THE MARCH OF TELEVISION

RADIO NEWS

March
25 Cents

Radio Surgery
Triple-Twin Tube
Newest Set Tester

Televising the "Races"

Train *with* R.T.A. *for* Radio *Service* Work

Important and far-reaching developments in Radio create sudden demand for specially equipped and specially trained Radio Service Men.

This excellent set analyzer and trouble shooter included with our course of training

MANY skilled Radio Service Men are needed now to service all-electric sets. By becoming a certified R. T. A. Service Man, you can make big money, full time or spare time, and fit yourself for the big-pay opportunities that Radio offers.

We will quickly give you the training you need to qualify as a Radio service man . . . certify you . . . furnish you with a marvelous Radio Set Analyzer. This wonder instrument, together with our training, will enable you to compete successfully with experts who have been in the radio business for years. With its help you can quickly diagnose any ailing Radio set. The training we give you will enable you to make necessary analyses and repairs.

Serving as a "radio doctor" with this Radio Set Analyzer is but one of the many easy ways by which we help you make money out of Radio. Wiring rooms for Radio, installing and servicing sets for dealers, building and installing automobile Radio sets, constructing and installing short wave receivers . . . those are a few of the other ways in which our members are cashing in on Radio.

As a member of the Radio Training Association, you receive personal instruction from skilled Radio Engineers. Upon completion of the training, they will advise you personally on any problems which arise in your work. The Association will help you make money in your spare time, increase your pay, or start you in business. The easiest, quickest, best-paying way for you to get into Radio is by joining the Radio Training Association.

This amazing Radio Set Analyzer plus the instructions given you by the Association will transform you into an expert quickly. With it, you can locate troubles in all types of sets, test circuits, measure resistance and condenser capacities, detect defective tubes. Knowing how to make repairs is easy; knowing what the trouble is requires expert knowledge and a Radio Set Analyzer. With this Radio Set Analyzer, you will be able to give expert service and make big money. Possessing this set analyzer and knowing how to use it will be but one of the benefits that will be yours as a member of the R. T. A.

Write for No-Cost Membership Plan

We have worked out a plan whereby a membership enrollment need not cost you a cent. Our thorough training and the valuable Radio set analyzer can be yours. Write at once and find out how easily both of these can be earned.

Now is the time to prepare to be a Radio Service Man. Greater opportunities are opening up right along. For the sake of extra money in your spare time, bigger pay, a business of your own, a position with a future, get in touch with the Radio Training Association of America now.

Send for this No-Cost Membership Plan and Free Radio Handbook that will open your eyes as to what Radio has in store for the ambitious man. Don't wait. Do it now.

RADIO TRAINING ASSOCIATION OF AMERICA
Dept. RNA-3 4513 Ravenswood Ave. Chicago, Ill.

Fill Out and Mail Today!

RADIO TRAINING ASSOCIATION OF AMERICA
Dept. RNA-3, 4513 Ravenswood Ave., Chicago, Ill.

Gentlemen: Send me details of your No-Cost Membership Enrollment Plan and information on how to learn to make real money in radio quick.

Name..

Address..

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

S. Gordon Taylor
Technical Editor

William C. Dorf
Associate Editor

RADIO NEWS

Raymond J. Kelly
Associate Editor

Jos. F. Odenbach
Art Editor

Edited by Laurence M. Cockaday

VOLUME XIII — March, 1932 — NUMBER 9

CONTENTS

(*Cover Design by Morey*)

DEPARTMENTS

Published Monthly by Teck Publishing Corporation, *Washington and South Avenues, Dunellen, N. J.*

EDITORIAL AND EXECUTIVE OFFICES
350 HUDSON STREET, NEW YORK CITY, N. Y.

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Broadcasting stations need trained men continually for jobs paying $1,200 to $5,000 a year.

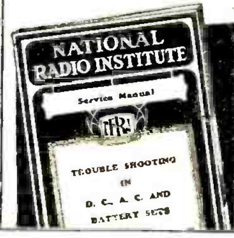
Television—the coming field of many great opportunities—is covered by my course.

Operators on ships see the world and get good pay plus expenses.

Aviation is needing more and more trained Radio men. Operators employed through the Civil Service Commission earn $1,620 to $2,800 a year.

Special Free Offer

Act now and receive in addition to my big free book "Rich Rewards in Radio," this Service Manual on D.C., A.C., and Battery operated sets. Only my students could have this book in the past. Now readers of this magazine who mail the coupon will receive it free. Overcoming hum, noises of all kinds, fading signals, broad tuning, howls and oscillations, poor distance reception, distorted or muffled signals, poor Audio and Radio Frequency amplification and other vital information is contained in it. Get a free copy by mailing the coupon below.



You'll Get *Thrills*-Adventure BIG PAY in RADIO

J. E. Smith, Pres.

I will Train You at Home to Fill a Fascinating Job in Radio

Radio's Amazing Growth is Opening Hundreds of Big Jobs Every Year

You like action, romance, thrills! You'll get them in Radio—plenty of them! Big pay, too. That is why I urge you to mail the coupon below for my free book of startling facts on the variety of fascinating, money-making opportunities in this great, uncrowded field. It also explains how you can quickly learn Radio through my amazingly simple 50-50 method of home-study training, even though you may not now know the difference between a "Screen Grid and a Gridiron." Thousands of men who knew absolutely nothing about Radio before taking my course are today making real money in this growing industry.

Thrilling Jobs That Pay $50 to $100 a Week

Why go along with $25, $30 or $45 a week in dull, no-future work when there are plenty of good jobs in Radio that pay $50, $75, $100 and more a week? For instance, by taking my training, you can see the world in grand style as a Radio operator on shipboard. There are many splendid openings in this line with good pay plus your expenses. You'll also find thrills and real pay in Aviation Radio work. Broadcasting is another field that offers big pay and fascinating opportunities to men who know Radio. And think of the great, thrilling future for men with *Radio training* in Television and Talking Movies. My free book tells all about these and many other branches of Radio that bring you in contact with interesting people, pay big money and make life pleasant for you. Without doubt, Radio training is the key that opens the way to success. And *my* training, in particular, is the *only* training that makes you a *RADIO-TRICIAN*—the magic word that means valuable recognition for you in whatever type of Radio work you take up after graduation. You'll see *why*, when you receive my interesting book.

Many Earn $200 to $1000 in Spare Time While Learning

You don't have to quit your present job to take my course! You stay right at home, hold your job, and learn in your spare time. I teach you to begin making extra money shortly after you enroll. My new practical method makes this possible. I give you experimental outfits that teach you to build and service practically every type of receiving set made. Many of my students earn $15, $20, $30 weekly while learning. Lynn Henderson, 817 Elgin Court, Jackson, Mich., writes: "I have made at least $1,500 servicing and repairing Radio sets and I am just starting my thirty-third lesson."

Get My Free Book

Send the coupon below for my 64-page book of opportunities in Radio and information on my home-study training. It has put hundreds of fellows on the road to bigger pay and success. It will tell you exactly what Radio offers you, and what my Employment Department does to help you get into Radio after you graduate. I back my training with a signed agreement to refund every penny of your money if, after completion, you are not satisfied with the Lesson and Instruction Service I give you. Fill in and mail the coupon NOW!

J. E. SMITH, Pres., Dept. 2CR
National Radio Institute
Washington, D. C.

Travelled 75,000 Miles

"Dear Mr. Smith: I have worked as Junior Operator on board S. S. Dorchester and Chief Operator of the Chester Sun. I have travelled from 75,000 to 100,000 miles, visited ports in various countries, fished and motored with millionaires, been on airplane flights, etc." Robin D. Compton, Radio Station KSAC, Manhattan, Kansas.

$400 a Month

"The Radio field is getting bigger and better every year. I have made more than $400 each month and it really was your course that brought me to this." J. G. Dahlstead, Station KYA, San Francisco, Cal.

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Act Now

Mail Coupon Today

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Dear Mr. Smith: I want to take advantage of your Special Offer. Send me your two books "Trouble Shooting in D.C., A.C. and Battery Sets" and "Rich Rewards in Radio." I understand this does not obligate me and that no salesman will call.

NAME..

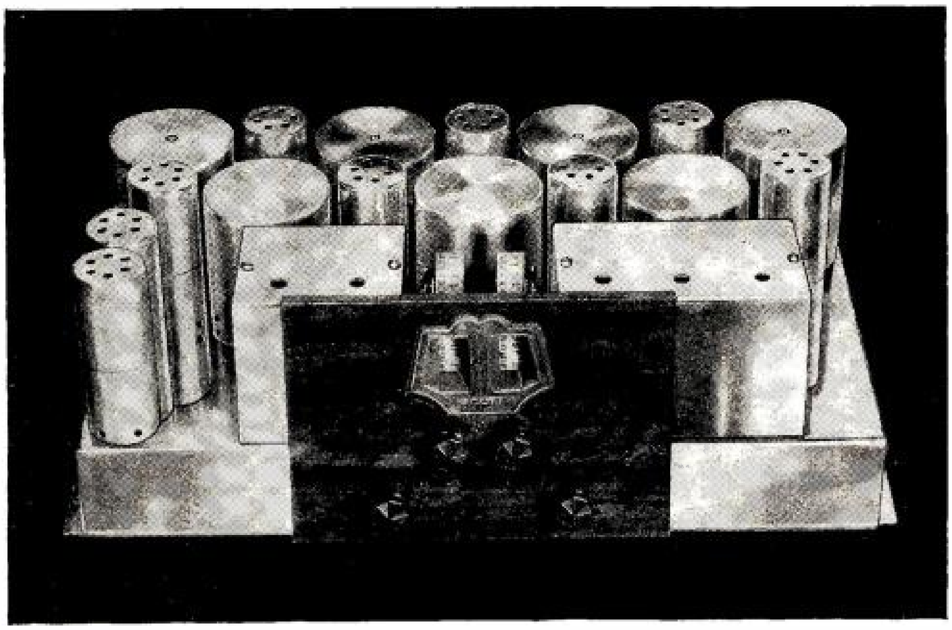
ADDRESS..

CITY.............................STATE............

"M"

OCCUPATION..

The SCOTT 15-550 METER ALL-WAVE is the only

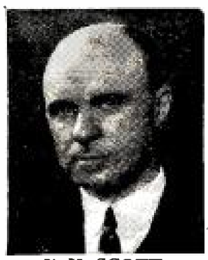


living in 63 foreign countries have voluntarily written their testimony of the Scott All-Wave's prowess as a dependable 'round the world receiver. Six big volumes of unsolicited praise from over 600 owners—and there are hundreds more Scott All-Wave users who are too busy listening to the whole world, to write us!

ZEESEN GERMANY

JOAK JAPAN

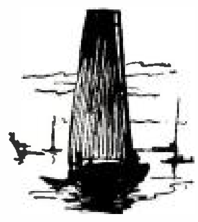
SINCE the advent of the Scott All-Wave 15-550 meter superheterodyne, this receiver has become the preference of extremely particular listeners, the world over. It has become the radio of Kings and Presidents—of American Consuls abroad and of Foreign Consuls here—of music masters—of broadcasting stations who use it to pick up short wave transmissions for re-broadcast—and it has become the dependable instrument of radio broadcast advertisers who need a receiver with a wide daytime range and with tonal capability by which the quality of advertising broadcasts may be accurately checked. And its owners have written enough praising letters about this receiver to fill six big volumes! Think! Not six volumes of ordinary testimonial letters, expressing mere satisfaction, but rampantly enthusiastic letters that tell of loud, clear, perfect reception from stations 7,000 to 10,000 miles away. They're letters from American owners who tune in Europe and the Orient as fancy dictates. And there are letters from foreign owners, men and women located at all points of the globe, who listen to America and other far-off lands with their Scott All-Wave receivers.



