 6 experimental and 4 educational, with a host of applications pending for construction."

We'll watch that prediction, Mr. David!

BROADCAST STATION TRANSMITTERS HAVE BEEN PLAYING AN UNUSUAL role on the war front. When Africa was about to be invaded, it was a five-kilowatt transmitter that had been originally sold to a station in New Jersey but not installed, that carried the announcement of the coming of the American armed forces. The transmitter was located on a war ship docked near the shores of Africa.

The interesting story of the installation of this transmitter is told in a booklet entitled "Allo Maroc!" by C. L. Stong of Western Electric. The title was derived from the historic words that the Arabs, Sengalese and Frenchmen heard, when this mystery transmitter cut in on the frequency of radio station, Radio Morocco at Rabat. The message was "Allo Maroc! Allo Maroc! This is the transmitter of the American armed forces." A swift series of messages followed telling the inhabitants that they should lay down their arms and cooperate. The messages were from the President of the United States.

When the Italian fleet was told to surrender it was a reconstructed transmitter in Algiers that conveyed the message. Under the direction of Morris Pierce, chief engineer of WGAR, on loan to the psychologial Warfare Division as Chief Engineer, a transmitter was changed over in a period of 15 hours, tuned down from 1100 to 500 kc. and the message was put on the air.

Remember the familiar broadcast from the Seth Parker? Ten years ago a sensational series of broadcasts were put through on this one-kilowatt transmitter. Today this transmitter is serving the armed forces in Africa.

MR. WHITESIDE HAS DONE IT AGAIN. The very active WPB vice-chairman has arranged for a nationwide consumer survey involving visits to 7000 homes. Mr. Whiteside wants to obtain answers to the following questions . . . (1)—To what extent are shortages and other consumer problems causing actual hardship? (2)—What products now in short supply are most needed by the civilian population, and is the lack of any specific item so seriously affecting health and morale as to interfere with the productive efficiency of war workers, farmers and other civilians? (3)—Is the available supply of consumer goods being distributed fairly? (4)—What is the quantity of durable goods, such as electric irons and washing machines now in the hands of consumers and what condition are they in?

The 7000 homes that will be visited represent every geographic area, every income group and every type of worker. There are 7 groups of commodities. Radio and radio repair appear in two of these groups.

This is the first scientific survey on this vital consumer project, and the results are awaited with national interest.

In Iowa, WHO of Des Moines, has just completed its sixth consecutive annual survey of radio listening. The results are most interesting in that they reveal that 97.2% of the set owning families reported working receivers. Urban families have the highest percentage of operating sets or 98.4%, while farmers reported only 94.7% working receivers. This low farm figure is attributed to the fact that 35% of the farm sets operate on battery power.

The survey which was made in April and May by Dr. F. L. Whan, shows that 25.8% of the inoperative battery sets have been out of order from 3 to 6 months; 28.1% have been out of order for 2 months and 26.8% for one month. The WPB program of rescheduling battery productions to aid the farmers is believed to have relieved the shortage materially.

(*Continued on page* 52)

No. 8 OF A SERIES EXPLAINING THE USES OF ELECTRONIC TUBES IN INDUSTRY

BACK THE ATTACK! – BUY WAR BONDS!

Two electronic tubes, the G-E phanotron and the G-E pliotron, supply the high-frequency waves used in electronic brazing

THROUGH General Electric electronic developments, this steel ring can be brazed to its steel bearing in *82 seconds* — faster than ever before!

No special skill is required to perform this brazing operation. Absence of scale and blackening on the finished part further reduces costs, and steps up production levels.

Another — and an even greater advance in electronic heating — is the brazing of copper and silver, perfected by General Electric, and now in high-production use in war plants.

A third application of electronic heating is the air-tight fusing of glass to metal in as little as 11 seconds.

Two General Electric electronic tubes are used in the brazing process. The G-E phanotron supplies the direct current. The G-E pliotron converts this current to high-frequency waves and creates the heating field—precisely controllable as to amount, direction, or area limit.

It is the purpose of the G-E electronic tube engineers to aid any *manufacturer* of electronic devices in the application of tubes. General Electric, through nation-wide distribution, is also prepared to supply *users* of electronic devices with replacement tubes.

FREE BOOKLET ON ELECTRONIC TUBES

We would like to mail you, without charge, an illustrated book entitled "How Electronic Tubes Work," written in easy and understandable language, and showing typical electronic tubes and their applications. Address *Electronics Department, General Electric, Schenectady, N. Y.*

* *Tune in* "The World Today" *and hear the news direct from the men who see it happen, every evening except Sunday at 6:45 E.W.T. over CBS. On Sunday listen to the G-E* "All Girl Orchestra" *at 10 P.M. E.W.T. over NBC.*

THERE'S A G-E ELECTRONIC TUBE FOR EVERY PURPOSE

GENERAL ELECTRIC

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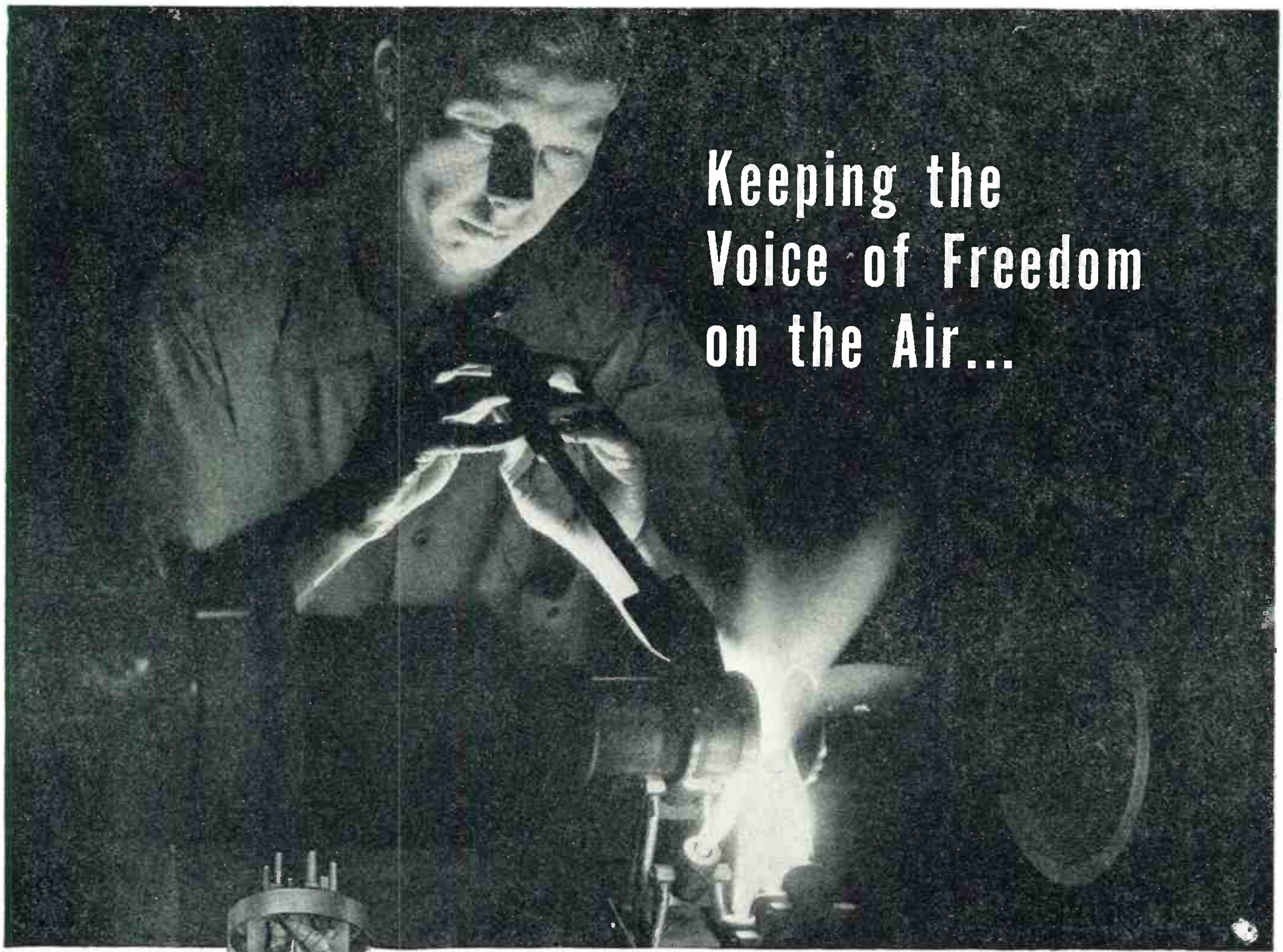

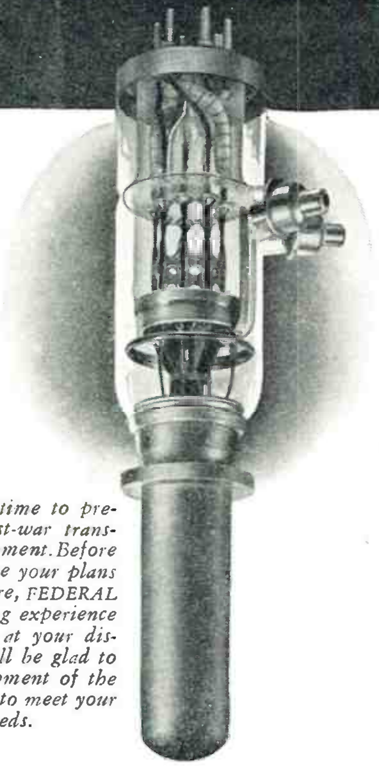

Now is the time to prepare for post-war transmitting equipment. Before you formulate your plans for the future, FEDERAL places its long experience in this field at your disposal and will be glad to discuss equipment of the latest design to meet your individual needs.

FEDERAL is devoting its major energies in the manufacture of transmitting and rectifying tubes to the war effort, turning out great quantities of essential types and sizes for vital military purposes.

Into each of its tubes goes the result of FEDERAL'S leadership in construction and design, in the use of rare metals improved in purity and mechanical properties, and in workmanship that represents the last word in tube building — all of which assure uniformity of electrical characteristics and longer life in performance.

These advantages have long been recognized and that is why many of the leading broadcast stations in the United States are equipped with FEDERAL tubes.

FEDERAL is, and always has been, in the vanguard of tube development and manufacture. Behind its facilities and outstanding achievements are some of the world's best engineering minds and technical experience. This leadership and ability are available to broadcast stations in meeting their tube requirements.

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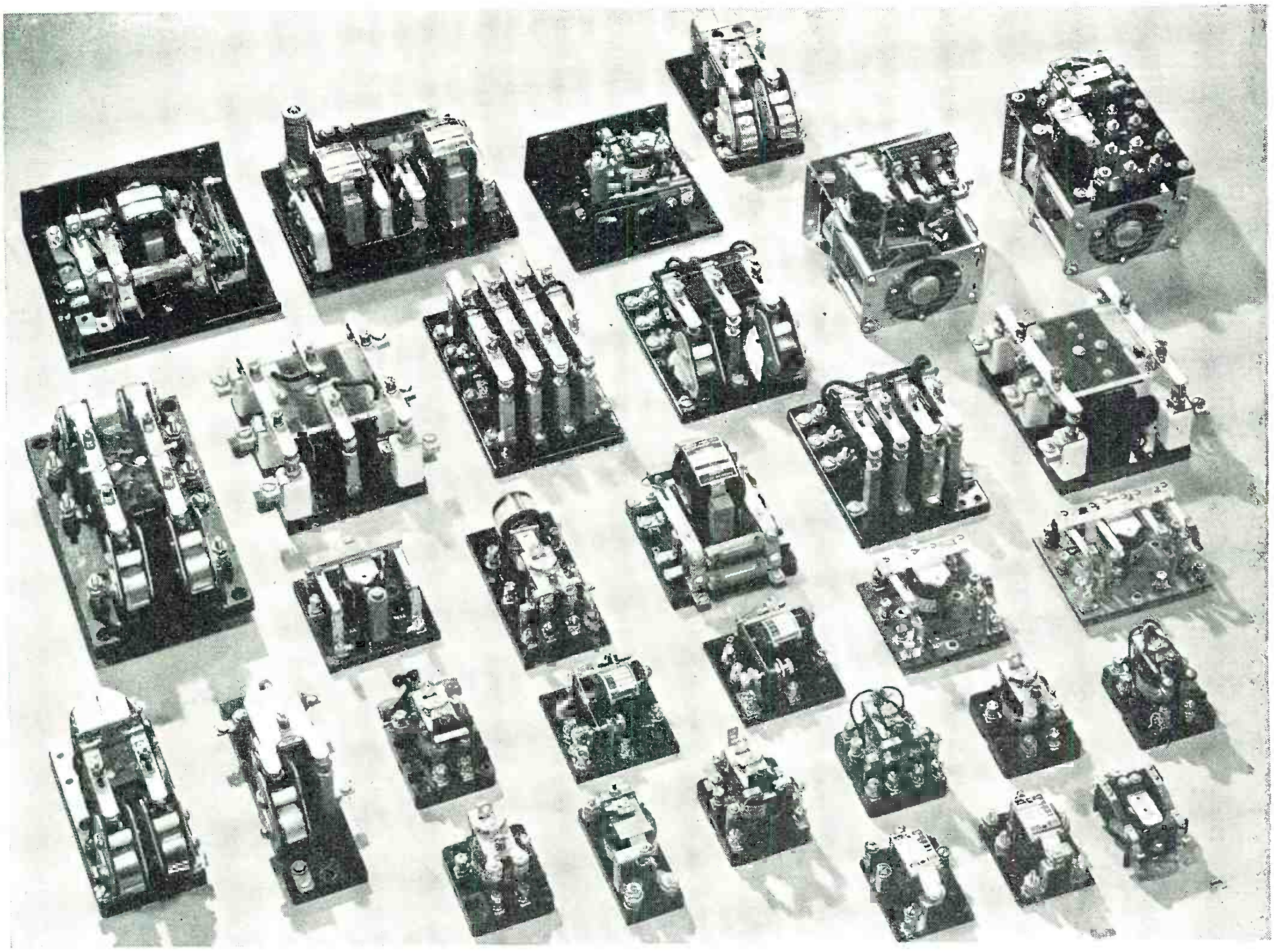

BULLETINS TELL THE WHOLE RELAY STORY

When you can select the relay that exactly meets your requirements from a regular line, you have saved man power, time and money. WARD LEONARD RELAYS include types and sizes for every application. They all have crisp action, are dependable and durable yet consume but little current. Send for the data bulletins of interest to you.

RELAY BULLETINS

Bulletin 105

"Little Giant Relay" single pole, single and double throw. Controls ¾ HP on 115-230V.

Bulletin 106

Midget Relays for light duty available in single and double pole, single and double throw.

Bulletin 81

Intermediate Duty Relays in single and multipole arrangements, single and double throw.

Bulletin 362

Motor Driven Time Delay Relays for operation on alternating current.

Bulletin 104

Midget Relay for tight places—Vibration resistant—Double Pole, Double Throw—Available for 6 to 115 volts A.C. or D.C.

Bulletin 131 and 132

Heavy Duty Relays single and multipole, single and double, contracts rated up to 25 amp. on 125-250V.

Bulletin 251

Sensitive Type Relays for direct and alternating current operating on .014 watts.

Bulletin 351

Thermal Time Delay Relays with thermostat built into relay assembly.

Bulletin 103

Aircraft Power Relay. Single Pole, Single Throw for 24 volts at 25 amps. D.C. Withstands high values of acceleration of gravity, shock, and vibration.

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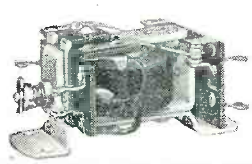
RELAYS • RESISTORS • RHEOSTATS

Electric control devices since 1892.



Midget Metal Base Relay measures 1¼ inches high for tight places in aircraft radio and control circuits where space is limited.

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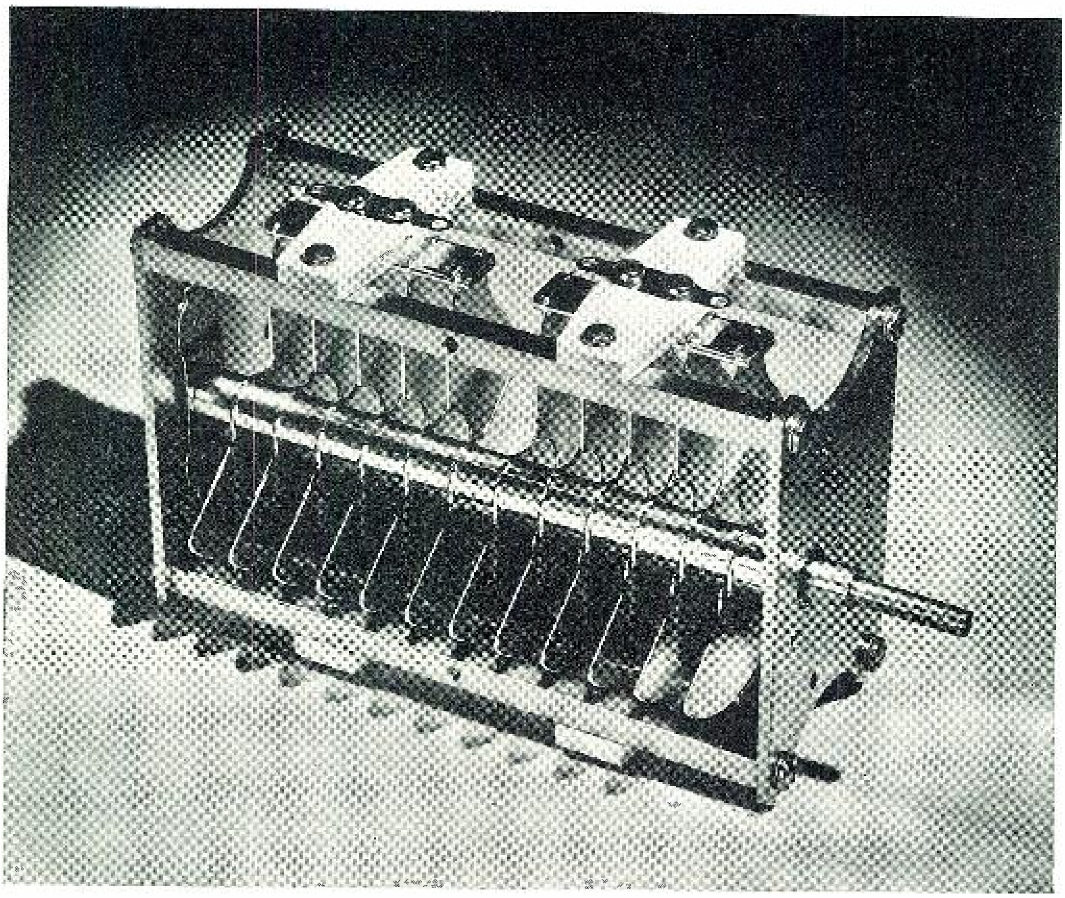
AN ENVIABLE RECORD



Hammarlund condensers like this are serving on all war fronts.

IN tanks, planes, ships, "walkie-talkies"—wherever mechanical and electrical characteristics must remain true under the most unusual conditions—there you will find Hammarlund variable condensers adding to their already enviable record of performance.

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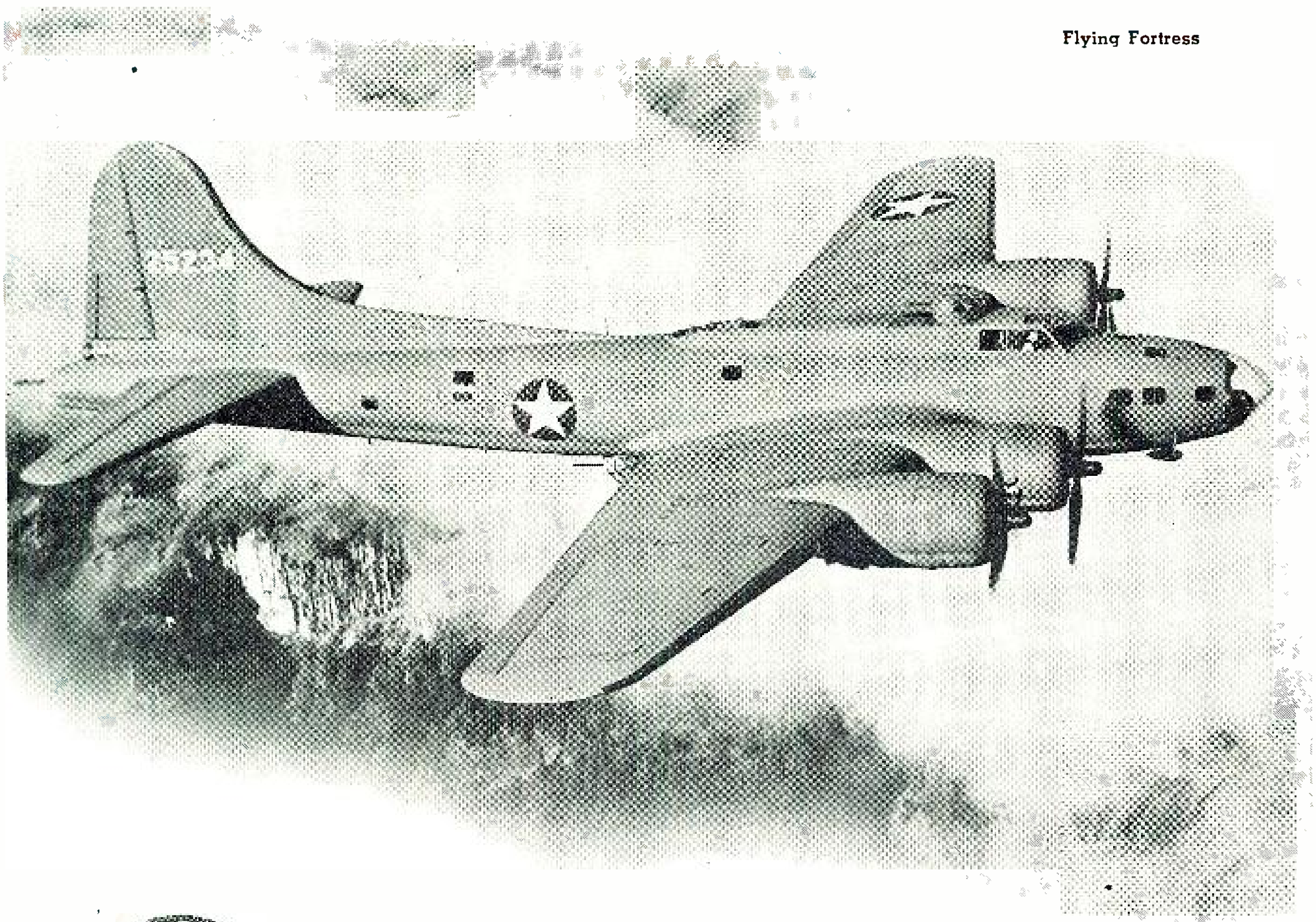
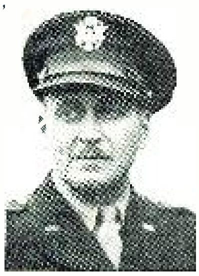
RADIO—ON A FLYING FORTRESS



Flying Fortress



The Author

by KENNETH R. PORTER

RADIO NEWS War Correspondent

The application of radio and the magnetic wire recorder in the actual bombing of a Nazi-held airdrome, as reported direct from England.

> **The "Jackie Ellen"**
>
> *Shortly before the "Jackie Ellen" a Flying Fortress of the 8th U. S. Army Air Force took off from Britain to bomb Le Bourget Airfield just outside Paris, the writer made a check flight to find out what goes on over the communication system during a combat mission. It was evident then that even the fastest shorthand expert would be unable to write a word-for-word account of the flight. However, an Air Force officer with a magnetic wire recorder attached to the intercommunication system obtained a description of the operational flight in the actual words of the crew and observer-commentator.*

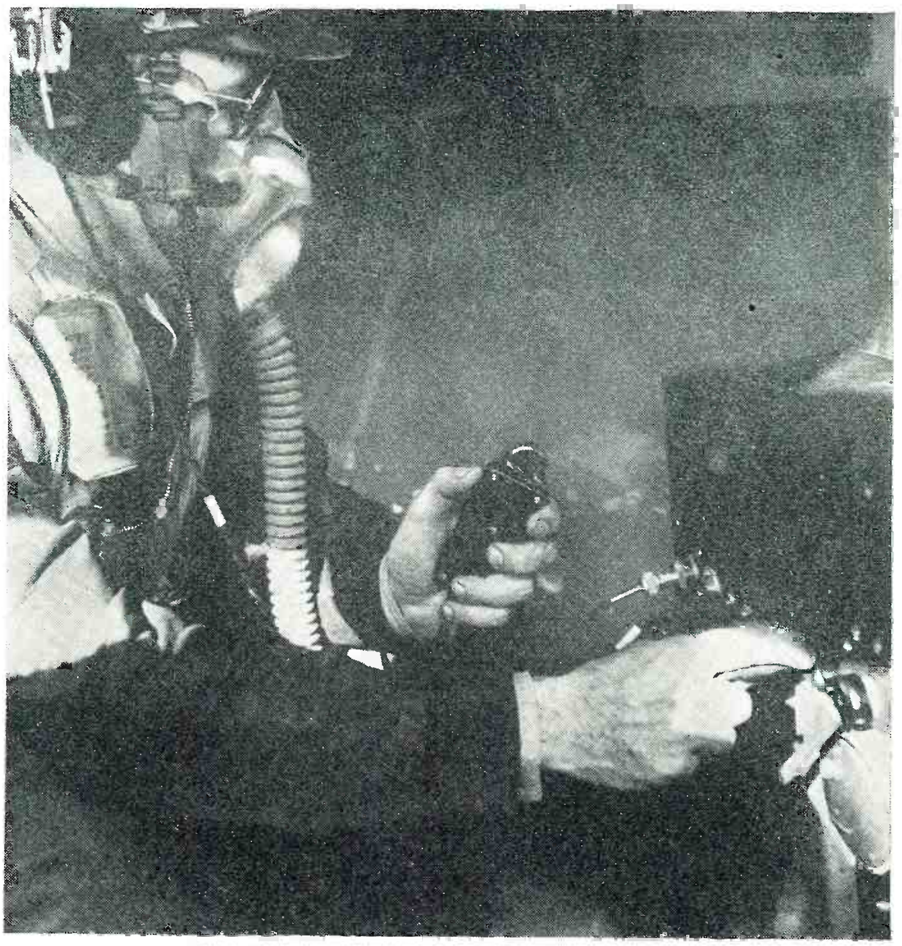
THE radio operator in a Flying Fortress during a bombing mission is far from the most talkative gent in the crew—either in buzzer code or actual conversation. His job consists of little or no transmitter work while on the way to and from the target. In fact, radio silence is paramount in the precautions of a raiding party and only in an emergency is the key or talker opened. The radioman becames primarily a listener—and if he's in the lead ship he must be an exceptionally good one, too.

On the day of a mission the radio operator is briefed with the other enlisted gunners. Then radio men, like the navigators, attend a special briefing of their own. Here they are handed the flimsy, or radioman's kit for the day. The flimsy is a brief-case containing papers—a station and frequency chart, bomber code, "Q" signals, hours of the day, and certain maps, all of which are secret and sacred to the radio operator. His flimsy is as well-guarded as the bombardier's sight, or the navigator's papers, or the special escape kits.

But radio procedure differs in the European theater of operations—it is a combined USAAF-RAF radio procedure. So radio operators are grounded for several weeks when they first arrive in England to attend this combined radio-procedure school.

The radioman is also an expert gunner, for interdependence is vital to a B-17 crew. He has his own fifty calibre playing out of his top hatch. He can operate either the top or ball turret to replace these gunners in an emergency. Since he is the only man in the ship who can see the waist gunners (through his half door) he "guards" them. The ball turret man depends on the waist gunners to free stuck mechanisms, feed him ammunition and do other related duties. The tail gunner is also a responsibility of the waist men.

The most important position of all for a radio operator, however, is in the lead ship. Here he must intercept every message from his home base, for other aircraft following in the flight depend on the leader to keep to a correct course. If the radio operator fails to hear a message calling the flight back or detailing it to another target, it might find itself flying alone or leading the other ships astray. With such vital information crackling on the receiver, and being unable to see what is going on, radio men often become so detached from the activity around them that even severe enemy action goes unnoticed. It has been known for them to return from missions in planes riddled to almost total destruction, to discover the damage only after landing.



By means of a small microphone which fits over the lip, and inside the oxygen mask, the operator was able to record his observations of a complete mission.

Closed off in a tiny, closely curtained compartment, concentrating on the radio receiver rather than the interphone, the operator often misses the battle entirely. He can hear shots behind and around him, hear his own turrets firing in reply, feel the plane buck and lurch—which might be enemy flak, cannon hits, or just plain evasive action—he's never sure which.

In preparation for the flight which was to become the first on-the-spot account of what actually goes on inside an American heavy bomber, a small portable recording device known as a magnetic wire recorder, was installed in the observers' compartment and plugged into the intercommunication system. In addition to the regular crew of ten, Major Howard L. Nussbaum, former New York radio network executive and now Radio Public Relations Officer of the E.T.O., was to go along and record his own description of the flight.

The ground and flying crews of the Flying Fortress "Jackie Ellen."

The plane used was the *Jackie Ellen,* so christened by the bombardier, Lt. Walter Z. Morey, of Manchester, New Hampshire, an expectant papa who explained, "if it's a boy we'll name him Jackie; if it's a girl it'll be Ellen."

Painted on the nose of this bomber were nineteen yellow, red and blue miniature bombs, indicating that it had made that many missions over enemy territory—ten over France, eight over Germany and one over Belgium. It was manned by the oldest complete living combat crew in the "claypigeon" squadron.

There was nothing unusual in the briefing of the crew the day of this particular flight. The men knew they were to bomb Le Bourget airfield just outside Paris and they had been informed about the magnetic wire recorder attached to the intercom. They were also aware that they were participants in a unique experiment which might prove of great tactical value in future bombings.

Major Howard L. Nussbaum showing the magnetic wire recorder to Gen. Arnold, Commandant of the U. S. Army Air Forces.

After the briefing, T/Sgt. Joseph C. Bocelli, Philadelphia, Pa., radio operator of the *Jackie Ellen,* entered the radio compartment and started his log: "On watch—0810 hours," he wrote . . . "have tested all equipment—OK . . . have tested interphone from every position in plane—OK. . . ."

With this the radio operator's duties were over for the moment. He had only to listen for messages meant for his ship and note them in his log, for the pilot takes over with a command radio for the directional control of other planes in the flight and for coordination with fighter escort or for liaison with the other bombers.

The balance of the crew, consisting of S/Sgt. Walter D. Sherrill, Rock Island, Ill., tail gunner, S/Sgt. Charles A. Adams, Cheltenham, Pa., and S/Sgt. William R. Earnest, Delmont, Pa., right and left waist gunners respectively, S/Sgt. Francis W. Pulliam, Greeley, Colo., ball turret gunner, T/Sgt. Gus Riecke, Trinidad, Cal., upper turret gunner, Lt. Walter Z. Morey, bombardier, Lt. C. A. Alexander, Manlius, N.Y., navigator, Major Nussbaum, observer, and Lt. Douglas H. White, Fort Worth, Texas, co-pilot, all checked in over the interphone to pilot Captain Thomas F. Witt, of Cookville, Texas, and the plane took off in regular formation on its history-making flight.

(*Continued on page* 62)

☆

Demonstrating the oxygen mask with built-in microphone. The wire recorder had its first trial on the "Jackie Ellen" which was attacked 10 times during the flight.

SQUARE-WAVE TESTING OF AMPLIFIERS

by JOHN WILLIAMS

Determination of amplifier frequency characteristics by observing changes in oscilloscope patterns.

IN THE testing of amplifiers, the usual method calls for injecting various frequencies into the amplifier and noting the response curve obtained. With increase of uniform frequency-response width due to higher fidelity requirements, the point-to-point method becomes lengthy and time consuming and does not allow rapid changes to be made in circuit design. What is needed is some method which will allow rapid adjustment of amplifier circuits and at the same time not lose any accuracy because of the speed requirement. Such a means has been found and is known as square-wave testing.

In order to appreciate this method, let us review some of the properties of square waves, one of which is pictured in Fig. 1. The equation of this wave shows that it is made up of an infinite number of sine waves superimposed on each other. The lowest frequency sine wave is, of course, the fundamental, and each of the other sine waves are odd harmonics of this fundamental. There are no even harmonics. Therefore, if we have a fundamental of 300 cycles, then the sequence will run 300; 900; 1500; 2100 cycles, etc. The lowest frequency wave is the strongest, the strength of each harmonic varying inversely to the frequency. Hence, to a good approximation we need only include about 30 harmonics with our fundamental to get a good square wave.

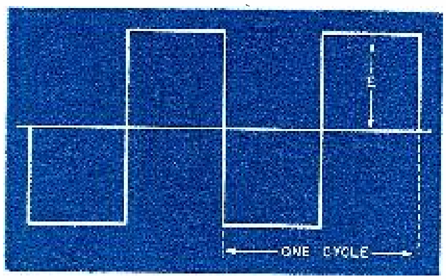
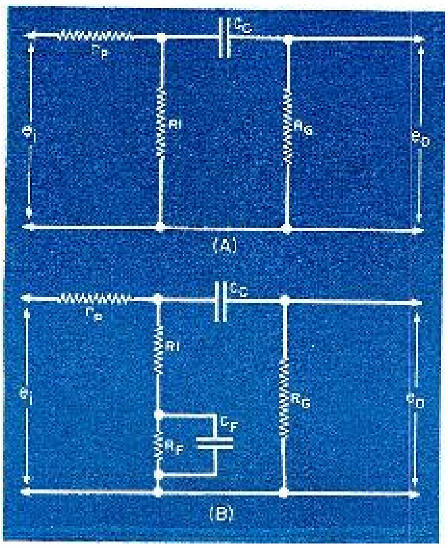


Fig. 1. Square wave.

If any of the frequencies making up the square wave are not transmitted through a network in the same manner, relatively speaking, then the resultant square wave in the output will have its shape modified. It is through these changes in waveform that the basis for this method of testing amplifiers is formed. Although any type of distorted wave rich in harmonics can be used for the testing, the square wave has a convenient form, in which changes are quickly noted. Another important feature of amplifier testing is phase distortion, an ever present menace in television receivers. Here phase distortion means picture displacement with resultant marring of detail. This type of distortion cannot be found by the point-to-point method of testing.

The frequency of the square wave itself, called the repetition frequency, is the same as the fundamental. By varying the repetition or fundamental frequency of the square wave we can test an amplifier for low- or high-frequency response independently of each other. The repetition frequencies used for testing the networks in this article were 60 cycles for the low end and between 1000 and 2000 cycles for the high end. Due to the harmonics a band of frequencies was obtained that extended from 60 cycles to almost 100,000 cycles. While this is far greater than is needed for ordinary audio amplifiers, television requirements call for flat-top response from 30 cycles to 4,000,000 cycles.

Fig. 2. Equivalent circuit of a resistance-coupled amplifier at the low frequencies. (A) Uncompensated. (B) Compensated.



All the apparatus necessary is a square-wave generator and an oscilloscope. After the square wave is passed through the amplifier under test, it is viewed on the screen of the oscilloscope and any distortion noted. Rapid and accurate adjustments can then be made on the equipment, meanwhile noting the effect on the output wave.

It might be pointed out by some readers that since a square wave consists of a set of discrete frequencies and not a continuous band, we are only testing the amplifier at various points on its response curve, not all along the curve. This might appear as a disadvantage but actually it is not, since response curves tend to vary smoothly and do not usually have sharp breaks. Also, by varying the repetition frequency we can cover any lapses that occur and bring to light sharp breaks in the frequency-response curve.

Since experience in recognizing the various patterns of square waves obtained is necessary for interpretation of results and the rapid adjustment of the amplifiers, representative square wave patterns will be examined, and their shapes interpreted. In order to further facilitate this work, the low- and high-frequency responses will be separately analyzed.

Low Frequency

In Fig. 2A, we have the equivalent circuit for a resistance-coupled amplifier at the low frequencies. As is well known, low output is usually attributed to the relatively large voltage drop across the coupling condenser C_C. A typical response curve of an amplifier with such poor low frequency response is given in Fig. 3. If the square wave, depicted in Fig. 1, is now sent through this amplifier with a repetition frequency of 60 cycles, the oscilloscope picture will appear as in Fig. 3. This distorted square-wave pattern shows two things very clearly: phase and frequency distortion. Frequency distortion is indicated by the fact that the wave is not flat-topped and phase or delay distortion is brought out by the sloping of the square wave.

Making C_C larger or increasing R_G

will improve the low frequency output, because then more input voltage will appear across R_G to be amplified by the succeeding stage. Fig. 4 is the response curve plotted for such an amplifier after the improvement mentioned above has been made and the oscilloscope picture shows the square wave after it passed through the amplifier. It will be observed that the distortion is now less.

The above process of making C_C or R_G larger cannot be carried on indefinitely to improve the low end response for several reasons:

1. As C_C gets larger, its leakage current will increase, and soon a fairly large positive voltage will be placed on the grid of the next tube.
2. Increasing R_G can prove injurious if there is even a slight amount of gas in the next tube.
3. And lastly, if too large values of either R_G or C_C are used, relaxation oscillations may set in.

With these limitations in mind, designers turned to a compensating circuit such as shown in Fig. 2B. The added resistor R_F and condenser C_F, if chosen right, will give the response pictured in Fig. 5. Slight over-compensation will result in the pattern of Fig. 6 and slight undercompensation, in the pattern of Fig. 7. The condenser C_F shorts out the added resistor at the high frequencies so the upper portion of the response curve is not altered by the insertion of C_F and R_F. It can also be shown that this added network introduces a phase shift opposite to the shift of C_C and R_G, thus further aiding the low-frequency output. The latter is very important in television work, where the phase characteristics of a network are sometimes much more important than the gain. Since this is not an article on amplifier design, methods of computing the values of C_F and R_F have been omitted. However, references 1-4 at the end of this article will serve as an excellent guide.

Pictured with the square-wave patterns of Figs. 5, 6 and 7 are found the frequency-response curves applicable to each. Study of the figures will demonstrate how sensitive the square-wave method is and some grasp of its possibilities obtained.

These pictures are only representative of what can be had. While there are many more in the low-frequency region, they usually fall close to one of the types shown.

High Frequency

Turning now to the high-frequency portion of the audio spectrum we find the response falling off because of the capacitance shunting the load resistor R_L. An equivalent circuit is drawn in Fig. 8, and all the shunting capacitance is grouped together and denoted by C_T. Analysis shows that the greater portion of C_T is due to the inter-electrode capacitances of the input and output tubes, with the remainder added by the wiring of the circuit. The latter can usually be decreased very easily, while the former is taken care of by using tubes carefully designed for low inter-electrode capacitances.

To test the network response, the repetition frequency of the square-wave generator is turned up to somewhere between 1000 and 2000 cycles and fed into the amplifier. Two output square waves are shown in Figs. 9A and 9B along with the frequency response curves of the amplifiers tested. Inspection of the oscillograms show

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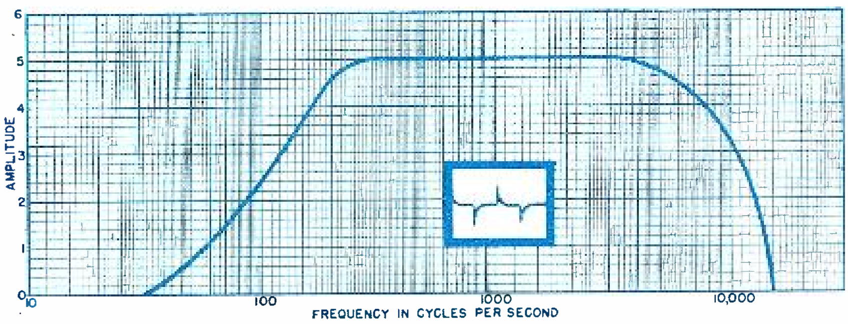


Fig. 3. Response curve and pattern indicating poor low-frequency characteristics.

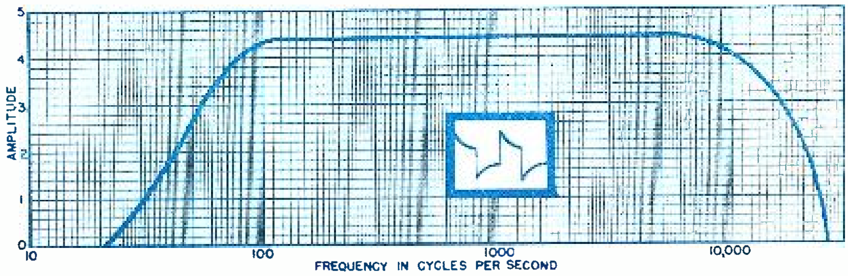


Fig. 4. Curve showing improvement after low-frequency correction has been made.

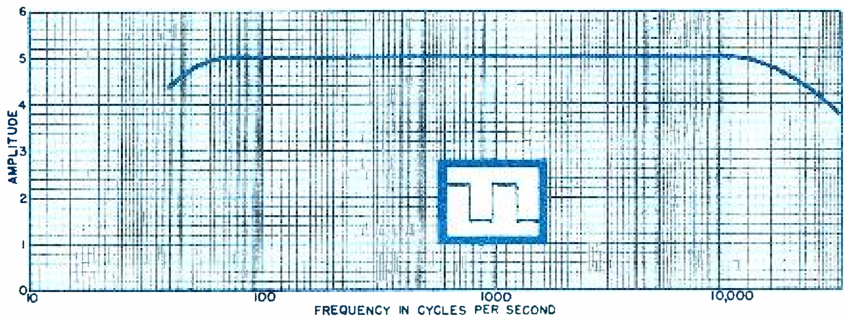


Fig. 5. Frequency-response curve obtained by using satisfactory compensation.

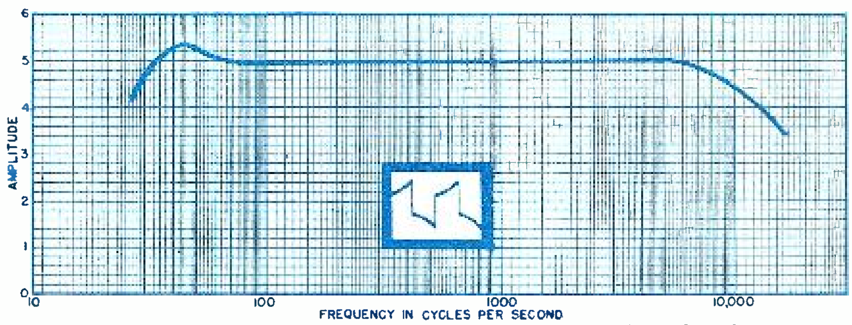


Fig. 6. Characteristic curve obtained by over-compensation of the low frequencies.