E. H. SCOTT
Pioneer Builder of World Record Receivers

Scott owners living in every state in the Union have written, just to tell us that the Scott All-Wave they purchased, gives them more than the results we promised them—more than we are promising you here. And people

SPECIFICATIONS
Custom built in the laboratory—by laboratory experts and entirely to laboratory standards. Superheterodyne circuit. Covers all wave lengths 15-550 meters. Twelve tubes. Pre-selector R. F. stage. Three I. F. stages. Double push-pull audio. Perfectly matched speaker. All coils treated to withstand climatic extremes. Chassis and amplifier chromium plated.



VK3ME AUSTRALIA

Expect Great Things

If you live in the United States, order your Scott All-Wave in full anticipation of hearing London, Paris or Rome! Your set will be tested on actual reception from one of the stations in these countries before shipping. Order it too, in full belief that you will hear Germany, France, Holland, Australia, Indo-China, South America, Central America, Cuba, and the other strange places you've always wondered about. You'll *hear* them with your Scott All-Wave—and with perfect clarity and exact tone! Then remember, your Scott All-Wave is guaranteed for five full years against defect in material or workmanship—the broadest, most completely protective guarantee ever placed on radio equipment.

Result of Round-the-World Research

The Scott All-Wave was not designed to be just a good receiver for domestic reception. Instead, it was designed and built especially for foreign reception, by an engineer who has made 3 complete trips around the globe to study radio conditions—and overcomes the difficulties heretofore encountered in such work. Perfected for reception of foreign stations, the Scott All-Wave automatically became the most efficient receiver possible to buy, for domestic work.

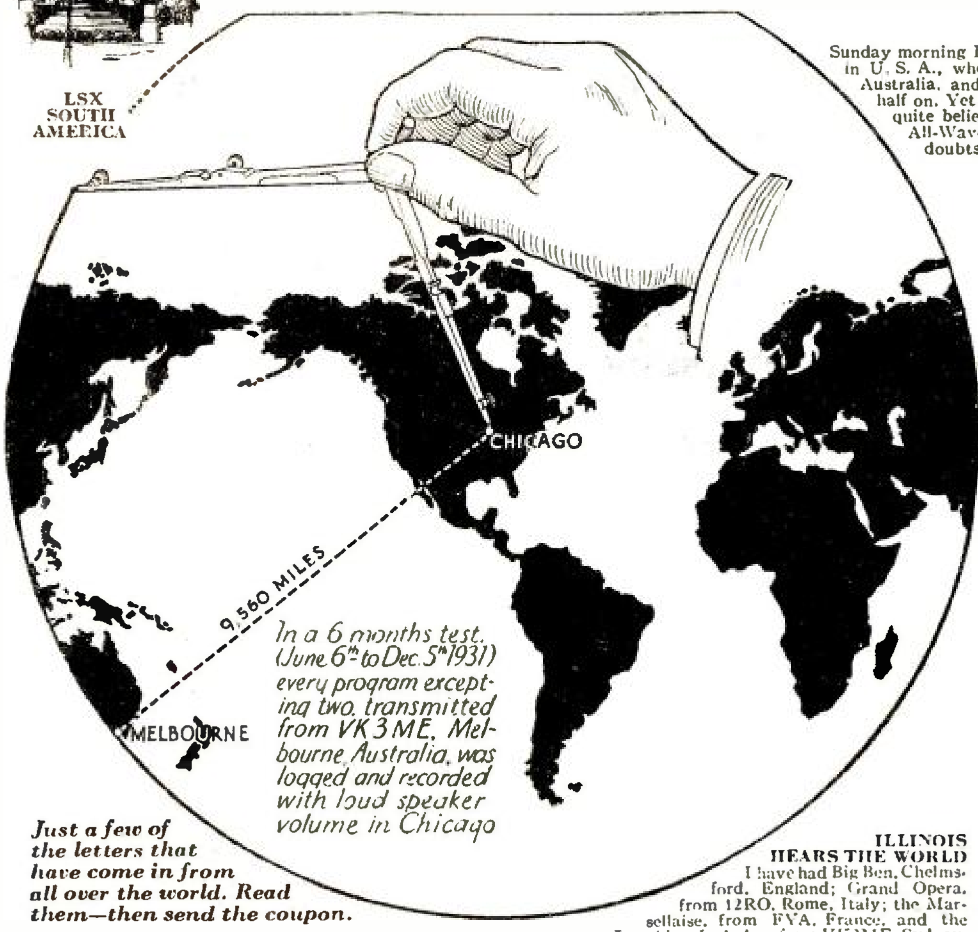
The E. H. SCOTT RADIO LABORATORIES, INC.

(Formerly Scott Transformer Co.) • 4450 Ravenswood Avenue • Dept. N3 • Chicago, Ill.

G5SW
ENGLAND

receiver built especially for FOREIGN RECEPTION...

LSX
SOUTH
AMERICA



Just a few of the letters that have come in from all over the world. Read them—then send the coupon.

VK2ME TOO LOUD

Sunday morning I was listening to what I thought was a station in U. S. A., when in comes the call-letters, VK2ME, Sydney, Australia, and I only had the volume control turned about half on. Yet it was too loud for room reception. I could not quite believe all the testimonials I read about the Scott All-Wave, but results this morning have removed all my doubts that the Scott is the King of all radio sets.
B. Firmer, Mich.

EUROPE LIKE LOCAL

I am getting England, Italy and France, good as local stations on just an inside aerial.
B. Leger, Mass.

CUBA HEARS CHICAGO

The Scott Receiver is just what we need here in Cuba. On the long wave we have had over 50 stations in U. S.; on the short waves, I have had Schenectady, Pittsburgh, Boston, Chicago, etc. Also Italy, with as much volume as I get Pittsburgh.
B. Chibas, Cuba.

GREECE HEARS THEM ALL

Performance on the set has been very satisfactory. Have been receiving London, Budapest, Prague, and Belgrade, Poulouse, Barcelona, etc., and a score of unknown stations.
M. D. Cenerales, Greece

HAWAII LIKES SCOTT

Station F31CD, Indo-China, comes in every night as clear as a bell, while W2XAF, I can tune in any time of the day they are on the air.
E. Bernard, Hawaii.

THE PHILIPPINES, TOO

The Scott All-Wave Receiver is far beyond my expectations. So far I have logged London, Romanapoli, Radio Colonial France, Moscow, Russia, Saigon, Indo-China, and Japanese stations on short wave.
R. A. Balanquit, P. I.

ITALY LIKE LOCAL

The performance is simply wonderful. The same day the set arrived I got Italy as clear and strong as though it were a local station.
R. Collazo, Porto Rico.

PORTO RICO GETS ENGLAND

Daylight reception of English, French, and Italian stations is constant with loud speaker volume. They come in with a bang.
J. M. Lieber, Porto Rico.

SIAM HEARS EUROPE

Although in a reputed bad location I have logged Chelmsford, Rome, Holland, Paris, and U. S. A. stations with fine volume.
W. Knox, Siam.

ILLINOIS HEARS THE WORLD

I have had Big Ben, Chelmsford, England; Grand Opera, from 12RO, Rome, Italy; the Marsellaise, from FYA, France, and the Laughing Jack Ass, from VK2ME, Sydney, Australia. I am writing to express to you my greatest thrill since I began twisting the dials.
G. Bermel, Illinois.

RECORDED AUSTRALIA

Last Saturday night I received VK2ME, Australia, loud enough to make a record of it. It suddenly gave me a thrill to hear the announcer say "The time is 20 minutes to 4, Sunday afternoon," when it was 20 minutes to 12 Saturday night here.
J. R. Cole, Miss.

NEW ZEALAND REGULARLY

Have had 5 nights consecutive reception of complete program from 2YA, Wellington, New Zealand. One night I had them for nearly 3½ hours, using an aerial only 49 ft. long.
A. R. Miller, Calif.

CONNECTICUT HEARS EGYPT

Reception on short wave nothing short of marvelous. I picked up the Belgenland, in Alexandria Harbor, Egypt. Australia comes in as loud as a local.
J. B. Tracy, Conn.

SEND COUPON *for full Particulars*

Read a few of the letters from the six big volumes of praise. They're reproduced on this page. Then send coupon for the whole story of the Scott All-Wave—for particulars of the advanced design and precision engineering and custom construction which make its sensational performance possible. You'll be surprised, too, at its moderate price. Clip the coupon—mail at once.

THE E. H. SCOTT RADIO LABORATORIES, Inc.
4450 Ravenswood Ave., Dept. N3, Chicago, Ill.

Send me full details of the Scott All-Wave

☐ SET BUILDER ☐ DXER ☐ DEALER

Name..............................

Street..............................

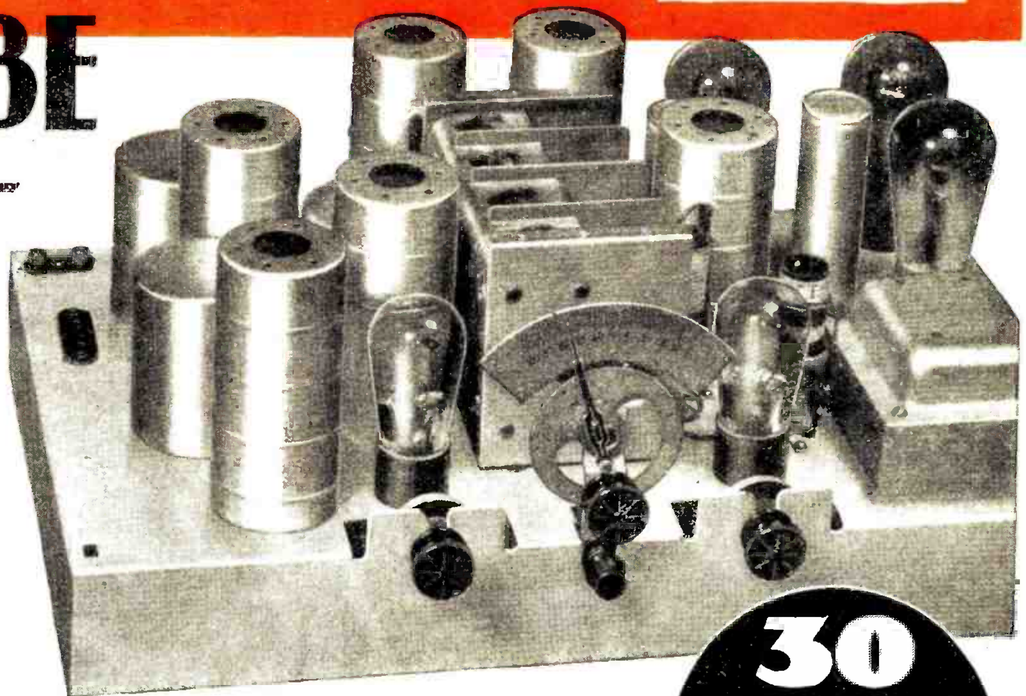
Town.................... *State*....................

Only $37.50

COMPLETELY ASSEMBLED WITH LARGE DYNAMIC SPEAKER!

Pentode Variable-Mu and REAL AUTOMATIC VOLUME CONTROL

11-TUBE Super-Het.



RADIO FANS! What a radio! A powerful new 11-tube super-het. at an unbelievably low price. Reception equal to *fifteen* ordinary tubes — in a perfectly balanced, non-oscillating, non-radiating, super-heterodyne TEN-TUNED circuit with *real automatic volume control* that holds those powerful locals down to the same volume as the distant stations and counteracts that annoying fading on weak stations. Two Push-pull Pentode power output tubes with twice the power and four times the sensitivity of ordinary 45's—and Multi-Mu tubes, together with a –24 first detector, gives you SIX SCREEN GRIDS. These six screen grids, together with the –27 oscillator, second detector, first A. F., and automatic volume control—the –80 tubes—gives total of ELEVEN TUBES. The use of a *band-pass* or *pre-selector* stage, together with Multi-Mu full range tubes, makes this radio actually surpass 10 K. C. selectivity. Absolutely eliminates those noisy singing "birdies" and annoying cross talk. You'll be positively amazed and delighted when you see this sensational new set—hear the beautiful, mellow, cathedral tone—know what it means to have that pin-dot selectivity and unequaled sensitivity together with true tone fidelity.

Be convinced—TRY A MIDWEST 30 DAYS BEFORE YOU BUY. Don't send a penny. Mail coupon right now for amazing FREE trial offer and complete details. You'll be surprised.

TERMS AS LOW AS $5.00 DOWN

30 DAYS FREE TRIAL

Deal Direct with Factory

SAVE UP TO 50%

Never before in the history of radio has such a powerful set been offered at Midwest's amazing low price. Deal direct with the big MIDWEST factory. Save the jobber's profit. Your outfit will reach you splendidly packed, rigidly tested with everything in place ready to plug in. No assembling! Entertain yourself for 30 days absolutely FREE—then decide. Save up to 50 per cent in buying direct from factory—insure satisfaction—deal direct with the world's veteran radio builders—MIDWEST. And don't forget—every MIDWEST outfit is backed by an absolute guarantee of satisfaction. You take no risk.

Complete Line of Consoles

Rush the coupon for big, beautiful catalog that illustrates the complete line of MIDWEST console cabinets. All new. All different. You'll gasp with admiration when you see the vast selection of beauty, style and grace that is crafted into every MIDWEST Console. The catalog is FREE—it doesn't cost you a penny! Rush the coupon—NOW!

Read What Enthusiastic Users Say! . . .

California User Hears Japan and Australia

"It is a great thrill to jump to all parts of the U. S., Mexico, Canada, as well as Cuba and Honolulu with my eleven tube Midwest. From 1:00 to 5:00 A.M. nearly all the Japanese and Australian stations come in, weather permitting. Every day I am finding new stations that I have never heard before."
Harry C. Jones, Graeagle, Calif.

Gets California, Mexico Havana, Nova Scotia

"I have received my Midwest set in perfect condition and am well pleased with the Cowboy Model L-11. I have received stations KFI and KGO in California, CMK—Havana, VAS—Glace Bay, N. S., XER—Villa Acuna, Mexico. I have a log of 38 stations for the first night. I have received police stations from Chicago and Cincinnati and am able to separate the stations better than I have seen on any other set regardless of price. I can compare my set with my mother's set which cost $225.00 which is four times as much as I paid."
Edw. Billingham, Lebanon, Pa.

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USER AGENTS
We pay you BIG MONEY just for showing your radio to friends and neighbors. Easy EXTRA MONEY! Check coupon for details!

Midwest Radio Corp.
Dept. 53,
Cincinnati, Ohio

Without obligation on my part send me your new 1932 catalog and complete details of your liberal 30-day free trial offer. This is NOT an order.

Name ....
Address ....
Town .... State ....

☐ Send me SPECIAL USER AGENTS' PROPOSITION

MIDWEST RADIO CORP.

Dept. 53 — Established 1920 — Cincinnati, Ohio

The Editor—to *You*

DO you know how the broadcasts from ships, airplanes, submarines, and even the play-by-play reports of golf tournaments are made possible so that you can hear the results over your favorite broadcasting station? It is not possible to run wires from a broadcasting studio to moving vehicles and it is not practical to run trailing wires between the studio and the out-of-the-way places a golfer gets into. Many people wonder how it is done. It is actually done by means of a new short-wave broadcasting link, what we have termed a "walking transmitter," that can be carried by the announcer or by a field engineer, which sends out, via radio, the events to be broadcast. These low-powered short-wave signals are then picked up by a short-wave receiver, located nearby at a base or directly at the studio, and placed upon the modulating apparatus of the transmitter. Everett Walker tells of this new development in this issue.

* * *

DID you know that most of the fundamental principles of television were discovered and put into actual practice many years ago and that the scanning disc is "as old as the hills"? Read Lieut. Wenstrom's survey under the title "The March of Television."

* * *

DID you know that radio waves of very short lengths could produce fever in living individuals and if applied in sufficent amounts to certain small animals could produce paralysis and even stop the action of the brain? Dr. Saxl tells of some of the new applications of radio in surgery and, as well as discussing some of the biological phenomena, tells how these extremely short waves can be used instead of the surgeon's knife in performing bloodless operations.

* * *

Do you know the principles upon which the various types of loudspeakers operate, how they are constructed and how they are being improved? Dr. Free gives you this information in his article on page 758.

* * *

DID you hear about the new triple-twin tube which can be used to replace the detector and all of the audio amplifier and power tubes in a modern radio receiver? See the contents page for John Borst's enlightening article on this subject.

* * *

HAVE you heard what RADIO NEWS is doing for the hard-of-hearing, in a series of articles telling how the science of electronics can be applied in overcoming this handicap for the deaf by means of vacuum-tube circuits, amplifiers and microphones? Read Mr. Royce's article on a group hearing device for the hard-of-hearing to be used in theatres, auditoriums and churches.

* * *

Do you understand how curves and charts are used in technical descriptions in radio, or are they "over your head"? Read the series of articles on the use of graphs and charts in radio of which the article on page 772 of this issue is the third.

* * *

Do you need a set tester in your work that will perform many new tasks and that you can build, simply, on your work-bench at a reasonably low cost? Read of this new development in Mr. Gerber's article in this issue. He tells you how to build it and how to operate it satisfactorily for all servicing and testing work.

* * *

Do you read all of the articles and the departments in which you are interested in RADIO NEWS, consistently and carefully? If you are occupied in the radio industry it will pay you to do so. If you are a student trying to gain needed education in this field, it will pay you well. If you are an engineer, you will find many things in the following pages that may have a direct bearing on your present work. If you are an experimenter, you will find new things to do and new solutions to your problems. If you are a set builder, you will find advanced designs to work on, whether you are experienced or a beginner. If you are interested in radio at all, you will find a complete monthly roster of new developments and activities in the radio field.

* * *

THE Editors are always glad to hear from readers regarding their needs and desires for future articles. We shall feel well pleased if we are able to include, each month, one article of specific interest to every type of reader, as well as the general articles which keep a man posted on what is going on.

* * *

THE following are excerpts from readers' letters regarding the contents of RADIO NEWS:

"I have not been a subscriber to RADIO NEWS very long, but, believe me, I certainly do enjoy reading it. When I get through with one issue I can hardly wait for the next one. I enjoy articles by Mr. Zeh Bouck and by Mr. S. Gordon Taylor especially well."

ELDON W. PAYNE, Hudson, N. C.

* * *

"I HAVE enjoyed your articles in RADIO NEWS and think they are of great value to us who keep radio and electrical equipment in repair. After going to school to learn repair methods, I was in need of a tester and built the one described in RADIO NEWS by Mr. George Fleming. I still am using it and feel that I have a home-built tester that has an edge on a lot of the factory jobs."

EARL MASTERSON,
East St. Louis, Ill.

* * *

"MAY I congratulate you for the excellent articles and circuits you publish in your wonderful magazine. RADIO NEWS. It may be of some interest to you to know of the results I have had on the short-wave set published in the October issue. Among some of the stations I have received on it are VK2ME, Sydney, Australia; 13RO, Rome, Italy; PCJ, Holland; G5SW, Chelmsford, England; VRY, Georgetown, British Guiana; SUS, Cairo, Egypt; CM2MK, Havana, Cuba; XDA, Mexico; CGA, Drummondville, Canada; KIO, Kahuhu, Hawaii; KIXR, Manila, P. I.; LSN, Buenos Aires; VE9CL, Winnipeg, Canada."

FRED L. DAVEY,
Port Hope, Ont., Can.

* * *

SOME of our readers take great pains to insure their copies of RADIO NEWS from going astray. Here is a letter from Burton Proctor of Preston, Maryland. He says: "Wouldn't it be possible for you to make up my address plate with the name 'Maryland' written out in full? The reason I want this done is because my last copy went to Preston, Missouri, before it came to me and held me up a few days. Anyone can mistake the abbreviation Md. for Mo., and, as this has happened a number of times, it delays me in getting my magazine. I hope you can do it, because I expect to be a subscriber to RADIO NEWS as long as I last and it lasts."

* * *

"FOLLOWING the contents of RADIO NEWS for a considerable length of time, I am convinced that it is the only medium by which radio men can keep in close contact with all branches of radio science and industry."

ABDUL KERIM, Istanbul, Turkey.

* * *

"IT IS not often I write to RADIO NEWS. I have taken it for nine years and have preserved every number. I should hate to be without it. Here is wishing you every success."

FRANK VINCENT,
N. Battleford, Sask., Can.

* * *

"AS A reader for some years now of RADIO NEWS, I take the opportunity, notwithstanding that a foreigner's views may not cut much ice, on your magazine. I like it. I read it with avidity and considerable interest. I get the September issue in the middle of August. It is, I think, more comprehensive and intelligently instructive than any we have here."

C. J. TEMPERLEY,
Newcastle-on-Tyne, England.

* * *

"YOUR publication stands alone as a textbook for the serviceman and engineer."

GEO. V. SANGOMEE, Harrisburg, Pa.

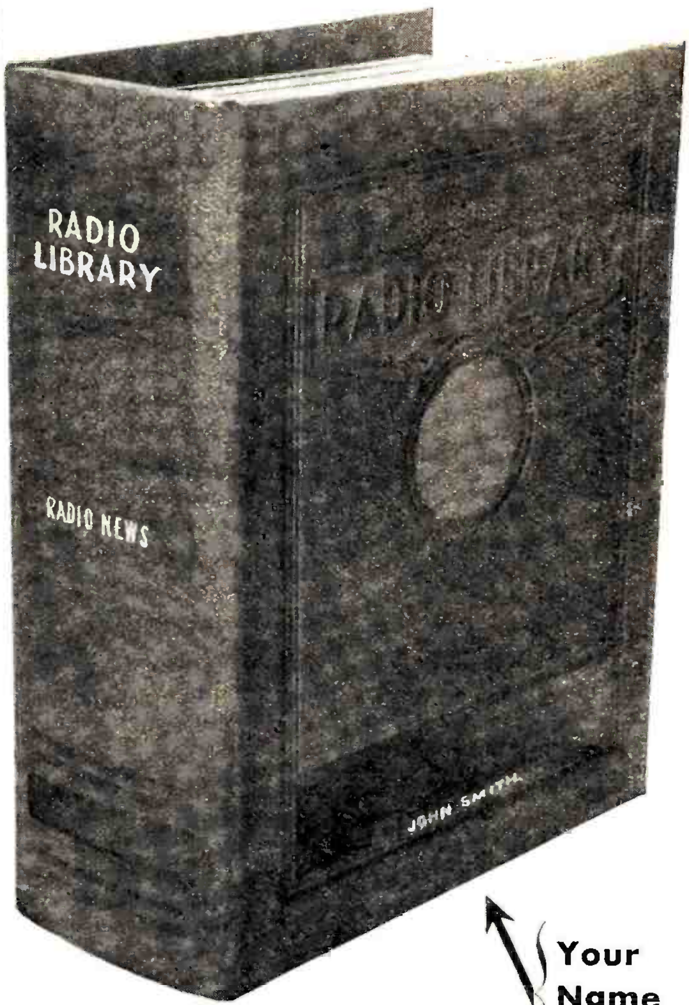
* * *

"BELIEVE me, there is nothing like RADIO NEWS in the radio world."

EDW. L. MARVIN, Los Angeles, Cal.

Laurence M. Cockaday

File Your Copies of RADIO NEWS



Your Name Here

This Beautiful Magazine Binder FREE with 2-Year Subscription for RADIO NEWS

AFTER months of experimenting and exhaustive tests, we have secured for you this handsome binder, manufactured to hold 24 copies of Radio News. A complete two-year file of issues.