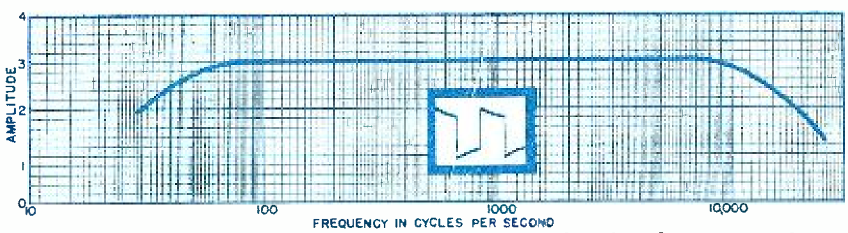


Fig. 7. Frequency-response curve showing the results of under-compensation.

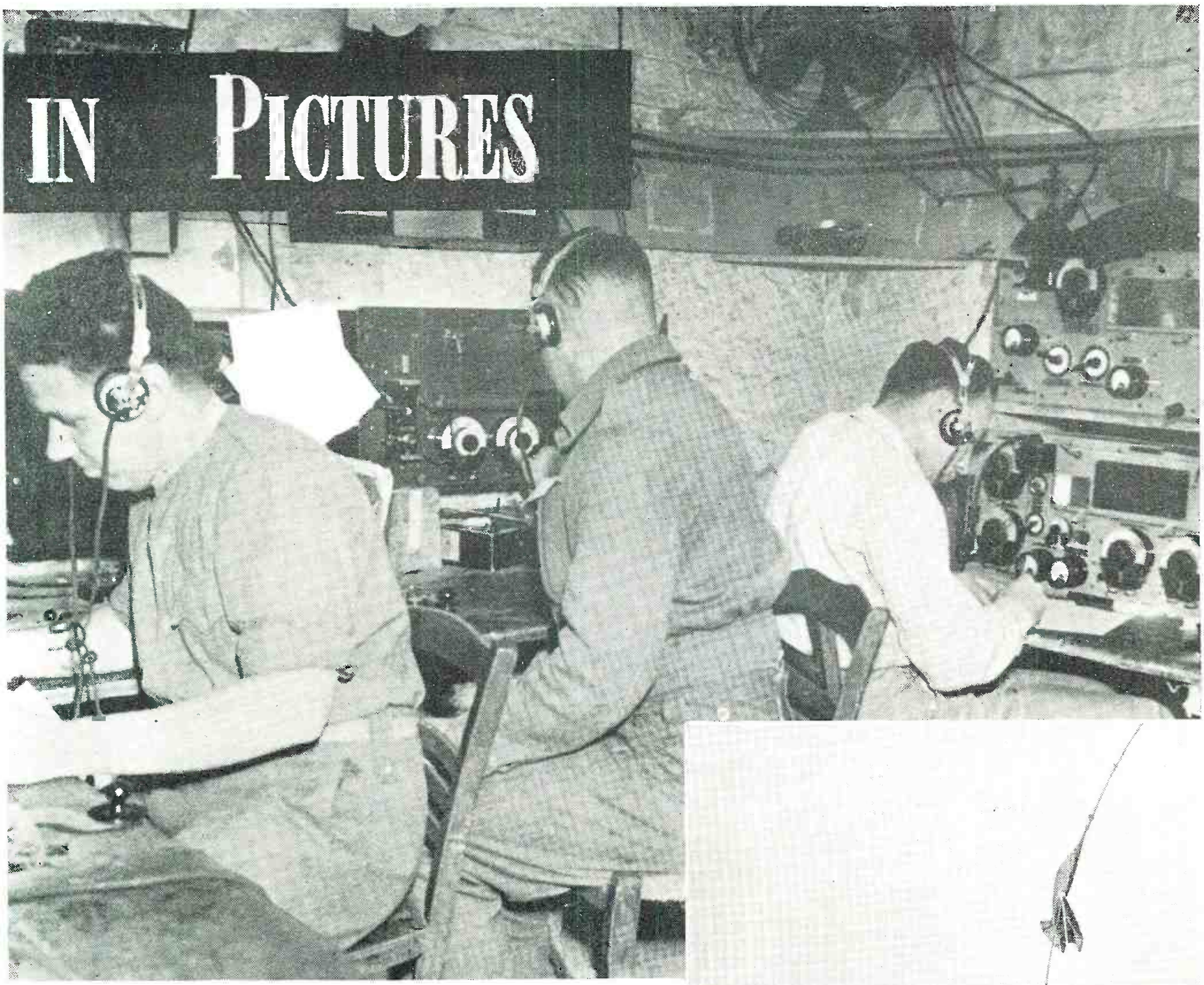
COMMUNICATIONS

Linesmen of the U. S. Signal Corps string telephone wires toward the town Cerami in Sicily.

Battery commander of a 155mm unit, receiving message from observer at a forward post.

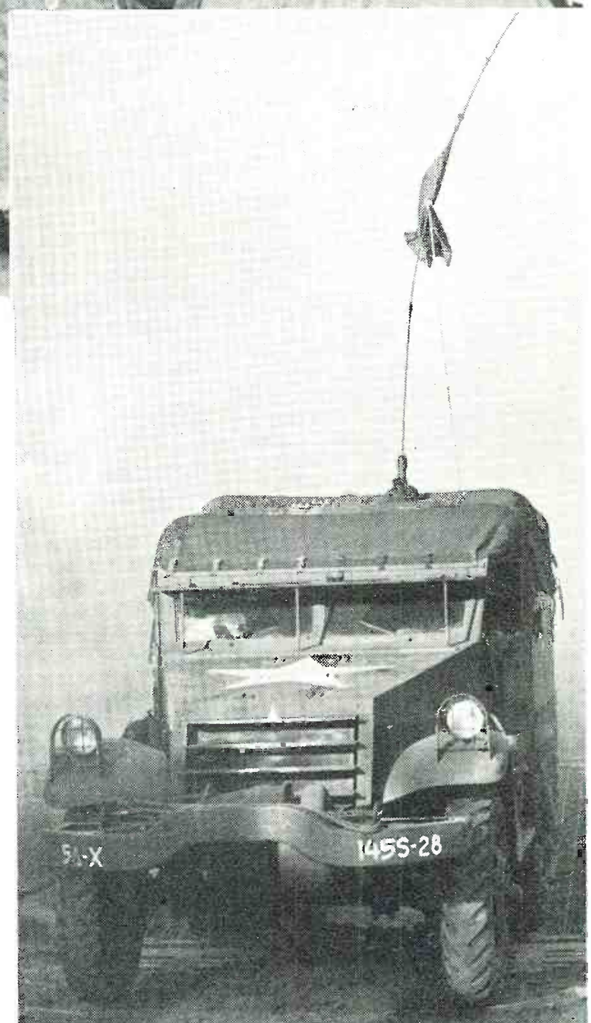
RADIO is playing an important part in our present conflict by maintaining a constant chain of communication between our various fighting fronts. The home-front keeps up-to-date with the news by way of radio-telephoto pictures of our fighting men in action. Through the smoke and fury of battle, men of the Signal Corps maintain constant care of communication lines, fixing those that are damaged and stringing new lines at necessary points, so that the men at one position may keep in touch with other task forces; and instructions can be sent from a Commanding Officer at one post to the men firing at the enemy target. Trucks carrying men and vital equipment can drive blindly and reach their goal by the use of two-way radio. With radio as the connecting link, Allied forces push forward until final Victory is attained.

IN PICTURES



Working inside their underground Naval wireless-telegraphy station at Famagusta, Cyprus, operators carry on military correspondence.

A radio-telephoto, from Sicily, of an observation post. Smoke rises from target as the artillery, directed from the post, hits its mark.



Radio-equipped army truck moving swiftly through a thick smoke screen laid by opposing forces.

Inductance Measurements

Many practical methods of measuring various inductances with the application of present-day test instruments.

By GUY DEXTER

PRECISION-TYPE inductance bridges and inductance standards will not be found in the small laboratory of the wartime radionic hobbyist. Nor were they frequently in amateur hands before the present shortages. Such apparatus is costly.

Lack of highly specialized instruments need be no hindrance to the serious experimenter who needs to know coil values, since it is possible with simple radio instruments to measure inductance with sufficient accuracy for most experimental purposes. This article will explain the practical methods of making such measurements.

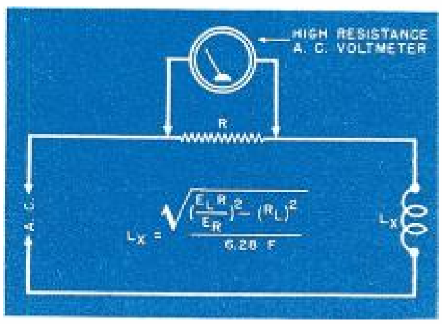
The reader will find in this discussion one or more methods which will tie in with the apparatus he has on hand. In general, no new equipment will be required. The only piece of equipment apt to be missing from a large number of shops is the a-c vacuum-tube voltmeter. But this device is not necessary to all of the methods; and, even when particularly desired, a simple version may be assembled readily from spare parts. In lieu of a circuit employing a milliammeter, a magic-eye tube may be employed, as will be shown later.

The various systems of measurement will be described completely in separate sections. While the experienced technician will recognize standard practice in the methods, less versed workers will find new or refresher information.

Fundamental Relations

Before explaining the simple methods of measuring inductance, it is advisable to review briefly certain fundamental electrical relations upon which our procedures will be based. The first of these is the relation of inductance (L), reactance (X), impedance (Z), and resistance (R), all properties of a coil. In all of the equations

Fig. 1. Voltmeter method.



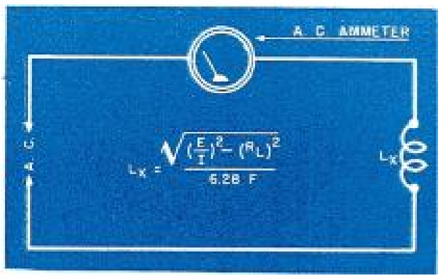


Fig. 2. Ammeter method.

which follow, unless specifically stated otherwise, L will be rated in henries; R, X, and Z in ohms; and frequency (f) in cycles-per-second.

$$X = \omega L \quad \ldots\ldots\ldots (1)$$

Where ω is 6.28 f. (Table I lists ω for common frequencies)

$$L = \frac{X}{\omega} \quad \ldots\ldots\ldots (2)$$

Equation (2) would be sufficient, except that a coil has a resistive as well as a reactive component, and these two vector quantities combine to give the joint property of *impedance*. The following equation is therefore more closely true:

$$L = \frac{Z}{\omega} \quad \ldots\ldots\ldots (3)$$

Impedance is a vector term ($Z = R + j\omega L$), therefore:

$$Z = \sqrt{R^2 + X^2} \quad \ldots\ldots\ldots (4)$$

Expanded, Equation (4) becomes:

$$Z = \sqrt{R^2 + (6.28 f L)^2} \quad \ldots\ldots\ldots (5)$$

Now, it is seen that if we measure R and Z by means of simple instruments, we may determine L after rewriting Equation (5):

$$L = \frac{\sqrt{Z^2 - R^2}}{6.28\ f} \quad \ldots\ldots\ldots (6)$$

The next relationship to be considered is that between impedance (Z), voltage (E), and current (I). In the equations applying to this relationship, unless specifically stated otherwise, E will be rated in volts and I in amperes.

Current passing through a coil will encounter the opposing action of impedance. The current forced by a given voltage will attain the value:

$$I = \frac{E}{Z} \text{ and } Z = \frac{E}{I} \quad \ldots\ldots\ldots (7)$$

Current passing through the coil in a suitable circuit will produce a voltage drop across the coil proportional to the impedance:

$$E = IZ \quad \ldots\ldots\ldots (8)$$

Thus, it is seen that if current or voltage associated with a coil is measured with suitable a-c meters, the deflection of the latter will be governed by both resistive and reactive properties of the coil and the impedance of the latter may be determined by the proper one of the immediately preceding equations. If this impedance value is then substituted in Equation (6), together with the frequency of the test voltage or current, the coil inductance may be determined.

The final relationship to be considered is that between inductance (L), frequency (f), and capacitance (C) in a resonant circuit in which the coil under test is connected either in series or parallel with a capacitor of known value. In the equations applying to this relationship, unless specifically stated otherwise, L will be rated in henries, f in cycles-per-second, and C in farads.

Since in a resonant circuit, either series of parallel:

$$f = \frac{1}{6.28\sqrt{LC}} \quad \ldots\ldots\ldots (9)$$

Then:

$$L = \frac{1}{39.4 f^2 C} \quad \ldots\ldots\ldots (10)$$

From these relations, it is seen that

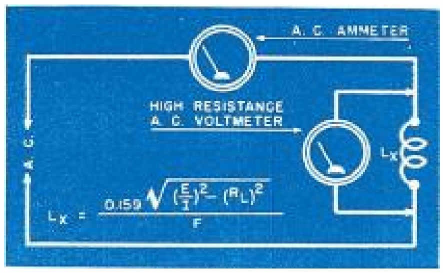


Fig. 3. Voltmeter-ammeter method.

if a coil of unknown inductance is connected in a resonant circuit with a known capacitance, and the resonant frequency of the circuit determined by means of a suitable oscillator, the inductance may be calculated by means of Equation (10).

Voltmeter Method

Apparatus required for measurement by this method include a high-resistance a-c voltmeter (preferably a v.t. voltmeter), a small resistance, preferably non-inductive, and a source of alternating voltage. The circuit is shown in Figure 1. L is the coil of unknown inductance and R is a resistor of any value, provided it is not so large as to reduce the flow of current through the coil to too low a value. The alternating voltage may be supplied by an a-f oscillator or by a filament transformer.

The voltmeter is first connected across the coil and the voltage drop recorded as E_L, then it is connected across the resistor and the corresponding voltage drop recorded as E_r. The voltage drop across the resistor is proportional to the current flowing through the resistor, and therefore through the entire circuit. This current is equal to E_r/R. The voltmeter is actually serving as an ammeter in this position. Since impedance is equal to E/I, the impedance of the coil in Figure 1 will be:

$$Z = \frac{E_L R}{E_r} \quad \ldots\ldots\ldots\ldots\ldots\ldots (11)$$

The coil is then disconnected from the circuit and its resistance measured with an ohmmeter or bridge, calling this value R_L. The unknown inductance may then be calculated by means of Equation (6), substituting $E_L R/E_r$ for Z, and R_L for R.

Ammeter Method

The second system, illustrated in Figure 2, is similar to the one just described, except that an a-c ammeter is employed and the resistor is not necessary unless high input voltage necessitates reduction of current through the coil.

The resistance of the coil is measured with an ohmmeter or bridge, calling this value R_L, and the coil is placed in the circuit. The reading of the ammeter is then noted, recording this value as I. Then I will be proportional to the impedance of the coil, as indicated by the Equation (7) and Z is equal to the input voltage divided by I. The unknown inductance may then be calculated from Equation (6) by substituting this E/I value for Z, and R_L for R.

Voltmeter-Ammeter Method

In some cases, both an ammeter and a voltmeter will be available. The voltmeter must have high input resistance and is preferably a v. t. voltmeter. The circuit for the voltmeter-ammeter method is shown in Figure 3.

The resistance of the coil, R_L, is first measured with an ohmmeter or bridge and the coil is inserted in the circuit. The ammeter deflection is recorded as I; the voltmeter deflection as E. The unknown inductance may then be calculated by means of this relationship:

$$L = \frac{.159\sqrt{(E/I)^2 - (R_L)^2}}{f} \quad \ldots (12)$$

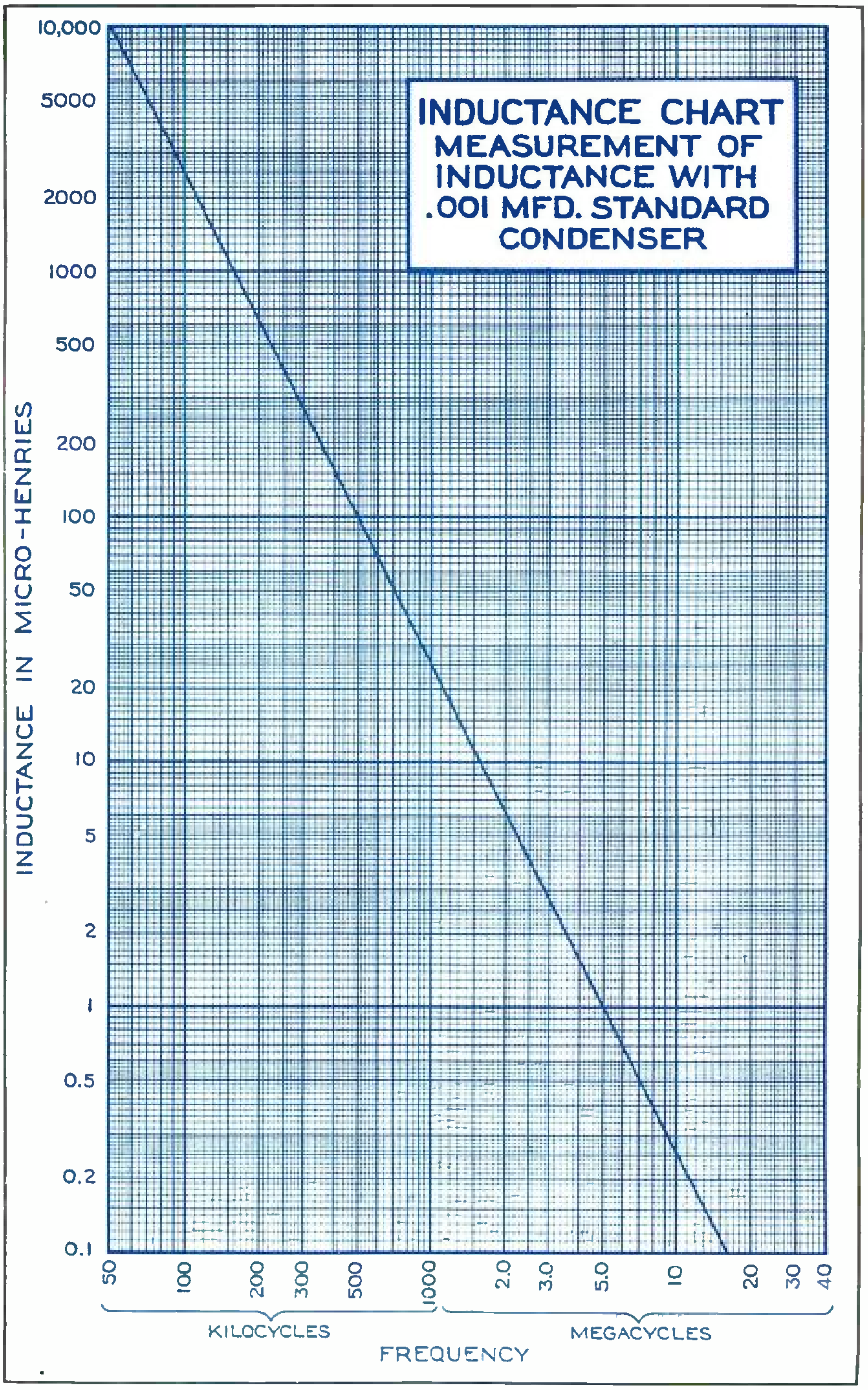


Fig. 4. Inductance chart.

where f is the frequency of the input voltage.

Constant-Impedance Method

The constant-impedance method is illustrated in Figure 8. Here an a-c ammeter is the indicating instrument. The circuit contains, in addition to the coil of unknown inductance, a switch, S, and a capacitor, C. Since this capacitor must be variable, the C element will actually be a series of capacitors (preferably a decade arrangement).

In this circuit, the line current, indicated by the ammeter, will be the same with the switch open or closed when the proper value of capacitance has been switched-in at C. In manipulation, the capacitance is adjusted, while opening and closing the switch, until this equilibrium is obtained. At that point, the unknown inductance is calculated from:

$$L = \frac{1}{2\omega^2 C} \quad \text{Where } \omega = 6.28f \ldots (13)$$

Z-Meter Method

The method illustrated in the circuit of Figure 6 utilizes the well-known impedance meter. A vacuum-tube voltmeter is required here.

The coil of unknown inductance is connected in series with a calibrated variable resistor, R, and the source of

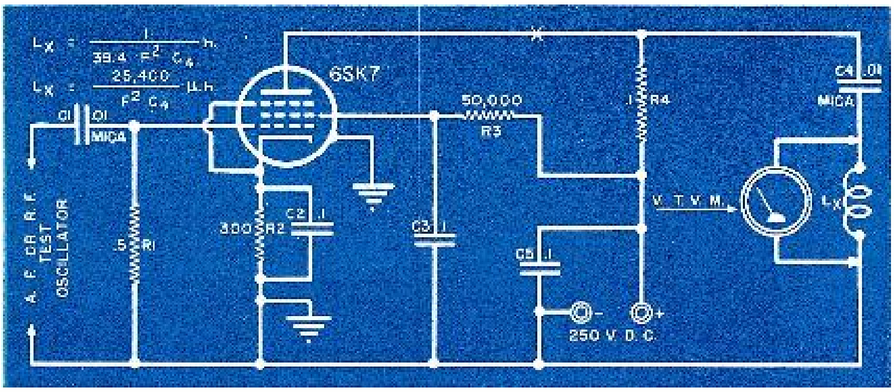


Fig. 5. Amplifier used for the measurement of inductances.

a-c voltage. The v. t. voltmeter is arranged with a single-pole, double-throw switch so that the meter may read the drop across the resistor or the drop across the coil.

In operation S is thrown to position 1 and the drop across the resistor, E_r, noted. S is then thrown to position 2 and the drop across the coil, E_L, noted. R is adjusted until the same drop appears across both R and L and no change takes place in the meter deflection as S is thrown from one position to the other. E_L then being equal to E_r, the resistance of R at that setting is equal to the impedance, Z, of the coil. The resistance of the coil is then measured with an ohmmeter or bridge.

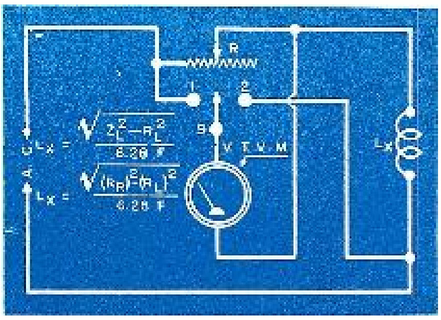
The values of R and Z, thus obtained, may be substituted in Equation (6) to obtain the inductance of the coil.

The impedance meter is very handy for the measurement of impedances as well as inductances over a wide range and may be assembled from stray parts. The variable resistor, R, may be a radio volume control type of rheostat. The input voltage may be supplied by a filament transformer, operated by the 60-cycle line, for common measurements, or by a 1000- or 400-cycle oscillator for measurement of impedance of transformers, voice coils, and similar audio equipment.

Amplifier Method

The method illustrated in Figure 5 is very useful in that it may be employed with large iron-cored coils as well as the tiny inductors used for radio-frequency work. The other methods described up to this point are most useful only for measurements at low frequencies where the coils almost always will be of the filter choke variety, or in any case will possess rather large inductance. The amplifier method is universal.

Fig. 6. Z-meter method.



In this arrangement, the coil of unknown inductance is made part of a series resonant circuit, the capacitor of this circuit being included permanently within the instrument. The resonant circuit is connected in the plate portion of a pentode amplifier, the resonant-circuit capacitor serving

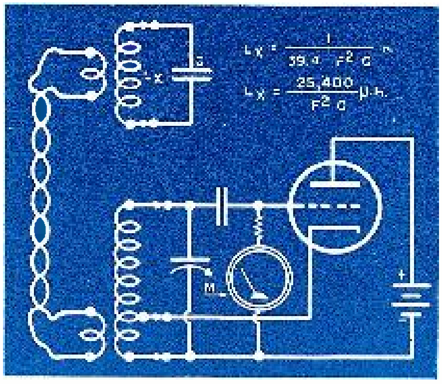


Fig. 7. Grid-dip meter.

as the blocking capacitor of the shunt-fed arrangement.

An a-c vacuum-tube voltmeter is connected across the coil; or if the v. t. instrument is not available, a d-c milliammeter may be inserted in the plate lead at the point marked "X". The grid input terminals are connected to a variable-frequency oscillator. If the inductance values expected are larger than 1 millihenry, an audio oscillator must be used; if smaller, a radio-frequency oscillator (preferably tuning from 50 kc., or lower, to 30 Mc.) will be required.

In manipulation, the oscillator is tuned until a sharp upward deflection of the v. t. voltmeter, or downward deflection of the d-c milliammeter. indicates resonance. Knowing the exact value of the capacitor, C4, and the oscillator frequency at resonance, the inductance of the coil may then be calculated by substituting these values in Equation (10).

A very reliable method for use at radio frequencies makes use of a variable-frequency r.f. oscillator (See Figure 7) in which a d-c milliammeter is connected at M in the grid circuit.

TABLE I

f (Cycles per Second)	ω
20	125.6
25	157.0
30	188.4
40	251.2
50	314.0
60	376.8
100	628.0
120	753.6
133	835.24
150	924.0
200	1256.0
400	2512.0
500	3140.0
800	5024.0
1000	6280.0

Tabulized values of ω for common freq.

In lieu of the meter, a magic eye tube might be used. The coil of unknown inductance is connected in parallel with a capacitor, C, the capacitance of which is known very precisely, and is coupled to the oscillator tank coil.

At the resonant frequency of the L-C combination, the oscillator will be thrown out of oscillation, or will have its oscillation strength reduced, sharply by wave-trap action of the combination. The grid milliammeter will indicate this condition.

In manipulation, the frequency of the oscillator is varied until a sharp deflection of the meter indicates resonance. The oscillator frequency is noted. The inductance of the coil may then be calculated in terms of the capacitance, C, and the resonant frequency by substitution of these values in Equation (10).

Since Equation (10) is set up with henries, farads, and cycles, and these values are all rather out of size for radio-frequency calculations, it will be found somewhat more convenient to employ the formula:

$$L = \frac{25{,}400}{f^2C} \qquad (14)$$

Where: L, is in microhenries,
C, in micromicrofarads, and
f, in megacycles.

For rapid determination of inductance between .1 and 10,000 microhenries, a chart is given in Figure 4 for use with a C capacitance of .001 μfd.

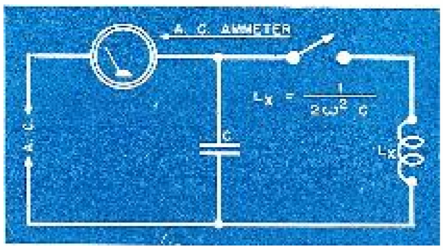


Fig. 8. Constant-impedance method.

Larger capacitances might be employed, whereupon the inductance values from the chart must be multiplied by C1/C2, where C1 is .001, the capacitance upon which the chart is based, and C2 is the capacitance of the capacitor employed.

—30—

Resistance or Capacitance Chart

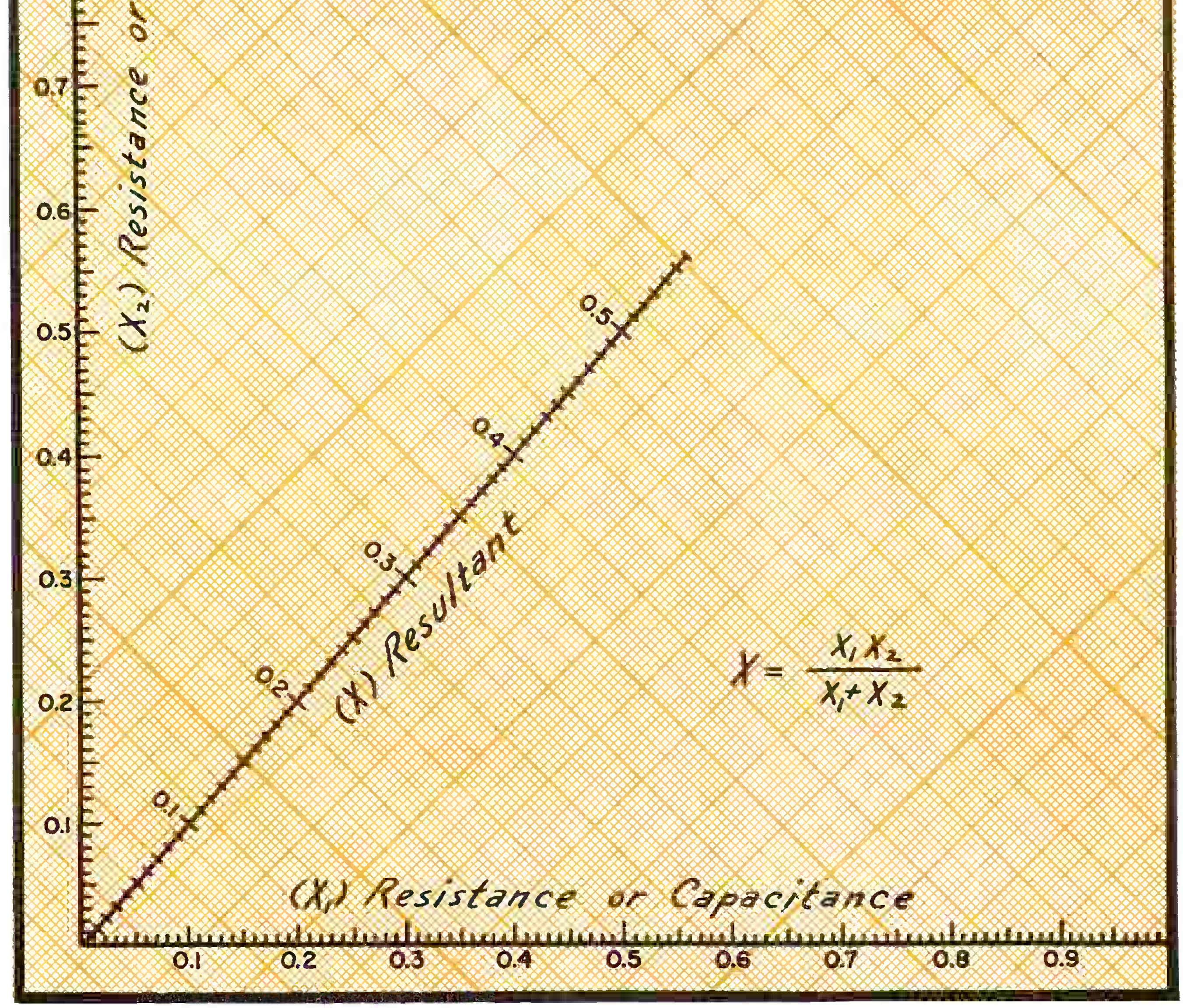
THIS chart may be used for computing the resultant capacity of two condensers in series or the resultant resistance of two resistors in parallel. Place a straightedge across the three lines passing through X_1 and X_2. The intersection of the straightedge with the inclined axis indicates the calculated resultant. The scale range of this chart may be extended by multiplying or dividing the numbers on each axis by multiples of ten.

EXAMPLE:

X_1 = 0.4 mfd.
X_2 = 0.3 mfd.
From the chart, X = .171 mfd.

EXAMPLE:

X_1 = 40 ohms
X_2 = 30 ohms
From the chart, X = 17.1 ohms



THEORY AND APPLICATION OF [illegible]

by MILTON S. KIVER

Part 2. Presenting basic theory of velocity modulation and its application to cavity resonators in ultra-high frequency amplifier and oscillator tubes.

THE difficulty of constructing high-frequency oscillators, using coil and condenser tank circuits, has been analyzed in a previous article, with the aid of the formula relating the inductance, capacitance and frequency. The maximum obtainable frequency for a given triode, tetrode or pentode tube oscillator, ultimately depends upon the distributed capacity and inductance of the leads and electrodes, as well as the electronic transit time within the tube.

To obtain low loss and high Q characteristics, cavity resonators and Lecher-wire systems have largely replaced the tuned tank circuits. The Lecher wire systems are usually a quarter-wavelength long or some odd multiple thereof. The cavity resonators, on the other hand, are not so simply related to the resonant frequency.

Since the conductance in the grid circuit of the tube usually shunts the tuned grid circuit, an increase in this conductance will increase the energy loss. One method of overcoming this undesirable effect due to the electron transit time is accomplished by increasing the operating voltages of the electrodes, but this also increases the energy loss at these elements and so has practical limitations. Moving the elements closer together will help to remedy this difficulty, but again the practical disadvantages are obvious.

To overcome these limitations, the Klystron tube was developed and actually took advantage of the transit time phenomenon. The method whereby energy is transferred from the input to

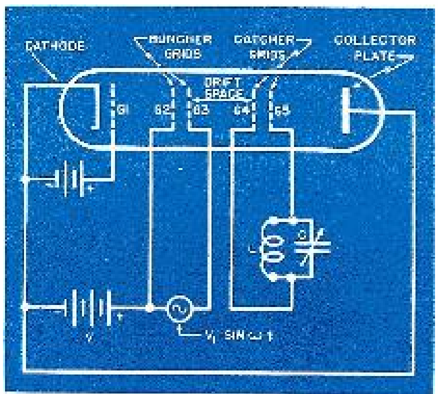


Fig. 1. Arrangement of electrodes and resonant circuit to produce velocity modulation.

the output, within the tube, is known as velocity modulation and will be described in detail.

Before proceeding, however, it should be mentioned that there are several types of commercial tubes that utilize the same principles, but the operation of the Klystron is simple to understand and therefore will be used in the following discussion.

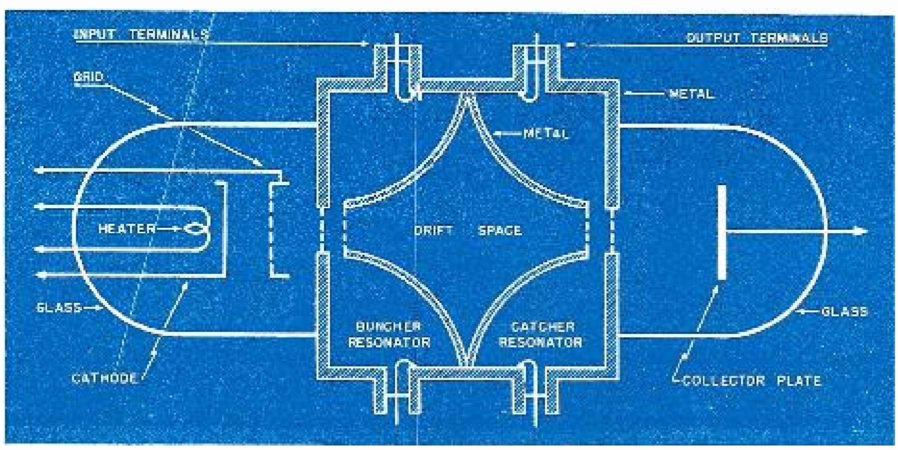
In Fig. 1 we have a setup that will produce velocity modulation. A stream of electrons produced by the cathode and focused into a sharply defined beam by the first grid, G_1, is accelerated toward G_2 and G_3 by the high positive voltage V. The two grids, G_2 and G_3, are placed very close together so the electron spends a relatively short time between them. If an electron reaches the grids when the alternating voltage between them is zero, then it will pass on unaffected. However, any electron reaching the grids when the voltage $v_1 \sin \omega t$ is going positive will be accelerated and similarly, when the alternating voltage is going negative, will be decelerated. Thus, the electron stream will tend to have different velocities dependent on their time passage through the two grids, called the buncher grids. Since the voltage $V_1 \sin \omega t$ is very small in comparison to the accelerating voltage V, practically the same number of electrons will pass out of the grids each moment as went in, and therefore there will be no resultant current produced in the grids G_2 and G_3, leaving the conductance of that circuit unaffected. The power loss in the buncher circuit is thus small, which is a very desirable feature. In this way, the above process avoids the pitfalls of the ordinary tube, namely an appreciable input energy dissipation.

The velocity-modulated beam obtained so far is not directly usable but if it could be changed into a density modulated beam then we could convert the power in it to some useful purpose. There are several conversion methods but the one that gives the best results is the drift-tube process. If the beam is allowed to move down a relatively long field-free tube, then the electrons that were speeded up in going through the buncher will catch up with the electrons that were decelerated and tend to form bunches. At the center of these bunches will be found, of course, those electrons that passed through G_2 and G_3, with their velocities unchanged.

Thus, at some point down the tube the electrons will pass in bunches and the velocity-modulated beam is now a density-modulated one. Transit time, which worked against the operation of the ordinary vacuum tube, is now being used to advantage.

Two other grids, G_4 and G_5, placed at a sufficient distance from G_2 and G_3 and connected to a tuned resonant circuit such as a cavity resonator incorporated in the Klystron, will be set into oscillation if the bunches of the electrons pass through at intervals equal to the natural period of the circuit. These two grids are called the catcher electrodes. Energy will be delivered to the catcher grids only if the electron bunches pass through when the field set up between them is a retarding field. It is only by deceleration of the

Fig. 2. Structural arrangement of buncher and catcher resonators in a Klystron tube.



beam that an energy transfer takes place in the right direction; that is, from the bunched electrons to the cavity resonator.

In order to catch the most power there are several requirements that the catcher grids must satisfy:

1. These grids should not be placed too far from grids G_2 and G_3. There is a certain bunching form that gives best results;
2. The voltage phase across catcher grids must be correct and;
3. The strength of the oscillations should be such as to absorb as much energy as possible.

After the beam has given up its high frequency power to the catcher, it expends its direct-current power on a collecting electrode which then returns these electrons to the cathode, thereby completing the circuit. It should be remembered that the total current remains the same throughout the entire process. This current is referred to as the conduction current.

From the above process of velocity modulation we can draw the following summarization:

1. Velocity modulation of the beam is first required;
2. By means of a drift tube we convert the velocity modulated beam into a density modulated beam and;
3. Finally, removal of the high-frequency power of the density-modulated beam by means of a resonant circuit, in this case, a cavity resonator.

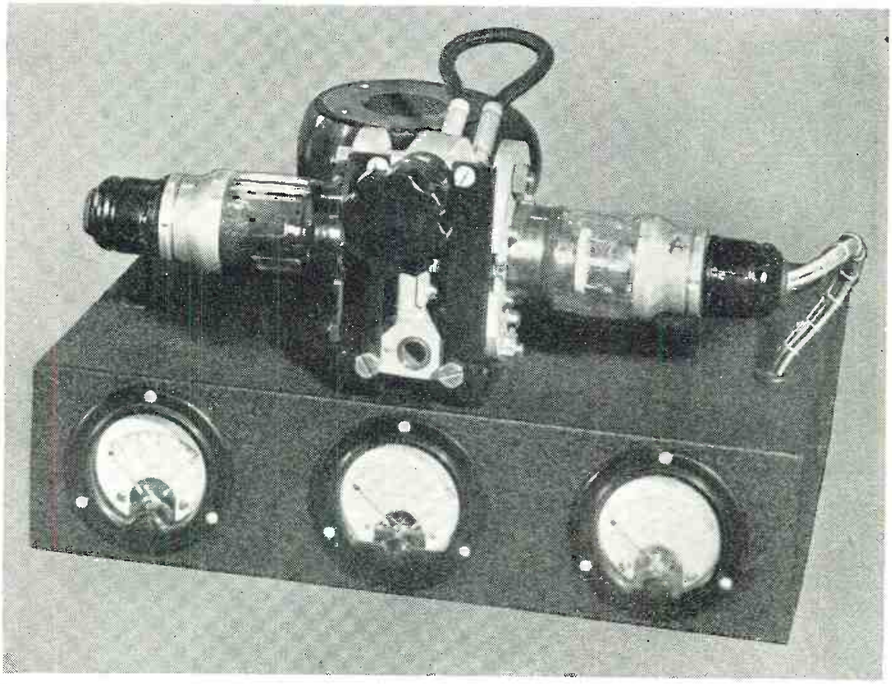
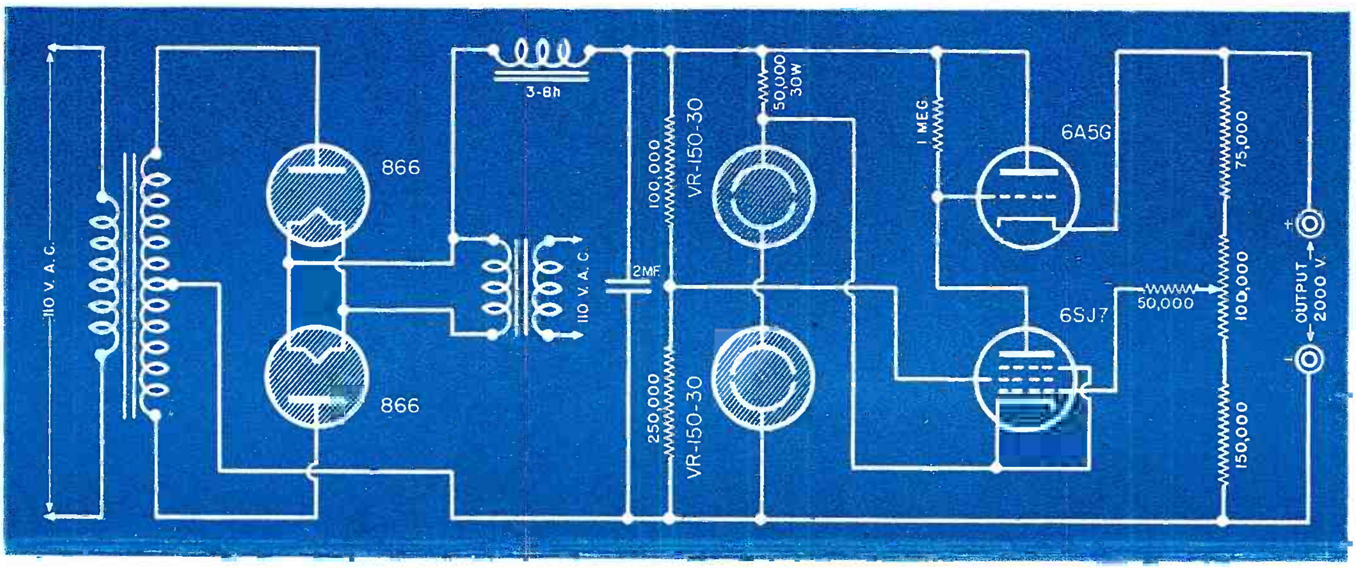


Fig. 3. Klystron tube with transmission-line loop feeding energy to buncher from catcher resonator. Centrifugal blower, in rear, maintains tube at safe operating temperature.

In Fig. 3 we have a photograph of an actual Klystron tube. When used as an oscillator, part of the energy is drawn off from the catcher and fed back to the buncher through a transmission line. The remainder of the energy is fed to a wave guide where it can be sent out to be picked up by a receiver. Behind the tube is a blower to maintain the temperature of the tube at a safe operating value.

Fig. 2 gives the structural diagram of a commonly used commercial type Klystron. The cavity resonators attached directly to the tubes are of a solid hollow structure except where the electron stream passes through. At this point a grid-like structure is built to allow free passage of the electrons. Both the buncher and catcher are built alike, as they would have to be for oscillatory purposes. The resonant frequency of the cavity resonators, in actual practice, can be varied over a narrow range of frequencies by a screw adjustment which allows one side of the resonator to be slightly deformed. The fact that a cavity resonator is limited by structural considerations is one of its greatest disadvantages. It should be noticed that the energy is removed from the resonator by a small hairpin-loop antenna that picks up the electromagnetic waves and transmits them via concentric cable to wave guides. Since it is usual to have the high operating voltages connected to the exposed metal parts of the apparatus, the high voltages are usually at ground potential. The power supply should be of the regulated output type since, as will soon be shown, voltage variations can keep the unit from oscillating. One suggested unit is diagramed in Fig. 4. The diagram of a Klystron tube hooked-up as an oscillator is shown in Fig. 5. As in all oscillators, energy must be fed back to the grid from the plate circuit in correct phase. In this diagram power from the plate cavity resonator is fed back by means of a coaxial transmission line. Because of the inherent characteristics of the tube there is a considerable phase shift. This large amount of phase shift is due mostly to the relatively long drift length of the tube. Signals which act at the buncher show up at the catcher only after the electrons have travelled down the relatively long drift tube.

Fig. 4. High-voltage power supply, compensated for changes of input voltage and load current by using a two-stage inverse-feedback circuit.



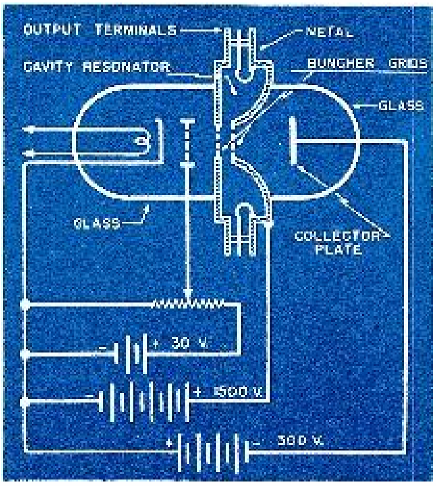


Fig. 5. A reflex-Klystron oscillator with single resonator as buncher and catcher.

The calculations needed to analyze the shift are not involved but since we are only interested in the results, the phase shift due to the drift tube is given as

$$\theta = \frac{\omega S}{6\sqrt{V}} \cdot 10^{-7} \text{radians}$$

where:

S = length of drift tube in cms.

V = d-c accelerating potential.

$\omega = 2\pi$ f, where f is the operating frequency.

As an example, if f is 1000 megacycles, V is 1600 volts and S is 3.6 centimeters, then substituting in the above will give

$$\theta = 3\pi \text{ radians}$$

The above, while being the most important phase shift, is not all. There is also a phase displacement due to the coaxial cable feeding the energy back from the catcher to the buncher. This phase shift shall be called θ_2.

And last, but not least, there is an additional phase shift of 90° due to the relationship of the buncher to the catcher. If you recall, it was stated that the electrons would tend to reach the catcher in groups, and at the center of these groups would be the electrons that passed through the buncher when the field intensity was zero. Now supposing the field to be going from negative to positive, then electrons going through the buncher previous to zero voltage would be retarded and those going through after the zero voltage would be speeded up. The electrons just mentioned would produce a congested region of electrons somewhere in the drift tube space between G_3 and G_4 (Fig. 1).

Thus it can be seen that the electrons that passed through the buncher at zero alternating voltage arrive at the catcher with the electrons that just preceded them and also with those that followed them. In other words, the maximum current at the catcher is associated with zero field at the buncher. From this reasoning a 90° phase shift is evident.

In order for the oscillator to maintain functioning, these three phase shifts, just given above, must equal 2πn where n is any whole number. When these phase angles are set equal to 2πn the following equation results:

$$\frac{fS \cdot 10^{-7}}{6\sqrt{V}} = \left(n - \frac{1}{4} - \frac{\theta_2}{2\pi}\right)$$

where all the symbols have the notation previously defined. Inspection of the above equation shows that there will be various voltages at which oscillation occurs. The operation of the tube is quite critical and the catcher and buncher must be at the same resonant frequency before the oscillation will commence. In practice this difficulty is overcome by inserting an alternating voltage in series with the direct-voltage supply. If the amplitude of the alternating voltage is great enough, the range of voltages obtained will cover one of the operating potentials given by the above formula and the Klystron tube will operate.

An alternate form of the Klystron oscillator is shown in Fig. 5. Here a single cavity resonator is used to perform both the functions of the buncher and catcher. The electrons are still velocity modulated by the buncher and travel on to the plate. Since the plate is at a negative potential, the electrons will be slowed down and eventually turned back to the buncher. If they pass the buncher at the right time they will deliver energy to it and thus oscillations will take place.

As shown in Fig. 6, the grid between cathode and buncher may serve as a modulator. However, due to the variation of frequency with accelerating voltage, it is rather difficult to obtain linear amplitude modulation. Frequency modulation may be more easily obtained, however, by introducing a small modulating voltage in the cathode circuit.

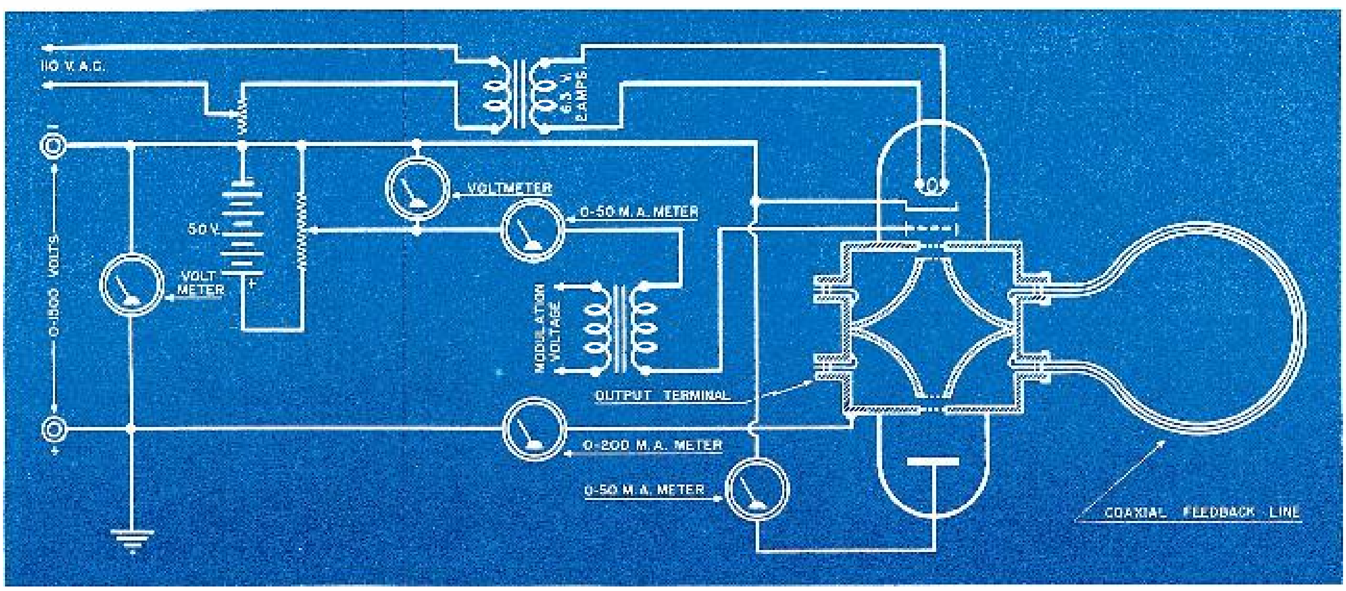
Driving the buncher, by an external source of power of correct frequency, and having the electron beam high enough to deliver more energy to the catcher than is required to drive the buncher, will convert the Klystron tube into an amplifier. About 15% efficiency can be obtained when the Klystron is acting as a power amplifier and a voltage amplification of 20 per stage at a frequency of 3000 megacycles is possible as a voltage amplifier. It should be pointed out that this is the only ultra-high frequency tube capable of amplifying signals in the hyper-frequency band.

Insertion of a grid between the catcher and collector allows the tube to be used as detector. A small positive voltage is applied to the grid so that with no excitation at the buncher, most of the electrons will strike the collector plate. Excitation of the buncher results in the building up of a field at the catcher and therefore some of the electrons will be slowed down and the collector current reduced.

In closing, mention should be made

(*Continued on page* 62)

Fig. 6. Connections from heater and high-voltage supplies to a Klystron tube used as an oscillator.



THE Q-JIG

By S. W. EDWARDS

A simple laboratory fixture, used in conjunction with a signal generator and a VTVM for rapid measurement of inductance, capacity, and Q.

TODAY practically every laboratory or service shop has a signal generator and a vacuum-tube voltmeter. Many have Q-meters as well. However, many do not, and during the present crisis, when instruments are scarce, it is frequently desired to measure Q, L or C at some radio frequency without the help of this versatile instrument. The writer has long used what he calls a "Q-Jig" which does a nice job of pinch-hitting for the Q-meter he does not have. The jig can be made from a handful of odds and ends found around any laboratory and it can be quickly used with the signal generator and VTVM without tying up either of these instruments.

Fig. 1 shows the circuit diagram, if we can dignify anything so simple with such a name. Fig. 2 shows the mechanical lay-out used by the writer to mount the components of Fig. 1. C_1 and C_2 are variable condensers, the latter being a small vernier type. They are mounted on a small bakelite panel which in turn is secured with a pair of angle-irons to the shelf above the work-bench. As the figure indicates, a calibration is provided for each condenser. This can be done by substituting small mica condensers of assorted values and known accuracy for the respective variables when the jig is in use and continually readjusting their resonance. The input and output terminals are provided by banana-type jacks.

When using the jig the signal generator is set for full output (usually 1 volt) and its energy applied to the network R_1, R_2. It is, of course, desirable to make R_2 as low as possible while R_1 has to be as large as feasible in order to protect the signal generator. In the writer's unit R_1 was 261 ohms, while R_2 was 9 ohms. These resistors are mounted on the panel with leads as short as possible in order to reduce the effects of shunt capacity. With one volt applied to the input terminals approximately .03 volt appears across R_2 and is injected into the series resonant circuit. At any chosen frequency within the range of the coil under test the condenser combination C_1, C_2 is adjusted to resonate the circuit as indicated by maximum response on the VTVM.

The ratio of the output voltage to the input across R_2 (.03 volts) is the gain of the circuit. If R_2 were small enough to be neglected, this would then also be the Q of the coil. However, as a couple of examples will show, R_2 cannot be neglected. For instance, if we have a coil with an inductance of 200 microhenries and a known Q of 200 and test it at 1 megacycle, we know since the reactance of the coil is $2\pi fL$ it will have a reactance (X_L) of approximately 1000 ohms. Since its Q, $\frac{X_L}{R}$, has been stated as 200 then the resistance of the coil must be approximately 5 ohms. In our jig the resistor R_2 is nearly double this value and the apparent Q (or gain of the circuit; let us call it "k") is approximately 70 and differs from the real Q of the coil by nearly three to one. It would be nice if we could simply use some such multiplying factor to arrive at the correct value of Q. Unfortunately different values of Q call for different correction factors.

Since Q is one of the unknowns we are after, we cannot predict what this factor should be. Just the same, it is not difficult to calculate the correct value of Q if we first determine the inductance of the coil, which in most cases we have to do anyway. From the input frequency and the capacity setting we can determine the coil's inductance and its reactance X_L. Nearly every radio handbook has a table of LC values and a chart of inductive reactance versus frequency. Once we have measured X_L and the circuit gain k we can calculate Q from this simple formula since the resistor R_2 is of known value (9 ohms):

$$Q = \frac{X_L}{\frac{X_L}{k} - R_2}$$

This formula assumes that the input impedance of the VTVM used is high at all operating frequencies. In most cases this will be sufficiently true.

This fixture can of course be used to measure the capacity of small fixed condensers by the substitution method merely by employing any serviceable coil that will resonate at the desired input frequency.

While no great claim is made for the accuracy of this gadget a comparison of readings made with a good laboratory-type Q-meter indicated agreement within 10%. In many cases this accuracy is sufficient and the simplicity of the fixture should recommend it to those who, like the writer, cannot justify the investment a real Q-meter entails, even though they are occasionally called upon to make measurements of this kind.

—30—

Fig. 1. Simplicity is the keynote of circuit design.

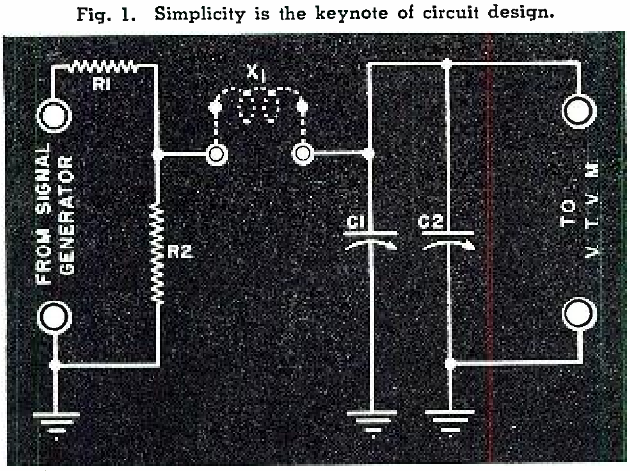
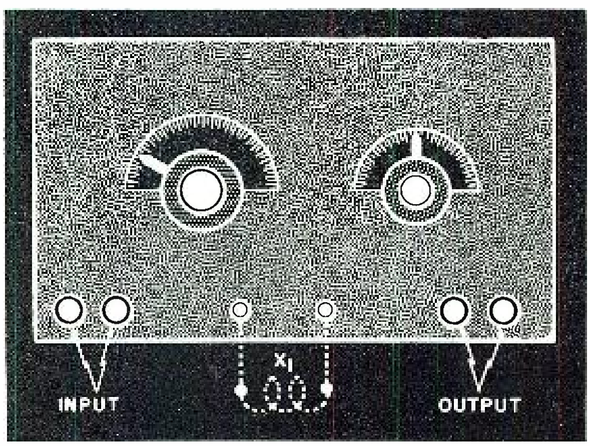


Fig. 2. Front panel layout of the versatile Q-jig.



A-F SIGNAL TRACERS

by

RUFUS P. TURNER
Consulting Engineer, RADIO NEWS

Constructional details of easy-to-build signal tracers for servicing amplifiers.

☆

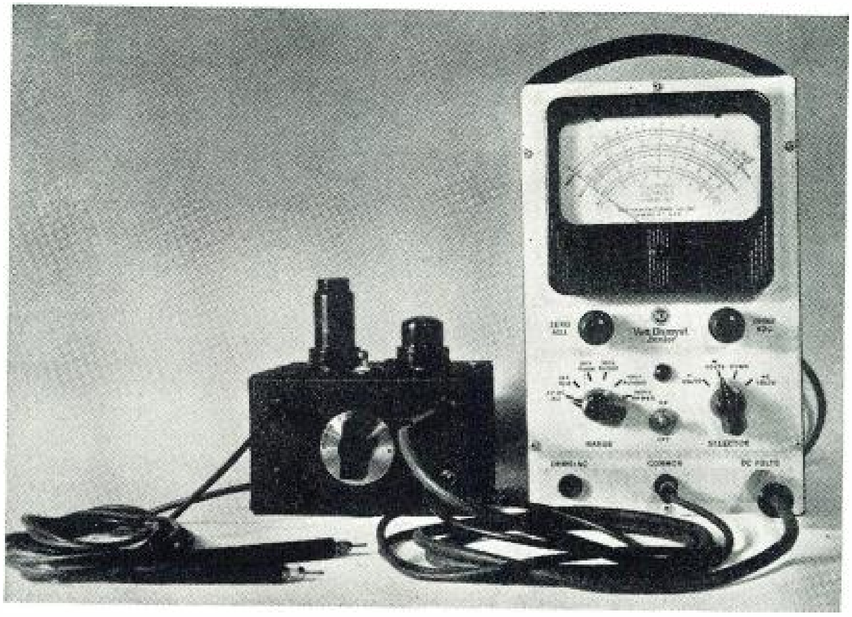


Fig. 1. External view of the complete tracer shown in Fig. 4.

THE merits of signal tracing are well known. For localizing trouble in radio circuits, this method has no equal. The chief advantage of signal tracing, or *channel analysis,* is its dynamic nature, its reference to the signal itself.

Signal tracing is as effective in localizing trouble in audio-frequency circuits as in r-f systems, although it is in the latter application that it has grown most popular up to this time. There has been a tendency to look upon channel analysis as a radio service technique having no application to amplifier checking.

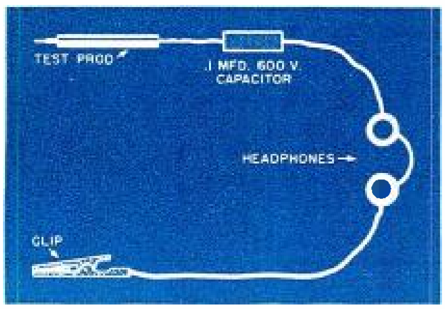


Fig. 2. Headphones used to detect signals of rather large intensity.

Radio signal tracers are not usable in amplifier trouble shooting. Special devices may be constructed for audio-channel analysis, however, and these range from the simple capacitor-coupled headset to the tuned-audio amplifier. It is the purpose of this article to describe the construction of these a-f signal tracers and to explain their use.

Tracer No. 1

The simplest a-f signal tracer is a pair of phones. The presence of an audio signal at various points in the circuit is checked with this arrangement by simple listening tests. Since signal circuit checks must be made at various high-voltage d-c points, a blocking capacitor (generally .01 to .1 μfd.) is included in the headphone circuit to prevent injury to headphones or operator by the high d-c voltage. The circuit schematic is shown in Figure 2.

A pair of test leads complete the tracer circuit. Only one of these leads need terminate in a test probe. Since most signals will be taken between some circuit point and ground, the other lead may be provided with an alligator clip for easy and continuous connection to the chassis. A single exploring probe is then the only contact needing to be moved about the circuit when tracing a signal.

A variation of the Figure 2 arrangement is given in Figure 3. In this adaptation, the blocking capacitor is mounted inside a shielded test-probe sleeve, and a shielded lead extends to the headphones. The low-potential lead is connected to the sheath of the high-potential lead and terminated in an alligator clip for chassis connection.

The special test probe, shown also in the photograph (Figure 7), is made from a bakelite or fiber tube ¾ inch in outside diameter and 6½ inches long; wall thickness of this tube is ⅛ inch. The tube will admit a 600-volt 0.01-mfd. tubular capacitor, such as Aerovox type 684, comfortably after the interior has been lined with a shield of tinfoil, aluminum foil or thin sheet metal. After connections are made, the ends of this tube are sealed by cemented-on bakelite or fiber discs, one holding a standard screw-type prod tip and the other being drilled to pass the shielded test lead.

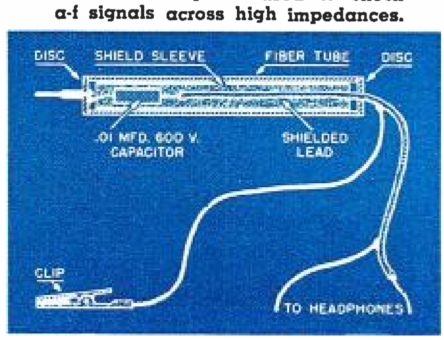
The headphone-type tracer has the advantage of simplicity, but this is offset by the disadvantage of relatively low sensitivity and inability to control signal strength in the phones. In some portions of a circuit, such as at points in and near the output stage, the volume level will be too high to permit wearing the headphones and will even damage them unless the amplifier gain control setting is reduced.

Tracer No. 2

The a-f signal tracer diagrammed in Figure 8 and shown in photograph, Figure 6, includes a gain control, R. This component is a 1-megohm potentiometer which gives the tracer high input resistance, a desirable feature which insures a minimum of electrical disturbance to the circuit under test.

The .1-μfd., 600-volt tubular capacitor, C, serves to couple the tracer to the test circuit and at the same time to isolate the tracer from any d-c component in the amplifier circuit. The

Fig. 3. Test probe used to check a-f signals across high impedances.



test leads, one provided with a test probe and the other with an alligator clip for the chassis, are connected to two insulated banana jacks, and a midget single-circuit jack is provided for the headphones.

For quiet operation and increased sensitivity, an a-c vacuum-tube voltmeter of any type may be plugged into the output jack in lieu of headphones. It should be borne in mind when using the meter, however, that a hum signal (with or without a normal signal) will give a deflection. And the presence of this hum will not be revealed unless headphones are occasionally plugged in for a listening test.

By means of Tracer No. 2, a signal supplied by an audio oscillator, may be followed rapidly through an amplifier by touching the test probe successively to the grid and plate terminals in each amplifier stage, progressing from the amplifier input terminals to the voice coil of the speaker. The gain control may be turned down whenever the signal strength rises; and if a voltmeter is employed instead of headphones, the gain of each stage may be noted from the ratio of plate to grid signal voltages.

Tracer No. 3

Some PA servicemen prefer a simple amplifier-type v. t. voltmeter for audio signal tracing. A circuit of this sort is diagrammed in Figure 4 and the tracer is shown in photograph, Figure 1.

The amplifier is a compact single-stage, self-powered unit which actuates a voltohmyst, or similar d-c vacuum-tube voltmeter. Figure 1 shows the input amplifier connected to the Voltohmyst Junior.

The input circuit of the amplifier stage includes a blocking capacitor, C_1, and a 1-megohm gain control, R_1. The test probes are connected to insulated banana jacks, T_1, and T_2. The 6J5 amplifier tube is resistance-capacitance coupled to a shunt-fed diode rectifier embracing the first half of the 6H6 tube.

The d-c output voltage delivered by the first section of the 6H6 tube is equal to the peak value of the signal voltage, except between 0 and 10 volts when the d-c value deviates somewhat from signal peak values.

The isolated d-c probe of the Voltohmyst is plugged into the insulated tip-jack terminal, T_3, and the probe of the common lead connected to the grounded terminal, T_4.

The midget power supply for Tracer No. 3 comprises a 1:1-ratio transformer (T) and a half-wave rectifier including the second half of the 6H6 tube, midget filter choke (CH) and a dual electrolytic filter capacitor (C_6-C_7). If a small 1:1-ratio transformer for 115-volt operation is not available, an improvisation may be made by connecting two filament transformers (T_x and T_y) "back to back", as shown in Figure 4. AC-DC operation of the tracer power supply is not recommended because of the possibility of grounding the high side of the power line when testing a-c—d-c amplifiers and because of the likelihood of electric shocks.

Tracer No. 3 offers the advantage of sensitivity. By means of this instrument, relatively weak signals may be traced in the input stages of an amplifier under test, and at low-impedance points. An amplifier may accordingly be checked at low settings of its gain control. As a result of the amplification afforded by the input section of the tracer, the d-c Voltohmyst may be used as a direct-reading audio-frequency millivoltmeter.

In order to identify hum, noise, and oscillation voltages with Signal Tracer No. 3, the audio signal is switched off. Any signal present at any point in the circuit will then be due either to hum,

(*Continued on page* 82)

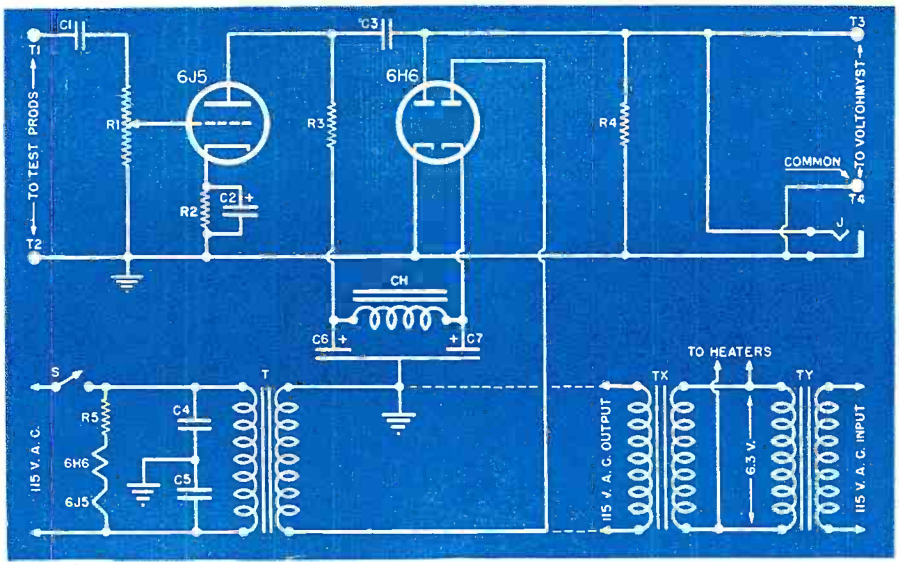


Fig. 4. Diagram of a simple amplifier-type v-t voltmeter for audio-signal tracing.

C_1—.1-µfd. 600-v. tub. cond.—Aerovox
C_2—25-µfd., 25 d.c.w.v. midget tub. electrolytic—Aerovox PRS
C_3, C_4, C_5—.1-µfd. 400-v. tub. cond.—Aerovox
C_6, C_7—Dual 16-µfd. 150 d.c.w.v. midget tub. electrolytic—Aerovox
CH—12-15-hy. midget broadcast filter choke
J—Miniature open-circuit phone jack—Yaxley
R_1—1-megohm pot.—I.R.C. Type CS
R_2—7000 ohm 1 watt res.—Aerovox 1098
R_3—.25-megohm 1 watt res.—Aerovox 1098
R_4—10 megohm 1 watt res.—Aerovox 1098
R_5—340 ohm 75 watt wirewound res. Ohmite
S—S.p.s.t. toggle switch—Arrow
T—1:1 line transformer—Kenyon (see text)

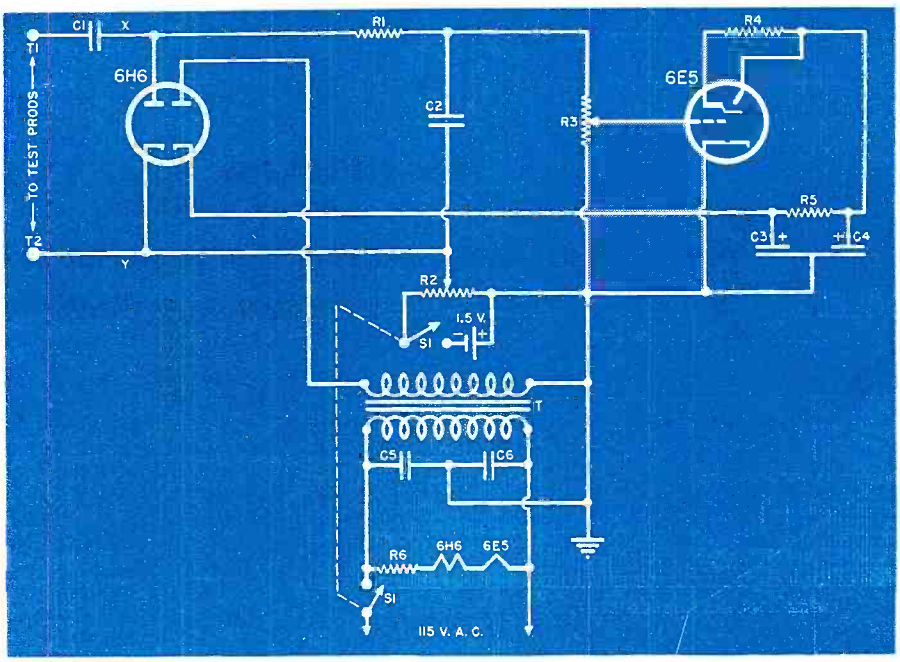


Fig. 5. A shunt-fed diode rectifier and an electric eye used as a signal tracer.

C_1—.1-µfd. 600-v. tub. cond.—Aerovox
C_2—.02-µfd. mica (2-.01 in parallel) cond.—Aerovox
C_3, C_4—Dual 16-µfd. 450 d.c.w.v. midget tub. electrolytic—Aerovox PRS
C_5, C_6—.1-µfd. 400-volt tub. cond.—Aerovox
R_1—1000-ohm 1 w. res.—Aerovox
R_2—1000-ohm w.w. pot.—I.R.C. Type W-1000
R_3—1-megohm pot.—I.R.C. Type CS
R_4—½-megohm ½-w. res.—Aerovox
R_5—1500-ohm 5-watt wirewound res.—Ohmite
R_6—340-ohm 75-watt wirewound res.—Ohmite
S_1—Toggle switch d.p.s.t.—Arrow
T—1:1 line transformer—Kenyon (see text)

Fig. 73

Fig. 74

Fig. 75

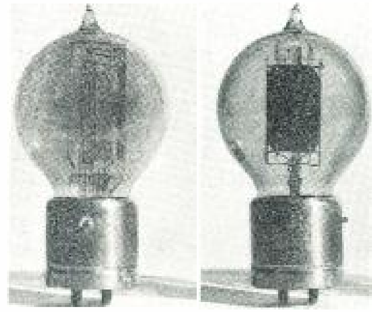


Fig. 76

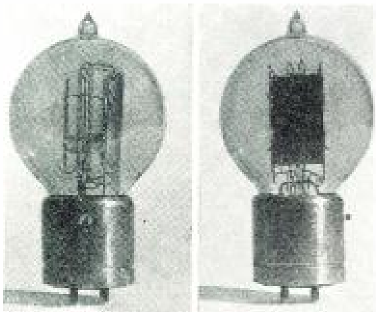


Fig. 77

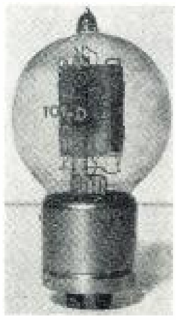


Fig. 78

Fig. 79

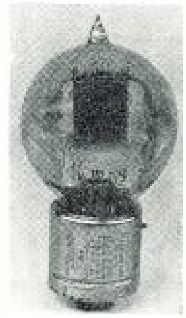


Fig. 80

THE SAGA OF THE VACUUM TUBE

by GERALD F. J. TYNE
Research Engineer, N. Y.

Part 9. The early constructional problems of the Western Electric type-101 vacuum tube—covering its multiplicity of shapes and sizes.

NOW we come in our story to the point where we need to know a bit more about this modern Aladdin's lamp; how it looked, how it was constructed, and the multiplicity of forms into which it grew.

To the tube collector, the tube is known by its appearance. So much emphasis in what follows is laid on appearance; on significant changes in construction and markings. The identifying of these changes is a reminder that a great deal of engineering effort goes into developing something which is really serviceable to mankind. Few people have any idea of the multitudinous details of construction and materials involved, or the meticulous measurement work and performance testing.

In this article our consideration will be of the Western Electric 101-type vacuum tube, from the point at which it was left at the end of the preceding article up to the present time, for it is still in use. The early Western Electric tubes merit particular attention for several reasons. They were little known to the public, having been developed for use in the telephone repeater plant, which is largely "behind the scenes." They were by far the best of the early tubes, and they provide a striking example of intensive organized research to produce an article, not for general use or sale in the market place at an attractive price, but for service in a highly specialized application, in a plant where they were treated with care, and in which reliability and long life were the desiderata to be attained.

Late in 1917 the type of base used on Western Electric Vacuum Tubes and Repeater Bulbs was changed. As has been described, up to this time it was a heavy, machined brass, seamless shell. The new base was a formed casing of German silver. Into the bottom of this formed casing was fitted an insulating member on which the contact studs were mounted. (See Fig. 73). The space around the insulating member was filled with a red wax known as "Zinssner's Regular Insulating Wax." This was a mixture of red iron oxide with shellac gums. The wax was poured in to fill the base flush with the bottom of the formed shell and a die applied to form the letters and numerals of the code marking in the center, in raised characters. This type of base was used until about 1925, although later a different filling compound was used. The color of the Zinssner's wax was always red, although the shade varied from lot to lot, sometimes almost to brown. The compound which was later used was black in color.

When the new type of shell was put into use the patent marking read as follows, (see Figure 74):

PAT. IN USA
1-15-07 TWO PATENTS
2-18-08 4-27-15
12-19-16
PAT. APPLIED FOR

The first of the tubes made using this shell bore the code marking only in the wax filling of the shell.

Late in 1918 the markings on the base of the 101B and all other repeater bulbs were changed (as shown in Figure 75) to include the property marking of the A. T. & T. Co. The marking of the 101B thus became:

PROPERTY OF
AMERICAN
TEL. & TEL.
COMPANY
101B

PAT. IN U.S.A.
1-15-07 TWO PATENTS
2-18-08 4-27-15
12-19-16
PAT. APPLIED FOR

The construction of the 101B Repeater Bulb up to this time was that shown in the bulb depicted in Figure 76. The element assembly was supported by a glass arbor which was sealed to the edge of the press, and the plane of the element assembly was at right angles to the plane of the press, both being vertical. Difficulties were experienced with this form of assembly however, the most common source of trouble being breakage of the arbor at the point where it was welded to the press. Many of the tubes still in existence show such breakage.

To overcome these difficulties the element was redesigned and, beginning early in 1919, the arrangement shown in Figure 77 was used. Here the arbor has been made heavier and was welded to the stem somewhat below the press. The positioning of the arbor was such that the element assembly was made parallel to the press instead of at right angles to it. The grid structure was changed from 9 to 11 laterals and the plates were made rectangular with edges turned up at right angles to provide stiffening. The tie wires at the top of the assembly were welded to the turned-up edges instead of the flat surfaces, as had previously been the case.

Late in 1919 the patent marking was changed to read as follows:

(*Continued on page* 54)

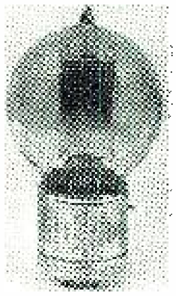


Fig. 81.

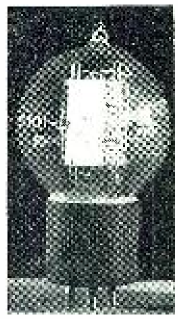


Fig. 82.

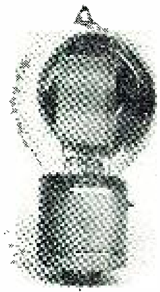


Fig. 83.


Fig. 84.

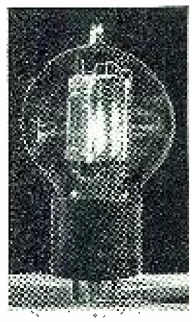


Fig. 85.

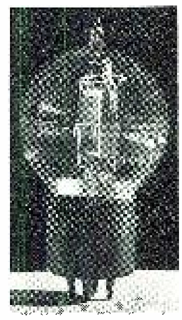


Fig. 86.


Fig. 87.

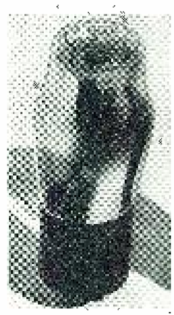


Fig. 88.

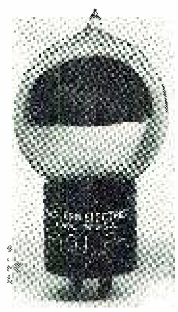


Fig. 89.

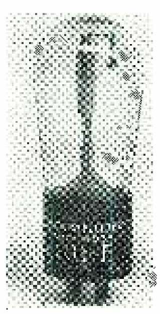


Fig. 90.


Fig. 91.

TECHNICAL BOOK & BULLETIN REVIEW

EXPERIMENTS IN ELECTRONICS AND COMMUNICATION ENGINEERING, by E. H. Schulz and L. T. Anderson, published by *Harper and Brothers,* New York. 377 pages. Price $3.00.

This book is intended to serve as a laboratory text for courses at college level in electronics, communication networks, radio and ultra-high-frequency phenomena. In addition, sufficient experiments in basic d-c and a-c circuits necessary for these courses are included. An attempt has been made to organize the material in such a way that it will be adaptable to the Army-Navy College Training Program and to other accelerated War Training Programs. Sufficient information is provided to make it possible for the student to perform the various tests with a minimum of verbal instruction. The text includes 108 experiments ranging from simple direct-current measurements to complete video amplifiers, radio receivers, radio transmitters, antenna systems, etc. The material is divided into chapters according to subject matter. Each experiment consists of a brief discussion of the principle involved, the procedure to be followed and the suggested equipment. Each experiment is as complete as possible, but certain parts of the experiment may be selected for performance in order to adapt the material to time or subject schedule.

SHORT-WAVE WIRELESS COMMUNICATONS, including Ultra-Short Waves, by A. W. Ladner and C. R. Stoner. Published by *John Wiley and Sons, Inc.,* New York. 568 pages. Price $6.00.

Because of the exigencies of the times, the Fourth and wartime edition of Short-Wave Wireless Communications does not contain references to many of the new and interesting applications of short-wave, particularly ultra-short-wave developments. However, a great deal of new material has been added, including 180 new diagrams.

A change in the chapter sequence has been made. The increased use of transmission-line technique in many circuit problems suggested that line theory should be treated rather earlier in the book than formerly, and it appeared desirable that aerials should be more closely associated with the propagation of wireless waves. The chapter on high-frequency feeders has been treated in an excellent manner.

The greater utilization of ultra-short waves has necessitated that greater attention should be devoted to them, but since short and ultra-short waves have much in common, both are dealt with throughout the text in appropriate chapters, instead as formerly of devot-

(*Continued on page* 86)

By CARL COLEMAN

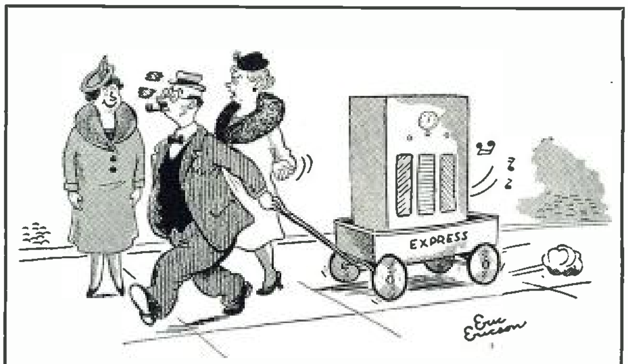
THE assignment turnover has picked up rapidly during the past two months but most likely will slacken after the holidays. This condition is the usual trend at this time of year when many of the boys who have been away for many months naturally want to get home for Christmas and at the same time obtain a much needed shore leave. Men going to sea under present conditions certainly deserve at least one decent vacation a year, ashore among family and friends.

R.O.U. reports that many men who need a furlough, and who would like to take one, are confused by the War Shipping Administration registration system which allows only a couple of weeks ashore between ships. The W.S.A. plan was, however, designed to catch up with the draft dodger and there is no intention to use it to deny any bona fide seaman a spell ashore. The present system is being simplified so that the ship's master or clerk will have little difficulty in making out the cards correctly.

J. W. Gullet recently completed a vacation, following the loss of his last vessel, and returned to sea again on a Liberty. Glenn K. Ellis took out another tanker down in the Gulf. Otto Vandefford had a brief vacation at his home in Petal, Miss., between assignments. Alvin Hertz ditto while his "Cape" ship was at an East Coast port. T. G. Scott is on an assignment out of the Gulf after quitting a Liberty on the East Coast a while ago. Mendle Goldberg on a Liberty which took several Nazi torpedoes, arrived safely back at a U.S. port with the ship and was immediately assigned a new Liberty operated by Mississippi Shipping Co. Leon Breedlove Jr., enjoyed a vacation at Nola after his last berth. Karl Seibold shipped aboard one of the new Liberty tankers recently. Karl has a son in the Merchant Marine. Robert Boucher, who joined the Torpedo Club about a year ago, is now the proud father of a baby girl. David Morgan took out a freighter assignment for the U.S. Lines after terminating employment with Higgins Industries at New Orleans. Dave just can't seem to stay put ashore. J. J. Papke also took out a Liberty tanker.

THE War Shipping Administration completed arrangements for assigning two Liberty ships, the "Chung Shan" and "Chung Cheng," to the Chinese government. The vessels were named in honor of Generalissimo Chiang Kai-shek and Dr. Sun Yat Sen. Admiral E. S. Land of W.S.A. and Dr. T. V. Soong, Chinese Foreign Minister, signed Bareboat charters for the ships' transfer to Chinese control.

Many Liberty ships are now being named after Americans who were not statesmen. The Maritime Commission's change from its earlier policy honors many famous Americans. The Liberty "George M. Cohan" was launched in mid-summer at Baltimore and has since been followed by many others. Liberty vessels are still being produced at a rapid rate; however, some of the yards constructing ships of this type have been given contracts by the Maritime Commission for building Liberty Tankers. Many ships of this latter type have already been added to our rapidly growing Merchant Marine. Some yards likewise have been diverted to the construction of the "C" type boats and small freighters while others are making preparations to lay keels for the new Victory Ships.



"The salesman told him it was portable!"

FRED ULRICH is still holding down a berth at WQXR. How about a little news from the broadcast boys, Freddie? Edward Barnes is holding down a C-2 on the West Coast. Ed is a former Chief of Mississippi Shipping Company

(*Continued on page* 88)

Fast Keying Audio Oscillator

by Sgt. ARTHUR A. BERTRAM
Asst. Chief of Maintenance, Station WVR

Constructional details of an audio oscillator that may be used either as a test unit or for code practice.

IN renovating the main patch-board at Radio Station WVR, Fort McPherson, Georgia, it was decided to install a built-in audio oscillator to accomplish three separate purposes: By furnishing a steady tone to enable instant checking of remote lines to receiver and transmitter stations; by appropriate patching to provide a keyed tone source for code practice at any operating position; and to check the adjustment of the Boehme Hi-Speed keying head.