Strongly made, durably covered in washable tan pigskin fabricoid, embossed in gold, with all metal parts plated, this binder is built to give a life-time of service.

It is a binder which you will be proud to add to your "Radio Library" shelves.

For a limited time, we are offering one of these handsome binders FREE with a 2-year subscription for Radio News.

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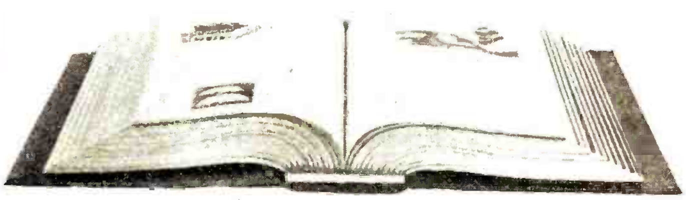

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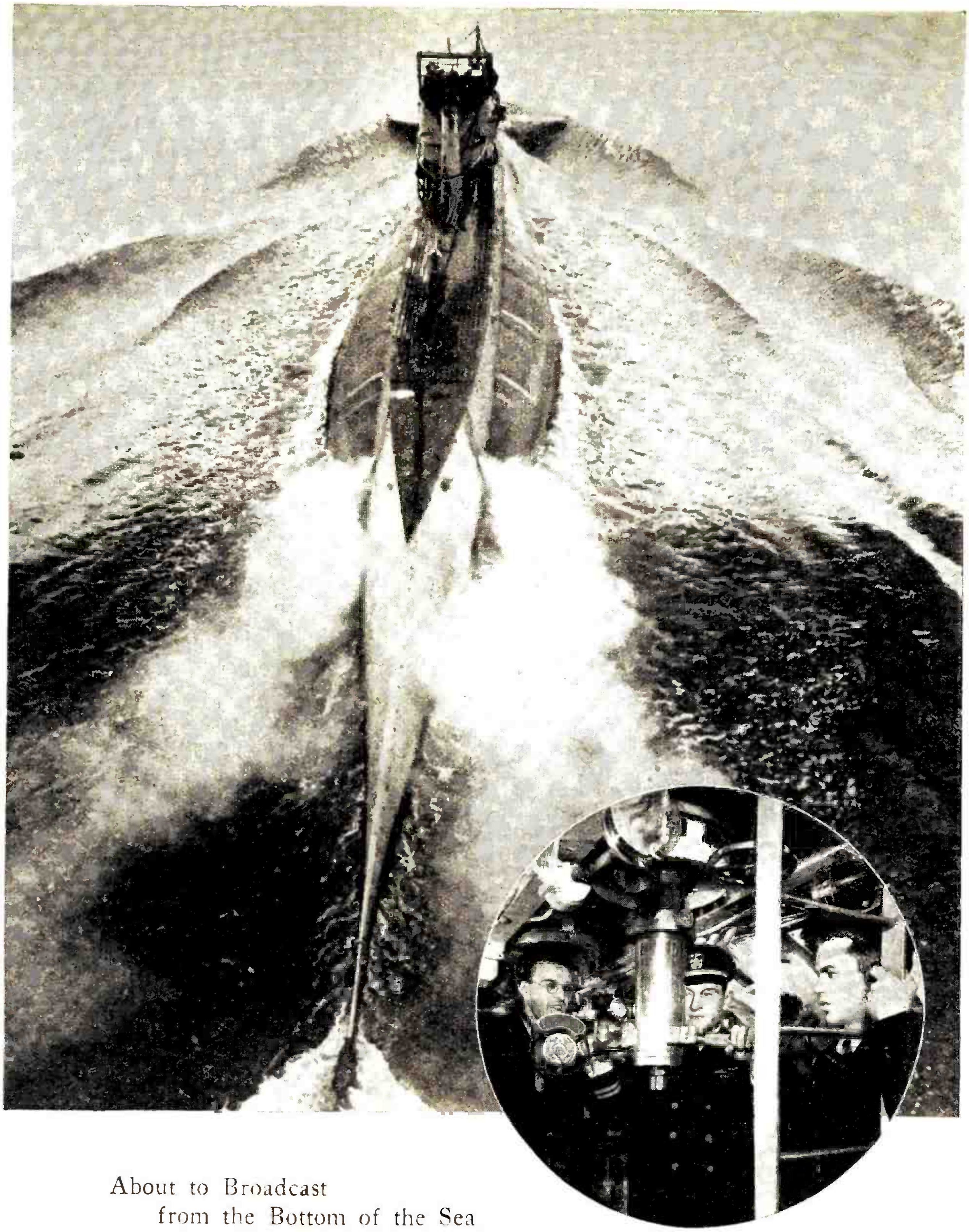
Pioneers in Developing the Radio Service Field

Service work is now recognized as of first-rank importance in the radio industry, as it has long been in the automotive industry. It is the progressive radio serviceman who keeps sets "sold" by keeping them in perfect working condition. He repairs sets for second-hand sales and thus makes way for new set sales. He is the logical scout for new prospects for radio. He sells direct to the set owner by far the largest amount of radio accessories, replacement parts and tubes. He is the set owner's trusted adviser, a position he has gained through past faithful service.

RADIO NEWS *is the pioneer in recognizing the importance of the serviceman and service work. Its pages have given the serviceman the necessary technical data for servicing, kept him advised of the newest developments in the art and set his feet on the path of business efficiency and success.*

Arthur Moss

President,
Electrad, Inc.



About to Broadcast
from the Bottom of the Sea

A view of the submarine O-8 just before its descent during which a description of the dive was broadcast to listening thousands. Insert: The Commander of the vessel, the announcer and one of his aides, gathered around the periscope during the description which was made over a short-wave broadcasting link.

Radio News

VOLUME XIII — March, 1932 — NUMBER 9

"Walking" Transmitters Link Out-of-the-Way Broadcasts

By means of tiny short-wave transmitters mounting like a knapsack on the operator's back, broadcasting is now possible on locations formerly inaccessible on account of the lack of communication lines. Events on the golf links, in submarines under the sea, airplanes in the air, boat races, are now adequately described by means of these portable links between the station and the event

By Everett M. Walker

BROADCASTING has the advantage of presenting to the public descriptions of important events as they occur. But coverage of happenings during the earlier days of broadcasting was usually confined to the studio, the banquet hall, the auditorium or the athletic field.

Early in June, 1929, the late Buddy Bushmeyer, noted parachute jumper, climbed into the cockpit of a small plane at Curtiss Field, L. I. Strapped to his back was a small rectangular-shaped box, and over his face was a mask-like arrangement which, combined with his helmet and goggles, gave a weird spectacle.

The box contained a small radio telephone transmitter and the face mask housed a specially developed microphone. Bushmeyer was to fly to an altitude of 5000 feet, jump, set his radio transmitter in operation, and tell a nation-wide radio audience how it feels to float through one mile of space.

Because of an entanglement with the antenna wires, the first attempt failed. But on Bushmeyer's second attempt the experiment was successful, and countless thousands throughout the country were thrilled by the first-hand description of his exciting drop to earth.

Thus embarked a new mode of broadcasting. The experiment gave the larger broadcasting companies a new idea. Wire lines had always limited the scope of broadcasting. By their use it was possible to transmit a word picture of an event only from a fixed point, and to describe only that which was within the view of the announcer at that particular point of vantage. It was impossible for them to describe happenings across the field, down the bay, around the corner, just beyond the range of the eye and ear and wire-line terminal.

Columbia Photo

ADJUSTING "WALKING" TRANSMITTER

Announcer Harry Von Zell carrying his one-watt portable transmitter as the field engineer, Seth Butler, tunes up

Bushmeyer's parachute jump had opened a new broadcasting field. By means of low-powered transmitting sets it would be possible for announcers, with such sets strapped to their backs, to follow a rowing race, golf player or any event which required wide-area coverage. The descriptions could be sent out by these "walking" transmitters to a receiving station within easy reach of land wires, where it could be carried to broadcasting networks throughout the country.

The idea of using these small "walking" radio transmitting sets as go-betweens, between the announcer and the fixed land wire, was enhanced to no small extent when the Graf Zeppelin made her maiden trans-Atlantic voyage in August, 1929. Floyd Gibbons, famous news commentator, with the aid of two assistants carrying the same parachute set used by Bushmeyer, wandered all over the Naval Air Station landing field at Lakehurst, N. J., as the giant dirigible made her first landing on American soil, describing the eventful conclusion of the three-way flight to countless thousands of listeners through a nation-wide network of the National Broadcasting Company.

As a result of the successful Graf Zeppelin broadcast from the field, broadcasting stations, notably the national networks, began to concentrate on the development of special apparatus for conveying spectacular events to listeners by the aid of portable transmitters. As extensive plans are being promulgated for future expansion of such facilities, networks already have achieved marked success in the use of portable short-wave sets in broadcast pick-up service. Transmitters with only one-watt output, strapped to the backs of announcers, have been used to "feed" huge networks.

Special Wavelengths for This Service

Such broadcasts have been made from submarines under water, surface craft on the high seas and from airplanes overhead. A broadcast has been accomplished from even a zoo.

Both the N. B. C. and the Columbia System have available four complete short-wave relay installations of varying powers which may be set up on a moment's notice in an airplane, automobile, train, boat or any other type carrier which will give the radio announcer a better point of vantage in conveying the description of a special event.

With the advantage of such short-wave rebroadcasting apparent, the Federal Radio Commission a year ago set aside six short-wave frequencies for "temporary broadcast pick-up service." Two of these were assigned to the N.B.C. and two to the Columbia System. The remaining two were allocated for the use of independent stations when the occasions warrant.

Although ninety-day licenses are issued to both broadcasting companies, they are required to file application with the commission twenty-four hours in advance when use of the frequencies is desired. N.B.C. has allocated for its use the frequencies of 1584 and 2392 kilocycles, Columbia has 1544 and 2476 kilocycles, and the independent channels are 1564 and 2368 kilocycles.

For use on broadcasts which take announcers beyond the range of wire lines, the N.B.C. maintains four short-wave transmitters—two 50-watt units, one 7½-watt unit and the tiny ½-watt transmitter which Bushmeyer carried on his parachute descent. In addition to this equipment there is a truck which carries a fixed antenna and is surmounted by a manhole through which an announcer can protrude his head while watching in motion any scene he may wish to describe. Development of the portable transmitting equipment for the N.B.C. has been under the direction of Robert Morris, engineer in charge of research and himself an ardent short-wave experimenter and amateur.

The parachute set, Morris told the writer, is the "granddaddy" of the whole scheme. Since the successful development of that set, no end of time has been devoted to the development of other and more powerful apparatus with greater range. Problems were encountered, but perhaps the most difficult was designing the equipment to meet the quality standard of modern broadcasting. The small portable transmitters and receivers had to be constructed to give the same wide-range frequency response as the special wire circuits and the broadcasting transmitters themselves.

The two 50-watt remote transmitters employed by the N.B.C., of course, have the greatest range and are used when it is necessary for the announcer to travel a considerable distance from the receiving-station, land-wire link. These transmitters are virtually the same as those designed for aircraft work with necessary alterations for giving the required quality standard.

Both these transmitters have an approximate service range of fifty miles and are pressed into service when broadcasting is to be done from an airplane, battleship at sea, moving train (such as is used in describing a collegiate boat-race), regatta, etc.