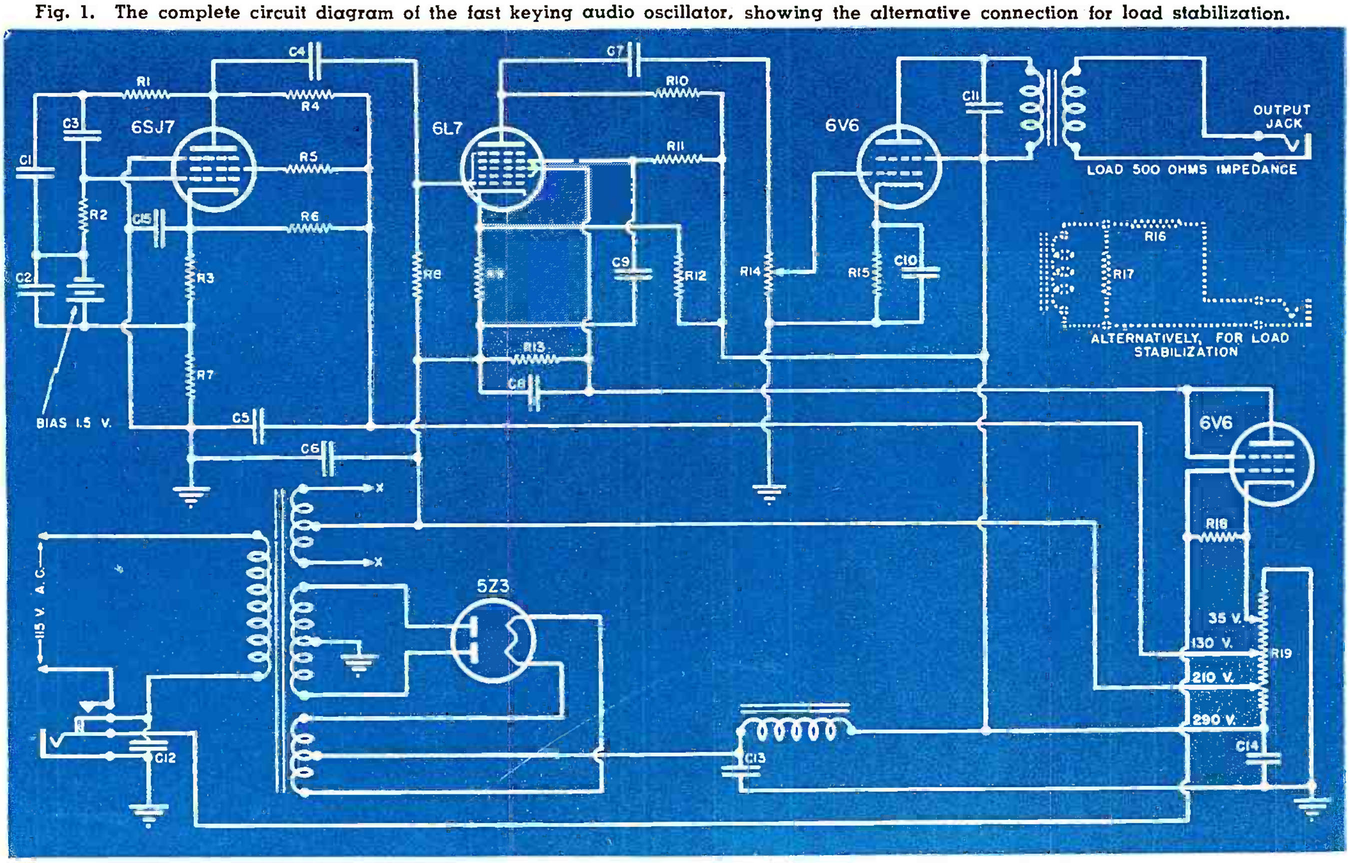
For this tri-purpose oscillator the following considerations were important: For line checking the output must be stable as to amplitude and frequency and of reasonably pure waveform; for code practice the keying must be free of clicks, especially on the break, and the amplitude must be high enough for several pairs of phones whenever necessary; for checking Boehme equipment the keying must possess the same characteristics from slow speed up to several hundred words a minute, and the resistance in the keying circuit should not be so high as to allow stray keying whenever the points are touched by hand or to allow the effect of shunting condensers to become too strong; moreover, it should not be so low as to make the keying unstable through series resistances or inductances, line loss and/or contact resistance.

A negative resistance circuit seemed to answer the oscillator considerations and no trouble was experienced there. A frequency of 1000 cycles was decided on for several reasons. It is about right for code practice, and is a very easy frequency for computation. It was eventually decided to make the oscillator output as near to pure sine-wave as possible, in spite of the slight unpleasantness to the ear over long periods of time. An amazingly pure waveform was obtained.

It was found that none of the common keying circuits used in radio transmission gave satisfactory results in audio over a wide range of speed. From the start, it was seen that it would be a great advantage to have the resistance in the keyer circuit ex-

(*Continued on page* 70)

Fig. 1. The complete circuit diagram of the fast keying audio oscillator, showing the alternative connection for load stabilization.

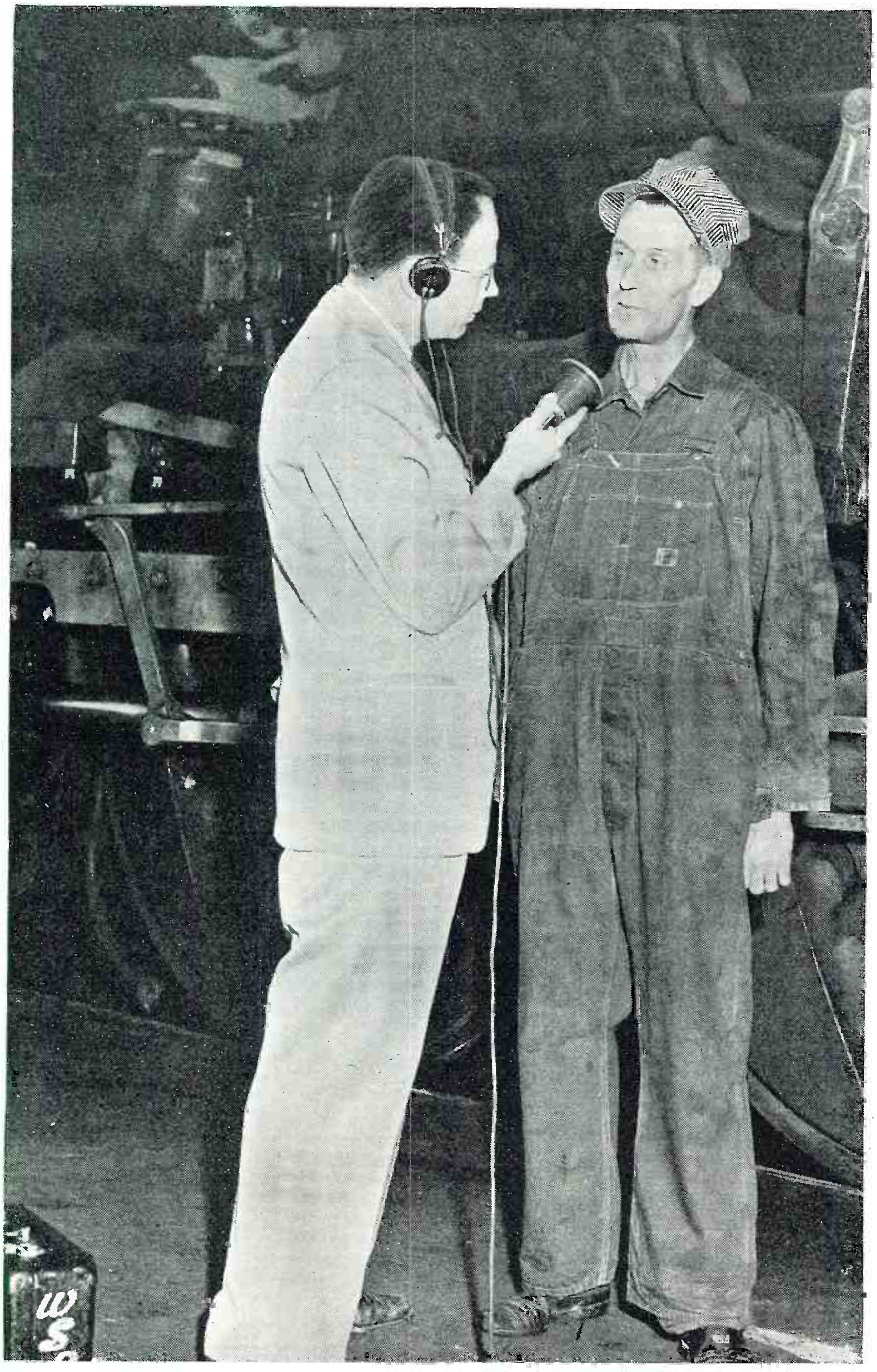


C_1, C_3—.0006 µfd. mica cond.
C_2, C_5—.1 µfd. @ 400 v. tub. cond.
C_4—.006 µfd. @ 400 v. tub. cond.
C_6—16 µfd. @ 350 v. elec. cond.
C_7—.003 µfd. @ 400 v. tub. cond.
C_8—.00004 µfd. mica cond.
C_9—.001 µfd. @ 400 v. tub. cond.
C_{10}—8 µfd. @ 25 v. cond.
C_{11}—.02 µfd. @ 400 v. tub. cond.
C_{12}—.05 µfd. @ 400 v. tub. cond.
C_{13}—1 µfd. @ 400 v. tub. cond.
C_{14}—30 µfd. @ 400 v. elec. cond.
R_1—150,000 ohm ½ w. res.
R_2, R_{13}—.5 megohm ½ w. res.
R_3—400 ohm 1 w. res.
R_4—125,000 ohm ½ w. res.
R_5—25,000 ohm ½ w. res.
R_6—75,000 ohm ½ w. res.
R_7—600 ohm 1 w. res.
R_8—100,000 ohm ½ w. res.
R_9, R_{16}—500 ohm 2 w. res.
R_{10}—250,000 ohm ½ w. res.
R_{11}—350,000 ohm ½ w. res.
R_{12}—40,000 ohm ½ w. res.
R_{14}—250,000 ohm pot.
R_{15}—300 ohm 5 watt w.w. res.
R_{17}—1000 ohm 5 watt w.w. res.
R_{18}—10.000 ohm ½ w. res.
R_{19}—10,000 ohm 50 watt bleeder res.
2—6V6 tube
1—5Z3 tube
1—6L7 tube
1—6SJ7 tube

UNIQUE RADIO BROADCAST

by FRANK E. BUTLER

Wartime meeting of Norfolk and Western Railway employees held by radio through the combined efforts of nineteen broadcasting stations.



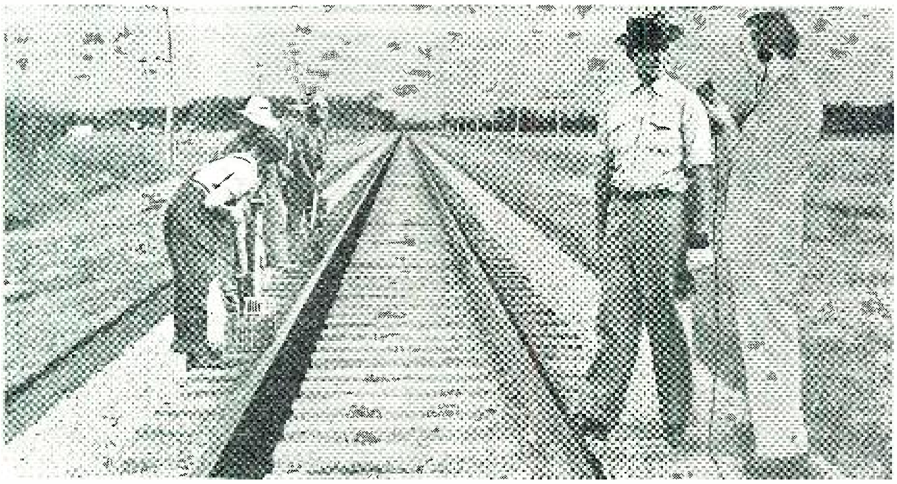
Machinist being interviewed beside a locomotive upon which he was working.

ANOTHER instance of how radio broadcasting is contributing to wartime economy was demonstrated recently when twenty-three thousand employees of The Norfolk and Western Railway "got together" through the hooking-up of nineteen broadcasting stations located in six southern states.

This occasion was the second in a series of wartime railroad meetings which were designed to supplant their regular annual system-wide "Better Service Conferences" that have been discontinued for the duration of the war to enable these railroad employees to remain on their job, thus saving thousands of manhours of labor and likewise conserving valuable space on trains for servicemen and persons compelled to use railroad traffic for essential war activities.

The broadcast program consisted of an "on-the-job" series of unrehearsed, spontaneous interviews by staff announcers working without prepared script and governed only by a skeleton outline of time which detailed the various features of the program. These interviews were conducted by Tom Slater, Director of Special Events for Mutual Broadcasting System and by Edward D. Skotch of the operating personnel at radio station WSLS, Roanoke, Virginia.

In order to have these interviews with typical N. & W. employees, replete with realism, it was planned that a background of actual on-the-spot sound effects should be provided. This meant pre-recording of the sounds of fast rumbling freight trains, the bumping of switching cars, speeding passenger trains, screeching whistles, clanging bells and clamping on of hissing air brakes. All went well with the work of recording until the sound technicians stationed themselves away from the noisy roundhouse and located their microphone and turntables alongside the railroad track out in the presumed quietude of the country. Here, they had hoped to record only the flyer as it high-balled over the rails and smooth roadbed in front of them, accompanied



Obtaining first-hand story from section foreman on condition of the road-bed and how it is constantly maintained for efficient military operation.

WSLS	Roanoke, Virginia
WDBJ	Roanoke, Virginia
WGH	Norfolk, Virginia
WLVA	Lynchburg, Virginia
WSVA	Harrisonburg, Virginia
WMVA	Martinsville, Virginia
WOPI	Bristol, Virginia
WRVA	Durham, N. C.
WSJS	Winston-Salem, N. C.
WJEJ	Hagerstown, Maryland
WHIS	Bluefield, W. Va.
WBTH	Williamson, W. Va.
WBRW	Welch, W. Va.
WPAY	Portsmouth, Ohio
WHKC	Columbus, Ohio
WCPO	Cincinnati, Ohio
WJHL	Johnson City, Tenn.

Stations that were included in the network.

by the characteristic blast of "two long . . . and two short" crossing blasts of a Norfolk & Western locomotive whistle. However, they found difficulty, not in recording the exact railroad sounds in their proper perspective and proportion of decibel strength, but they experienced an unexpected over-all outside interference created by the birds and beasts because they refused to desist from their normal songs and sounds. The feathered friends assembled en masse in nearby trees, seemingly resentful toward the two-legged invaders who had usurped their age-old sanctuary with their strange electrical equipment. Crows in a cornfield near the tracks caw-cawed in no uncertain tones their raucous voices which "filtering" could not eliminate. A grazing calf . . . curious . . . left off eating grass, meandered close enough to the mike to sniff and apply the taste test which all but wrecked the delicate instrument. Pig squeals from a distant farmyard added to the conglomerating "static voices" which the disc recorded for posterity; but in reality, it all sounded very faithfully like the side of a typical railroad track in springtime.

This was the setting for the first interview which originated on a section of the railroad's track between Portsmouth and Cincinnati, Ohio. Against the background of trackmen chanting, driving spikes and shoveling ballast, Section-Foreman Ernal McCann explained to the listening audience how N. & W. tracks and roadbeds are kept at a high standard of excellence and the importance of track maintenance, especially in wartime. The railway radio drama was next switched to Chicago for an interview with Freight-Traffic Manager Frank H. Pittman and General Freight Agent E. M. Dudley who explained the intricacies of freight rates and freight handling. It was pointed out that while the cost of practically every commodity in the country has been increased during the past year, the cost of rail transportation has veritably decreased. The radio audience then listened to the actual conversation as these freight executives discussed traffic and rate problems with the traffic manager of a war production plant located in the Middle West, demonstrating how this department helps shippers to comply with government regulations and embargoes; how they assist in routing wartime freight in order to avoid congested areas; how war production is expedited by the swift loading and unloading of cars.

C. W. Parrish of the Transportation Department, one of the railroad's strategists who are on the job day and night regulating the movement of troop trains, gave the radio listeners a graphic picture of the control center which directs the railway's troop transportation through a staff that handles several special trains daily and upwards of 40 special movements of troops in a 24 hour period.

The importance of well-serviced locomotives and the increased speed in servicing them was described by employees working in the N. & W. Shaffer's Crossing engine terminal at Roanoke. By recent expansion and improvements, the servicing capacity of this one terminal has been increased from 80 to 135 engines a day.

The next interview was with the manager of mail, passenger and express traffic, also at Roanoke, who explained the control center which directs the movement of troop trains and the special movement of smaller groups of the armed forces.

President W. J. Jenks concluded the

(*Continued on page* 92)

Railway employees who had important parts in the broadcast. On-the-job broadcast was held in place of annual employee's meeting.

WHAT'S NEW IN RADIO

SOLDERLESS SPLICING TERMINAL

Aircraft-Marine Products, Inc., announces a new solderless splicing terminal with insulation support which affords a quick positive splice for connecting wires until intentional quick disconnection is desired. Precision installation tools make all three crimps in one operation.

Only two identical parts are required to make a connection, thereby eliminating the necessity of stocking and identifying more than one part. The tensile strength of the splice is greater than that of the wire itself, yet the assembly is easily and quickly uncoupled when desired. A unique four-point "knife-switch" wiping action assures minimum contact drop through the coupling, and gives a perfect electrical connection even under adverse conditions. The contour of the assembly is such that insulation sleeving slips on easily and is then held firmly in place.

Bulletin 27 covers the details of the AMP splicing terminal. A copy will be sent upon request to *Aircraft-Marine Products Inc.,* Dept. R, 1521-31 North Fourth Street, Harrisburg, Pa.

LOCK-TYPE PROTRACTOR

Xactor, the new pocket-size, lock-type protractor is a timely, valuable contribution to the field of expert engineering, tool grinding, machine work and inspection. It is designed for accurately measuring angles of drill points, tool bits, machine ways, depths of deep holes; for sketching and laying out tools and machine parts, dies and jigs; and inspection of manufactured parts.

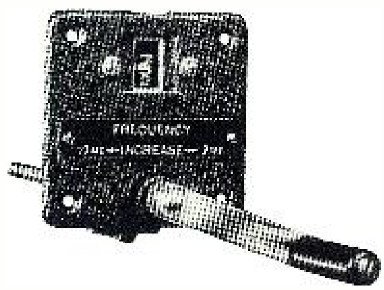
Made of the finest materials and vernier equipped, Xactor's adjustable lock-type sliding scale pivots the full 360 degrees, assuring measurement of any angle instantly to an accuracy of ½ of 1 degree. Deeply etched graduations afford easy readability, even in poorly lighted shops.

Aside from its fine accuracy, this new protractor has the added advantage of a quick acting and compact locking feature on the vernier turret which rigidly secures any specific measurement or angle by locking both the vernier turret and the sliding scale. This enables accurate mass gauging necessary when many items of the same size or angle must be checked.

For prices and descriptive literature, write manufacturer: *Industrial Engineering Co., Inc.,* 141 West Jackson Blvd., Chicago 4, Illinois.

CYCLOMETER

Designed for registering rotary coil turns, the B. & W. Cyclometer type counter unit proves to have many additional uses and is now being produced as a separate item. It is adaptable to practically any application where a shaft must be turned a pre-determined number of times, or set at any pre-determined position. The exact number of turns, down to tenths of a turn, are recorded on the counter.



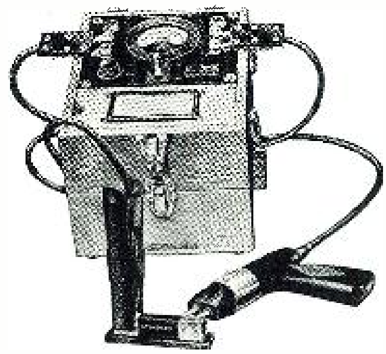
Standard counters record 10 turns. Others, also available, record up to 100-1000 turns.

Used with rotary coils, the counters provide a quick, easy means of setting the contacts at any desired inductance value. Other uses range all the way from recording vertical and horizontal stabilizer adjustments on airplanes to practically any job where a shaft must be rotated more than 360°, and the exact rotation recorded.

B. & W. Cyclometer counter assemblies have direct shaft drive (1:1 drive shaft to driven unit). Shafts can be any length. A veeder-root counter is used. The gear drive is direct, with precision cut steel gears. Units are light in weight (8 oz.), extremely sturdy, and pass war-time specifications. They are available with either right or left hand rotation, and can be supplied with name plates to suit the application. For further details write *Barker & Williamson,* Radio Manufacturing Engineers, 235 Fairfield Ave., Upper Darby, Pa.

LOW-RESISTANCE TEST SETS

Two new *Shallcross* Low-Resistance Test Sets, Type 645 (Army range) and Type 653 (Navy range) include all popular features of previous models with the added convenience of complete portability and greater freedom, ease, and speed of operation.



The test unit containing the meter, batteries, switches, control, etc. is supported comfortably and conveniently in front of the operator by means of adjustable shoulder straps. Bond or contact resistance measurements as low as .0001 ohms can then be made, simply by attaching the fixed clamp to one side of the bonded surface, then touching the hardened points of the pistol grip exploring probe to the other side.

Both hands are free at all times to adjust and operate the instrument. The weight of the pistol grip exploring probe is reduced to a minimum by incorporating the meters, batteries, etc. in the cabinet suspended from the operator's shoulders.

In addition to their widespread use in testing aircraft bonding these *Shallcross* Sets are unexcelled for testing railroad bonds, radio equipment, contact resistance of relays, circuit breakers, switches, and various others. They make bar-to-bar resistance measurements on commutators as simple as making a voltmeter reading.

Type 645 (Army range) is 0.005 and 0.5 ohms full scale. Type 653 (Navy range) is 0.003 and 0.3 ohms full scale.

A copy of the *Shallcross* Low-Resistance Test Set catalog describing these and other popular models will gladly be sent upon request to *Shallcross Mfg. Company,* Collingdale, Pa.

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ESMWT TRAINING COURSES

By M. S. KAY

A U.S. Government-sponsored educational program for civilians interested in obtaining a knowledge of radio theory and application.

SOME of the most notable changes brought by the war are in the mechanical fields. New machines have had to be built and manned. Quick, accurate and thorough education is needed for a complete understanding of these machines. Therefore, the government has sponsored a nation-wide program for education in specific subjects—an education that can be imparted to the greatest number of people in the shortest possible time.

The facilities for this gigantic program were, fortunately, already well established. Our great colleges and universities and even our technical high schools were already prepared with both the equipment and the instructors. And it was to them that the government appealed. The answer was a vociferous yes!

The program first went into effect in November of 1940 and was known as the Engineering Defense Training program. It dealt specifically with engineering subjects, ignoring the allied fields of management and supervision. The courses were, for the most part, for those people who already had an engineering background and who were employed in the engineering field. It soon became apparent, however, that more elementary courses in science were needed, especially for new people entering the mechanical industries with no previous experience or scientific education. Management and supervision were also brought under the new program which by now was called the Engineering, Science and Management Defense Training program or ESMDT for short. With the advent of war, the name became ESMWT, the only difference being the change from the word defense to war. And thus has it remained to date.

The entire program is administered by the United States Office of Education and the portion of most interest to us, the radio portion, is under the supervision of Professor F. W. Marquis who is known as the Principal Specialist in Engineering Education. It is his duty to review the contents of each course and to see that it meets the necessary requirements as dictated by the changing needs of our armed forces and the war industries. By setting up a unified system, any necessary changes can be quickly and easily brought about with a minimum of waste and duplication.

The courses offered usually run for a period of sixteen weeks and in general are of a college level. High school graduation or equivalent education is a minimum essential for any ESMWT course, while some courses may require several years of experience or of college training, or even a graduate degree. Any person who is employable in a defense activity, immediately available for employment on completion of his training, and capable of performing academic work of college grade meets the general requirements for admission. There are no age or citizenship requirements except as they may be imposed for particular courses due to employment restrictions in certain industries.

ESMWT funds, provided by laws passed by Congress, are intended to meet all expenses of the institution ordinarily covered by tuition fees, student health fees, and laboratory charges. Hence, no such fees or charges are to be required of ESMWT trainees. These funds may also be used to provide trainees with miscellaneous supplies, materials, and reference books such as are usually furnished by the institution to its regular students in similar courses. Trainees, however, are expected to provide their own subsistence, textbooks, transportation, and such incidental materials and supplies as notebooks, paper, pencils, and erasers. Students may also be required to make such deposits as the institution normally requires of its regular students to assure proper use and return of institutional property. These deposits are to be refunded on return of this property in good condition.

Let us look at the radio courses offered, study their requirements and, in general, see what the trend is. In this way everyone can get some sort of idea as to where he or she could best begin and where this will lead. The object of these free courses must always be kept in mind—to train men and women for jobs in the radio field and for those who are already in—to aid them in securing jobs requiring a higher skill.

The two starting courses should not both be taken, only one being necessary for all newcomers to the radio field. The division is made on the basis of previous knowledge of electricity

Students in laboratory, learning the functional operation of a vacuum tube.

and electrical circuits. All persons having no knowledge of electricity will take the course titled "Fundamentals of Radio" whereas those having some knowledge of Ohm's law and its applications can gain more by taking the course "Introduction to Radio." Both cover essentially the same material and either one is a prerequisite for the next course. The general background of High School graduation still holds and is the minimum requirement for all the courses.

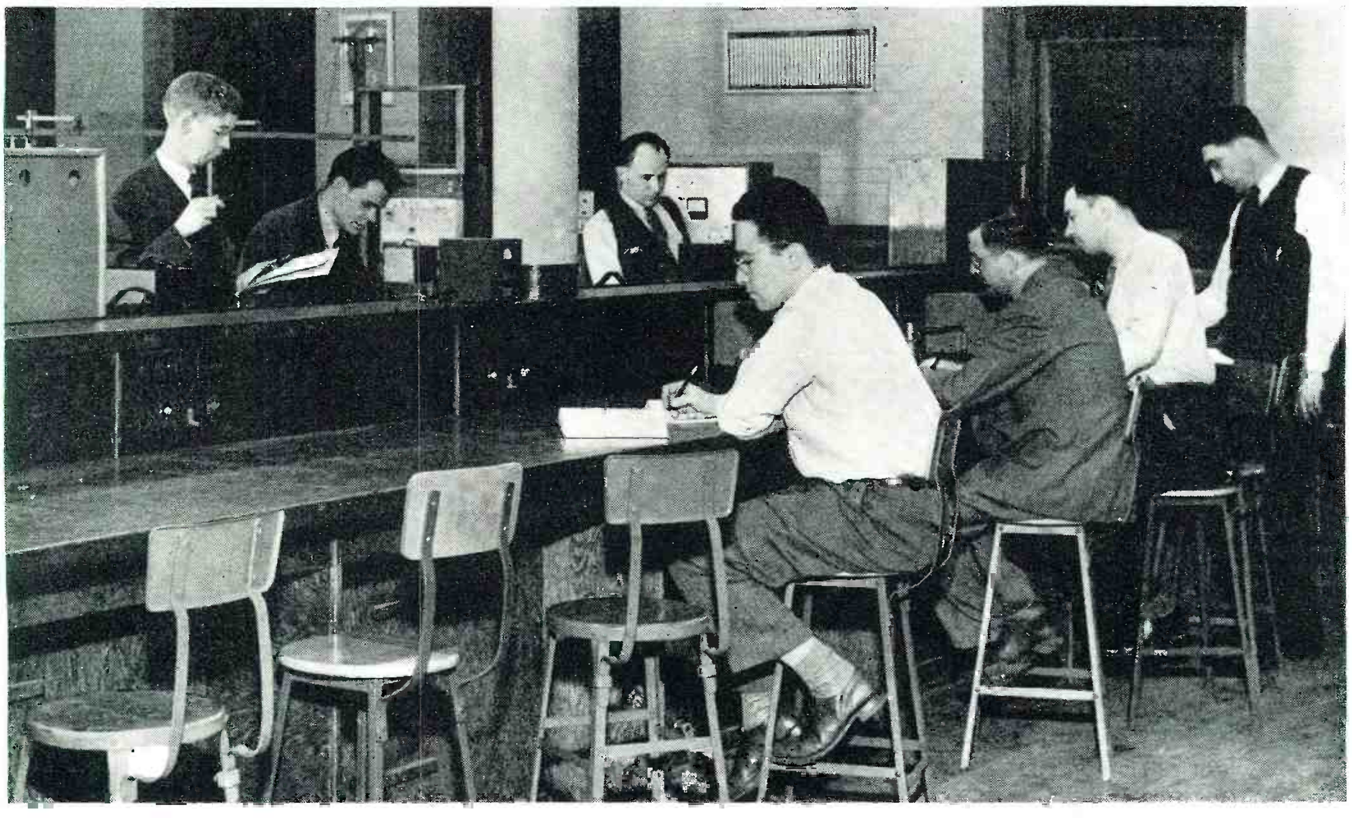
However, many people may make up for a lack of this educational requirement by showing other achievements in the business world. In any event, if you do not have a High School diploma, do not give up the idea of taking any of these courses. On the contrary, visit the school nearest you which gives these courses and discuss your problem with the proper authorities. They will be glad to advise all men and women on what they may or may not take. This article does not attempt to lay down rigid rules, but merely to point out what the general requirements are. There are many exceptions that may be acceptable.

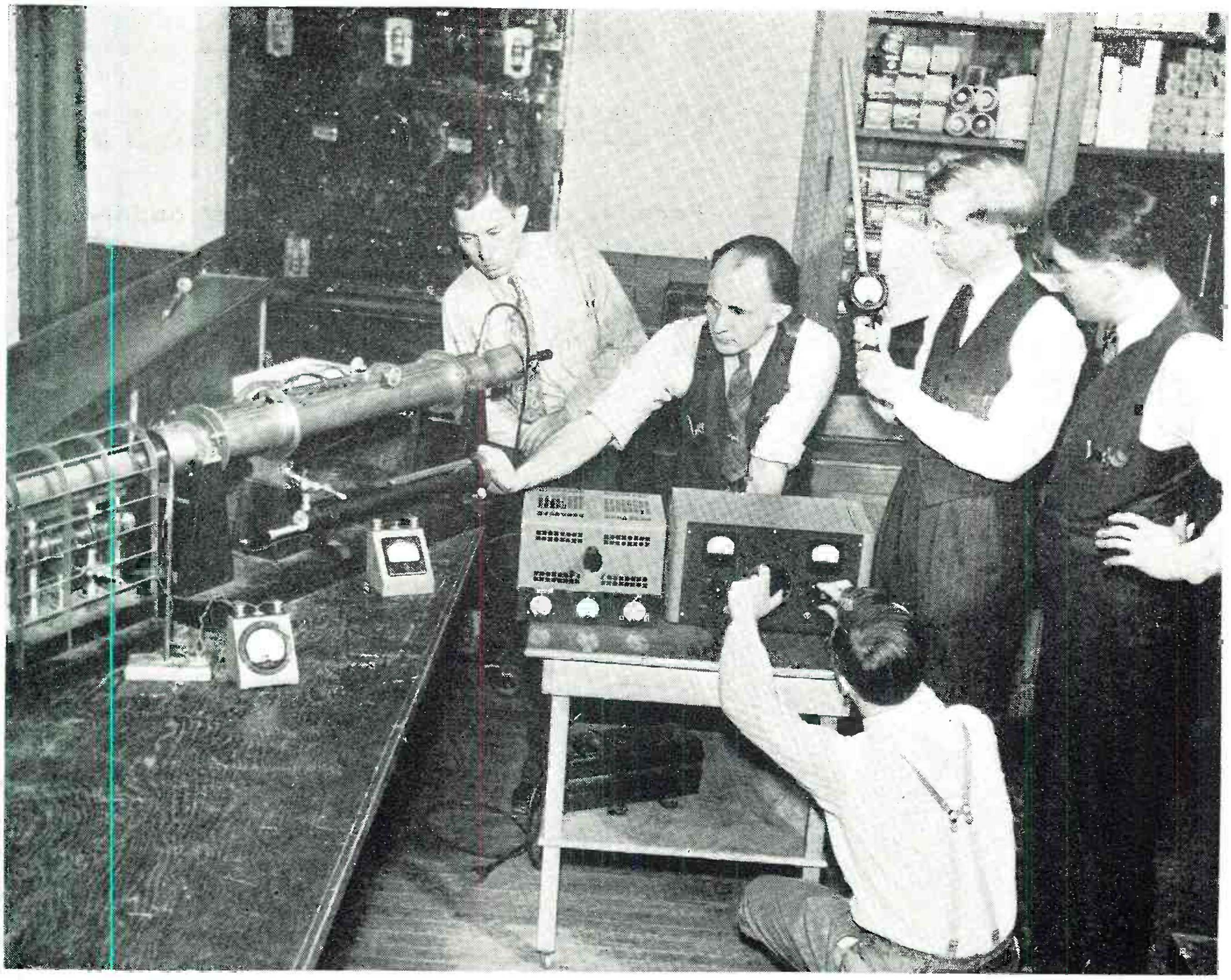
Returning to the two courses mentioned, namely "Fundamentals of Radio" and "Introduction to Radio," the material outline calls for a series of lectures and laboratory work, both being closely connected. The usual procedure will call for one or two lecture periods followed by one laboratory period, where the laws and facts of the lectures are put to actual test so that the student will learn how the apparatus should be handled. Some schools have the same instructor for both lecture and laboratory periods, whereas other schools break up the routine between two instructors, one for each session. In any event, the personnel used must be competent and of the type ordinarily employed for similar courses given by the institution. What many colleges have done is to dig into industry and ask men in charge to conduct these classes so as to be sure that actual industrial practices are brought into the classroom. The commercial plants, realizing the aid given to them by these courses, have contributed generously of their personnel and, if war obligations allow, equipment. The student, thus taught, can step into an industrial position immediately upon the conclusion of the course without very much additional company training.

There is one thing about these courses that has troubled many of the students in the various classes taught. This is the matter of mathematics, a word that leaves most men and women with a mental numbness akin to fear. From personal observations, it was noticed that the reason most people find mathematics difficult is based on two facts—firstly, because it had been presented to them, at one time or another, in a dull, uninteresting manner, and secondly, the students have the erroneous idea to begin with, that the subject is difficult and that only a chosen few can master its mysteries. It is only through long, patient lectures that these people can be persuaded to attack the subject again. Mathematics is needed in all sciences, and especially in the more advanced radio courses where calculus is used quite extensively. But all the mathematics needed should be tied in with the particular phase of radio being taught, and not presented as a separate, distinct subject. This is done in many of the elementary ESMWT radio courses where the mathematics used is very simple and easily mastered by most people of ordinary intelligence. As one gets further and further into the advanced phases, however, the mathematics needed, becomes quite complicated so that time must be taken out for a mathematics course or two. It should be emphasized, however, that this is applicable to the advanced radio courses only and need not worry those taking the elementary courses. Most schools offering the radio courses also have concurrent mathematics courses to aid those who need this extra help. In any event, do not develop a needless fear of mathematics. It is based on logical principles.

The course that follows the introductory radio courses is entitled "Elements of Radio." This is a basic course on the elements of modern radio practice and includes audio and radio frequency amplifiers, radio frequency coupled circuits, vacuum tube detection, amplitude and frequency modulation, and elementary transmitter and receiver theory. It will probably be necessary to devote eight hours a week to cover all this work, the eight hours being split up between two evenings. The pattern of lecture and laboratory follow closely the outline suggested for the previous two courses.

Students in laboratory completing experiments by applying their basic knowledge of radio principles.





Investigating electromagnetic wave patterns in cylindrical wave guides at 3000 megacycles, using a Klystron oscillator.

While an instructor is present in the laboratory to supervise each student's work, the instructor does not devote as much attention to the student's effort as was necessary in the elementary course. The student is taught to rely on his own knowledge and resourcefulness and to seek out the supervisor only in cases where he believes himself incapable of continuing. Self-reliance is stressed throughout these courses where the students are mostly of a mature age and can understand this method and appreciate its significance. From personal observation, the author has found that in 99 per cent of the cases it works out extremely well, and, while the people taking the courses may complain in the beginning, it works out to their advantage in the end.

Continuing, we find that "Radio Inspection and Measurements" follows next. This course is designed to acquaint workers in the radio and allied industries with a better knowledge of circuits and testing equipment used in routine tests. The course would probably contain topics and experiments on electric circuit schematic diagrams, test circuits used in routine mass inspection of radio parts, standard measurements at audio and radio frequencies, bridge measurements, vacuum tube voltmeters, Q meters, cathode-ray oscilloscopes and finally radio-frequency measurements on resistors, inductances and capacitances. There are many more subjects that could probably be covered, the few mentioned being the more important. Persons completing this course would be eligible for positions in the testing, trouble-shooting and engineering laboratory divisions of most radio companies. After the war this knowledge could easily carry over to the radio servicing industry where trained trouble shooters are always in demand, the more experienced commanding excellent salaries. It is needless to state that laboratory work is stressed, the emphasis being on individual work by each student, facilities permitting.

We have now ended the elementary phase of radio instruction, the emphasis now being on engineering. With this advancement comes the added requirement of calculus, which is a must as far as the engineer is concerned. Many schools allow the student the privilege of taking these advanced courses, if at the same time, enrollment in a calculus class can be shown. Remember, this is a privilege, however, and may be withdrawn at any time by the school authorities. It is best for the people contemplating taking these advanced courses to consult the school authorities and find out what the requirements are in each case.

The first of these advanced courses deals with high vacuum tubes, filament emission, space charge effects, diodes, triodes, pentodes, beam power tubes and gas filled tubes. It then delves into the theory of the arc and glow discharge rectifiers, thyratrons, ignitrons and other special purpose tubes both of the gas and vacuum variety. The circuit portion of the course deals with impedance networks, Thevenin's theorem, the superposition theorem and problems in maximum power transfer. It is to be noticed that while the above subjects are not entirely confined to the radio field, they are all essential to a thorough understanding of radio and its engineering problems. Now that the elementary courses are over, it will be found that radio principles extend into many allied fields and an understanding of all these is necessary if full advantage is to be taken

(*Continued on page* 72)

Manufacturers' Literature

Our readers are asked to write directly to the manufacturer for this literature. By mentioning RADIO NEWS and the issue and page, we are sure the reader will get fine service. Enclose the proper sum requested when it is indicated. This will prevent delay.

ELECTRONIC SEARCHRAY

Two Searchray bulletins have been recently released, introducing the Searchray 80, a new rayproof, shockproof, self-contained X-ray unit. The new Electronic Searchray is a simple, compact X-ray unit; for safe, rapid inspection of small parts, assemblies, moulds, and castings of light alloys, ceramics, plastics, rubber and similar products in the factory and laboratory. It can be operated efficiently by unskilled personnel. No elaborate or expensive tubes are required either for its operation or installation. All that is necessary is to place it in position in the production line or in the laboratory. It operates directly from a 110-volt a-c power supply.

Copies of these bulletins may be had by addressing requests to A. E. Snyder, Manager of the Industrial Electronics Equipment Division of the *North American Phillips Company,* 419 Fourth Avenue, New York, New York.

CIRCUIT TESTER

The *Communications Measurements Laboratory* has recently issued a new folder covering the Rotobridge Automatic High Speed Mass Production Circuit tester. The bulletin offers interesting facts to makers of all tubes and electronic equipment and describes how the instrument detects trouble and errors automatically and rapidly.

The Rotobridge tests a circuit a second and checks circuit response values as low as .001 ohms. It can easily be operated by inexperienced workers and requires but one setup. It will maintain specified tolerance and so releases skilled labor for other work.

Copies of the Rotobridge folder may be obtained directly from the *Communication Measurements Laboratory,* 116-118 Greenwich Street, New York, New York.

TIMING MOTORS AND DEVICES

The *Haydon Manufacturing Company* has released a new catalog. This catalog constitutes twenty-four pages of illustrations, with descriptions of many of the more recent developments in the field of Timing Engineering.

New applications of timers, brought on by war-time demand, include ra-

(*Continued on page* 90)

CANADIAN WALKIE-TALKIE

Portable communications equipment and its effect in a fast moving military offensive

CANADIAN military headquarters for the first time took some of the wraps off a closely-guarded, hitherto secret war weapon, designed in Ottawa, and built in a Toronto plant.

Officially it is wireless set (Canadian), No. 58, Mark 1.

Slangwise, it is a walkie-talkie.

To radio men it is a midget miracle, a tiny but tough combined broadcasting and receiving set, easier to operate than a hand telephone set, light but tough enough for paratroopers to take along in aerial assaults on enemy airfields, versatile enough so in combination, they become a military network of broadcasting and receiving stations for attacking troops.

To infantrymen the walkie-talkie is like giving a football team a quarterback. Before the walkie-talkie, battalions in today's swiftmoving warfare, often would be like a football team without a signals-calling quarterback because of inadequate or broken-down communication lines.

Today with the walkie-talkie, battalion headquarters can direct units over wide stretches of battlefront the way a quarterback sends his team plunging into action, and in addition the headquarters will know all the time what is developing in each area of operations.

"Think we have the right hook-up, Joe? All I hear is a lady saying: 'Deposit a nickel, please'."

Most of the fruitless throwing away of soldiers in battle throughout history has been due to faulty transmission of commands, or battle headquarters' ignorance of what was transpiring in front-line areas.

A dramatic example was the Charge of the Light Brigade. Stunned commanders saw the charge begin but were powerless to stop the men. Today a walkie-talkie message could stop them before they travelled 75 yards.

Staff workers at the National Research Council in Ottawa conquered a difficult task in meeting the Canadian army requirements for a new kind of portable radio.

The new machine, the army insisted, must be lighter, tougher, smaller and more compact than the cumbersome sets they were to replace.

One requirement that was met enables the machines to become impromptu military radio broadcasting and receiving networks right in the battle lines. A dozen or more walkie-talkies scattered among attacking units over a wide front can talk back and forth freely, with the headquarters set sending out instructions to all the units at once.

Battle noises would have to be screened out, the army insisted. This was solved by having two grille openings in the microphone. Noises coming into both grilles, such as battle noises, cancel each other out. But when a speaker uses only one grille opening his words are broadcast distinctly.

Telescopic Aerial

The story of the aerial equipment for the walkie-talkie illustrates how the machine is designed for complex and varying requirements, yet its size is not sacrificed.

One telescopic aerial, to be used under certain conditions, can be collapsed into a small cylinder.

Another aerial, a rod type, is in 16 sections of four different sizes, and by using different combinations, many different

(*Continued on page* 90)

PRACTICAL RADIO COURSE

by ALFRED A. GHIRARDI

Part 20. Basic theory, including the advantages, and disadvantages of positive and negative feedback as applied to amplifier circuits.