N. B. C. Photo

BROADCASTS BIG "JUMP"

Charles Julienne De Bever, parachute instructor at Roosevelt Field, equipped with portable transmitter before his broadcast of the sensations of a parachute jumper on the way down

N. B. C. Photo

TRANSMITTER ON WHEELS

Mobile short-wave transmitter with announcer sticking his head through a hatch in the top while broadcasting an aviation event. A balloon antenna is one of the features of the equipment

GOLF VIA RADIO

Left: O. B. Keeler, sports announcer, speaking into the microphone of the "walking" transmitter at the American Open Golf Meet. Transmitter works on 5 meters and contacts the broadcasting system

N. B. C. Photo

Operation is possible under any circumstances. When the equipment is used aboard a carrier of some sort, where power supply is limited, current for operation is obtained from a storage battery and dynamotor. For aircraft use, a wind-driven generator is available. And for fixed-point broadcasts, where either alternating or direct current is available, power sources for each may be employed.

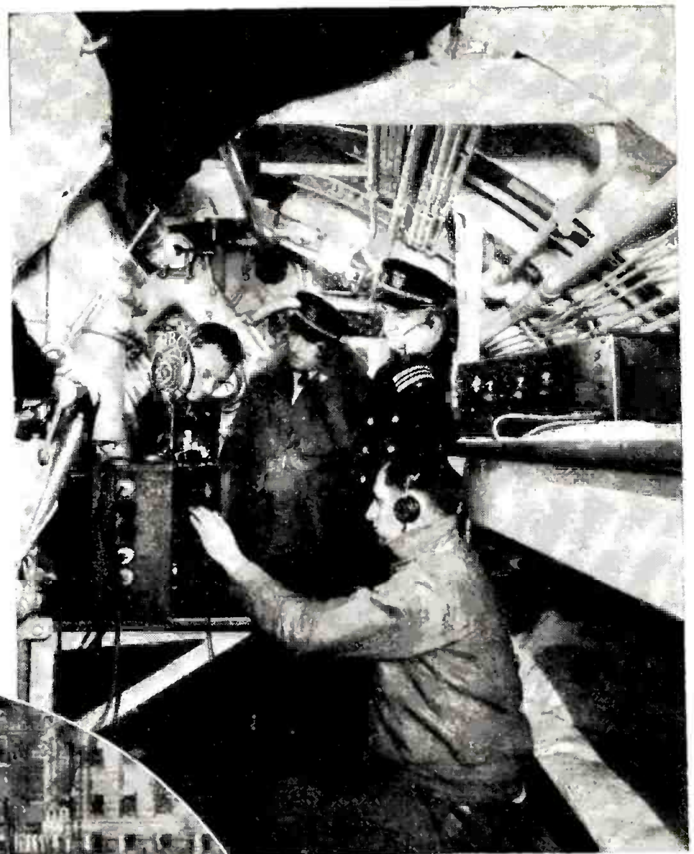
The Columbia Broadcasting System has available two similar transmitters for such broadcasts. These transmitters, which have a power rating of fifty watts, were especially designed by the Western Electric Company.

A Fifty-watt Transmitter

The N.B.C.'s 50-watt transmitters employ a master-oscillator arrangement, conventional for transmitters of this type. Speech amplifiers and 100 watts of modulating power complete the equipment.

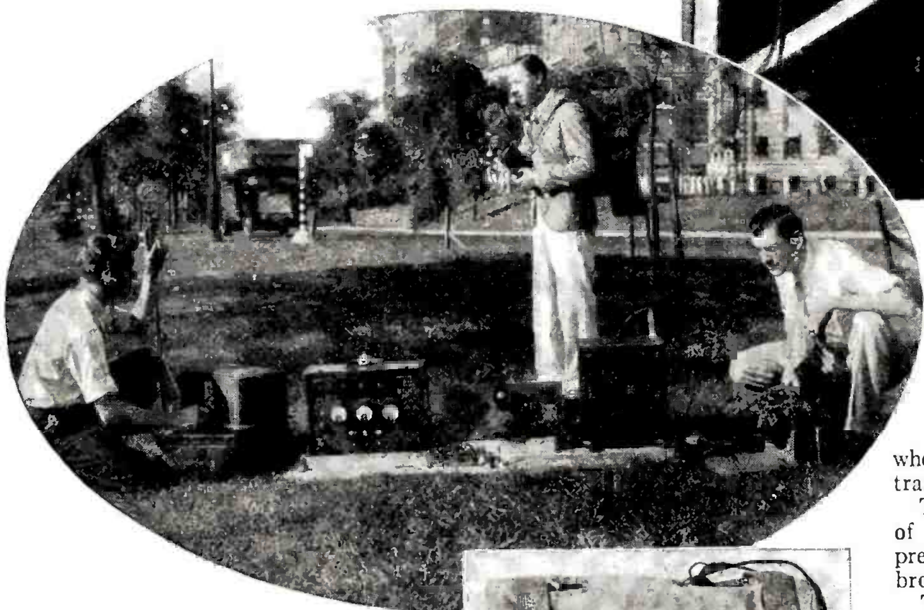
Miniature control boards similar to those employed in the main stations enable the operator in charge of the equipment to control transmission similarly to dissemination of programs for the larger stations. Several hundred feet of wire is provided for the microphones, so that the announcers may carry them about the point of vantage with ease.

The 7½-watt transmitter used by N.B.C. is less complicated and, of course, much lighter. It is highly adaptable to remote broadcasts where greater portability with less range is required. This set has a reliable range of ten miles and has been used for transmission over even greater distances with good reliability. It is operated entirely from dry-cell batteries and may be carried to a location by a single operator.



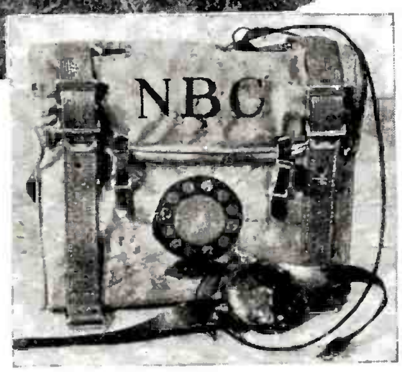
AT THE SEA BOTTOM

Equipment set up in the submarine O-8, over which the deep-sea broadcast is transmitted. At left is the transmitter and at the right on a bunk is the receiver over which the officers are listening in



PACK TRANSMITTER AND FIELD LINK

At the left is an engineer operating field receiver which picks up the broadcast from the "walking" transmitter. Signals are then sent through the control apparatus at center to the broadcasting system over a wire line



PACK TRANSMITTER

This is the parachute jump equipment in its padded pack case equipped with chin strap microphone

The famous parachute set is still in use and is frequently pressed into service where it is desirable to have an announcer cover considerable ground within a short distance of the receiving station. It has proven highly adaptable to the transmission of golf-tournament reports, directly from the green of the course.

Employing nothing more than dry-cell tubes, similar to those used in the standard battery radio receiver, the complete installation may be strapped to the back of the announcer, who carries the sending set, microphone and antenna. While the set has a range of several miles, it operates at its best when there are no obstructions between the transmitter and the receiving station.

The Columbia System has a similar group of portable transmitters which may be pressed into service for any type of remote broadcast beyond the reach of land wires.

The "pack transmitter" used by the C.B.S. was specifically designed for Edward B. (Ted) Husing, sports announcer, under the direction of Edward K. Cohan, technical director of the company, for describing golf matches.

A Low-power Transmitter

The set is somewhat different than the parachute transmitter employed by N.B.C., in that it uses a battery-operated master-oscillator transmitter made up of two –71A type tubes. One of the tubes serves as the master oscillator while the second as a final stage radio-frequency amplifier. A small speech input amplifier and modulator also is included.

Several types of antenna are available for this transmitter. The one most used for portable work is made of an old fishing pole wound with copper wire. The antenna inserts in a coupling atop of the box containing the set. A regular full-size, half-wavelength antenna is provided for use when the set is operated from a fixed point.

Both broadcasting companies' portable transmitters are designed to fit within a canvas knapsack, which, in addition to facilitating strapping to the back of the announcer or caddy, protects the instrument from rain.

For such broadcasting, standard short-wave receiving sets are employed to pick up the (*Continued on page* 793)

About Television Lieut. Wenstrom Makes the Following Pertinent Remarks—

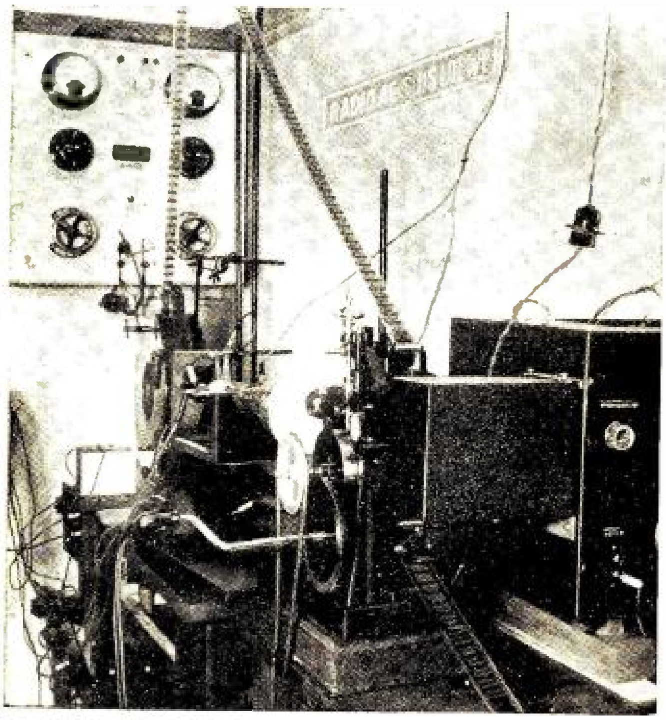
¶ Our present age is distinguished by increasingly rapid technical progress. The entire growth of aviation, for example, has taken place within very recent years, and the extent of this growth has been such as no serious thinker of the nineteenth century would have dared to predict.

¶ It is the same with radio broadcasting. So many new arts have developed in this startling way that we have come to expect like progress of every concerted technical endeavor, and we apply the same rule indiscriminately without regard for history or natural limitations.

¶ Television, introduced four years ago, was looked upon as an entirely new field—an art without a past. Having evolved from nothing to something in no time at all, it would soon evolve from that something to near perfection. When this rapid improvement failed to materialize, public interest turned to impatience if not indifference.

¶ The truth is that television principles are far from new. Their development, having begun long ago, has been rarely rapid and often painfully slow. By the same token, it is unreasonable to expect perfection immediately.

¶ If these tenets are accepted, it is possible to view present-day television not as a disappointment, not as something about to change overnight, but as a creditable achievement, born of past research and privileged to undergo constant improvement in the future. Let us see what evidence there is to support this view.



A FILM TELEVISION TRANSMITTER

This is the apparatus used by Manfred von Ardenne for transmitting moving pictures by means of the cathode ray oscillograph method

The March

By Lieut. William

Part

ONE hundred years ago the electric telegraph captured the imagination of scientifically inclined men much as radio and its ramifications do now. After the invention of the first practicable system by Morse in 1832, attention centered on improvements in the method of recording signals. Alexander Bain, a Scotch watchmaker, came to London in 1837 and attended some popular lectures in electricity. These set his mind at work upon electric clocks and printing telegraphs to such an extent that by 1840 he had completed models of both. His telegraph receiver used a strip of paper soaked in certain chemicals, moving on a metal cylinder under a metal point. When current flowed between the point and the cylinder, the paper was discolored in dots and dashes corresponding to the transmitted signal. Bain also is said to have devised a crude system of pictorial message transmission using many wires.