THE behavior of an amplifier circuit may be radically affected by feeding back a small proportion of its *output* signal energy and coupling or injecting it into the *input* grid circuit of the same (or a preceding) tube, as shown in Fig. 1. Usually, the energy fed back is in the form of a *voltage* that is proportional to the amplified output signal current or voltage (or a combination of the two). Many circuit arrangements have been developed for accomplishing this, as we shall see later, but in order to maintain the high input impedance of the tube it is necessary that the voltage fed back into the grid circuit be inserted in *series*, and not in parallel,

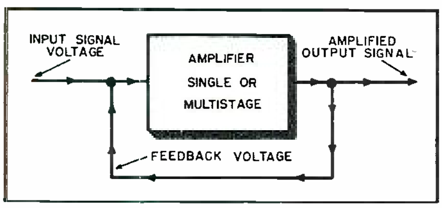


Fig. 1. Fundamental feedback circuit.

with the original signal voltage. Furthermore, it must bear the *proper phase relationship* to the input signal voltage, and be of *proper* magnitude.

Defining Feedback Terms

The *magnitude* and the *phase relationship* which the fed-back signal voltage bears to the input signal voltage determines the type of feedback and the resulting effect obtained. If the feedback voltage is applied *in phase* to the input signal (see Fig. 2), it is called *positive* or *direct feedback*. This results in regeneration, and we then have a *regenerative* amplifier (or an oscillator). If the feedback signal voltage is applied to the input circuit in *opposite* phase to the input signal (see Fig. 3), it is called *inverse* or *negative* feedback. This results in *degeneration*. In either case, the closed loop path *A-B-C-D-A*, from the point where the feedback signal voltage is taken off around to the point where it is applied and then through the amplifier to the take-off point is known as the *feedback loop*.

Positive (regenerative) feedback in an amplifier sometimes occurs unintentionally, and so uncontrollably; for example, through the presence of impedances common to certain circuits in two or more stages. Usually, uncontrolled regenerative feedback is avoided, as a precautionary measure, because it is liable to result in amplifier instability and objectionable oscillation. Recent developments in amplifier design, on the other hand, have led to the deliberate introduction of a certain amount of controlled inverse feedback to improve the over-all operating characteristics of the amplifier, even though it causes a reduction in the gain.

In the present lesson we are interested only in the operation and effects of the *inverse* feedback action. Positive feedback will be discussed more fully in the later lessons devoted to oscillation and to oscillators.

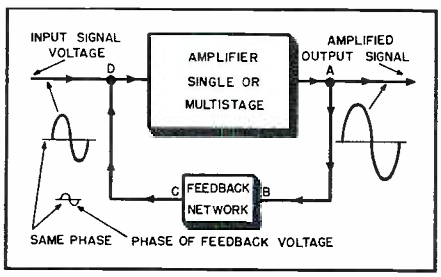


Fig. 2. Positive feedback (regenerative amplifier or oscillator).

During the past few years much has been written about inverse feedback applied to audio amplifiers, and the beneficial effects to be obtained from its use. Unfortunately, these articles have treated the subject strictly from a mathematical viewpoint which fails to present to the novice a clear physical picture of the actions which take place. In this and the following article the theory of inverse feedback action together with a simple but adequate mathematical treatment will be presented as clearly as possible so that its effects on the performance of the amplifier, its limitations, and its applications to amplifier circuits may readily be understood. Inverse feedback is really quite simple to understand, even if it is somewhat difficult to make it operate properly under certain circumstances. In the preliminary discussions, perfect inverse feedback conditions (feedback voltage always exactly 180° out of phase with applied signal voltage, and feedback network free from frequency discrimination, etc.) will be assumed. Later, the practical effects of variation from these ideal operating conditions will be discussed.

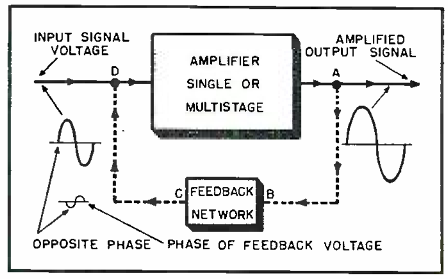
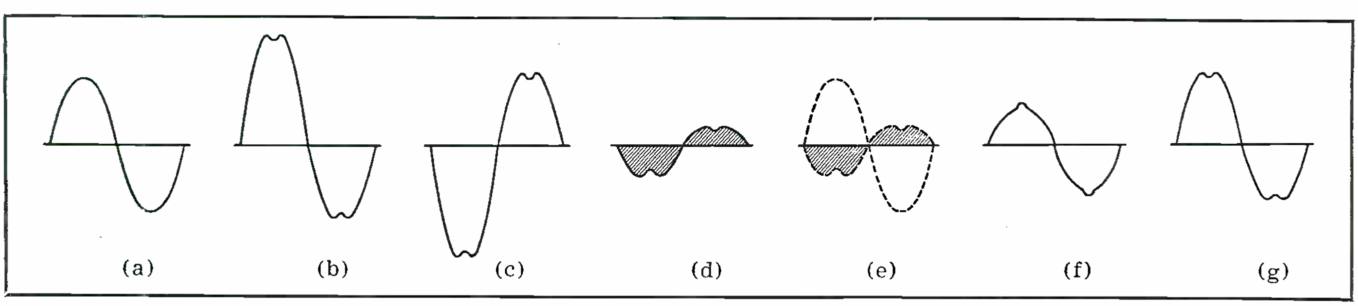


Fig. 3. Inverse feedback (degeneration).

How Inverse Feedback Reduces Harmonic (Amplitude) Distortion

Harmonic and cross-talk distortion can be considered as being generated in the amplifier and, as already explained previously, is produced to the greatest extent in the *output* stage of an amplifier connected to a loudspeaker. Accordingly, let us consider first

Fig. 4. Waveforms of instantaneous voltages and currents in amplifier with inverse feedback. (a) Applied signal voltage. (b) Distorted plate current. (c) Net distorted plate voltage. (d) Feedback voltage. (e) Feedback voltage combined with applied signal voltage. (f) Resultant signal voltage impressed upon grid. (g) Resulting plate current; less gain and lower distortion than in (b).



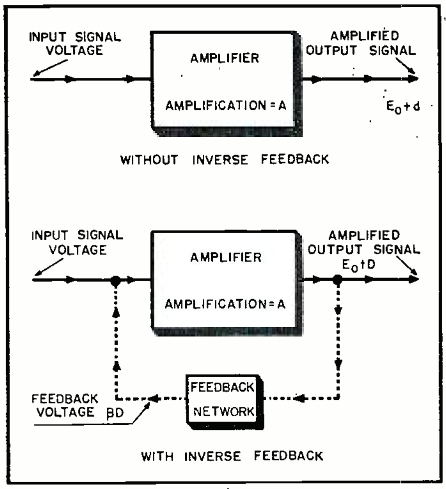


Fig. 5. Illustrat'ng how inverse feedback reduces amplitude distortion.

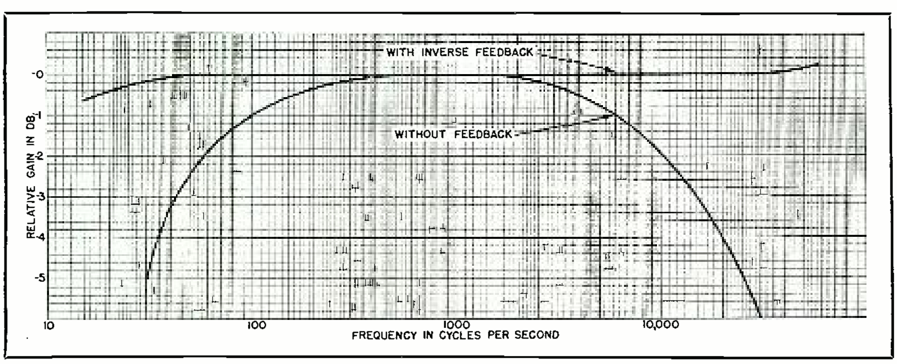
an output stage (preferably a power pentode) feeding into a loudspeaker without the use of inverse feedback. Assume also that a pure sinusoidal signal voltage, illustrated at (a) in Fig. 4, is applied to its input grid circuit. It has been shown previously in this series of articles that harmonic distortion is likely to occur in such an amplifier circuit, and the corresponding plate-current variations could conceivably be distorted to the exaggerated waveform illustrated at (b). The dips in this waveform indicate the presence of third harmonic distortion, and the fact that the negative half cycles are smaller than the positive half cycles (ratio 2:3) indicates *second* harmonic distortion. The plate-voltage waveform, shown at (c), is inverted compared to the plate-current waveform because a plate-current *increase* produces an *increase* in the voltage drop across the plate load. Since the net voltage appearing at the plate at each instant is the difference between the drop across the plate load at that instant and the fixed plate-supply voltage, when the plate current *increases* the net plate voltage *decreases,* and vice versa. Hence, the plate voltage variations are 180° out of phase with those of the plate current, as illustrated.

Now suppose that inverse feedback is applied to the amplifier by taking a fraction of the output signal voltage (c) shown at (d), and feeding it back to the input circuit in series with the applied signal voltage, but exactly 180° out of phase with it. Notice that the feedback voltage (d) while being of smaller amplitude, contains all of the waveform irregularities (distortions) of (c). This feedback voltage combines (vectorially) with the applied signal voltage in the input circuit as shown at (e), so that the actual effective input to the grid of the amplifier consists of the applied signal voltage (a) minus the feedback voltage (d), producing the resultant signal voltage of waveform (f). Notice that the distortions in this waveform are the reverse of those which the tube produced in (b): a hump instead of a dip appears at the peak of each wave, and the positive half-waves are weaker than the negative half-waves. Consequently, this tends to counteract the reverse distortion which the tube circuits will cause. This is the basis of all distortion correction by feedback—*the feedback voltage counteracts undesirable effects that take place in the amplifier circuits.*

The plate current waveform (output) resulting from the action of this resultant signal voltage upon the grid is shown at (g). It should be noted that waveforms (f) and (g) are approximations only; an "infinite series" method would be necessary to arrive at the true waveform.

The illustration at (g) merits careful study, for it shows what the inverse feedback has accomplished. First, since the resulting signal voltage (f) acting on the grid is less than the applied signal voltage (a), the amplitude of the resulting output plate current (g) is *less* than that of the distorted plate current (b). The overall gain of the amplifier, and the power output have been decreased by the inverse feedback action! The dips in the peaks of the resulting wave are less pronounced than they would be if no feedback were employed, (b), and therefore the third harmonic distortion has been reduced. Since the positive and negative half cycles are now more nearly equal in magnitude, the second harmonic distortion also has been reduced. It is important to notice that *the distortions have not been completely eliminated* but are reduced by approximately the amount that the over-all gain of the amplifier was reduced by the degeneration. Thus, one advantage is secured at the expense of another. This is important to remember, for it points out one of the limitations of inverse feedback. The quantitative effects of the feedback voltage will be discussed later.

Fig. 6. Output fidelity curves showing the advantage of using inverse feedback in an amplifier, to produce a more linear over-all frequency response.



It should be remembered that for inverse feedback to reduce amplitude distortion, the distortion must be developed somewhere in the amplifier portion of the feedback loop. Distortion occurring in any other part of the amplifier system, either ahead of or after this loop, will not be affected by the feedback and hence *will not be reduced.*

Quantitative Analysis of Harmonic (Amplitude) Distortion Reduction

Harmonic distortion, as we have seen, can be thought of as being generated in the amplifier, usually in the output stage. A mathematical expression for the reduction in harmonic distortion that results from the application of inverse feedback to the stage in which it is generated is easily arrived at. Referring to Fig. 5, let (d) represent the amount of distortion appearing in the output of an amplifier, (in the absence of inverse feedback) whose amplification is A (expressed as voltage multiplication) when the output signal voltage is E_0. Now assume that inverse feedback is introduced, as shown below, and that the applied signal voltage is increased sufficiently to maintain the same output voltage E_0. Then, since a portion of the distorted output is now being fed back to the amplifier input through the feedback circuit, and reamplified in such a way as to cancel out the distortion generated within the amplifier, the new distortion voltage D now actually appearing in the output in the presence of feedback will be *less* than d. Consider that a fraction β of the new distortion voltage D is being applied to the amplifier input by the feedback circuit. If 25 per-cent is being fed back, then $\beta = .25$ and so on. The feedback voltage then is βD, and this is amplified A times by the part of the amplifier

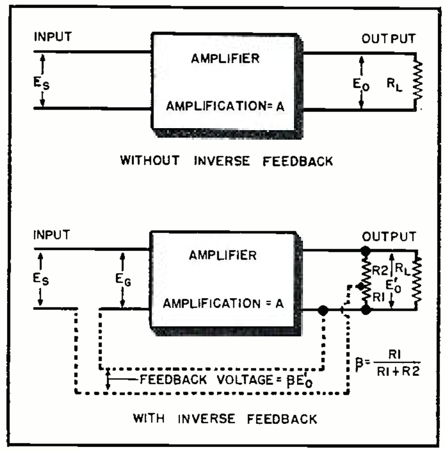


Fig. 7. Circuits used to illustrate the loss of gain due to the inverse feedback.

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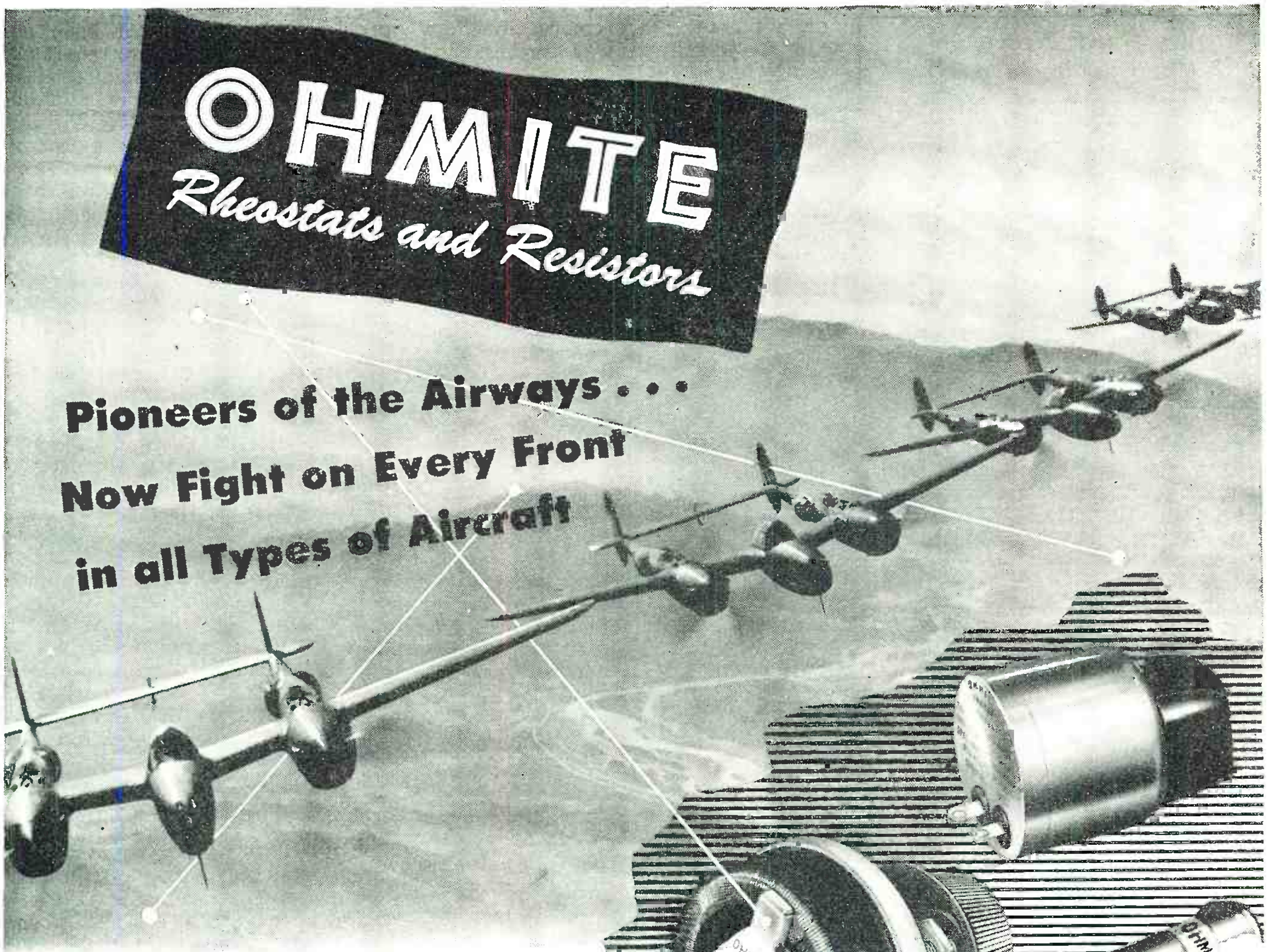

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Spot News

(*Continued from page* 14)

Interesting survey figures were also reported by the Gallup poll conducted by the American Institute of Public Opinion at Princeton University. According to this poll, there are only 500,000 radio homes in need of tubes or parts. This is a rather low figure considering previous estimates. However, coming as it does from one of the most reliable survey services, it appears to have great merit. The poll also showed that 1,100,000 families would buy receivers if they could get them.

Whether or not the Gallup poll covered as great a cross-section of homes and persons as previous surveys or the survey began by Mr. Whiteside, is not known. It is generally believed that a representative answer to the question will be forthcoming when the results of Mr. Whiteside's survey are available.

A P-A SYSTEM plays a major role in the new sensational Air Forces show *Winged Victory,* which recently opened in New York. Sound effects are an important element in this production. But because of the five revolving stages and some 19 scenes, there is no room back stage for the sound-effects men. Accordingly, the sound men have been located in the basement and through the facilities of a p-a system follow cues and provide the correct sound effects.

P-A systems have been around front lines on many war fronts too. When our boys landed on Attu and Kiska, a p-a system was used to direct the landing of supplies.

In Lieutenant Mason John Browne's new book, "To All Hands," the p-a system is the hero and heroine, all rolled up in one. For Lieutenant Browne's story revolves about his position as a battle announcer on the flag ship of the Atlantic Fleet Amphibious Force. Over the p-a system Lieutenant Browne told the boys below just what was going on, on land, on sea and in the air.

COORDINATED EMERGENCY RADIO UNITS AGAIN PLAYED A HEROIC ROLE during a flood. During the recent rampage of the Mississippi and Illinois rivers in the state of Illinois, complete disaster was avoided by the activity of FM stations of the Illinois State Police. Portable stations were set up in back rooms of restaurants, high schools, and other forms of shelter. Stations remained in operation until rising water made it impossible to continue and then the equipment was shipped to another location.

The interesting part of the story of heroism stems from the fact that the radio equipment had only been installed a month before the flood. Accordingly, it was up to comparatively inexperienced police officers to complete the necessary emergency links. Yet the operation was flawless and complete.

A resounding round of applause to the members of the Illinois State Police radio system!

DURWOOD D. ALLEN, secretary of the Universal Microphone Company, Inglewood, Cal., thinks that 1944 will offer a distinct challenge to microphone manufacturers in preparation for postwar merchandising of products.

"The peacetime microphone," he says, "will not just 'sell itself.' That is, consumers will not merely be satisfied with any microphone. They will want a specific microphone for a specific purpose. And, carrying out this theme, manufacturers will pay more than ordinary attention to scientific packing and labeling and the proper display of microphones and accessories."

TELEVISION INTEREST ROSE TO NEW HEIGHTS in November and December, with predictions that caused many an executive to ponder. The forecasts came from such notables as Tom Joyce, vice president and manager of the Radio Phonograph Department, RCA; Robert Gibson, assistant broadcasting manager of General Electric; Allen B. DuMont; Thomas Hutchinson of Ruthrauff and Ryan advertising agency; John Southwell, of BBD & O, and Norman D. Waters, president of the American Television Society. At a joint dinner meeting of the Society and the Advertising Club of New York Mr. Joyce predicted that television sets costing but $200, will be available as soon as television service is available in moderate quantities.

According to W. R. David of General Electric, 5 years after the war we should have 100 television stations and in the intervening period a gradual approach to that estimate. It appears, therefore, that about a year after the war suitable television services should be available to warrant perhaps the production of moderate priced television receivers. Incidentally, Mr. Joyce also predicated that when television service is available, television receiver sales will be at the rate of approximately 2,500,000 units a year, at the $200 retail price.

To demonstrate the progress that has been made in television, General Electric invited a group of editors and correspondents to visit the transmitters and studios in Schenectady. Your correspondent, who was among those at the demonstration, can report that substantial progress has been made in both transmission and reception. Picture size and scope, and interference elimination appear to be the two problems that have not been completely solved. Engineers report however that when commercial television is available even these stumbling blocks will have been overcome.

The television impetus has prompted the planning of a Television Broadcasting Association. The plan has already been submitted to members of the industry. A committee of the Society of Television Engineers prepared the format, on which the Association is based. The television director of Paramount Pictures, Klaus Landsberg, is chairman of this committee.

Television, this time, appears to be going in the right direction!

SECRET MILITARY MESSAGES are now being flashed directly from Italian battlefields to the War Office in London from the world's largest mobile radio station, run by Britain's Royal Corps of Signals. More than 30,000 words are received and transmitted daily.

Nicknamed the "Golden Arrow," because it resembles the famous London-Paris boat-train, it can be driven into battle areas and—within a few hours—provide as much energy as a small but high-powered radio station.

Each station—for there are other "Golden Arrows" scattered throughout the world—contains a receiving vehicle which carries the operators and high-speed telegraph equipment. A second vehicle houses a transmitter whose 70-foot aerial masts are carried in sections on other cars. Each of the two vans pulls a trailer carrying Diesel-driven generators. The big valves of the transmitter are equipped with specially-sprung mountings to withstand jolts.

The whole outfit is staffed by 32 crew members—operators, mechanics, electricians, drivers and a cook.

FOR THE THIRD TIME International Resistance Company has been awarded the Army-Navy "E" flag for excellence in production of war materiel.

In an inspiring message, Ernest Searing, President of I R C, urged continuance of the splendid cooperation which made possible this unique recognition.

ALNICO, THAT POWERFUL MAGNET MATERIAL used in speakers and other radio equipment, recently became an effective tool of the medical profession. When a five-year old boy swallowed a steel lock, an inch long and a half-inch wide, an Alnico magnet was used to attract the lock so that it could be extracted by the attending surgeon.

Alnico, which is composed of aluminum, nickel and cobalt, is a permanent magnet with an unusually high coercive force.

An electromagnet and a radio unit also played a part in surgery recently. A steel splinter that flew into the eye

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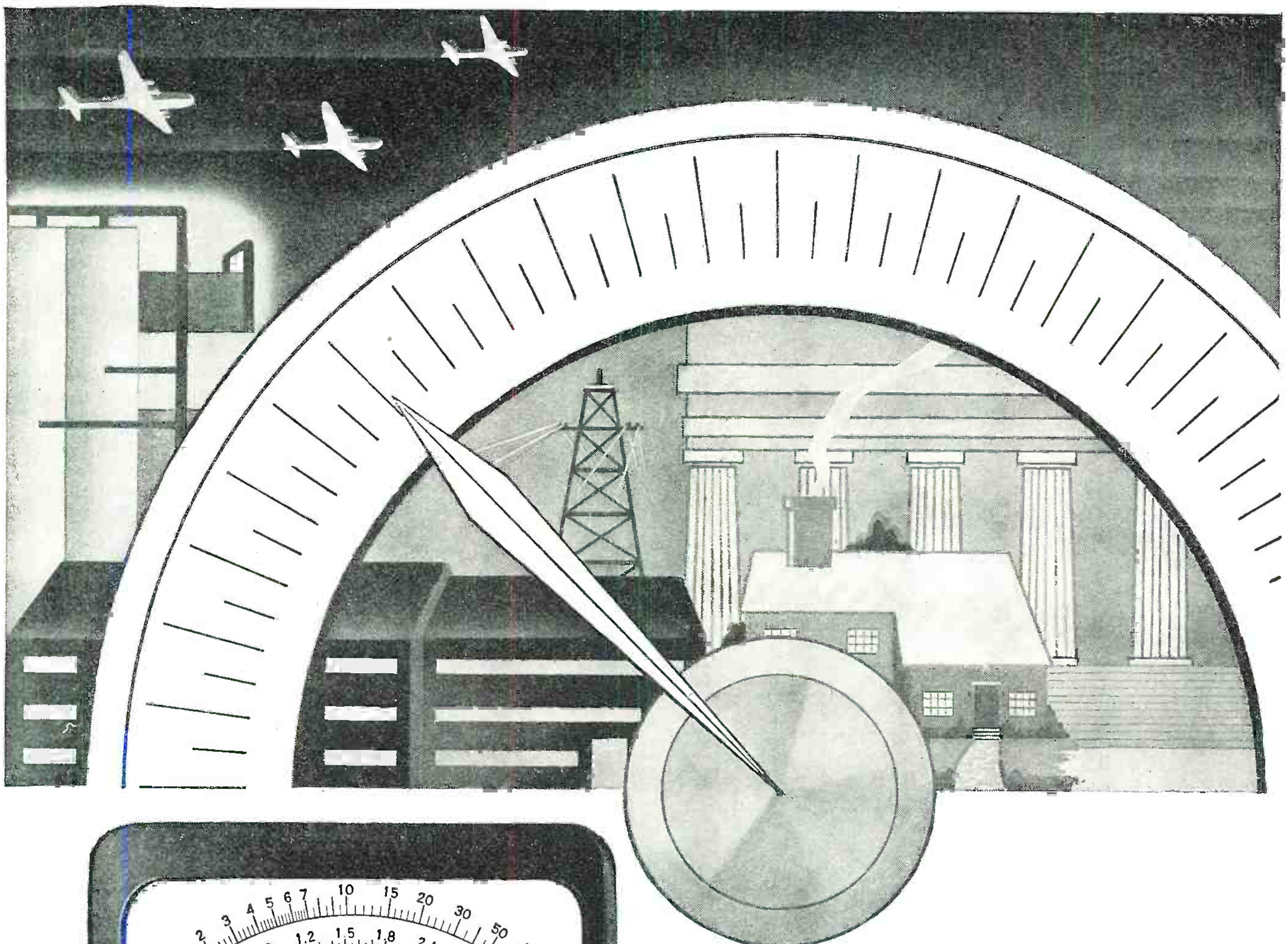

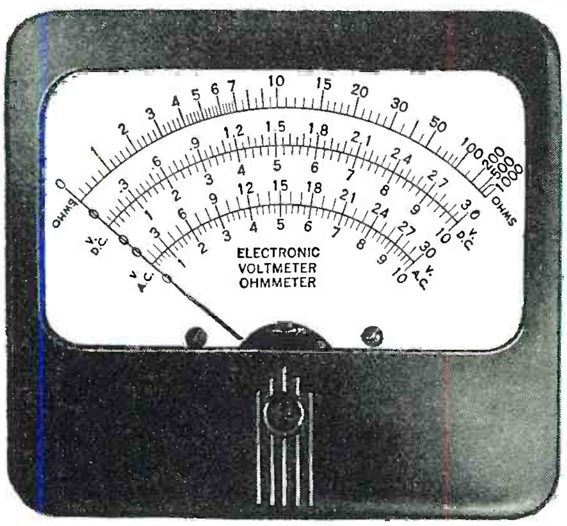

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Saga of Vacuum Tube

(Continued from page 39)

PAT. IN U.S.A.
1-15-07 TWO PATENTS
2-18-08 4-27-15
10-17-16 12-19-16
12-17-18
PATS. APPLIED FOR

Early in 1921 the patent date 10-5-20 was added to this marking.

Meantime, work had been carried on with a view to improving the characteristics of this tube, especially in the matter of power required for the filament. By 1921 theoretical studies and laboratory experience indicated that this could be done without sacrificing the other characteristics, and accordingly, late in 1921 the 101B was replaced by the 101D.

The 101D was the same as the 101B except for the filament; the first of the 101D tubes operated at a filament current of 1.15 amperes as against the 1.30 amperes required for the 101B. The filament of the 101D had a platinum-nickel core instead of the platinum-iridium previously used, and was untwisted. In order to readily distinguish these lower current tubes from their predecessors, the tips were colored green by the application of lacquer. This practice was continued until 1924.

The manufacture of the 101B was discontinued in 1923.

The first of the 101D tubes had the code marking etched on one side of the bulb in letters approximately ¼ inch high, as shown in Figure 78, and had the serial number etched on the opposite side of the bulb. These tubes bore the following patent marking:

PAT. IN U.S.A.
1-15-07 TWO PATENTS
2-18-08 10-17-16
12-19-16 10-5-20
PATS. APPLIED FOR

Early in 1922 this marking was discontinued and the standard type of marking was applied on the base, both on the shell and in the wax. Soon thereafter the patent marking was changed to read as follows:

PAT. IN U.S.A.
1-15-07 12-19-16
2-18-08 12-17-18
10-17-16 1-27-20
PATS. APPLIED FOR

A short time later the patent date 10-5-20 was added. (See Figure 79.)

Early in 1923 the practice of the American Telephone and Telegraph Company was changed and vacuum tubes were sold directly to the Operating Companies instead of being leased to them. Hence the marking of tubes as the "Property of the American Tel. & Tel. Company" was dicontinued and henceforth they were marked "Western Electric—Made in U.S.A." (Figures 80 and 81).

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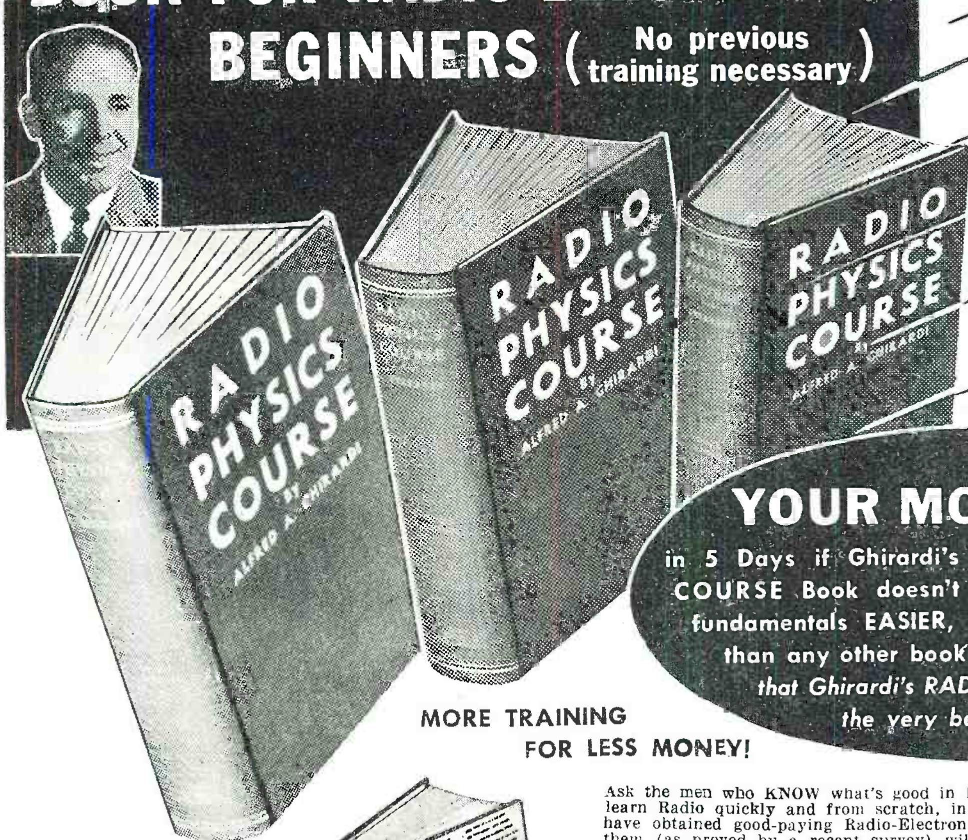

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In 1925, in order to effect economies in manufacture, and permit the use of the same shell on all tubes, the markings were removed from the base and applied to the bulb in a single band as shown in the tube depicted in Figure 82.

Later in 1925 the design of the 101D tube was changed to use a molded base, with the code and patent markings being applied to the bulb in a single band as before. The metal bases previously used were difficult to manufacture to the close dimensional limits required; the filling wax tended to flow out under extreme temperature conditions, and the micarta inserts on which the studs were mounted sometimes absorbed moisture.

The first design of molded base, which used soldering tabs on the contact studs, was employed for about a year and was then replaced by a molded base with a type of stud in which the lead-out wire was threaded through a hole in the stud and soldered on the outside. Essentially the same type of contact stud is still used on these tubes. In order to reduce the variations in the resistance of the contact between the stud and the socket spring, all repeater tubes have been equipped, since the early days of the metal shell, with precious metal contact tips on the base prongs.

The practice of magnesium flashing to aid in obtaining high vacuum was introduced just before the change from metal to molded base, and one of the metal-based flashed tubes is shown in Figure 83. Some tubes were still made without this flashing, for use in certain types of carrier systems.

By 1927 studies of filament materials and characteristics had progressed to such a point, and methods of manufacture had been so improved, that satisfactory operation could be obtained with a new type of filament which operated at approximately 0.5 ampere filament current, and approximately the same filament voltage. This represented a great increase of efficiency and consequent lower operating cost, since it halved the power required for filament operation.

Around this new filament was designed a new repeater tube, with approximately the same plate characteristics as the 101D. This new tube was known familiarly as the "half-ampere L tube" and officially as the "101F Vacuum Tube." At the same time the mechanical structure of the element assembly was entirely redesigned. The plate was made of the completely enclosing type, the grid a continuously wound spiral, and the spacing between the elements greatly reduced. One of these tubes is shown in Figure 84. The 101F did not completely replace the 101D, which still continued to be made.

In April 1927 there occurred a revision of the United States Patent Law which provided that the patent marking of any article made under a patent issued after that date should consist of the patent number rather than the date of issue, as heretofore. An article

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WANTED—Superior channel analyzer in good condition. Name best cash price. R. A. Boe, Drumheller, Alta. Canada.

WANTED URGENTLY—by Marine officer headed for S. Pacific soon: One Hallicrafter S-29, used or new. Wire price and condition. Capt. S. A. Cisler, USMC, Compound, NATTC, Ward Island, Corpus Christi, Texas.

URGENTLY NEEDED—A good V-O-M for Cash. Describe and name price. George N. Riggs, 1343 N. Bronson Ave., Hollywood 28, Calif.

WILL TRADE—Test equipment and a 15-watt Webster amplifier with 12" Jensen X speaker in good condition for any communication receiver, transmitters, or 2½ meter transceivers. John Hochmeister Radio Service, R.R. No. 1, Boonville, Ind.

FOR SALE OR EXCHANGE—Radio City No. 446 V-O-M; Triplett 666 V-O-M; Stancor 510 amplifier; Meissner coils; var. condensers; and 4 to 7-tube kits; long-distance Zenith portable; 0-5 V. D-C Weston No. 501 meter; also hundreds of fine radio components and tubes, new or slightly used. Will sell or exchange for cameras, movie projectors, etc. John Kasperski, 807 Front St., Hempstead, N. Y.

WANTED—Transformer, plate volts 600. 60 ma.; rectifier 5.0 volt, 3.0 amps; filament 1.5—CT volts 1. amps., filament 1.5 volts, 4. amps.; filament 2.5—CT volts, 4 amps.; 5.0 volts, .5 amps. Midway Electric Co., Route 1, Box 56, Adrian, Minn.

FOR SALE—New Meissner signal booster, $45. Carl Hart, Wyomissing, Pa.

FOR SALE—Power stage P.A. system only. Uses four 2A3's, one 80 and one 83. Also 0-1 ma. meter, and 0-200 ma. meter, both Tripletts. Want 12SA7; 12SK7; 12SQ7; 35L6; 50L6; 35Z5; 1N5; 1A7; and 117L7 tubes. Also want Philco signal tracer; AF-RF oscillator; V.T. voltmeter, & P.M. speakers; crystal mikes and pick-ups. Eslick Radio Co., 2825 E. 13th St., Wichita, Kans.

WANTED—Any good tube for use on UHF receiver and xmitter, such as 935; HY114; HY616; HY75, etc. Will be used for W.E.R.S. Send information. Christy's Radio, 1654 Wierfield St., Ridgewood 25, New York City.

FOR SALE OR TRADE—12 speakers, 6" to 10", 1,000 ohm fields; 2-, 3-, and 4-gang plate-tuning condensers; oscillator, new, model Osc. 42, signal generator with modulation (electric); juke box amplifier in perfect condition. Would like to trade for Hallicrafter receiver. A. W. Gorrell, 733 Central Ave., Hamilton, Ohio.

FOR SALE—Rider's manual Vol. 5 ($7); Vol. 7 ($9). Syrus Hanson, Gary, Minn.

WANTED—Signal generator, tube tester, and analyzer—any make. Have parts, etc. for swap or sale. Len's Radio Service, 7304 Superior Ave., Cleveland, Ohio.

FOR SALE—New G-E and K.R. tubes types 41, 27, 2A3, 6L6G @ 40% off list; also one Jewell 0-3-15-150 AC voltmeter (lab. type), $10. Most sizes of 10-watt w.w. resistors @ 25c ea.; also ½ and 1-watt @ 10c. Want 3" or 5" oscillograph in good condition, also Rider's manuals. Dell Penman, Hudson, Wisc.

URGENTLY NEEDED—1A7 tubes. Will pay cash or equal value in 35Z5GT's. Also need 80, 24, 45, 47, 12 volt series. Have many types of tubes, Hickok tube tester, battery oscillator, parts, and U.S. and foreign stamps to trade for movie projector, slide or film projector. Hasco Radio Service, Myrtle Creek, Oregon.

FOR SALE—Operadio No. 855 amplifier with 4 Jensen A-12 PM speakers, projectors, cable, 2 microphones & stands; also one each Thordarson transformer T15R06; T15C56 choke; T15S92 trans.; T15D35 audio transformer. Supreme Co., New Castle, Pa.

WANTED—One set of 2000 to 3000 meters, plug-in coils for National A-C SW5 receiver. Fred R. Bullis, 5727 Military Ave., Omaha, Nebr.

WANTED—Triplett 1200A V-O-M or other reputable make; also a good signal generator. R. W. Mangum, 501 Aransas, San Antonio, Texas.

WANTED—Want someone to wind 12 small coils to be wound with No. 36 wire, winding of each less than 3000 ohms. Must be done on coil-winding machine and done accurately. Wire and bobbins furnished. State price. W. P. Haughton, 3029A Rutger St., St. Louis, Mo.

FOR SALE—Brand new (never used) 1941 Meissner de luxe signal shifter. Has set of 80 meter coils. Also offer 3 Xtals, one 1966 kc., one 7215 kc., and one 7265 kc. Cash only. Ramon W. Gaffner, Box 1893, Sacramento, Calif.

WANTED—Instruction booklet for my model OC Clough-Brengle oscillator. Calvin C. Blauvelt, Fort Montgomery, N. Y.

TUBES FOR SALE—Following types (list, less 40%); 1C6; 1E5G; 1F4; 1J5G; 1G4G; 1G4GT; 15; 3S4; 3Q4; 2A5; 2A6; 2A7; 2B7; 6B4G; 6B8G; 6E6; 6F7; 6L5G; 6W7G; 6ZY5G; 6G6G-XX; 12A; 33; 34; 39/44; 46; 48; 49; 59; 82; 89; 950; 7A4; 7A6; 7F7; 7N7; 7H7; 7J7; 7Q7; 7V7; 12J5GT; 12H6; 12E5GT; 12A5; 12A7; 12AH7GT; 12SL7GT; 14A7; 25Y5; 25B6G; 25N6G., also new model "P" GTC porta-power (6 volt). D. A. Angulo, 5229 Beaufort Ave., Baltimore 15, Md.

WANTED—Communications receiver. Give details. Pvt. A. A. Kacprowicz, SCV 4433, Co. E—ASTU, University, Alabama.

FOR SALE—Radio shop with instruments and photo materials. Varela Radio Shop, Venegas, Esq. Derkes, Box 515, Guayama, P.R.

FOR SALE OR TRADE—One Philco 050 tube tester in A-1 condition. Am in need of good signal generator, Supreme 561 or Hickok 188X or equivalent. Frank Grinnell, 26 Queen St., Milton, Pa.

WANTED—Triplett V-O-M No. 1200-A; Triplett signal generator No. 1232-A. Would consider others, but must be in 1st class condition and for use on 25-cycle line current. Cash—American money. B. K. Hotchkiss, R. R. No. 1. Straffordville, Ont., Canada.

FOR SALE—One complete Triplett test lab in single case consisting of one No. 1200-A V-O-M; one No. 1232 all-wave direct-reading signal generator; one free-point tester, and tube tester. Complete kit purchased in 1938, used little, good as new. What do you offer? R. E. West, Box 93, Canadian, Texas.

WANTED—Late model V-O-M in good condition. Give full details in 1st letter. Jack Tarr, 1432 Sunnymede, South Bend, Ind.

WANTED—Rider's chanalyst for cash. State condition and price. C. Weik, 1414 Bradford St., Plainfield, N. J.

WANTED—Universal type V-O-M, tube tester, and signal tracer. Have 6- and 2½-volt tubes, I-F transformers, speakers, coils, etc. J. R. Reed, 2178 W. 3rd St., Durango, Colo.

FOR SALE—Clough-Brengle No. OC R-F oscillator; Clough-Brengle No. OMA R-F oscillator; Clough-Brengle CRA oscilloscope; Bogen No. D28 universal 6V-110V. amplifier; Webster-Chicago No. 61B universal 6V-110V amplifier; Aerovox L/C checker No. 95; Clough-Brengle No. 79B audio oscillator. Shannon Radio & Sound Service, 67 So. Third Ave., Mt. Vernon, N. Y.

FOR SALE—Triplett voltommeter No. 1200 with carrying case; also two Weston No. 301 0-1 mil. D-C meters. T/sgt. J. Jack, 30 Comm. Sqd., Mitchel Field, N. Y.

WANTED FOR CASH—Broadcast coil set for National FB7 receiver. State price & condition. W. A. Seaman, 308 Locust St., Findlay, Ohio.

WANTED—A good, sensitive voltmeter-ohmmeter. Will pay cash or trade Weston 1 ma. meter for same. C. W. Cook, 2540 McFaddin St., Beaumont, Texas.

WANTED TO TRADE TUBES—My list price to your list price. Have 12 and 35 volt tubes, also 3Q5, 1N5, etc. Can use other types. Make offer. Am also interested in test eqpt. Will buy damaged AC-DC radios. Knutson Radio, 1225 Charles St., LaCrosse, Wisc.

FOR SALE—Triplett V-O-M No. 321; Hoyt AC ma. 0-100; Weston 0-5 V. A-C meter. Make offer. Sgt. F. A. Disharoon, ASN 33002609, Co. A, 12th Engineers, APO No. 8, Camp Forrest, Tenn.