The first practical electrical picture-transmitting system, strange as it may seem to us, was actually set up and transmitting recognizable facsimiles between Brighton and London (a distance of fifty miles) before the middle of the century! This system, strikingly similar in principle to those which flash news photographs about the world today, was invented by Frederick C. Bakewell, an English teacher of electricity, in 1847. "The copying telegraph," wrote Bakewell, "transmits copies of the handwriting of correspondents. . . . Every letter and mark made with the pen are transferred exactly to the other instrument, however distant." The invention, as shown in Figure 1, included two metal cylinders about six inches in diameter, one at the transmitter and the other at the receiver. The message (or the picture) to be transmitted was drawn on a sheet of tinfoil with insulating varnish, the tinfoil being wrapped on the transmitting cylinder. As the cylinder rotated, a steel wire bore against its surface and was moved along by a screw. The surface of the cylinder was therefore "scanned" by one continuous spiral line. When the steel wire touched a part of the picture represented by insulating varnish, the line current was cut off until the wire again touched the unvarnished tinfoil. At the receiver a similar cylinder rotated in synchronism with that at the transmitter. The receiving cylinder, however, was wrapped with paper soaked in a chemical solution, as in Bain's printing telegraph. On this paper pressed another steel wire connected to the line, staining the paper under it *blue* whenever line current was flowing. The blank tinfoil at the transmitter was therefore reproduced as a blue background at the receiver, on which appeared white lines corresponding exactly to the varnish lines on the tinfoil.

Keeping the two cylinders exactly in step was of course a problem. Bakewell used the principle of the pendulum in some of his experiments, but he also devised an electromagnetic method, similar in principle to those used in modern television, which made use of a separate wire to transmit synchronizing impulses simultaneously to both the transmitting and receiving cylinders. In fact, so complete and well designed was his apparatus that one can scarcely believe it was actually demonstrated long before the outbreak of the Civil War.

Bidwell's Transmitter

The next forward step in television (or its slowed-down beginnings) had to wait on the discovery that selenium changed its electrical resistance in accordance with the amount of light falling upon it. When the Society of Telegraph Engineers and Electricians met at Paris in 1881, Shelford Bidwell, another Englishman, read before it a paper on some "apparatus . . . merely of an experimental nature." Bidwell's receiving apparatus was exactly like Bakewell's, except for a considerably smaller cylinder giving a picture about two inches square. The transmitter, however, as shown in Figure 2, was radically different. The picture or scene to be transmitted was projected upon a ground-glass screen, behind which a selenium cell moved slowly up and quickly down, gathering light through

of Television

H. Wenstrom, U. S. A.

One

a pinhole from successive portions of the picture in turn. For each upward motion, the selenium cell moved across the image 1/64 of an inch, and on the receiving cylinder a screw thread moved the platinum recording point across an equal traverse at each revolution. Bidwell pointed out that "the pictures to be transmitted are not mere artificial drawings upon tinfoil or some other substance, but the projected images of actual objects. . . ." The system thus might be termed "still television," as the subject would have to hold a given pose several minutes before a picture could be formed at the receiver.

During the sixties and seventies the first motion pictures made their appearance. They depended, of course, upon persistence of vision—the fact that if slightly different poses are seen at the rate of sixteen or more a second, the observer has the sensation of seeing continuous motion. It is not strange that this idea should have intrigued many workers in electrical picture transmission. Among them was the Frenchman, Senlecq, who proposed a multi-wire television system which included, at the receiving end, a commutator sliding over the terminals of many separate wires connected with individual lights on a large screen. Forty-six years later this idea, improved by the use of gaseous glow tubes rather than filament lamps, was used in a large-screen demonstration of sight transmission overland wires by the Bell Laboratories.

The Nipkow System

Undoubtedly the greatest name so far recorded in television history is that of Paul Nipkow, a German who is still living in Berlin. In 1884 the German Patent Office issued to him Deutschesreichspatent No. 30105, setting forth all the details of a complete and workable television system. Figure 3 is based on one of his drawings. At the transmitter and receiver are two disks, perforated with small holes along similar spiral curves, which rotate in synchronism. The small holes. sweeping by the picture along successive horizontal lines, vertically displaced, trace each element of the picture in turn, or "scan" it. This scanning disk was the heart of Nipkow's system in 1884, and it is the heart of most television transmitters and receivers today.

At the transmitter an image of the subject is focused directly on the disk, precisely as it is in the modern television cameras now available. There follows a condensing lens which converges the rays from this image on a selenium cell, the output of which is led over wires to the receiver.

At the receiver an arc light shines through a condensing lens and through a polarizer. Next the poralized light passes through sulphureted carbon gas or some substance which will modulate the light in accordance with the magnetic field changes caused by the changing "picture" currents in the coil. The modulated light then passes through the receiving disk which, in order to save light, is viewed directly by the eye. This electric modulation of polarized light, proposed by Nipkow in 1884, has been applied (*Continued on page* 810)

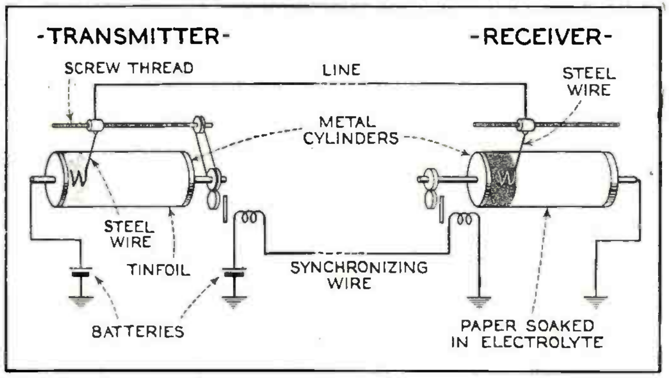


FIGURE 1. BAKEWELL'S FACSIMILE SYSTEM, 1847

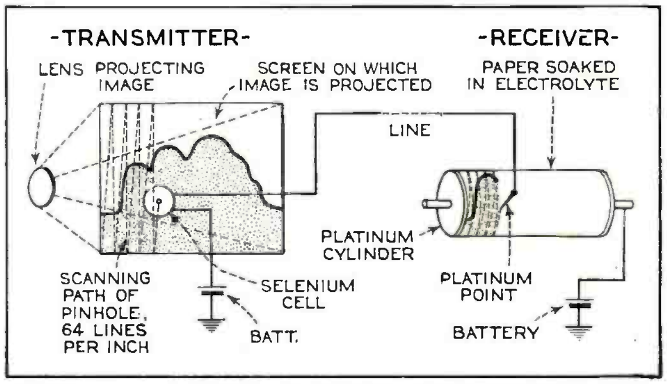


FIGURE 2. BIDWELL'S "STILL TELEVISION," 1881

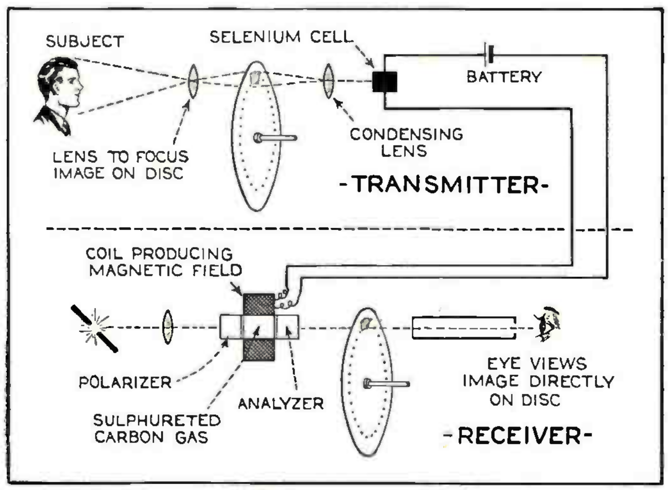


FIGURE 3. NIPKOW'S DISC TELEVISION SYSTEM, 1884

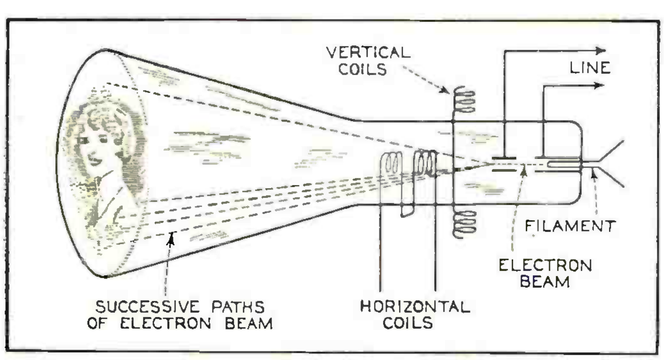
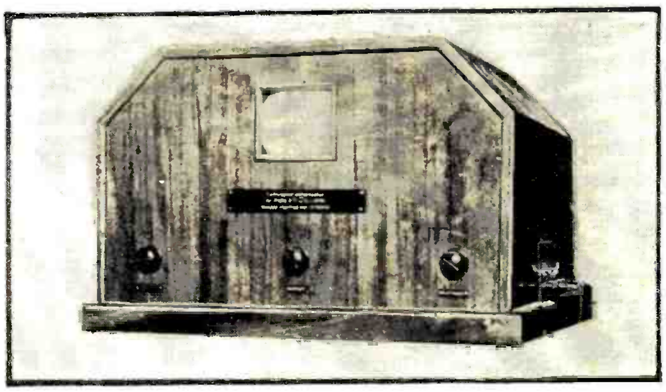


FIGURE 4. CAMPBELL-SWINTON CATHODE RAY RECEIVER, 1908



A CATHODE-RAY RECEIVER

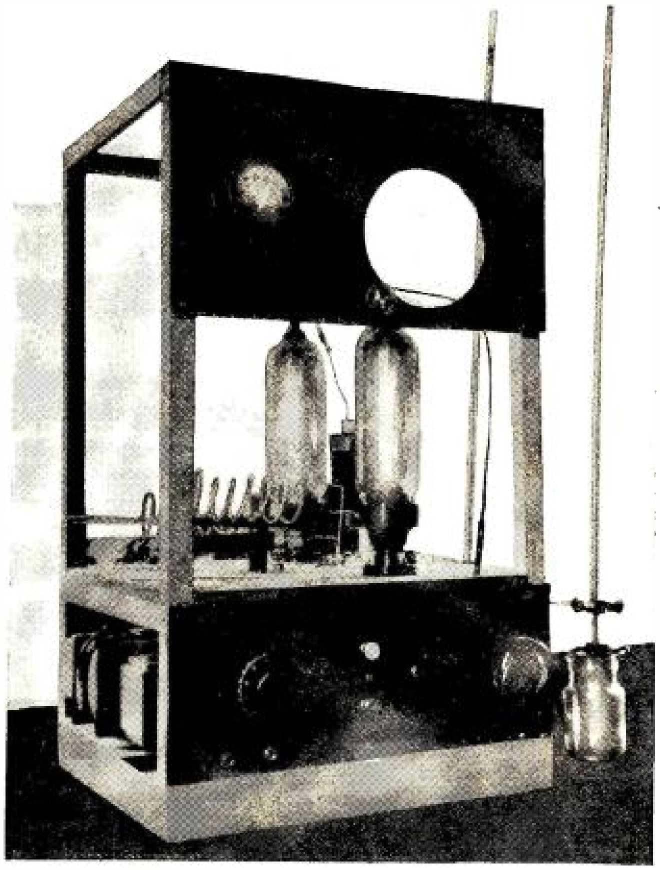
An example of the cathode-ray tube television system as developed by von Ardenne

RADIO

Biological Effects

Extremely short radio waves are now cutting living tissues bloodlessly and at is completely sterilized. The author, tour of scientific investigation for and methods, as well as giving an phenomena produced

By Irving



S.W. PUSH-PULL OSCILLATOR

Figure 6. The arrangement of the powerful oscillator used in the experiments. The schematic diagram for this unit is shown below

BY applying radio research and investigation to biological topics the radio sciences have developed again new tools for the conquest of human happiness and welfare, excelling the possibilities which seemed probable in the first days of the early development of wireless communication. Electro medicine, especially high-frequency surgery, has opened a new field for the modern physician.

Today, high-frequency surgery has saved the lives and health of thousands of persons. It makes possible operations which were heretofore not within the skill of the surgeon. It also simplifies and adds to the safety of difficult operations. Plastic surgery (beauty-surgery) has been simplified and made less expensive by these methods and in addition a new chance is given for the treatment of diseases heretofore considered as incurable ones.