WANTED—Tube chart for Million tube tester, model DF. J. Nardi, 4041 W. Harrison St., Chicago, Ill.

WANTED—35mm. Powers movie projector, sound or silent, or Powers parts. Have radio parts & cash, also new 9-wire analyzer cable with adapters. L. M. Wycoff, Marmaduke, Ark.

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made under patents issued prior to the effective date of the change in the law could be marked with either the date of issue or the patent numbers.

In accordance with the provisions of this law the markings on the bulbs of the 101D and 101F tubes were changed, in 1928, from dates of issue to patent numbers. Photographs of 101D and 101F tubes so marked are shown in Figures 85 and 86.

In 1929 the practice of magnesium flashing the 101D was discontinued and some minor changes in design, such as the relocation of the plate lead and the use of a shielded grid-lead-in wire, were made. About the same time the practice of putting the code marking on the base, in depressed characters, was adopted. (See Figure 87). The patent markings were, at the same time, removed from the bulb and applied to the carton in which the tube was packed.

The construction of the 101D remained practically unchanged from 1929 until 1940, when the tube was completely redesigned and modernized. This redesigned tube, which is in current manufacture, is shown in Figure 88.

The practice of putting the code marking and Western Electric name on the molded base, in depressed characters, was instituted for the 101F at the same time as for the 101D. Figure 89 shows a 101F tube with these markings.

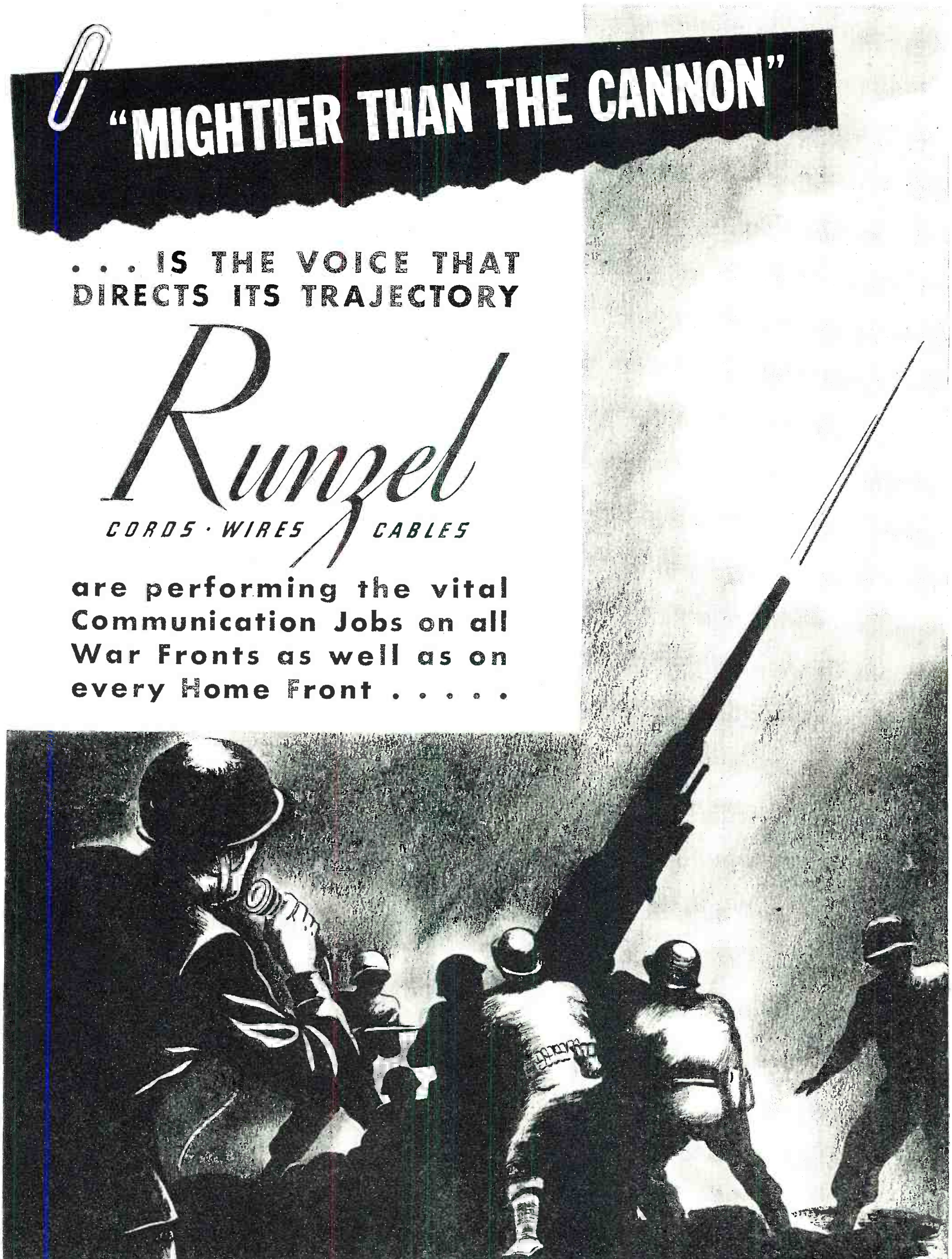
Later the 101F was changed to use a pear-shaped bulb instead of the spherical one, and this tube is shown in Figure 90.

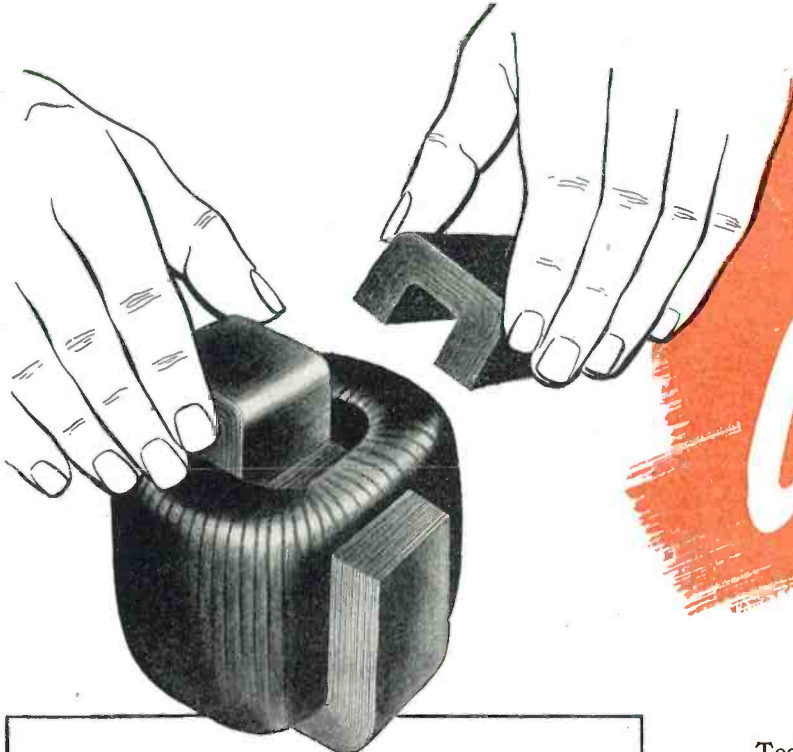
When the 101D was redesigned in 1940 similar changes were made in the 101F, resulting in the tube shown in Figure 91, which is of current manufacture.

Still further studies have since been made which have resulted in the realization of a tube which operates at one-half the filament current of the 101F, and this tube, known as the 101L, is now in production.

The story of the 101-type tube is a most interesting one. The evolutionary steps which they have gone through is an excellent example of what can be accomplished by continued study and long experience in the manufacture and use of a particular type for a definite purpose. The 101 types are, always have been, and probably always will be designed and manufactured for use in telephone repeaters. The conditions under which they operate are exacting, and it is greatly to the credit of the research workers, designers and manufacturer that these conditions have continued to be met satisfactorily. This has been accomplished in spite of the fact that the latest designs require only one-fifth the filament power of the first tubes of this type. And in the process the useful life of the tube has been increased a hundred fold, from the 400 hour life of the 101A to the 40,000 hour life of the 101D.

Truly a remarkable achievement!





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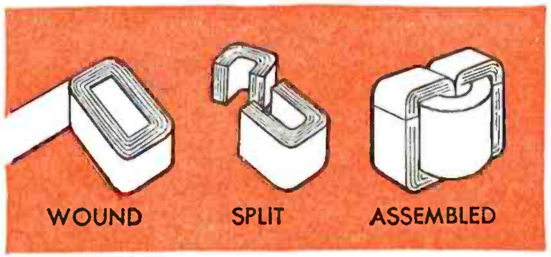

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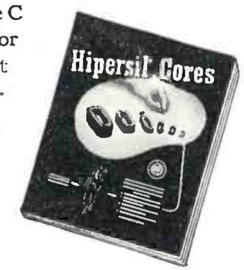

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CAPTIONS FOR ILLUSTRATIONS

Figure 73. Formed sheet metal base with micarta insert, used on Western Electric Repeater Bulbs and Vacuum Tubes 1917-1925. View before base has been filled with wax.

Figure 74. First type of 101B Repeater Bulb to use formed sheet metal base. The code designation appeared only in the wax filling of the base, and the patent marking was applied in depressed characters to the metal base shell. The markings have been filled white in the illustration, for photographic purposes.

Figure 75. Later manufacture 101B showing code marking and A.T.&T. Co. property marking applied to sheet metal base. The code number was also applied to the wax filling of the base.

Figure 76. Two views of the early 101B Repeater Bulb. This shows the construction in which the arbor supporting the element assembly was attached to the edge of the press. This particular tube was made at the Hawthorne Works of the Western Electric Company, as evidenced by the "H" following the serial number on the glass.

Figure 77. Two views of the improved 101B Repeater Bulb. The glass supporting arbor is heavier, and is welded to the stem below the press. This was a more sturdy construction than that shown in Figure 76.

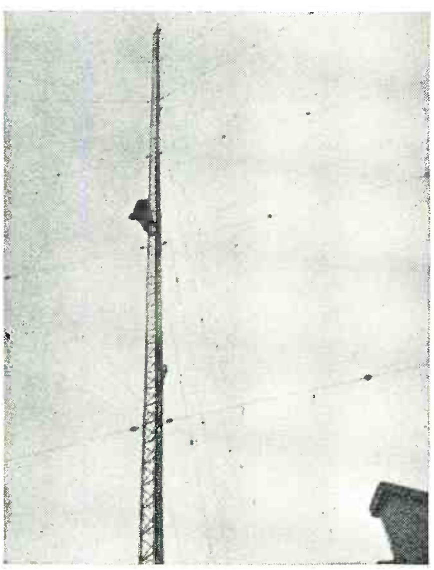
Figure 78. Early type 101D Vacuum Tube. The code marking appeared only on the glass bulb.

Figure 79. Later type 101D, showing code marking, A.T.&T. Co. property marking, and patent marking on base.

Figure 80. Later 101D than that shown in Figure 79. A.T.&T. Co property marking has been replaced by Western Electric marking and patent marking has been revised. Markings are in 1/16 inch high characters.

Figure 81. Same as Figure 80 ex-

Passing the half-way mark up the 200-foot tower of the Maine State Police Department WBNV, Augusta, Me. A ⅞" coaxial gas-fed line leads to a coaxial radial antenna on top of it.



cept that markings are in 3/64 inch high characters.

Figure 82. 101D Vacuum Tube with molded phenol plastic base, code and patent marking on bulb in baked enamel lettering. Patent marking given as dates of issue of relevant patents.

Figure 83. 101D Vacuum Tube with metal base and magnesium flashing.

Figure 84. Early 101F Vacuum Tube—code and patent marking on bulb, patent marking given as dates.

Figure 85. Later 101D Vacuum Tube—markings on bulb—patent numbers have replaced patent dates.

Figure 86. Later 101F Vacuum Tube—markings on bulb—patent numbers have replaced patent dates.

Figure 87. 101D Vacuum Tube with molded base. Code number is in depressed characters on base. Base markings have been filled white for photographic purposes. Patent markings were applied to the carton in which this tube was packed.

Figure 88. 101D Vacuum Tube of latest construction—new element assembly and domed bulb.

Figure 89. 101F Vacuum Tube with markings in depressed characters on phenol plastic base.

Figure 90. 101F Vacuum Tube in pear-shaped bulb.

Figure 91. 101F Vacuum Tube of latest construction.

(*To be continued in March issue*)

Theory of U.H.F.

(*Continued from page* 34)

of the various references given with this article. They contain practically all the published knowledge of the Klystron tube as used with ultra-high frequencies. Those references that have an asterisk contain a mathematical analysis of the Klystron while the others are more or less descriptive.

The operation of another ultra-high-frequency tube will be considered in the next part of this series of articles. The principle of operation will depend upon the instability of moving electrons in a magnetic field. This tube is commercially known as the Magnitron and is also capable of producing ultra-high frequencies in the range of 3000 megacycles.

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(*To be continued in March issue*)

Flying Fortress

(*Continued from page* 23)

The radio man sat back on his parachute pack, loosened his "Mae West," relaxed and listened. Over the intercom came the voices of the crew and observer-commentator as the ship sped towards the continent to bomb the Nazi-held airfield:

Nussbaum: "It's now 8:20. Zero hour is at 8:45. In exactly twenty-five minutes, at zero hour, every plane, every bomber, every fighter on this operational mission. . . . ."

Pilot: "Pilot to tail gunner. Check your glasses and see if you can get the number of that aircraft to the right of us."

Tail gunner: "Tail gunner—Roger. Four two eight. . . . . I think it is four two eight. Roger."

Pilot: "Thank you. Roger."

Nussbaum: "As I said, at 8:45, which is in about twenty-five minutes, all the planes on this mission, whether they be bombers or fighters, will be in the air on the way to the target. That is known as zero hour. I can now see the wing ahead of us. It is in perfect formation. They are scheduled to go into the target two minutes ahead of us. We have not as yet made our rendezvous with our fighter escort."

Bombardier: "Altitude 10,000 feet. Put on your oxygen masks. We are at oxygen level."

Tail gunner: "Tail gunner. Roger."

Nussbaum: "As you can hear, we are going on oxygen now. I have just put on my mask, and it may make my

voice sound somewhat muffled. Crews generally go on oxygen at around 10,000 feet. The pilot will check the crew every 10,000 feet altitude or so to make sure the men are still on oxygen and are all right. It is now exactly 8:48, and we are somewhere over the English channel. In just two minutes we are to rendezvous with the fighter escort, all P47 Thunderbolts — the bomber crew's best friend. The navigator is working over his maps closely now. That rendezvous is desperately important. If we are too early for it, our Thunderbolts might never find us, and if we're late, they'll use up all their gas circling and waiting for us, and won't be able to take us as far as Paris.

"We're right on the nose! Three huge formations of Thunderbolts are swooping down on us from the northwest. They're a good deal higher than we are. That is precision timing for you, especially when you remember that these Thunderbolts took off from different air fields ten or fifteen minutes ago, rendezvoused first with each other, and then came out here to meet us, at a precise time when we would be passing a given pin point on the map. The time is exactly 9:02. We are at bombing altitude. . . ."

Pilot: "Calling all to man your guns!"

Bombardier: "Bombardier to navigator—man your guns!"

Nussbaum: "We are now flying over enemy territory. Our parachutes have been adjusted. We have put on helmets to catch any flak that might be coming our way."

Crossing into enemy territory the radio operator checked his equipment to see that he had complete radio silence and noted it in his log.

Bombardier: "Bombardier to pilot—go ahead."

Pilot: "Go ahead."

Bombardier: "I'm going back to pull the pins out of the bombs now."

Pilot: "Roger."

Nussbaum: "That was the bombardier to the pilot. He is now leaving the bombardier's compartment and going back to pull the pins from the bombs. We are getting ready for business."

Bombardier: "That guy at twelve o'clock seems to be hit!"

Pilot: "Pilot—Roger—Roger."

Here the *Jackie Ellen* became engaged in the first contact with the enemy on this flight. Anti-aircraft batteries opened up on them from several quarters.

Nussbaum: "The flak is coming up. . . . . this is certainly flak-infested. . . ."

Right waist gunner: "Flak 4:30 high!"

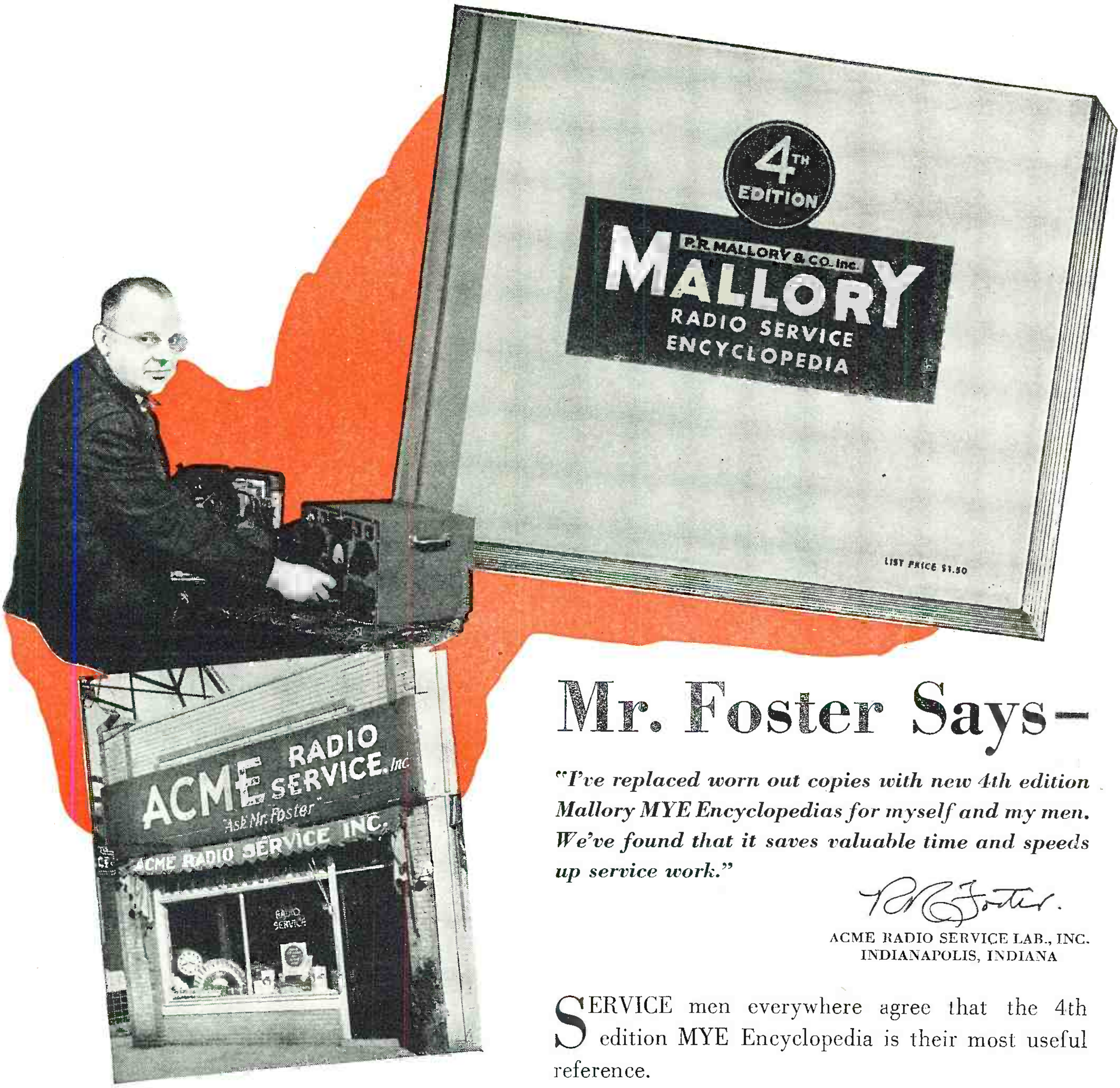
Top turret gunner: "There! Four fighters right above us—four fighters!"

Pilot: "Are they 47's?"

Top turret gunner: "Yes, sir, they're 47's."

Pilot: "OK."

Nussbaum: "We are nearing the target. We can see the field from here, and just beyond that we can see Paris it-



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self. We are getting some very bitter and determined opposition. They're giving us just about everything they have. . . . ."

Top turret gunner: ". . . . . . Something around, I think."

Pilot: "Cut the fussing around and get on the ball!"

Another field of flak spread out beneath them and the *Jackie Ellen* tossed and pitched like a bucking bronco.

Top turret gunner: "Enemy eleven o'clock level."

Nussbaum: "We are being attacked! We're being attacked! A Focke-Wulf 190 is coming in on us."

Pilot: "Get at your guns! Get at your guns!"

Nussbaum: "The guns are going—a Folke Wulf came in at about eleven thirty."

Pilot: "Report. Report."

Tail gunner: "Tail gunner—Roger."

Left waist gunner: "Left waist gunner—Roger."

Right waist gunner: "Right waist gunner—Roger."

Ball turret gunner: "Ball turret—Roger."

Radio operator: "Radio—Roger."

Navigator: "Bombardier navigator —Roger."

Pilot: "OK boys, keep your eyes open now."

Bombardier: "At twelve o'clock level there seems to be something burning—some plane or something."

Tail gunner: "Flak six o'clock! Six o'clock level."

Bombardier: "Bomb bay doors being opened."

Pilot: "OK. Open bomb bay doors."

Right waist gunner: "Three 47's at three o'clock high."

Nussbaum: "Our bomb bay doors are open."

Pilot: "Roger."

Top turret gunner: "There's something at twelve o'clock high."

Bombardier: "Don't bother me now, please! On the level there, boy, please!"

Nussbaum: "The bombardier is working with his Bomb Sights now. There's been a lot of flak. Our pilot has been taking evasive action. The bombardier wants the ship—he needs the ship level—we're levelling off. The flak is really coming up—some more bursts! The sky is . . . . the sky is just black with little puffs of smoke."

Bombardier: "Bombs away!"

Nussbaum: "The bombardier has just dropped his bombs and we are taking a wide turn to try to avoid the flak. We will be going due east now."

Tail gunner: "Watch there — one o'clock low—some enemy fighters!"

Nussbaum: "We are directly above Paris now."

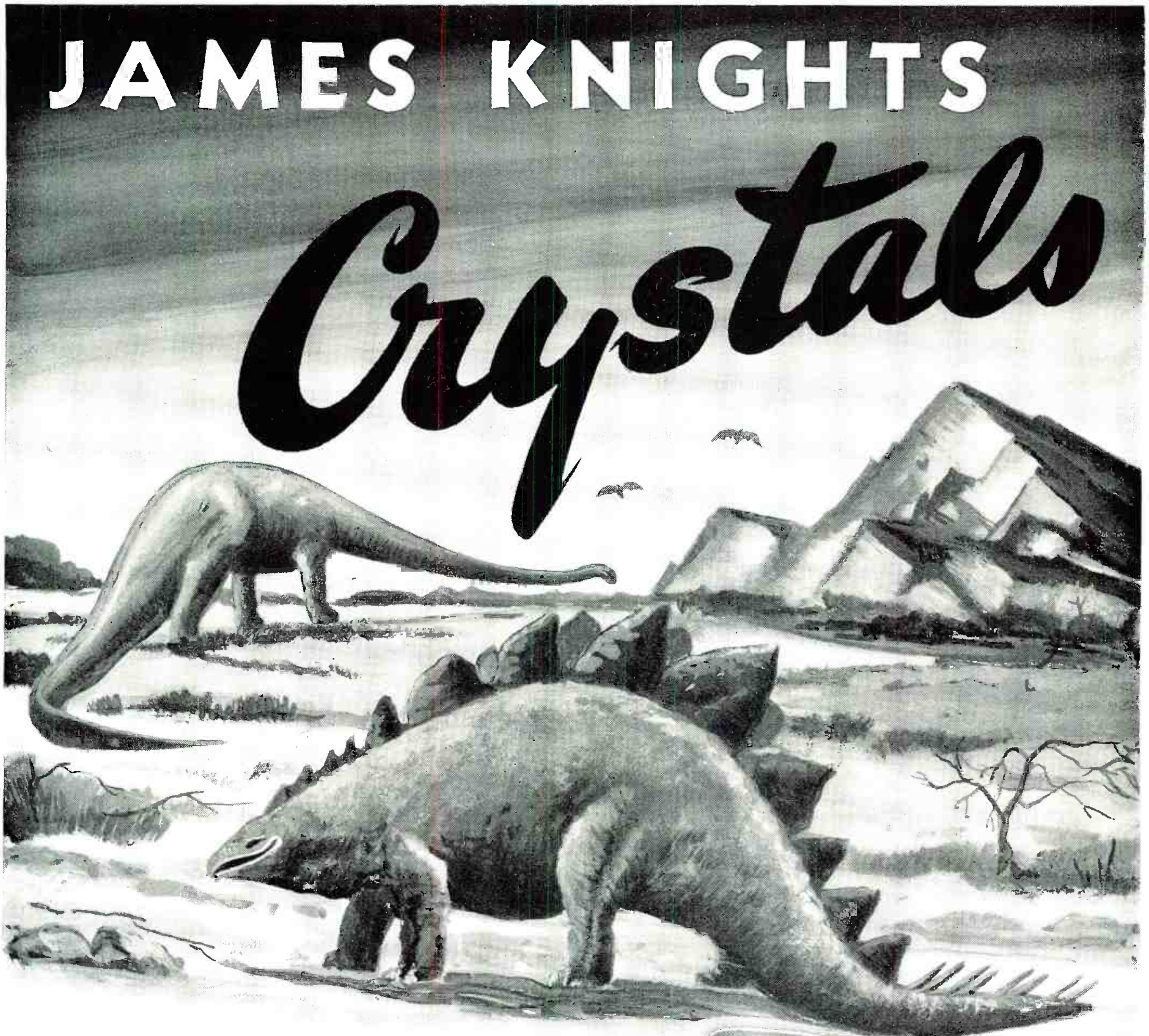
Right waist gunner: "Flak four o'clock low! Flak four o'clock low!"

Nussbaum: "Paris is just about four miles directly below. There is not a cloud between us and the ground. I can see the Eiffel Tower. . . . ."

Bombardier: "Where?"

Nussbaum: "Right out there just about one o'clock—see?"

JAMES KNIGHTS
Crystals



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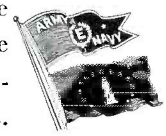

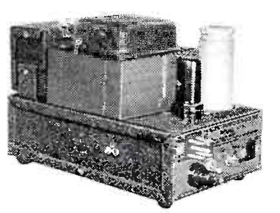

For Operation of Emergency Two-Way Radio Equipment from 115 Volts AC Line or DC from a 6-Volt Storage Battery *E·L* Model 619 Vibrator Power Supply. Input Voltage: 6 volts DC or 116 volts AC; Output Voltage: 300 volts DC at 100 ma. and 6.3 V AC at 4.75 amps.; Output Power: 60 watts; Dimensions: $5\frac{7}{16}$"x$2\frac{13}{16}$"x$5\frac{11}{16}$"; Weight: 10 pounds. Other *E·L* Vibrator Power Supplies are available with different combinations of input voltage and output wattage.

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E·L **ELECTRICAL PRODUCTS** — Vibrator Power Supplies for Communications . . . Lighting . . . Electric Motor Operation . . . Electric, Electronic and other Equipment . . . on Land, Sea or in the Air.

Bombardier: "Yes, that's what it is!"

Navigator: "Attack! Attack!—One o'clock!"

Nussbaum: "We are being attacked—there go our guns! It was an ME 109, a Messerschmidt 109. It came in at eleven o'clock right to the left of our nose. It swooped down on us, and under as our guns fired. If we missed him, the ball turret gunner got his chance, I guess."

At this point the radio operator decided to join the battle. He wrote in his log: "Off watch," closed his set and manned the fifty-calibre gun in the ceiling of his compartment.

When a radio operator engages in the battle as a gunner he must also keep constant vigil on his receiver for code signals come in at regular intervals and he must intercept and record them in the log.

After nearly four hours in the air with their mission successfully accomplished, the *Jackie Ellen* and her crew headed back to their base. Direct hits had been scored on the target and a total of thirty-seven enemy planes were knocked down by the entire flight.

Such phrases as "nine o'clock" and "eleven o'clock" used by the crew during their battle, indicate the direction from which enemy fighters were attacking. The use of the word "Roger" is a radio procedure term of acknowledgment, such as the expression, "OK," meaning everything is all right.

The entire crew was wearing oxygen masks, and with the exception of the observer - commentator, all the men used throat microphones. These can pick up only the individual's speech. A tiny lip microphone, enclosed in his oxygen mask, was used by the observer-commentator.

On the trip home the radio operator switched his automatic gadgets back on and tuned in a little dance music for the interphones while the crew unplugged oxygen lines and heating cables. The balance of the flight was uneventful.

Had the sky been cloudy on their return the radioman might have found himself a great deal busier, for after such battles planes usually become lost from their group and their course. In such weather the navigator cannot get a fix by celestial navigation or from his compass or maps. Then it's the job of the radio operator to take a chance on breaking radio silence to get a radio fix. This is done by working from the flimsy list of stations and frequencies, sending out the signal for a fix.

On long missions deep into Europe, Fortresses and Liberators sometimes land at the nearest airdrome to the English coast. Getting the ship into a strange airport is another responsibility of the radio man.

Back home the ship lands. The radio operator finishes his log for the flight: "Equipment OK, except for faulty interphone cables leading to tail gunner," or whatever flaws might have been found in radio, interphone, or other power cables. Then he signs: "Off watch — 1224 hours," with his name and rank affixed.

He gathers up his precious flimsy and log, attends the regular crew interrogation and his radio operator's interrogation where he is questioned on incidents of the flight. Finally he turns in his flimsy and log and goes to the mess for a drink from the pot of ever-waiting black coffee.

—30—

Audio Oscillator

(Continued from page 41)

actly the same as in the transmitters with which the Boehme equipment is to be used. This was achieved with a minimum of current, the keying being accomplished with less than 3.5 mills. It will be noted that there is a "straight" ground, which is to say, the rectifier plate return goes directly to ground, without the necessity of keeping circuits "below" ground.

It will be noted that the capacities throughout are very low except for the filter circuits. Although this necessitates short leads physically decoupled from one another, it cuts down on 60- and 120-cycle hum and other undesired signals. Short and heavy ground leads should be used, especially for the suppressor grid of the 6SJ7. The small cathode by-pass on the output tube provides current feed-back for frequencies below the desired signal. Resonating the output transformer to the signal frequency was found to produce no "hangover" effects at high-speed.

Since the equipment was to be installed permanently in a panel, obviously dependability was a prime consideration. The keying jack is so arranged that insertion of a plug turns on the equipment. By using a heavy power transformer and low-resistance choke sufficient voltage was obtained with a 1-μfd. paper condenser for input. Low voltages are used through-

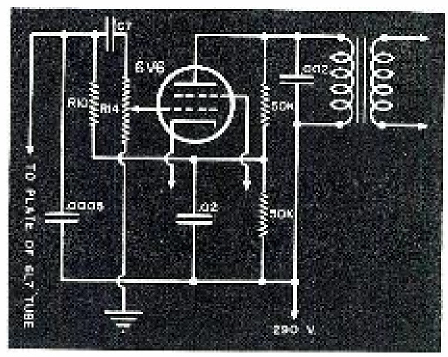
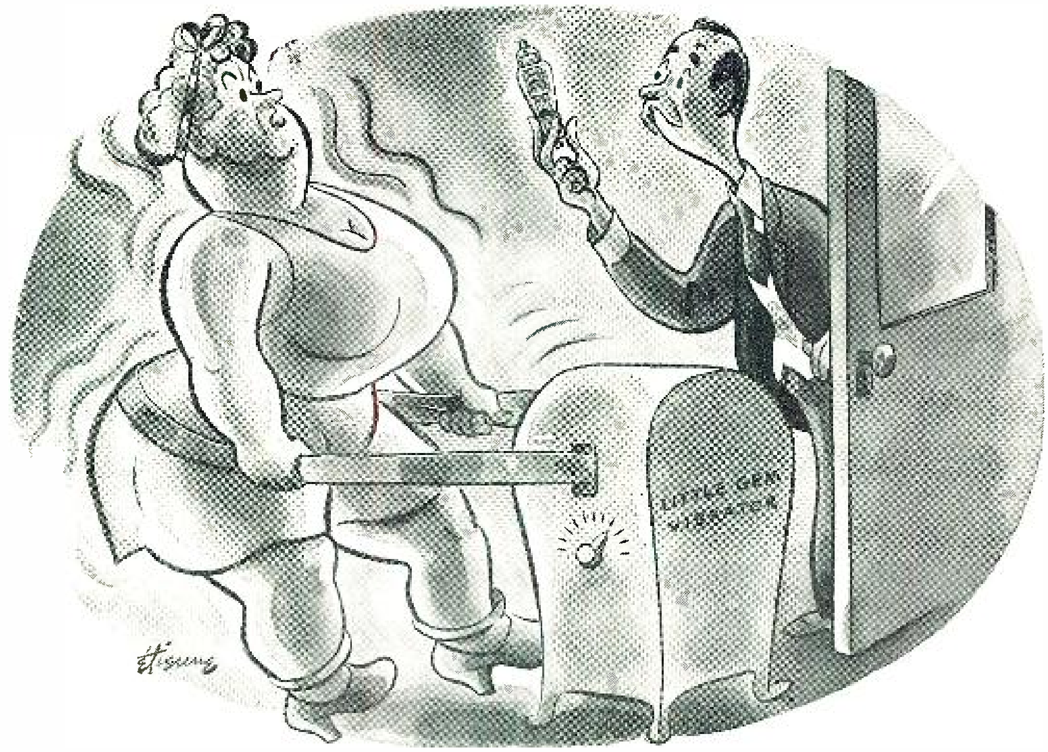
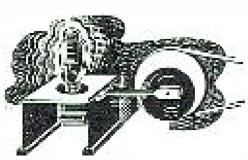


Fig. 2. Frequency-discriminating network. Of particular interest is the voltage feedback circuit for the lower frequencies, while the extreme highs are by-passed directly to a ground.

out except for the obviously high voltage on the 6V6 output. While it may be, that this is above the design rating for this "compromise" tube, no trouble has been experienced up to this time.



"We vibrate, 'em, too, Miss Gadfly . . . . ."



Miss "Tiny" Gadfly, impelled and inspired by the vision of a svelte, girlish figure, oscillates in phase with the vibrations of "Little Gem." With like determination, but with a different scientific purpose, Hytron tubes are also vibrated vigorously.

A motor-driven eccentric arm mercilessly agitates the tube while a sensitive vacuum-tube voltmeter discloses the slightest variation in the a.c. component developed across the plate load resistor. An imperfect weld—a loose element—a potential short circuit—these, and other trouble-makers are instantly detected.

Tubes which pass this standard Hytron factory test are not likely to fail. When subjected to the ruthless throbbing of machines of war by fighting men too intent on a battle for survival to baby them, these tubes "get the message through."

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The output signal is very low, less than half a watt. This is perfectly adequate for the purpose for which this circuit is intended. Greater power could be obtained by a well-decoupled voltage amplifier after the 6L7. Do not amplify between the oscillator and the 6L7. Although the sharp cut-off grid is used for keying and the remote cut-off grid used for signal input, the input grid will not handle a "hefty" signal without distortion. The oscillator output has been kept low, to the extent that about 0.4 volt is developed across the 6L7 grid resistor. The bias cell used in the oscillator is a standard full-size flashlight battery, soldered at both ends to terminal strips. It is expected to last a year or two without trouble, and can easily be replaced in one minute. The shunt condenser is simply insurance against high resistance as the cell grows old.

For normal purposes the load-stabilization network indicated in the diagram was not found to be necessary, the set giving quite as much satisfaction when mismatched to high-impedance phones as when properly matched to 500 ohms. The condenser for resonating the output transformer must be selected while the actual working load is reflected to the output tube.

So far so good. The equipment is in place and has worked satisfactorily. For those who would like to experiment, the frequency-discriminating circuit shown in Fig. 2 might be substituted to accentuate the signal frequency over hum, noise and Gremlins. However, the writer has not had very much success with such a circuit, although reports have been received that others have constructed similar units and have had fairly good results.

—30—

ESMWT

(*Continued from page* 47)

of our newly acquired knowledge. The name of the course just described is "Electronic and Circuit Theory," and involves the same time expenditure as the previous courses.

It will be noticed throughout this entire article no mention of any radio texts is made. The reason, of course, is obvious. Some schools use no texts at all, rather they use the notes of the instructor and the engineering department of the institution. Other schools that do use standard texts vary even in these, there being so many good books on the market. It is suggested that no purchases be made until instructed to do so by the respective school giving the course.

With the general circuit theory safely tucked away in our heads we find that the next course quite logically deals with vacuum tube circuits of a general nature. While this course called "Vacuum Tube Circuits" deals with exactly the same subjects encountered in a previous course, the amount of detail covered is now much larger and more comprehensive in nature. Mathematics is used quite freely, many times running into problems bordering very closely on the radio engineering side. It is here that the student is first brought face to face with some of the intricacies that must be solved in designing radio receivers and transmitters. For those persons who can absorb the type of material given here, the course will serve as an eyeopener and bring with it a better appreciation of the methods used in the radio industry. Graduates of this course could quite easily fill supervisory positions for many of the jobs required in the radio factory. It will also prepare one for the final course in radio as we knew it in our ordinary uses—namely, radio engineering.

Radio engineering, a term many times misused, is divided into two sections labeled "Radio Engineering 1," and "Radio Engineering 2." Each course involves lecture and laboratory periods and is primarily intended for design purposes. The method of division of the radio material is usually left to the individual school giving this course, the final result being always the same. The treatment of the course material will be from a theoretical point of view with special emphasis given to analysis and design. Usually in the laboratory students are allowed to design their own equipment (subject to existing facilities) and then run tests to determine the accuracy of the experimental results as compared to

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In a few cubic inches of space National Union tube designers plan and build their electronic skyscrapers. Many fragile parts of these intricate mechanisms are precisely balanced, buttressed and welded fast.

For N. U. engineers well know the *rough sailing* that's ahead for these tubes—the shocks, concussion, vibration—relatively far more shattering than the impact of an earthquake on a modern steel and masonry building. So their war job is to build tubes which will stand up and take what comes—whose parts will *stay* in precise alignment—whose exact clearances will not be altered—whose air seal will not be broken.

To master this complicated construction problem calls for precision engineering of the first order—and a minute knowledge of the strength, rigidity and other characteristics of many metals. The point is—modern electronic tubes are scientific instruments. For post-war tubes of highest character, teamed-up with service assistance to match, service engineers can *count on* National Union.

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Transmitting, Cathode Ray, Receiving, Special Purpose Tubes • Condensers • Volume Controls • Photo Electric Cells • Panel Lamps • Flashlight Bulbs those calculated from theoretical considerations. Student's originality is the goal strived for and encouraged. Usually the students who do the best work are quickly absorbed by radio companies who always keep an eye on these ESMWT courses for possible employees.

While we have now finished with the courses on radio as we knew it before the war, an entirely new field has come into existence since then, called ultra-high frequency radio. Frequencies as high as three billion cycles are now in rather common use with many of our plane detecting devices. Naturally, when we reach wavelengths this small we have to deal with new and different radio circuits and radio components. Ordinary tubes and radio parts have to be revised to meet new requirements. Since this phase of radio work is very vital to our war effort, the government has sponsored two of these courses under the ESMWT program.

They are known as "Ultra-High Frequency Techniques 1 and 2." To take this course, a student should have an excellent background in mathematics, including vector analysis. Maxwell's equations, the basis for all our electromagnetic wave theory, underlies all ultra-high frequency engineering. This course should only be taken after all the other radio and mathematics courses have been passed. The course outline would probably cover electromagnetic theory, ultra-high frequency transmission lines, wave guides, cavity resonators and antennas suitable for this work. In the laboratory all this built-up apparatus (it can not be bought) is thoroughly tested and the results studied. It is through this combination of lecture and laboratory experiments that this subject can be correctly understood. It is urged that all those qualified to take this course do so, since it gives excellent promise of being an outstanding field after the war.

In closing it is suggested that full advantage be taken of these free facilities for they will probably be discontinued after the war. A list of most of the colleges throughout the country now offering radio courses is given at the end of the article. At the time of writing this article the list was complete but it may not be now. If in doubt, seek out the college nearest you and they will probably be able to supply you with full information on any courses you may wish to take. The photographs were supplied through the courtesy of Dr. Paul F. Hawley, of the Illinois Institute of Technology.

ESMWT SCHOOLS

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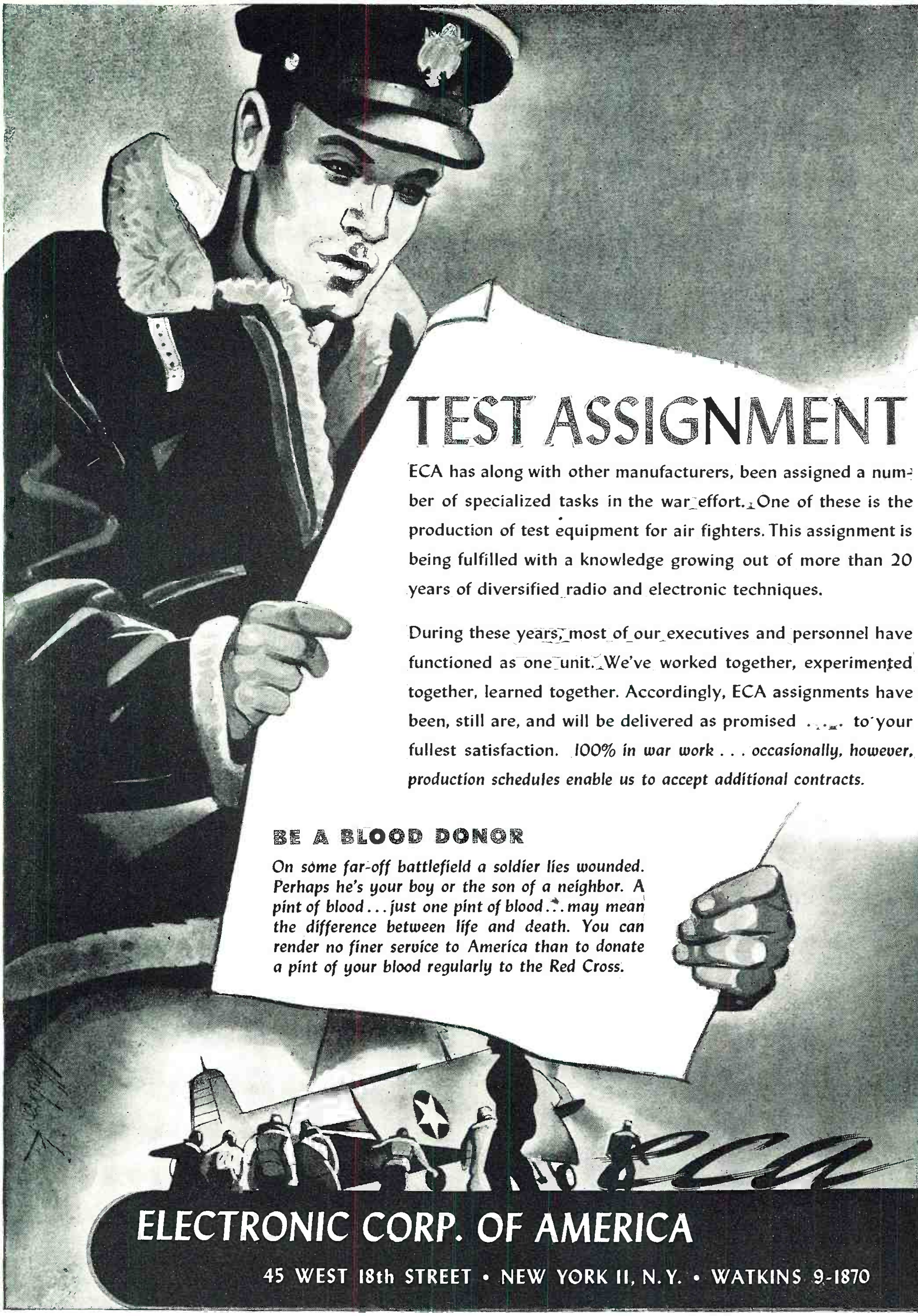
- Alabama Polytechnic Institute
- University of Alabama

CALIFORNIA
- California Institute of Technology
- University of California
- University of Southern California


TEST ASSIGNMENT
ECA has along with other manufacturers, been assigned a number of specialized tasks in the war effort. One of these is the production of test equipment for air fighters. This assignment is being fulfilled with a knowledge growing out of more than 20 years of diversified radio and electronic techniques.
During these years, most of our executives and personnel have functioned as one unit. We've worked together, experimented together, learned together. Accordingly, ECA assignments have been, still are, and will be delivered as promised . . . to your fullest satisfaction. 100% in war work . . . occasionally, however, production schedules enable us to accept additional contracts.
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On some far-off battlefield a soldier lies wounded. Perhaps he's your boy or the son of a neighbor. A pint of blood . . . just one pint of blood . . . may mean the difference between life and death. You can render no finer service to America than to donate a pint of your blood regularly to the Red Cross.
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IOWA
- State University of Iowa

MARYLAND
- Johns Hopkins University
- University of Maryland

MASSACHUSETTS
- Boston College
- Harvard University
- Northeastern University

MICHIGAN
- Detroit Institute of Technology
- Law Institute of Technology
- University of Michigan

MINNESOTA
- University of Minnesota

MISSOURI
- Missouri School of Mines & Metallurgy
- University of Missouri

NEBRASKA
- University of Nebraska

NEW JERSEY
- Rutgers University

NEW YORK
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- Cornell University
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- Polytechnic Institute of Brooklyn
- Pratt Institute
- Rensselaer Polytechnic Institute
- Syracuse University
- Union College

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- University of Oklahoma

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—30—

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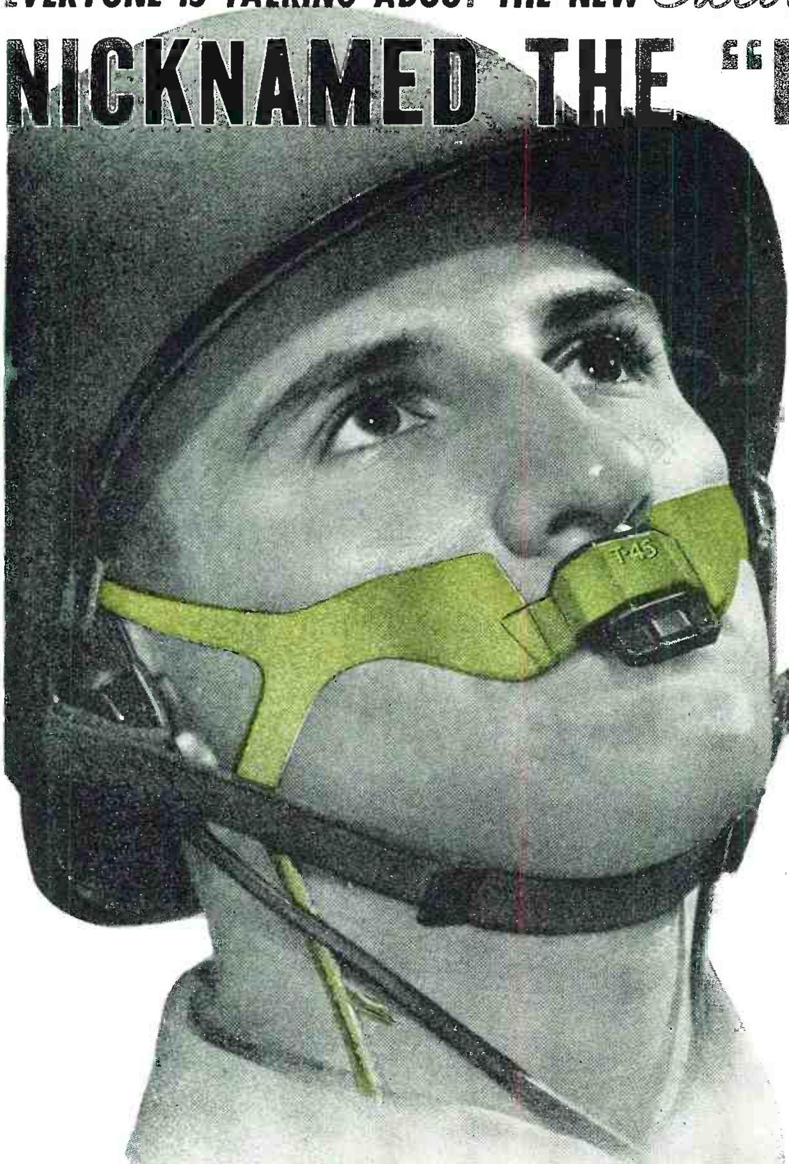

Officially known as the T-45, the

Electro-Voice DIFFERENTIAL MICROPHONE

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Developed by Electro-Voice engineers in close collaboration with the Fort Monmouth Signal Laboratory, the T-45 marks the beginning of a new era in which voice transmission is unaffected by ambient noise or reverberation. It accomplishes such complete suppression of background that speech from a battlefield or from the deafening interior of a moving tank is accompanied by hardly a trace of noise.

The "Lip-Mike" is a Differential Microphone designed to fit under a gas mask without breaking the seal — small enough to allow an Armored Force respirator to slide over it — and has been standardized for all Army Ground Forces.

- *Frequency response substantially flat from 200-4000 cps.*
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- *Uniform response in all positions*
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- *Unaffected by temperature cycles from —40° F. to +185° F.*
- *Ability to withstand complete immersion in water*
- *Physical strength to withstand 10,000 drops*
- *Weight, including harness, cord and plug, less than 2 ounces.*

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Square Wave Testing
(*Continued from page* 25)

that with frequency attenuation and some phase distortion, each corner of a square wave is similarly affected. Increasing phase distortion will cause the square wave to assume an assymetrical shape. Fig. 10 is a good picture of a square wave passed through an amplifier that had excessive phase distortion with some frequency distortion. Many times both appear simultaneously and are easily separated. This need cause little concern, since correcting one type of distortion will, in general, also correct most of the others.

One way to widen the flat-top portion of response curves of resistance-coupled amplifiers is to add a small amount of inductance (usually about 1 mh.) in series with the load resistor R_1. (See Fig. 8B.) This tends to form a resonant circuit with C_T and hence, neutralize the capacitive reactance. If the circuit constants are chosen correctly, this neutralization will occur at the high frequencies. For those who desire more information, references at the end will furnish the desired formulas.

Transformer-coupled amplifiers are sometimes troubled with a sudden rise in gain at the high frequencies due to the resonant circuit formed by the secondary winding and the distributed capacitance of the turns of wire. In Fig. 11, we have the pattern obtained when a square wave is passed through such an amplifier. The oscillations here are plainly visible. These oscillations can be stopped by sufficient damping of the circuit. A resistor across the secondary winding of the transformer corrects the undesired results very nicely.

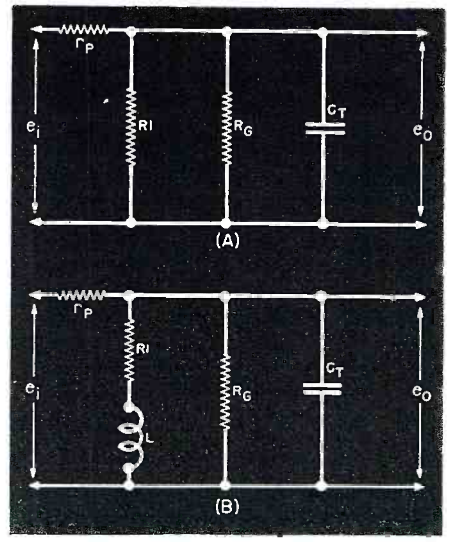
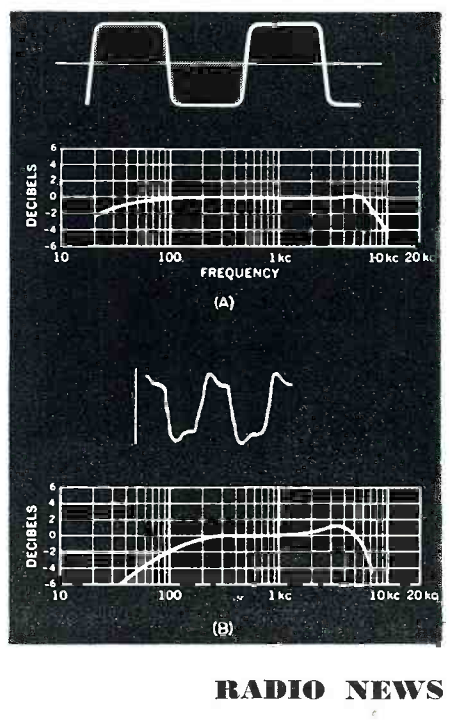


Fig. 8. Equivalent circuits at high frequencies for a resistance-coupled amplifier. (A) Uncompensated. (B) Compensated.

Without going into too much detail, a great deal of which would be repetitious, output patterns of square waves at the high end are shown in Fig. 12. Each type is explained by its associated captions.

Although the discussion so far has been confined almost entirely to wide band audio amplifiers, the response of

Fig. 9. Fidelity curves and wave shapes showing the attenuation at the high frequencies. (A) No phase distortion. (B) With phase distortion.



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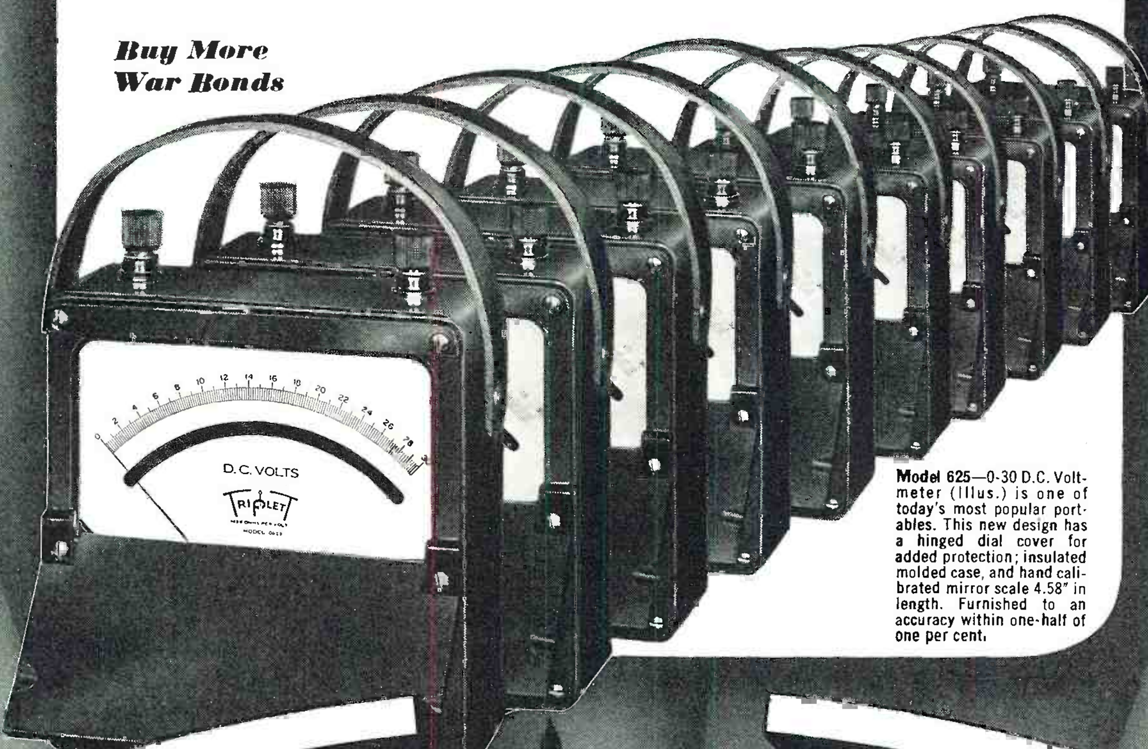

Model 625—0-30 D.C. Voltmeter (Illus.) is one of today's most popular portables. This new design has a hinged dial cover for added protection; insulated molded case, and hand calibrated mirror scale 4.58" in length. Furnished to an accuracy within one-half of one per cent.

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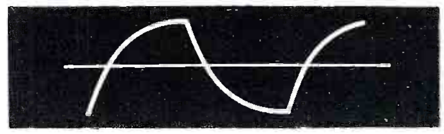


Fig. 10. Wave showing excessive phase and frequency distortion at high frequencies.

R.F. and I.F. amplifiers can likewise be examined for distortion. Many generators used by servicemen have provision for external audio modulation. Instead of the customary sine-wave audio, square-wave audio can be used for ordinary amplitude modulation of the generator on R.F. and I.F. frequencies. The instrument can then be used in the regular way for testing. For example, the generator could be

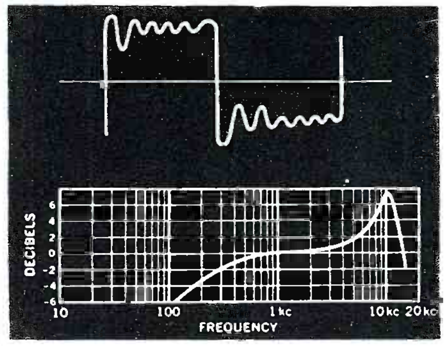
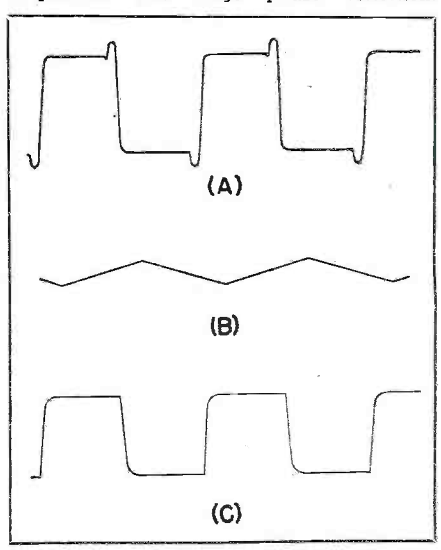


Fig. 11. Fidelity curve and wave shape of output signal showing excess gain at high frequencies and a pronounced underdamping.

connected to the plate of an I.F. tube through a .1-μfd. condenser and the output across the diode detector analyzed. Then the generator could be shifted to the grid of the I.F. tube in the receiver, and again pick up the output from the diode detector. Any departure will indicate distortion and can be accordingly corrected.

Fig. 12. Unusual output wave shapes obtained from faulty amplifiers. (A) Shows good high-frequency response; however, with slight underdamping of oscillations. (B) Both the low and high frequency response of the amplifier are unsatisfactory. (C) Shows some attenuation of high frequencies and large phase distortion.



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One precaution must be observed in using an ordinary oscilloscope for reproducing the square waves on the screen. Most three-inch scopes on the market will not give good response when the repetition frequency of the square wave is lowered to 60 cycles. Even the high-frequency end is not as good as expected, although the range usually extends beyond 30 kc. and will do for ordinary audio amplifiers. The best method of obtaining satisfactory results is accomplished by connecting the output of the amplifier to be tested directly to the vertical plates of the oscilloscope, although at times this may not be feasible due to the small magnitude of the output voltage.

In closing, it is important to mention that amplitudes of square waves are seldom measured. The shapes seen on the oscilloscopes are generally independent of amplitude providing no overloading takes place. Here again is a simplification of the ordinary point-to-point method.

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1. *Seeley and Kimball, "Analysis and Design of Video Amplifiers" RCA Review, October, 1937 and Jan. 1939.*
2. *Freeman and Shantz, "Video Amplifier Design," Electronics, August, 1937.*
3. *Donald G. Fink, "Television Engineering" McGraw Hill Publishing Co., 1940.*
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A-F Signal Tracers
(*Continued from page* 37)

noise, or oscillation. The exact nature of the signal may then be determined by means of a listening test with headphones plugged into the miniature open-circuit jack, J. And the stage

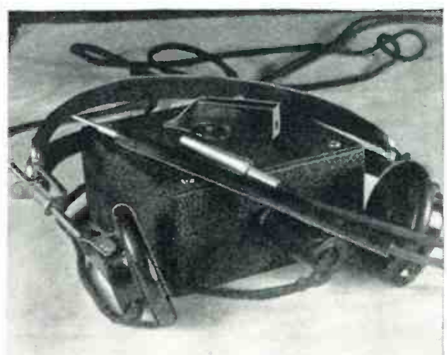

Fig. 6. External view of the complete tracer diagrammed in Fig. 8. The pointer knob in the center of the box is the R control. The instrument box is a 4"x4"x2" Bud case, but may be any convenient container, such as a shield can or miniature instrument case. This tracer has the advantage that the signal volume may be adjusted (with the tested amplifier operating at full gain) for headphone comfort. If the pointer knob is provided with an arbitrarily-graduated dial scale, gain measurements will be possible. In lieu of headphones, a v.t. voltmeter, low-range oxide-type a-c voltmeter, or magic eye indicator may be plugged into the output jack for silent operation or quantitative measurements.

in which this disturbance arises may be quickly isolated.

Tracer No. 4

Tracer No. 4 (See Figure 5) employs a shunt-fed diode rectifier as the input tube and a 6E5 magic-eye tube as the

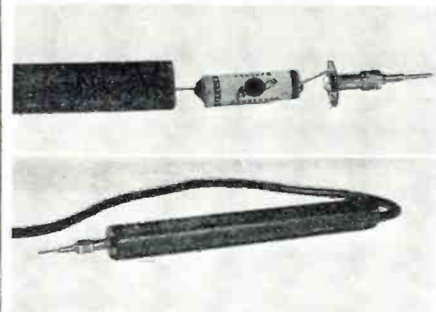

Fig. 7. Photographs of the special tracer probe diagrammed in Fig. 3. This probe is a complete audio-frequency signal tracer in itself. It is internally shielded against stray fields and the isolating capacitor is contained within the probe sleeve. This device may be connected directly to headphones, v. t. voltmeters, or magic-eye circuits. Handy to manipulate, the above probe may be moved successively to various circuit points in tracing the progress of an audio-frequency signal. Note that the blocking capacitor is mounted close to the probe tip to afford short leads. The probe shield is a cylinder of thin metal mounted snugly within the sleeve. For maximum stability, this cylinder may be cemented to the inner wall of the sleeve.

v. t. voltmeter-indicator. The circuit is powered by a built-in supply embracing filter resistor, R_5, the second half of the 6H6 as a half-wave rectifier tube, dual filter capacitor, C_3-C_4, and a 1:1 ratio line transformer, T. If a 1:1 transformer is not available, a substitution may be made by wiring-in two filament transformers "back to back", as shown in Figure 4. The tube heat-

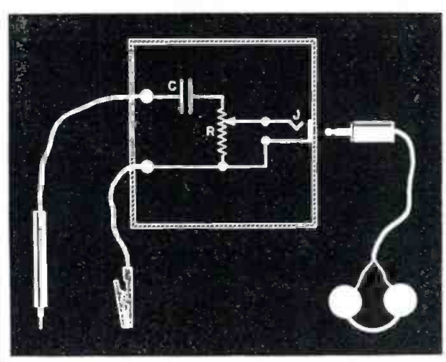

Fig. 8. Tracer, using variable volume control (R), for checking relatively high-level circuits.

ers are connected in series and to the a-c line through the dropping resistor, R_6, which may be of the line-cord variety. If the double-transformer arrangement is employed, however, the heaters may be wired in parallel and connected directly to the 6.3-volt windings, R_6 being dispensed with.

The signal gain control R_3, a 1-meg-ohm potentiometer, may be provided

...Throat Microphones

Sounds transmitted through the throat present different problems in microphone design than sounds transmitted through the mouth. For better design, correlation had to be established between throat vibrations and sounds transmitted by the mouth. To do this, special throat microphones having constant acceleration characteristics were developed for use in conjunction with laboratory standard microphones and frequency analyzers. Experiments covered the frequency range of speech sounds and tests included a variety of callers to study the effect of the thickness of throat tissues. Shure Research has produced a throat microphone that has been declared definitely superior. It is the kind of research that assures you the superior microphones of tomorrow.

SHURE BROTHERS, 225 W. Huron Street, Chicago

Designers and Manufacturers of Microphones and Acoustic Devices

SHURE MICROPHONES

with a dial graduated directly in terms of the ratio of rectified signal voltage (from the 6H6 input stage) to the 6E5 grid voltage required to close the eye shadow. The readings of this dial may then be employed to determine gain in various amplifier circuits.

Steady emission current of the input half of the 6H6, which would otherwise deflect the eye, is balanced out by the single 1½-volt flashlight cell and potentiometer R_2. In the initial adjustment of the tracer, the test leads are removed from terminals T_1 and T_2, and then R_2 is adjusted for a wide open pattern on the 6E5 screen. The balancing adjustment is then complete.

In using Tracer No. 4 for following a signal through an amplifier, the test leads are applied to desired circuit points. A deflection of the eye then indicates presence of the signal. If a number of a-c voltages have previously been applied to input terminals T_1 and T_2 and a voltage calibration made for the R_3 dial, the actual value of traced signal voltage may be determined by adjusting the dial until the eye just closes and reading the voltage from the graduated dial.

If the builder desires, a miniature open-circuit phone jack may be connected between points X and Y across the 6H6 input tube to accommodate a pair of headphones for identification of hum, oscillation, and noise.

Each of the audio-signal tracers described in the foregoing discussion is of simple construction and may be manipulated easily and without complicated adjustments. Care has been taken to select those circuits which make use of components to be found in the spare equipment of any shop or laboratory. No serious demands are made upon strategic parts.

The localizing of electrical trouble in all a-f circuits, whether amplifiers, lines, test equipment or similar systems, is greatly facilitated by the use of a signal tracer. The simplicity of the devices shown in this article in no way minimizes their utility.

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Book Review

(*Continued from page* 40)

ing one single chapter to ultra-short wave applications.

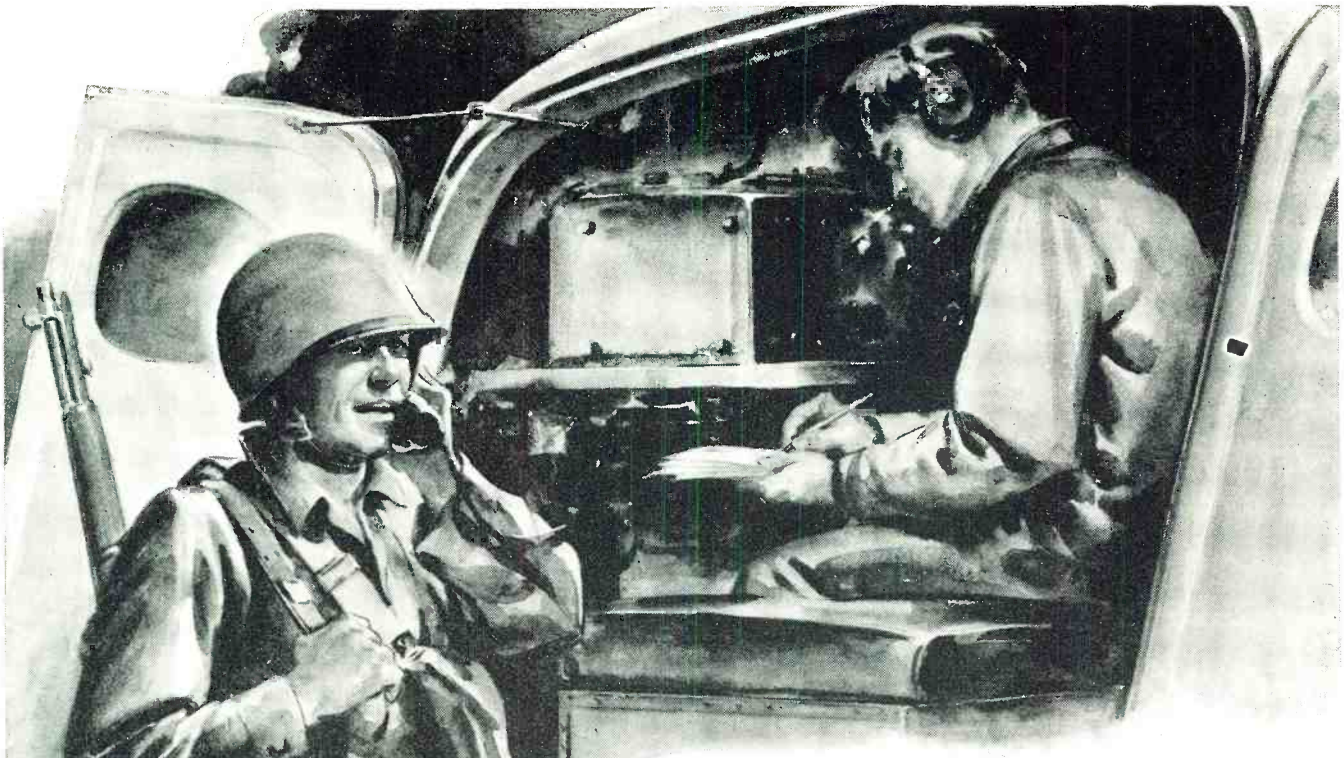
FUNDAMENTAL RADIO EXPERIMENT by Robert C. Higgy, Published by *John Wiley and Sons, Inc.*, New York. 91 pages. Price $1.50.

This laboratory manual describes 32 experiments designed to present the fundamental principles of electricity and radio in a manner that illustrates the application of these principles in radio communication systems. Sufficient theory is indicated to explain the tests to be performed, but the book is not intended to be a complete text. Reference to one of the standard textbooks on radio is desirable to supplement the suggested laboratory work.

In most cases a variety of tests on any one subject is indicated so that some choice may be made of work to be performed that will best fit the equipment available. The suggestions regarding equipment presented throughout the experiments and in the appendix should assist in following the tests with a minimum of equipment.

"A START IN METEOROLOGY," by Armand N. Spitz. Published by the *Norman W. Henley Publishing Co.*, 17 W. 45th St., New York City. 92 pp. plus index. Price $1.50.

The subject of meteorology is one of prime importance to the success of any military mission. The *U. S. Army Signal Corps*, for example, considers this to be one of their most important branches. Many students have sought concrete information which would give them the necessary background for entrance into this branch as a peacetime career. As air navigation itself ex-



When the Advanced Post Talks

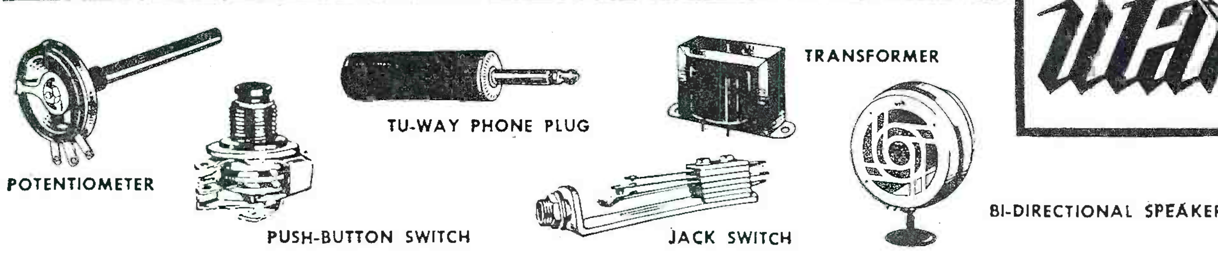
UTAH'S ON THE JOB! : : : Code messages must go through! Every piece of communication equipment must work with precision and perfection.

Utah parts have passed the battle test in advanced positions—behind the lines—in the air—on the sea—on scattered war fronts the world over. In the industrial plants, too, when the weapons of war are being forged . . . Utah parts are doing their job . . . helping to hasten the day of Victory.

When that day arrives : : : more, and even better Utah parts will be available to meet *all* civilian needs.

UTAH RADIO PRODUCTS COMPANY, 824 Orleans Street, Chicago, Illinois. Canadian Office: 560 King Street West, Toronto. In Argentine: UCOA Radio Products Co., S.R.L., Buenos Aires. Cable Address: UTARADIO, Chicago.

utah



pands, so will meteorology. Involving as it does the use of mathematics and radio theory, it is necessary to have a complete knowledge as to the behavior of wind currents, clouds and fog and other information which comes under this category. Many of our readers are also interested in the pursuit of aviation as a profession and there is more interest in meteorology from this viewpoint than ever before.

—30—

QTC

(*Continued from page* 40)

passenger ships. Paul Brown had his last three assignments taken over by the Navy. Paul's brother, Bob, is expected to return to sea. John Totty had some interesting experiences when his ship brought some Nazi prisoners from somewhere to somewhere else. Clarence Scott quit his Liberty assignment with United Fruit and is looking for another berth. Henry Gantt is still up on the Great Lakes with the Federal Barge Line. M. J. Brady is employed at Waterproof, La., on a Government pump barge. What became of Fred Kenzle—still with the airways? Robert Lacey, ex-Navy and more recently of the Merchant Marine has taken a shore job. Bob was in on the last war also.

OVER 6,500 experienced merchant seamen of all the various branches employed aboard ship have returned to the U.S. Merchant Marine during the past year from employment ashore. The War Shipping Administration announced the above figures recently as the results of maritime unions, the press, radio and U.S. Employment Service. Even this figure, combined with present training quotas, does not completely solve the manning problem. Many thousands of experienced seamen must be upgraded and hundreds more ashore must be returned to sea this year if the demands for personnel for our fast growing merchant fleet are to be met. All men with past sea experience are urged to enroll in the U.S. Merchant Marine, unless engaged in a very vital industry, as from the above figures it can be seen that the merchant service will require hundreds of marine radiomen to man the vessels now under construction. W.S.A. is contracting new construction constantly.

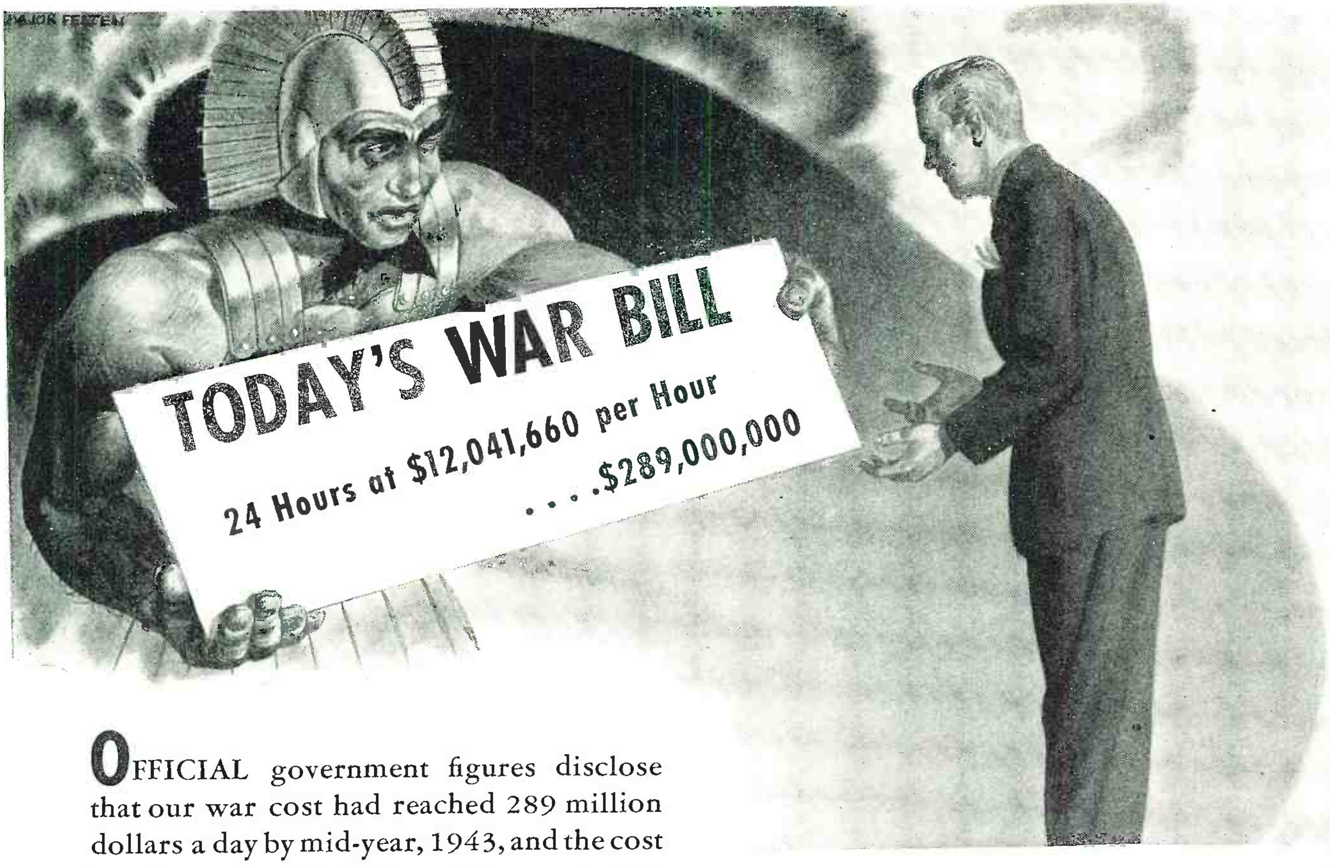
The War Shipping Administration obtained guide books, covering various foreign countries, from the U.S. Army and is putting same aboard ships as they arrive at the larger ports. Three sets are being given each ship, the books cover the customs, habits and peculiarities of the inhabitants and give advance knowledge of the countries which they may visit and will smooth the way for future relations with these people. It will pay well to read these books and obtain information which will be of great help when ashore in various foreign lands.

REGARDING our note not long ago to always carry your commission with you, not long ago at an East Coast port a young third mate was ashore having a bite with a couple of young ladies. He was wearing the uniform and insignia of the Maritime Service. A Maritime Service inspector arrived on the scene and requested to see the Third's commission. The Third produced seaman's papers, etc., and told the inspector that he had just come from one of the warfronts, but he couldn't produce the commission, so the inspector yanked out his knife and detached the Third from his stripes and other insignia to the embarrassment of all, (except the inspector) so let us warn you once again, carry that commission with you at all times. If you are not commissioned don't wear the insignia.

THE R.O.U. reports that not long ago at Baltimore a merchant seaman came ashore after a long and dangerous voyage and walked into the arms of the FBI, who carted him off to jail on charges of being a draft delinquent. It cost him a week in jail and $200 in lawyer's fees before the delinquency charge was lifted and he was then promptly inducted into the Army. All this because he had failed to keep in touch with his local draft board. It could happen to you. Have you been keeping in touch with your local board? Keep them advised of your movements as much as possible; don't take a chance on someone else doing this for you. The various draft boards are still making life hard for these ashore in marine, radio trying to get many of the boys back to sea even though they are doing a very necessary job.

Dr. Blain, Medical Director of the United Seamen's Service, had a very interesting and helpful article in ACA's "msg" on convoy fatigue. Would suggest everyone who can get a copy of this article to read same. There is a good article in same issue about the United Seamen's Service by D. P. Falconer, National Executive Director of the USS.

D. M. Daley is back in New Orleans after an interesting trip to Sicily. Having previously been torpedoed twice and been through aerial bombings constantly, Daley says he prefers nice quiet torpedoings to the ceaseless chatter of anti-aircraft guns. Leonard W. Passano still going strong with the airways. Robert L. Sherman, a Gallups Island man, returned from a 14-months' voyage with the "Malay" and some very interesting experiences. The exciting times the boys are having now will make some real stories when it can all be told after the present war is over. Joseph Bocuzzo returned from northern Russia after a voyage of over a year and collected a real payoff. Joe didn't seem to like the country up that way very much. After resting up back in the good old U.S.A., Joe shipped out again.



OFFICIAL government figures disclose that our war cost had reached 289 million dollars a day by mid-year, 1943, and the cost has been over 7 billion dollars a month ever since.

As manufacturers of communications and aircraft material on which human lives often depend, we know of one heartening reason for this tremendous cost: Uncle Sam will not compromise with quality at the expense of our fighting men. They are getting the finest, most dependable equipment any army ever had. And that saves lives.

Is it any wonder we are being asked to dig down and buy War Bonds until it hurts? And isn't it well worth it, knowing that our sacrifice is maintaining quality as well as quantity of weapons? Our people here at Connecticut Telephone and Electric Division think so . . . they are 100% pledged to regular payroll deductions for War Bonds, on an average of 15% of their incomes.

OUR CONTRIBUTION TO THE WAR EFFORT

GREAT AMERICAN INDUSTRIES INC.

CONNECTICUT TELEPHONE & ELECTRIC DIVISION

MERIDEN, CONNECTICUT

ARMY E NAVY

Engineering, Development, Precision Electrical Manufacturing

Ed Neal and Al Antonacci were in New York a while back to see the boys and say hello. There are still lots of new Gallups Island men coming along and being shipped out, and lots of the boys visiting ACA quarters, which were completely overhauled during the past summer. H. M. Meisinger, now going to school with the Army, has been transferred to the West Coast. Per Johannsen ex-unifruitco joined the Army nearly a year ago and is still unheard from. Uncle Sam picked up a good man when he got that boy. A. Cardella is with the Navy. S. Balcom and A. Hoglund are still sailing the deep blue sea. Another ex-unifruitco, A. Vandenberg, has been unheard from for ages. Uncle Sam is still carrying on a good postal service boys. Well the Christmas season is here again and we hope many of you will be able to enjoy the holidays at home with the folks. Best wishes for a Merry Christmas and Happy New Year.

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Walkie-Talkie

(*Continued from page* 48)

results are obtained. Maximum range is obtained with a 12-section aerial, but under battle conditions smaller aerials probably would be safer.

Aerials may be inserted vertically for use when the operator is in a standing position or at right angles when the operator is in a fox-hole in a prone position.

Two power supplies are provided for the walkie-talkie. The battle battery is a dry-type battery consisting of low-tension, high-tension and bias batteries in a single pack, which fits into a haversack carried on the operator's back.

The vibrator power supply is a separate unit from the set proper and is arranged so that it may be carried in a back pack by the operator. This supply provides high-tension voltage through a vibrator transforming system from secondary cells of the lead-acid type. These cells may be recharged from any storage battery in the field.

Much of the technical data on the instruments remain secret. Range, for example, is described only as "good reliable range for infantry working." The army experts report performance of receiver and transmitter is very satisfactory.

Lifting of the security ban on any secret device such as the walkie-talkie usually indicates that a better product is coming out of the factories. If that is so in walkie-talkies, the new ones probably will be a joint product of Canadian, British and United States designing and experience, for this standardization of signal equipment is one of the features of the co-operative program under way between these countries.

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Mfrs.' Lit.

(*Continued from page* 48)

dio keyers, time delay mechanisms for the protection of vacuum tubes, various types of multiple circuit repeat cycle timers, etc. In many cases, devices are illustrated where *Haydon* products are taking the place of former methods of timing, in which the timers are less complicated, less expensive, and more reliable.

The catalog contains an outline of the principles employed in timing motors, both a-c and d-c, with cutaway views of the motor, brake unit, reset unit, and friction device.

Technical data is included on the full range of timing applications, which will prove helpful to any engineer with a timing problem.

Copies may be obtained by sending a request for catalog No. 112, to the *Haydon Manufacturing Company,* Forestville, Connecticut.

CERAMIC CAPACITORS

"Ceramic Tubular Capacitors" is the title of an Engineers' bulletin now being distributed by *Centralab.* Its eight pages contain tubular capacitor dimensions and capacity and color code charts, beside general descriptive information.

One section is devoted to an explanation of test equipment and controlled temperature compensation. It explains correlation methods and results of experiments.

Send for your free copy of this bulletin by asking for Form 630 Revised; *Centralab,* Division of Globe-Union Inc., 900 East Keefe Avenue, Milwaukee 1, Wisconsin.

RELAYS

The *Guardian Electric Mfg. Co.* has released a new bulletin to provide the electrical engineer with a quick reference to standard relay types and assist him in making a preliminary selection without the necessity of sifting more detailed and time consuming descriptions.

Thumb-nail descriptions suggest applications, give contact ratings and combinations, power requirements, size and weight of 17 types of relays used in aircraft, radio, Signal Corps, and general industrial applications. A short explanation of two popular time relay methods is also included. Another section tells about the new lightweight solenoid contactors built to U.S. Army Air Force specifications. Following this is a paragraph on solenoids giving plunger stroke, lift, and power requirements for 8 standard types of intermittent and continuous duty a-c and d-c solenoids. Ask for Bulletin OF112.

Guardian Electric Mfg. Company, 1630 W. Walnut Street, Chicago, Illinois.