Today, electro-cutting, "the radio knife," has passed the state of trial and investigation and has become a valuable tool in the hand of the trained physician. It is a tool—and as such it can be used well or badly. Electric methods must not be applied schematically to the known technique which was usual with the knife. The electro-physician needs, in addition to his medical training, an understanding about the underlying, basic facts of high-frequency operation. These facts, however, are relatively simple and can easily be understood.

Short Waves Heat the Body

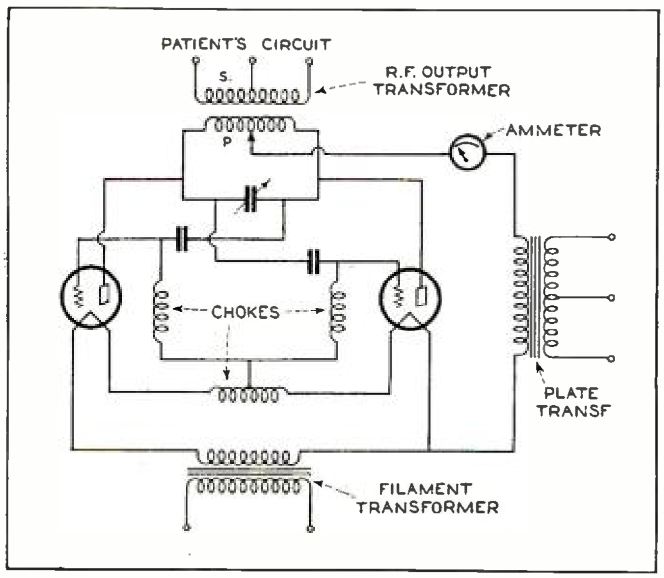
We know already the fact that a high-frequency field traversing the body produces heat in the body. This is used, for instance, in the diathermy where a high-frequency current is applied to the tissue by direct contact electrodes and this current traverses the body directly and produces heat within this body along its path. This is the new "radio fever" which is now used to kill off certain germs. Figure 1 shows the path of a current going, for instance, through an arm. Unlike an ordinary heating appliance, for instance, a hot water bag, brought into contact with the body, these high-frequency currents will warm up the *inside* as well as the outside.

If both electrodes are equally large, an almost equal distribution of temperature will take place inside of the body subjected to the high-frequency treatment. If, however, as shown in Figure 2, the electrodes are of a very different size, an unequal distribution of the power lines of the electric current will occur and, naturally, in the region of greater current concentration, a higher temperature will be observed than at the end with the larger electrode where the power lines are scarce. The more lines of power, per square inch, the greater is the heat produced therein at diathermy frequencies. An application of more than two electrodes, of course, will produce different paths of the current through the body and, by applying these facts to the anatomical and physiological properties of the human tissue, a great variety of types of heating is obtained.

The Radio Knife

If the electrodes are of very unequal sizes and the current intensive enough and of the proper characteristics, the heat concentrated near the small electrode will be so large that it cannot be fully dissipated by the tissue and the blood stream. Then the tissue will be separated. The small electrode, often in the form of a small needle or a little scalpel in an insulated handle is called the cutting electrode.

Cutting with a surgical knife known in its principal form for centuries has still certain advantages and will always play a foremost part in medicine. The natural cutting method, however, despite its mechanical and commercial advantages, fails just for some of the tasks which the highly developed surgery of our last decade has opened as a new goal for the physician and as a new hope for thousands of sufferers. The loss of blood occurring in vital operations, lack of accessibility in the brain or in small body cavities, the sealing of bleeders, the



PUSH-PULL AT SIX METERS

Figure 5. Here is given the connections for a 6-meter oscillator used by the surgeons in their latest experiments

Surgery

of Ultra-Short Waves

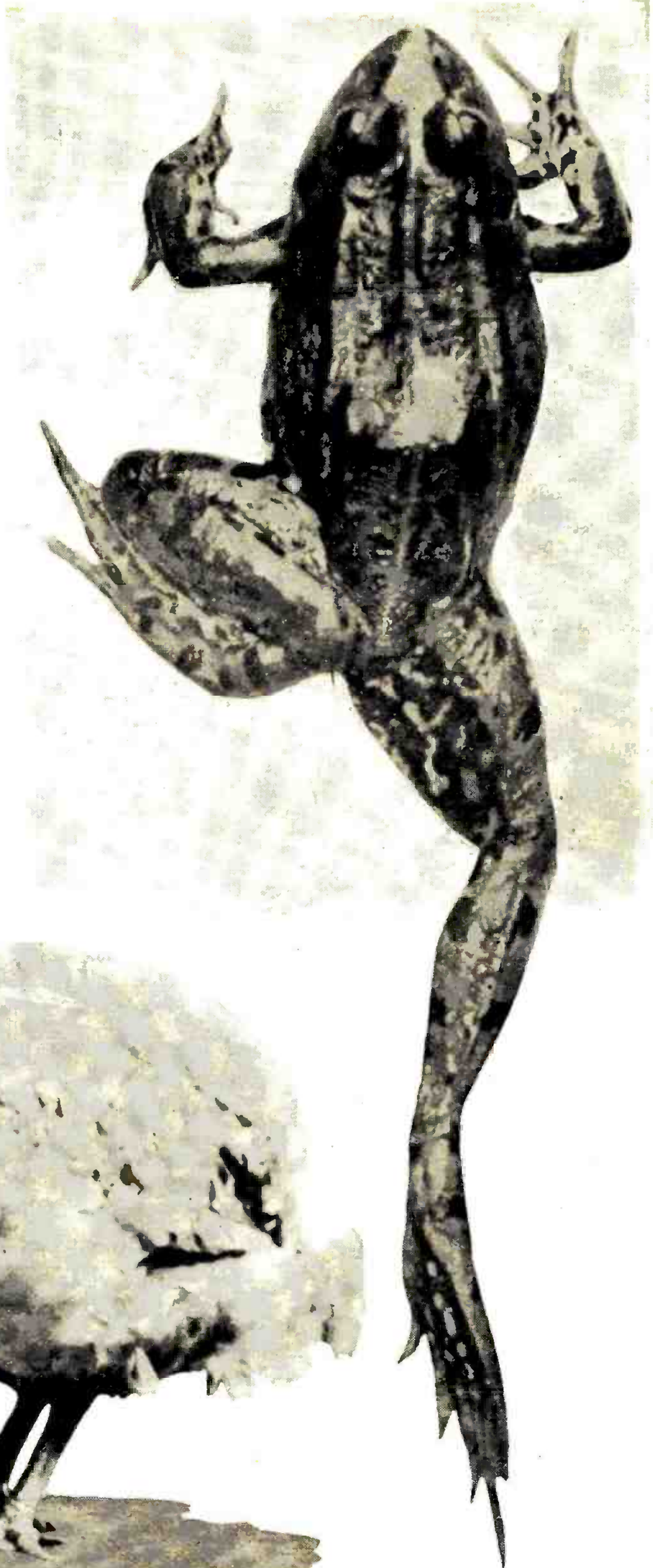
being used in the medical science for the same time leaving an incision that who has just completed a European RADIO NEWS, ***describes the equipment insight into some other little known by these waves***

Saxl, Ph.D.

danger of an infection, complicate certain operations to an extent that they are too dangerous and often impossible. However, with the electric needle-knife, many minor operations can be performed with great simplicity, unusual savings in time (for instance the shrinking of the inferior turbinates), and in most cases almost painlessly. This latter fact has proven of importance for dermatological and in some legitimate "beauty" operations.

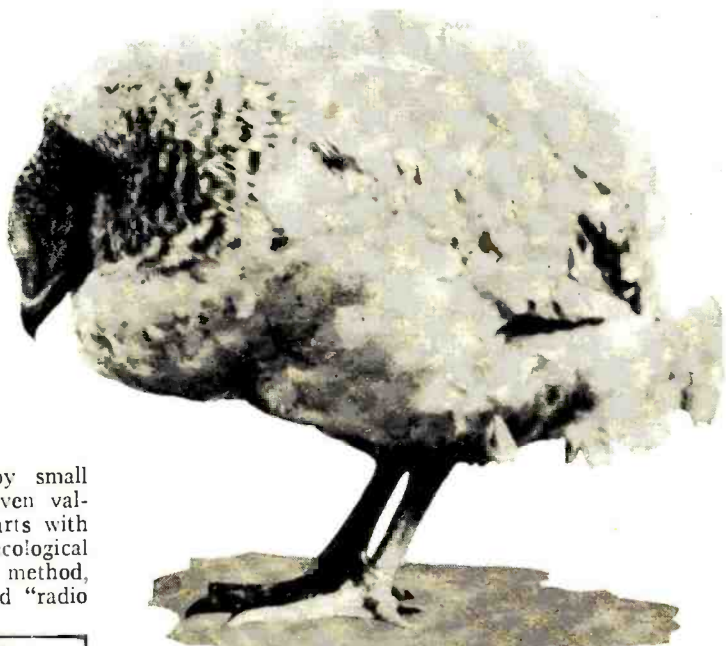
The disadvantages of the surgical knife lead to the search of other techniques in the field of surgery . . . as disadvantages, quite generally, have often given impetus to research and investigation. Thus, towards the end of the last century, electricity in general and the high-frequency technique in particular have been recognized as excellent tools for the improvement of surgical technique.

In the year 1899, shortly after the introduction of *Nicolo Tesla's* high-frequency currents in therapy, it was first recognized that a small arc was able to cut through living tissue if the number of sparks of the inductor was high enough and the electrode fastened to the tissue was sufficiently small. Thus, from the beginning, there were two methods which have been kept in use, a third method having been added in this year. The first method is the method of *electrocoagulation*, and eventually *carbonization*. Tissues are burned off and coagulated by small sparks. This method has proven valuable in the destruction of warts with the electric needle, moles, gynecological operations, etc. The second method, *cutting diathermy*, the so-called "radio



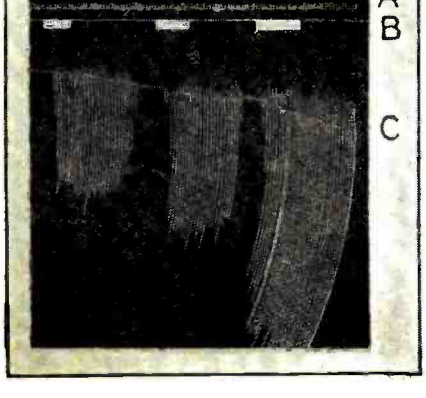
RADIO PARALYSIS

Figure 9. The right leg of this frog has been paralyzed by the application of short waves passing through the left side of the spinal column and a part of the brain



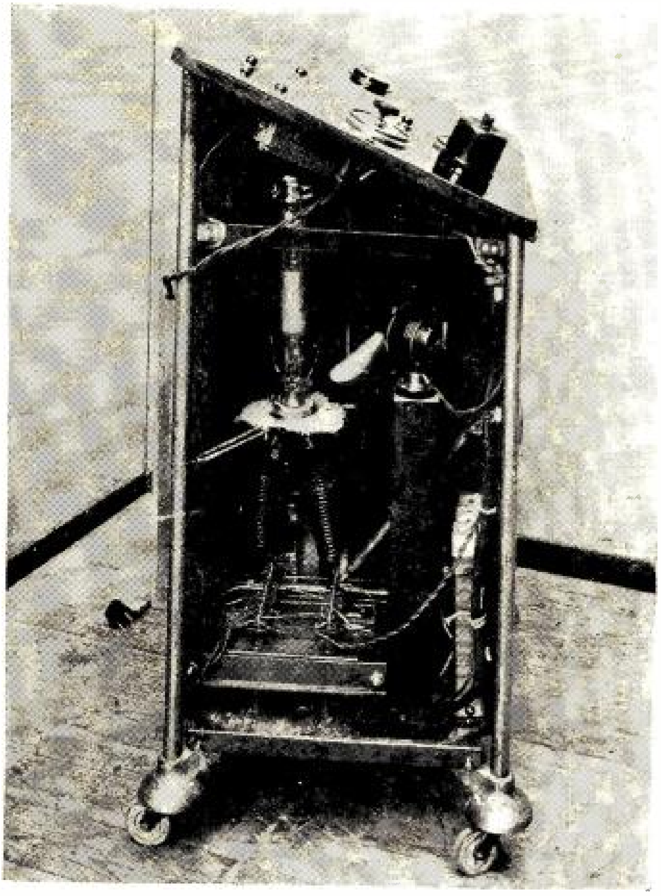
DEVITALIZES CHICKEN'S BRAIN

Figure 11. Posture of chicken whose brain has been subjected to high-frequency radiation. It acts like a brainless creature desiring neither food nor movement