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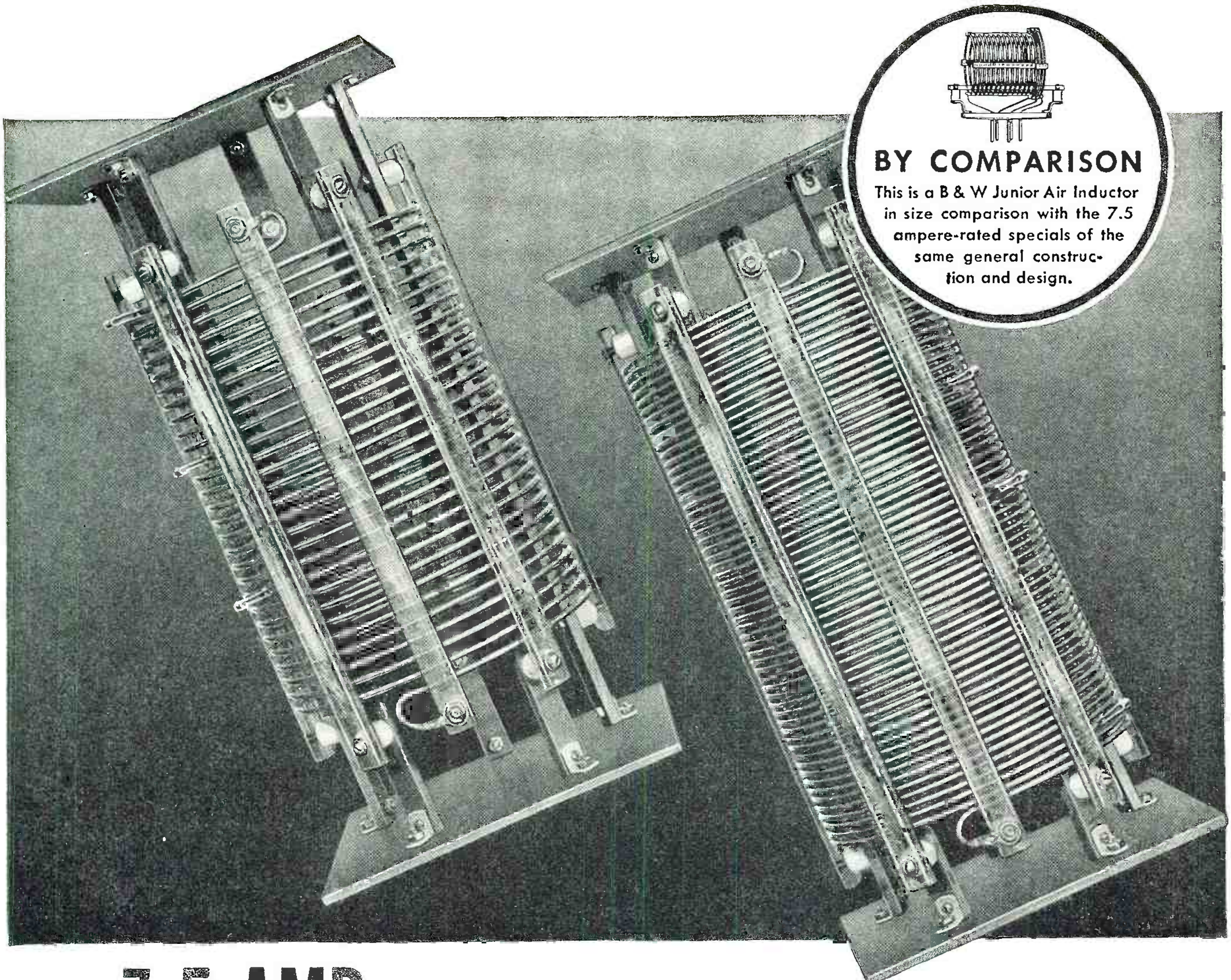
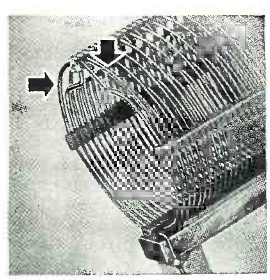


7.5 AMP. CONTINUOUS RATING

But the only thing "Special" is the size

Actually, these 20″ giant B & W Air Inductors, wound with #8 solid wire, are simply grown-up war versions of the famous B & W Junior "Air Wound" Coils of amateur radio fame. The only special feature is the size plus, of course, the attendant bracing of triple x bakelite strips and plates for absolute mechanical rigidity. They're attractive in appearance, sturdy as you'd ever expect coils to be, and serve as interesting examples of B & W's unexcelled facilities for the production of special units—often with only a minimum of change from standard designs of unquestioned dependability.

Coils of this type are available through the entire broadcast frequency range. Adaptations are available for specific applications on any frequency. Other B & W coils in both "Air Wound" and form-construction types can be supplied for practically any inductance requirement. Details on any type, or quotations to your specifications, gladly sent.



HOW TO TAP SMALL COILS—EASILY

Ever try to tap a tiny coil where the turns were so close together you felt as though you were trying to fasten a rope to a middle tooth of a fine-tooth comb? Then you'll appreciate this special B & W small coil indent feature. The windings on either side of the turn you want to tap are indented out of the way, thus making tapping quick and easy, anywhere on the Inductor.

B&W

AIR INDUCTORS

BARKER & WILLIAMSON, 235 FAIRFIELD AVE., UPPER DARBY, PA.

Unique Broadcast

(*Continued from page* 43)

broadcast with a review of the remarkable wartime record established by American railroads and pointed out that freight traffic on the N. & W. measured in ton-miles, per mile of road, is now greater than for any comparable railroad in the United States.

Thus, this system-wide broadcast constituted a conference and "employees meet" involving no loss of hours from a busy wartime job and no traveling for the "delegates." In addition, many thousands of radio listeners among the public served by the railway heard the interesting, first-hand story of what the Norfolk and Western Family is doing to speed victory.

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Spot News

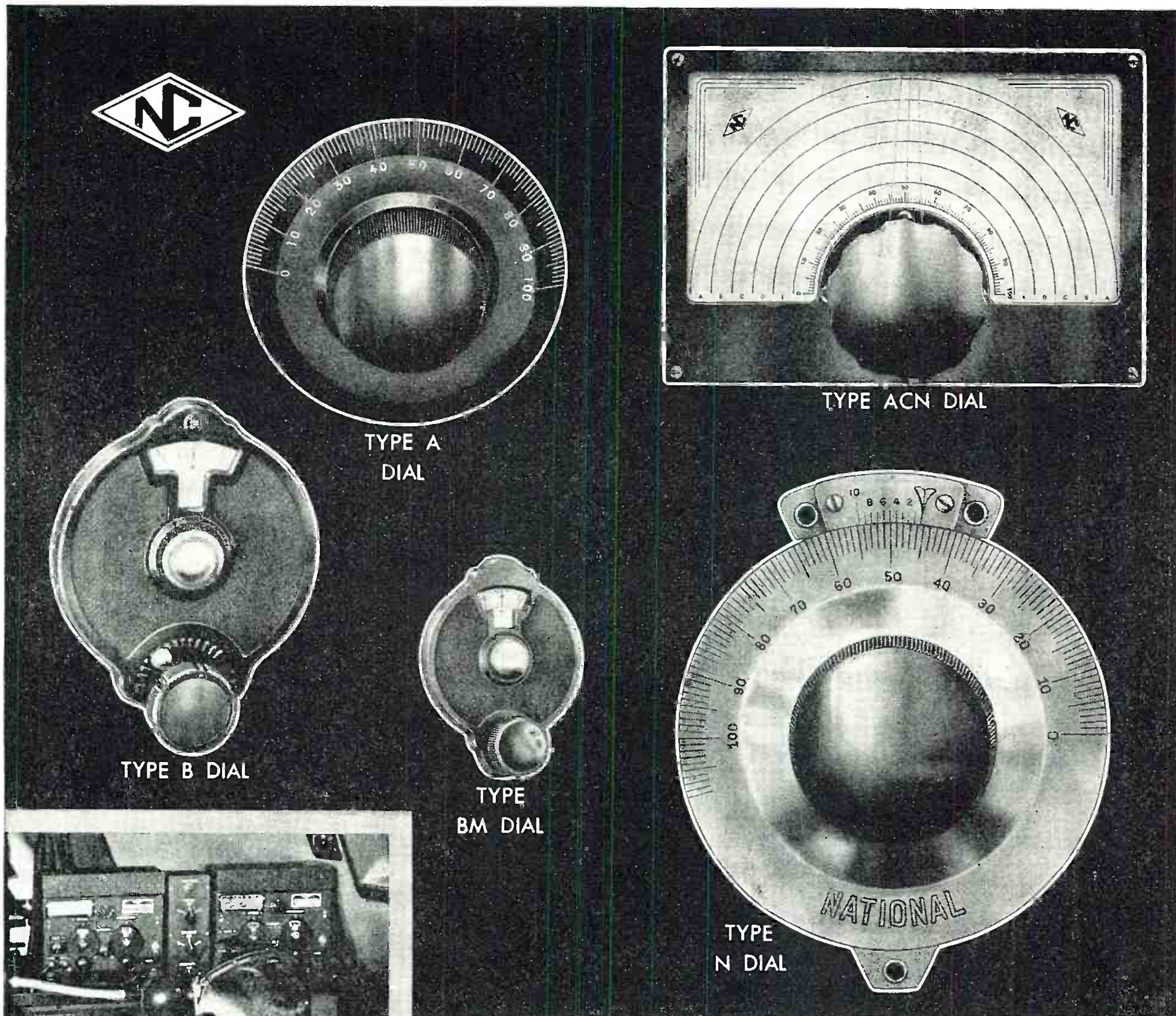
(*Continued from page* 52)

of a riveter was removed by an electromagnet and an ingenious locating unit. The splinter, ⅛" long and buried near the retina, was located by this device which employed the familar reflection method of operation. The exact location of the metal and its depth beneath the surface were indicated on a meter, which registered maximum deflection when the locator was placed over the splinter. Once, of course, the splinter was located, the necessary surgery brought the splinter to the surface. Then it was attracted to the electromagnet for complete extraction from the eyeball.

A REDUCTION of 85 per cent in the amount of copper used in systems to control outdoor and obstruction lighting, and other electrical apparatus at three military bases in North Carolina, Virginia, and New Jersey, is made possible by the use of carrier-current equipment, according to General Electric engineers.

The equipment transmits impulses over the regular power lines at the military bases. These impulses are picked up by receivers, which in turn operate relays to turn on or off the current flowing to electric lights, pumps, and other electrical apparatus. Use of this equipment at the military bases eliminated the necessity of running many miles of separate lines of copper cable to control the various electrical circuits.

FROM A HIDDEN TRANSMITTER IN A MOUNTAIN RETREAT of General Mihailovich's guerrilla forces in the wilds of Yugoslavia we have been receiving the news of the progress of this brave force. Just where the transmitter is, or what is its power is unknown. The station is identified as YTG and according to Press Wireless who is picking up the transmissions, the location is announced as the "woods and mountains of Yugoslavia."



The photograph immediately above shows an installation inside a Pan-American Clipper. National Dials have been a favorite with Pan-American Airways for many years.

TYPE N DIAL—Four-inch diameter with engine divided scale and flush vernier. 5 to 1 ratio.

TYPE ACN DIAL—Designed for direct calibration. Dial bezel size 5" x 7¼".

TYPE B DIAL—Compact, variable-ratio drive inclosed in bakelite case. Illuminator available.

TYPE BM DIAL—Similar to Type B, but smaller in size and having a fixed ratio.

TYPE A DIAL—The Original Velvet Vernier Dial, an unchallenged favorite for twenty years.

ACCURACY —and VELVET DRIVE

In War as in Peace, National Dials provide the smooth effortless control that makes the operator master of his equipment. Enormous increases in our productive capacity are meeting war-time demands, and National Dials are available with reasonably prompt delivery to users having the necessary priority.

NATIONAL COMPANY, INC.
MALDEN, MASS.

Transmission from this station has been fairly consistant according to Press Wireless. There have been moments of interruption.

"In each such instance, the station apologizes, explaining that a big battle was being waged and transmission was not possible," Press Wireless said.

Let's hope that YTG will soon be on the air, from a known destination and on a continuous schedule!

THERE'S A NEW SHELLAC SUBSTITUTE known as Zein, that is said to be as good as the original for many purposes, and in some instances even better. Developed by industrial chemists cooperating with the WPB and Navy, this new synthetic resin is being used in increasing quantities for phonograph records. It can be used, too, as a coating for furniture, radio cabinets, radio coils, etc.

The Navy has found this material so effective that it has transferred large holdings of shellac to the Defense Supplies Corporation for other war uses.

Of course, the new substance is not a complete alternate. There are still many applications requiring shellac. And accordingly, efforts to increase export of shellac from India are under way.

THE RADIO LEGISLATION BATTLE in Washington is gaining momentum daily. In Congress, committee meetings, inner sanctums, and even in the White House, it's radio morning, noon and night. When months ago the FCC investigation was begun by the Select committee with Representative Cox as chairman, only those who were familiar with radio activities entered the disputes. Soon, however, the interest seemed to spread and members of the House began to look into this radio picture. Then came the series of bills to amend the Communications Act. Senators and Representatives really pitched in.

The last few weeks have been exceptionally hectic, for hearings before the Senate Interstate Committee have brought forth the appearance of such specialists as FCC chairman Fly, NAB president Miller, NBC president Niles Trammell, who incidentally has just returned from a tour of the battle fronts, and a host of broadcast station executives and Senators. Testimony has been caustic, with word bombs bursting at ack-ack rate.

Some extent of the sharpness of the comments made during the hearings can be gleaned from the following bits of testimony:

When Senator Wheeler, who is chairman of the Senate Committee holding hearings on the Wheeler-White bill, asked FCC chairman Fly if the networks are still operating, Mr. Fly replied . . . "Yes. The networks are still operating and I think it may shock this committee, in view of the representations which were made and which I know were given serious consideration at that time, that the networks would be destroyed by the regulations; I say, it may shock this committee that the networks are making more money today than they have ever made. I think the past quarter was the most profitable quarter in the history of radio network operation."

It was brought out that the increased profit of stations was due to business conditions and should not, therefore, be taken as a point of direct criticism.

Chairman Wheeler, in discussing the power of stations, asked Mr. Fly if the stations in New York needed 50 kilowatts to cover the territory. Mr. Fly replied that such high power wasn't necessary, but that because of economics the New York stations were granted this power. Mr. Fly also referred to a 10 kilowatt station in the New York area which grossed over a million dollars, mostly on phonograph record playing. Mr. Fly pointed out that higher power stations ought to be located in the West and Middlewest to reach rural areas.

During the hearings, Senator White asked Neville Miller . . . "You take the general position that if there are penalties, prohibitions, or restrictions, which this Commission should have the power to put into effect, that Congress should write them in."

Mr. Miller's reply was . . . "That Congress should write them into the law. I think you get back to the old saying that the right to tax is the right to destroy. You have here a question where the right to license is the right to destroy. You not only destroy the value a man has in his radio station but the value private citizens have in wanting to deal with that radio station. If you extend that continually further you will find that the very power to license radio stations controls not only the business practices of the radio stations but the business practices of property owners in that town who want to deal with that station."

Senator Hawkes then asked . . . "What you are saying, Mr. Miller, is that you would like to have your industry controlled by the rule of law rather than rule of man."

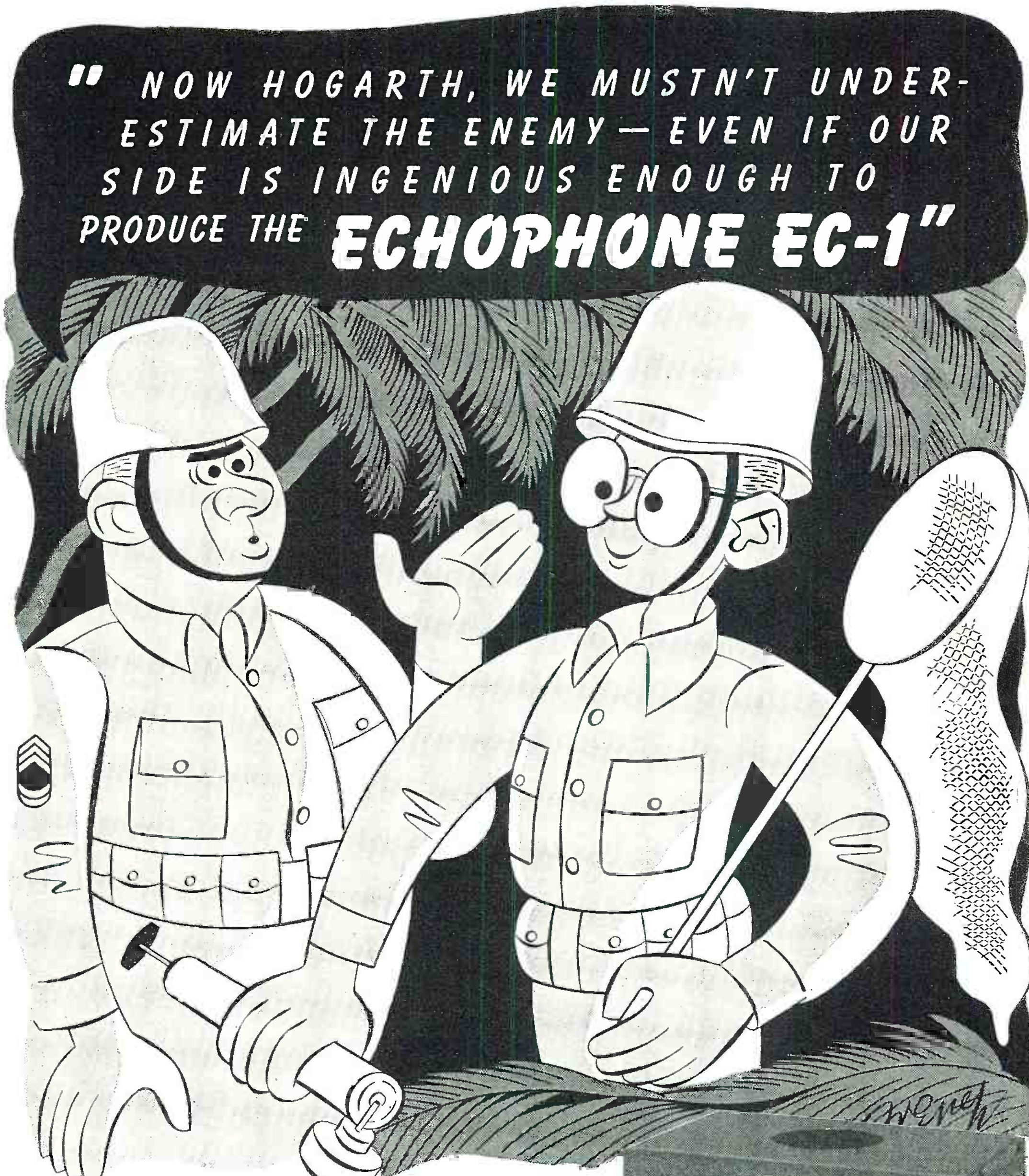
Mr. Miller replied . . . "Yes."

The proposed White-Wheeler bill will be revised undoubtedly as a result of these hearings, and probably presented in a new simplified format for early action by Congress.

We will be watching this Washington theater of operations very closely!

Personals . . .

When **Ted McElroy** received an "E" for his company, the McElroy Manufacturing Co., a host of industry celebrities were in attendance. These included . . . **W. J. Halligan,** president of The Hallicrafters; **J. R. Poppele,** chief engineer, WOR, New York; **Guy Entwistle,** president, Massachusetts Radio School; **William J. McGonigle,** president VWOA; Warrant Officer **F. C. W. Lazenby,** USNR; **J. Frank Rigby,** RCA Communications, Inc., New York; **Mark MacAdam,** chief engineer, Brockton, Mass. Police


" NOW HOGARTH, WE MUSTN'T UNDER-ESTIMATE THE ENEMY — EVEN IF OUR SIDE IS INGENIOUS ENOUGH TO PRODUCE THE ECHOPHONE EC-1"

Department; **Walter Butterworth**, FCC, Boston; **Col. K. B. Lawton**, Chief of Pictorial Section, Office of Chief Signal Officer and **G. H. Clark**, secretary, VWOA . . . **McMurdo Silver** has joined the Grenby Mfg. Co. as vice president and chief engineer of the newly formed radionics division . . . **William S. Paley**, president of CBS, has received the Order of Cristobal Colon—the highest civilian decoration of the Dominican Republic . . . **Parker E. Wiggins** has returned to Sears, Roebuck & Co. as manager of the radio and musical instrument buying division. He was with the War Department as chief business adviser, Procurement and Distribution Service, U.S. Signal Corps . . . **Belmont Radio, Clarostat, Sprague Specialties**, and **IRC** have won second white stars for the "E" flag . . . An "E" has been awarded to **Chicago Telephone Supply Co.** . . . **Rola Co.** has also won an "E" . . . **R. H. Siemens** has succeeded **Paul Bennatt** as chief engineer of RCA Victor in Argentina.

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Practical Radio Course

(*Continued from page* 50)

included between the feedback points. The distortion output is then the distortion d (still actually generated within the amplifier) minus the amplified feedback distortion βDA. That is:

$$D = d - \beta DA, \text{ or}$$

$$D\ (1 + \beta A) = d, \text{ from which}$$

$$D = \frac{d}{1 + \beta A}$$

This equation shows that for a given output the feedback reduces the percentage distortion appearing in the output by the factor $1 + \beta A$. If βA is made large by employing an appreciable amount of feedback, the value of $1 + \beta A$ becomes large and considerable reduction of the distortion results. Comparison of the foregoing formula with that to be derived later for the reduction in gain shows that the harmonic distortion is reduced by a factor approximately equal to the gain reduction factor; that is, the *distortion is reduced in the same ratio as the reduction of amplification that accompanies it.*

Reduction of Hum and Noise

A study of Fig. 4 will reveal why the theoretically ideal inverse feedback action we have been considering will act to correct in the plate circuit waveform any irregularity that does not correspond to the applied signal voltage waveform. Accordingly, noise or hum voltages *developed within the stages included in the feedback loop* will be reduced in exactly the same manner as are the distortions already mentioned, because these extraneous voltages distort the waveform of the output signal.

The effectiveness of the hum or

Micamold

Years ahead—
Years ago

MICAMOLD pioneered in the development of basic capacitor designs many years ago. These designs are still the standards in the field . . . applicable to new electronic techniques as well as to those in general use . . . superior in engineering, construction and service. If you are now engaged in an assignment . . . for present or future use . . . a *Micamold* engineer will be glad to work with you.

KEEP BACKING THE ATTACK . . .
KEEP BUYING MORE WAR BONDS

There's a Micamold Capacitor for All Radionic and Electrical Applications:

Receiving and Transmitting Mica Capacitors • Molded Paper Capacitors • Oil Impregnated Paper Capacitors • Dry Electrolytic Capacitors • Molded Wire Wound Resistors

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noise reduction depends upon the amount of feedback employed and upon the place within the amplifier where the hum or noise voltages are being generated. The reduction is greatest when the hum or noise is generated in the output circuits of the final tube, for then the hum or noise voltages are reduced by the factor $1-\beta A$. If the noise is generated in a lower level stage, the amount of reduction effected by feedback applied to it is decreased, since the loss of gain necessitates additional amplification which also brings up the noise and hum level. If the noise or hum is generated in a circuit *preceding* the stage or stages connected degeneratively, the signal-to-noise (or signal-to-hum) ratio will not be reduced by the feedback.

Negative feedback will therefore *not* reduce hum or noise picked up by a microphone or phono pickup input circuit; or hum pickup, distortion, and thermal agitation produced in the early stages of an amplifier, unless the feedback loop includes the circuits in question, and this usually is impractical. Its principal usefulness from the standpoint of hum is that because of its hum-reduction effect, it permits the use of a less-perfectly filtered power-supply system for the plate circuit of the final stage of amplification. Since this is the stage drawing the heaviest plate current, a worthwhile economy may be effected in the cost of the power supply filter components for it, and in the space they occupy. However, when inverse feedback is used in this way, other contributing factors such as the change of effective plate resistance of the output tubes (as we shall learn later) also affects the hum.

Linearity of the Frequency Response

The linearity of the frequency-response characteristics of the amplifier stages included in the feedback loop may be considerably improved by the correct use of inverse feedback. Consider the case of an amplifier whose frequency response falls off in a certain frequency range, for example, the 50-100 cycle range. When a signal voltage whose frequency lies in this range is applied to the input, the amplified voltage developed across the output circuit is *lower* than that which would be produced by a signal of higher frequency but equal voltage. If the feedback network feeds back the same *percentage* of the output voltage at all frequencies (i.e., is free from frequency discrimination), it is evident that less voltage will be fed back for 50-100 cycle signals than for those of higher frequency, thus allowing the 50-100 cycle input signal voltages effective on the grid to remain higher. Consequently, since the degenerative action does not reduce the over-all gain as much for these as it does for those of higher frequency, it tends to compensate for the falling-off in 50-100 cycle response.

Similarly, if the amplifier gain is

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above normal in any frequency range, such as the high-frequency range, then the output signal voltage at those frequencies will be greater than at the lower frequencies, and more high-frequency voltage will be fed back. This reduces the effective input voltage, so the high-frequency over-all gain is reduced, thus decreasing the high-frequency output and compensating for the original excessive output voltage at those frequencies.

If the feedback factor is increased, this corrective action will become more marked, and under ideal operating conditions with large amounts of feedback the output will remain practically flat despite wide variations in the original frequency-response of the amplifier section included within the feedback loop. Of course, this improvement will be obtained at the sacrifice of some over-all gain.

The two response curves illustrated in Fig. 6, show graphically how the linearity of frequency response can be improved by introducing correctly designed inverse feedback in an amplifier. In this case, the feedback made an enormous improvement in the flatness of both the high-frequency and the low-frequency response. In order to permit direct comparison of characteristics, additional amplification was provided in the amplifier when the feedback was added, in order to bring the over-all gain at 1000 cycles up to that produced by the original amplifier without feedback.

It is important to remember that the application of inverse feedback to improve frequency response functions in the ideal manner explained above, can be made only if the true voltage between the input grid and cathode is the difference between the input and feedback voltages, and if they remain exactly 180° out of phase at all frequencies being considered. As we shall see later, this is not always realized in practical amplifiers.

Analysis of Gain Reduction

It may easily be shown that the effective gain obtained after feedback is introduced is equal to the original gain divided by a figure which depends upon the amount of feedback employed. Referring to the upper diagram in Fig. 7, let E_o be the output signal voltage appearing across the load R_L when the input signal voltage E_s is applied to the amplifier producing amplification A—without inverse feedback. Now let us apply feedback by the simple circuit arrangement illustrated at the bottom. The output signal voltage now is E'_o. A voltage divider (R_1, R_2) across the loudspeaker load (R_L) provides a feedback voltage $\beta E'_o$, where $\beta = R_1/(R_1 + R_2)$, which is fed back in opposition to the input signal voltage E_s. It is assumed that $(R_1 + R_2)$ has a high value compared with the reflected speaker impedance n^2Z_{vc}, so that its shunting effect will not cause appreciable reduction in output power. (Here, n is the turn-ratio of the ouput transform-

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er, and Z_{vc} is the loudspeaker voice coil impedance). To avoid appreciable loss of output power $R_1 + R_2$ should have a value of about 10 times the load resistance. Remember that the amplifier itself is unchanged; that is, its voltage amplification is still A. Now,

without feedback, $E_o = AE_s$

and *with* feedback, $E'_o = A(E_s - \beta E'_o)$

from which $E'_o = AE_s - A\beta E'_o$

transposing, we obtain, $E'_o + A\beta E'_o = AE_s$

from which, $E'_o(1 + A\beta) = AE_s$

or, $E'_o = \dfrac{AE_s}{1 + \beta A}$

The gain reduction factor due to feedback is therefore

$$1 + \beta A$$

The quantity βA is termed the *feedback factor,* and represents the amplitude of the feedback voltage superimposed upon input signal E_s compared with the actual voltage applied to the input terminals.

It should be remembered always that whenever the amplification A is encountered in inverse feedback formulas and discussions, it refers only to the amplification produced by the portion of the amplifier included within the feedback loop. It does not mean the total amplification of the complete amplifier if the amplifier extends beyond this loop. For example, if a 3-stage amplifier is being considered and feedback is accomplished only over the last two stages, it is the amplification of *these* two stages only that is used in the equations, not the amplification of the entire three stages. For feedback analysis purposes, such a 3-stage amplifier is treated as a 1-stage conventional preamplifier and a 2-stage feedback amplifier.

Appreciable reductions in plate circuit distortion, plate resistance, hum, etc., may be obtained by the use of large amounts of inverse feedback. However, the amount of gain required from the stage in question is a limiting factor. In actual design, the amount of inverse feedback employed is a compromise between the gain required and the desired reduction in distortion or other objectionable effect. If there is enough gain in the previous stages, and if the driver tube can supply the necessary peak voltage, it will be advisable to increase the amount of inverse feedback in order to reduce the plate resistance and the plate circuit distortion, etc. However, if a tube having a fairly low plate resistance is

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being used, and if the plate circuit distortion has a reasonable value, there is not much advantage gained in further reducing the gain by the addition of more inverse feedback.

If the reduction in the overall gain and power output caused by the inverse feedback cannot be tolerated in the use to which the amplifier is to be put, they may be brought up to normal level by adding the necessary amount of voltage amplifier (driver) stages to the amplifier. Frequently, when inverse feedback is added to an existing amplifier, the additional voltage amplification required may be obtained by making the necessary circuit changes and employing more recent types of tubes, pending higher amplification. Care should be taken however, not to allow these changes to increase the distortion present in the signal applied to the stage containing the feedback loop for the inverse feedback exerts corrective action only on distortion, etc., originating in the part of the amplifier within the feedback loop—not on the input signal applied to it.

(*To be continued in March issue*)

For the Record

(*Continued from page 4*)

for use in China. These units would then find their way to a country which could well stand a vast network of reliable communications. Other countries too would welcome an opportunity to acquire such equipment. We here in America have the necessary production facilities and engineering skill to produce communications equipment of outstanding merit.

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THE 1944 Special U. S. Army Signal Corps Issue is fast taking shape. Since our original announcement last month several outstanding articles have been added to augment the impressive array of material previously scheduled. We can promise our readers that this outstanding contribution will set a new record in the radio publishing field.

SINCE this issue will find its way into your hands at the beginning of the holiday season, we would like to take time out from the routine of publishing RADIO NEWS to extend our sincere best wishes for a joyous Christmas. It is true that this Christmas will find many of our readers serving on various battlefronts and our Christmas wish is, sincerely, that these men will soon achieve the real "Peace on Earth, Goodwill toward men." As we begin the New Year, we cannot help but feel that in 1944 we will all have a renewed opportunity to dedicate ourselves to the winning of the war so that our families may be reunited for a really Happy and Victorious Holiday in 1944.

—O. R.

Statement of the ownership, management, circulation, etc., required by the Acts of Congress of August 24, 1912, and March 3, 1933, of Radio News, published monthly at Chicago, Illinois, for Oct. 1, 1943. State of Illinois, County of Cook, ss. Before me, a notary public in and for the State and county aforesaid, personally appeared A. T. Pullen, who, having been duly sworn according to law, deposes and says that he is the business manager of Radio News and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, as amended by the Act of March 3, 1933, embodied in section 537, Postal Laws and Regulations, printed on the reverse of this form, to wit: 1. That the names and addresses of the publisher, editor, managing editor and business managers are: Publisher, William B. Ziff, 540 N. Michigan Ave., Chicago 11, Ill.; Editor, B. G. Davis, 540 N. Michigan Ave., Chicago 11, Ill.; Managing Editor, Oliver Read, 540 N. Michigan Ave., Chicago 11, Ill.; Business Manager, A. T. Pullen, 540 N. Michigan Ave., Chicago 11, Ill. 2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company or other unincorporated concern, its name and address, as well as those of each individual member, must be given.) Ziff-Davis Publishing Co., 540 N. Michigan Ave., Chicago 11, Ill.; W. B. Ziff Co., 540 N. Michigan Ave., Chicago 11, Ill.; William B. Ziff, 540 N. Michigan Ave., Chicago 11, Ill.; B. G. Davis, 540 N. Michigan Ave., Chicago 11, Ill.; A. Ziff, 540 N. Michigan Ave., Chicago 11, Ill.; S. Davis, 540 N. Michigan Ave., Chicago 11, Ill. 3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities: (If there are none, so state.) None. 4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company, but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him. 5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the twelve months preceding the date shown above is .... (This information is required from daily publications only.) A. T. Pullen, Business Manager. (Signature of business manager.) Sworn to and subscribed before me this 30th day of September, 1943.
[Seal.] Mae Harris, Notary Public. (My commission expires Sept. 11, 1944.)

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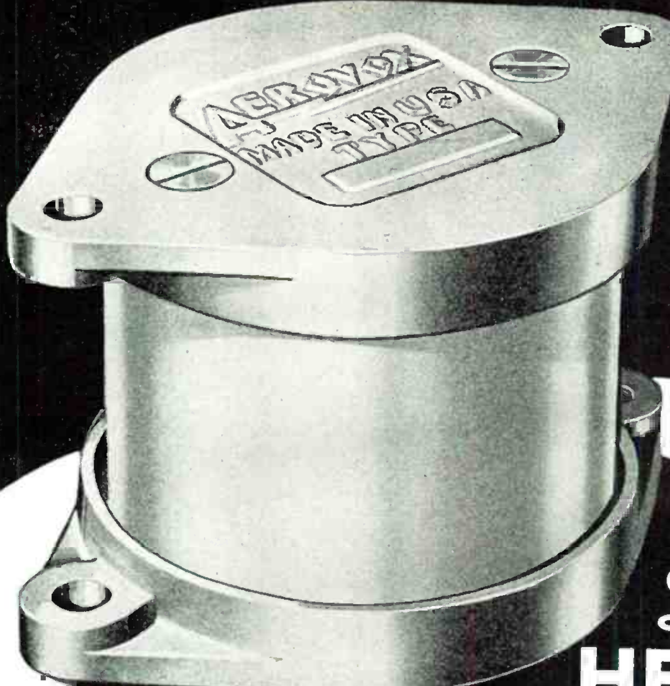

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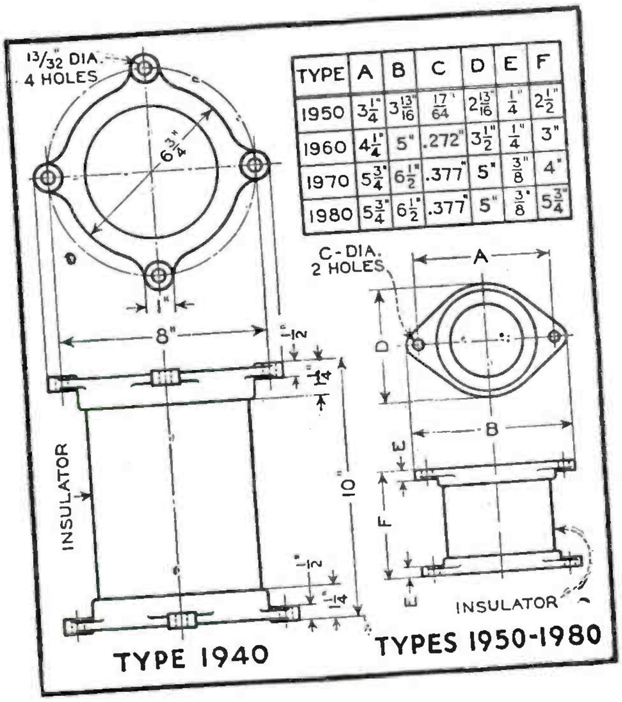

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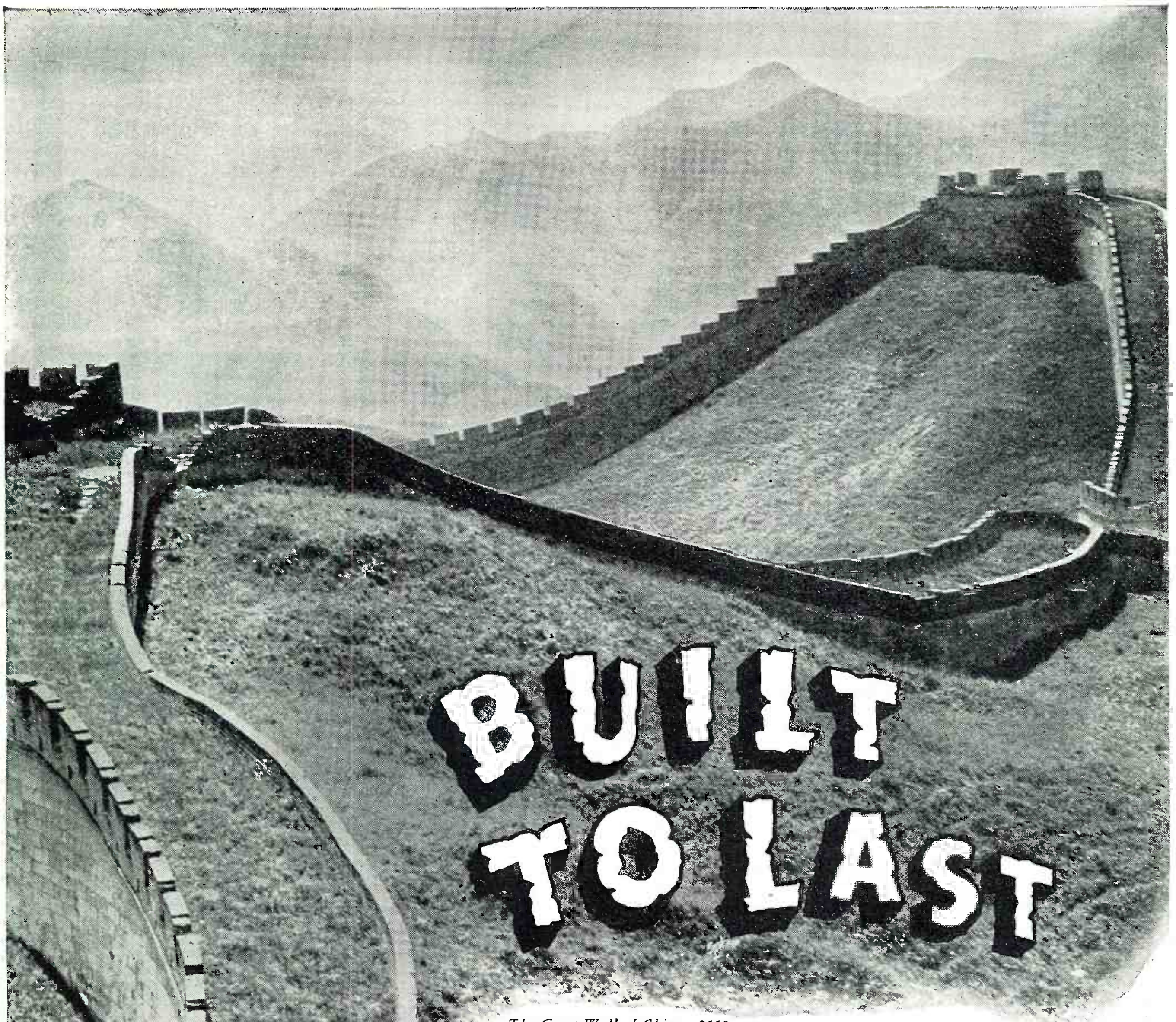

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TEST VOLTAGE . . .	Twice D.C. rating
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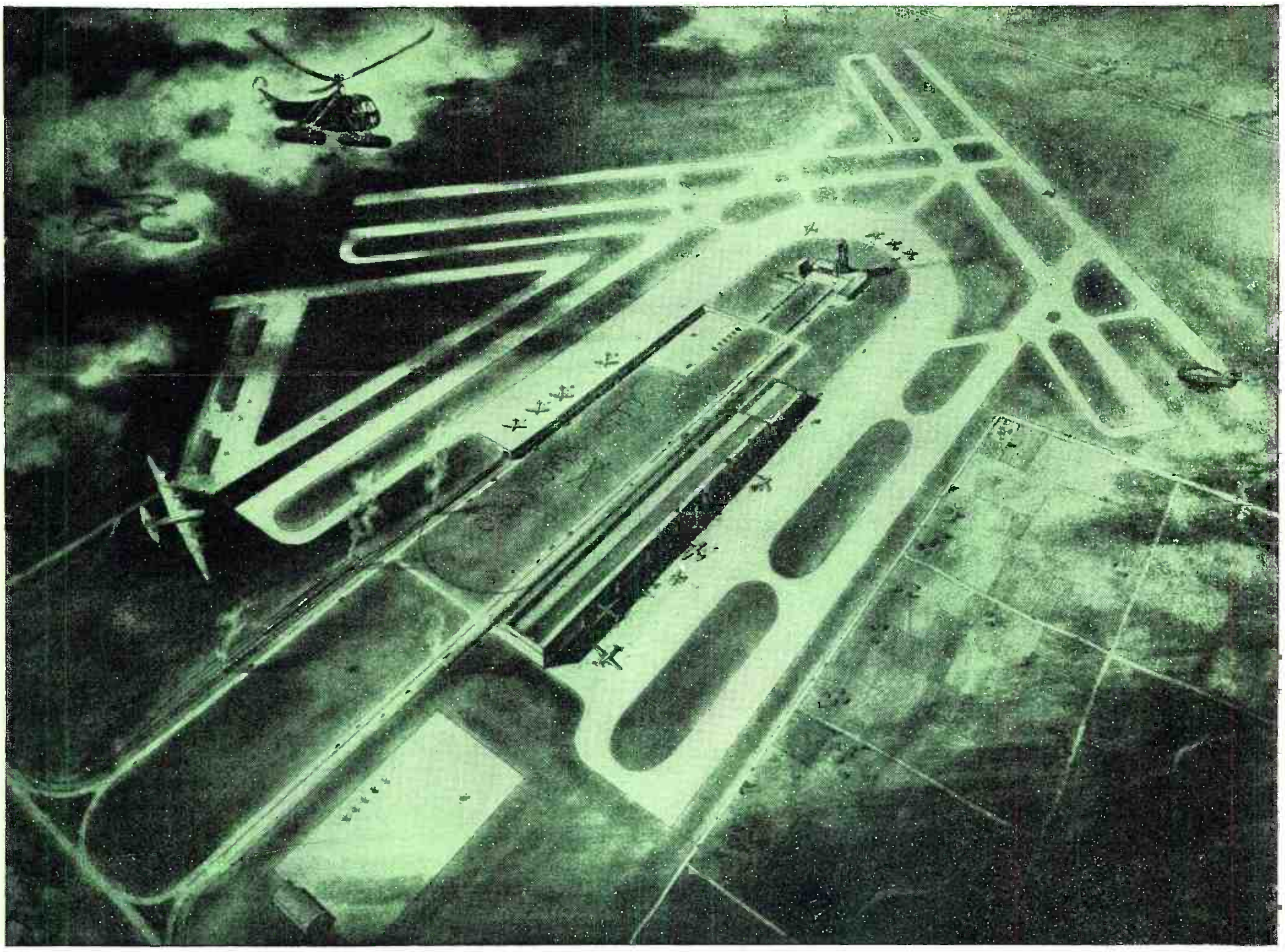

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