LAST SPASMS OF FROG

Figure 10. Left, Kymograph of frog leg motion after radiation. A equals times in seconds, B is short-wave application and C gives kicking impulses which cease after third application, denoting complete paralysis



ANOTHER MEDICAL OSCILLATOR

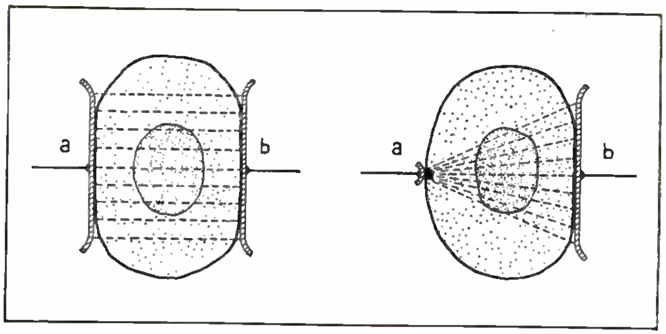
Figure 8. Close-up view of short-wave generator used with the radio-knife

knife." The third method, the concentration of *ultra short-wave fields within the body*, still in its state of development, gives hope of unusual achievements.

Basic experiments were made for cutting with the needle at the beginning of the twentieth century by De Forest. In 1909 Doyen followed with the bi-polar voltaisation from which, later on, Czerny and his pupils developed the arc operation. In the last years, the developments of Messrs. Liebel and Flarsheim have succeeded in the perfection of a high-frequency knife of unusual cutting qualities, which, under the name of the Bovie unit, has been used in a great number of American hospitals.

All these methods, theoretically speaking, have in common the fact that a minute, almost microscopic, arc is produced by concentrating the power lines generated by a high-frequency oscillator upon a very small surface of the tissue. Thus the tissue is separated at the place where the small electrode touches (actually a very small distance in front of the electric needle) and, by moving the cutting electrode, a bloodless separation of the tissue is made possible.

By this means the sharp knife of the surgeon becomes an electric knife, of different form, almost without cutting edge. The advantage in respect to practical medicine lies not only



HOW THE RADIO-KNIFE OPERATES

Figure 1, at the left, shows the two electrodes, a and b, which give an equal distribution of the radio field through an arm, for example. Figure 2, at the right, shows the concentration due to using a small electrode at a, the intense field of which will cut living tissues cleanly like a knife

in the fact that the tissue is separated with a knife which sterilizes itself automatically (an arc which separates biological tissue naturally kills any bacteria adhering at the same time), but that minor and medium bleeders are sealed off immediately. By the great heat dissipation of the cutting electrode, the liberated blood coagulates immediately, building a scarf which interferes with further bleeding. This scarf, being built of the same material as the tissue it is in, naturally is absorbed quicker than the catgut ordinarily used.

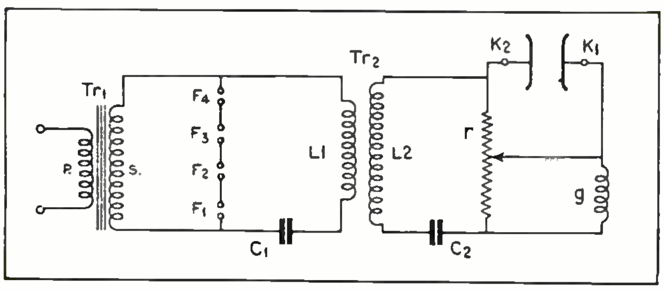
Furthermore, by sealing off lymphatic vessels, the travel of malignant parts to further regions of the body is made impossible—a most important factor in the operation of malignant and highly infected tissue where a transplantation of the tumor or the infection has to be avoided. Last, but not least, an operation is possible almost without any manual power, permitting work in small body cavities or inaccessible parts which could not be reached heretofore.

The electric knife, therefore, possesses those advantages which ordinary operating methods are lacking. The effect of the cutting is not so dependent upon the hand which holds the knife. The electro-knife "eats" its own way through the tissue, being guided by the physician but without the application of power or the feeling of resistance. The cutting effect is dependent, mainly, upon the electric current, its high-frequency characteristics, the number of sparks per second, the damping, the form of the cutting electrode, etc. The second electrode is a large plate, applied to a neutral part of the body, for instance, the back or the arm.

Surgeons Learning Technique

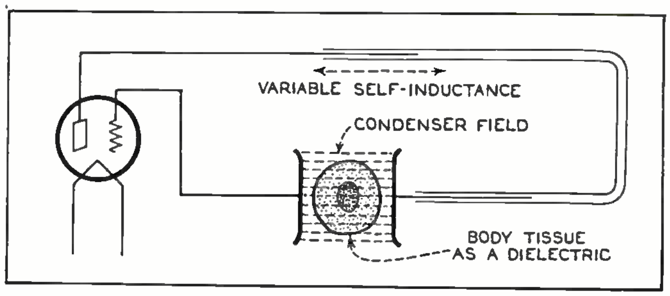
The surgeon has to have, therefore, the technical understanding of the underlying facts and simple mechanical means upon his apparatus to change those characteristics during the operation, to make the current more coagulating or more cutting, to regulate the depths of the cut (and with this the speed with which the needle has to be moved), etc. It therefore is necessary that the acting surgeon, in addition to his medical training, acquires the technical abilities necessary for this type of operations. These studies, however, are not very complicated and, once understood, a most valuable tool is added to the instruments of the modern physician.

An entirely new method for high-frequency operations with the aid of ultra-short waves has (*Continued on page* 794)



SPARK-GAP OSCILLATOR

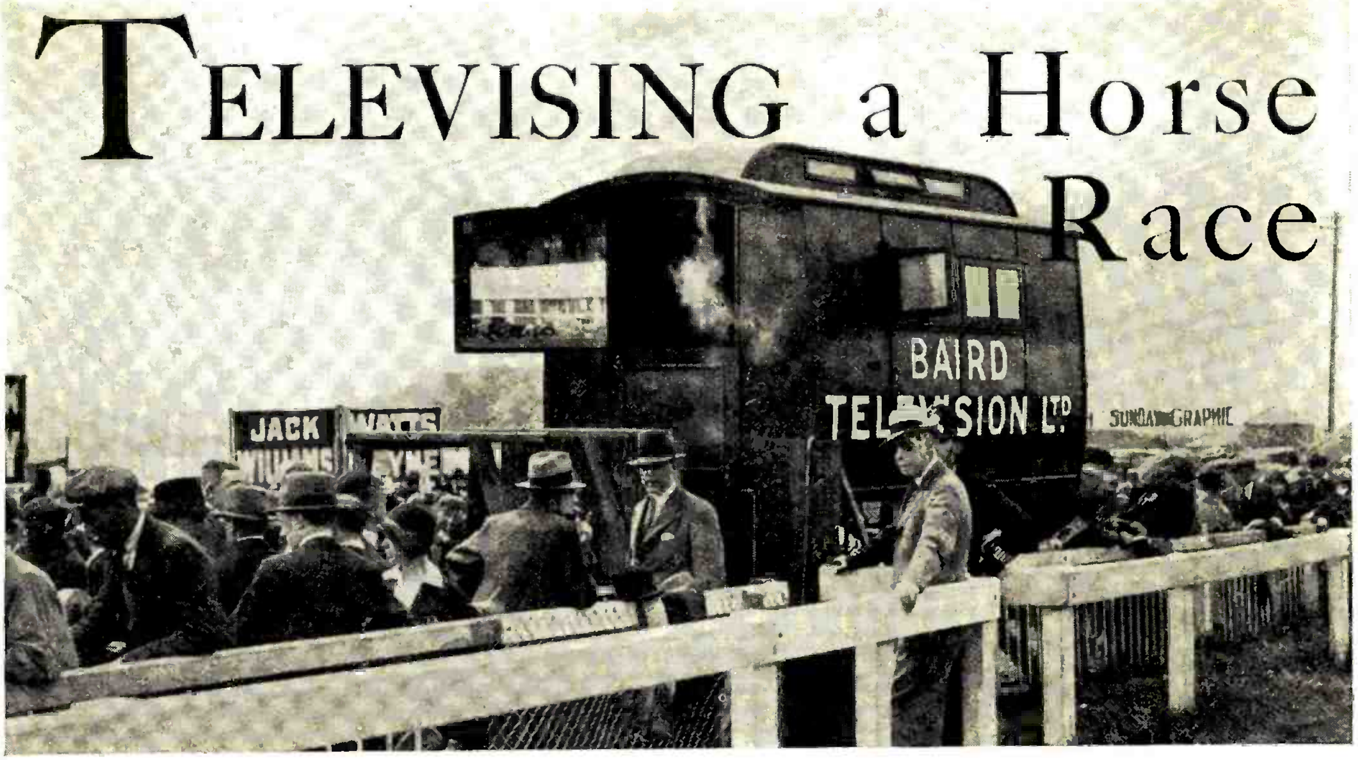
Figure 3. General diagram for the extremely short-wave spark type highly damped oscillator



APPLICATION CIRCUIT

Figure 7. Method of varying inductance of the output circuit for tuning into resonance with the oscillator

TELEVISING a Horse Race



THE TELEVISION TRUCK AS IT ACTUALLY APPEARED

The television equipment inside the truck is not visible here, but the mirror may be seen at the near end, and in it a reflected view of part of the grounds

What a shock for the originators of the Derby if they could know that during the 1931 running persons around London actually viewed the race on the screens of their television receivers at home!

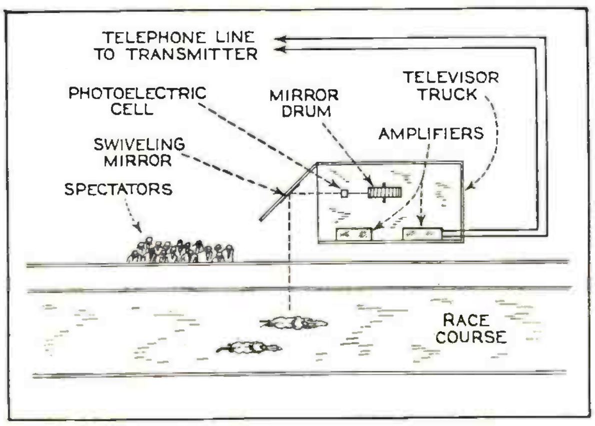
By H. J. Barton Chapple

FOR the first time in history a horse race has been successfully broadcast by television.

The Derby, historic race held on Epsom Downs outside London, was recently broadcast by the Baird Television Company through the British Broadcasting Corporation, and received on the screens of home televisors.

The television transmitter differed radically from the transmitters usually employed. It is obviously impossible to use a moving spot to traverse outdoor scenes, and in place of this Baird used the well-known Weiller drum, which has hitherto been confined to television receiving apparatus. The drum used was approximately 2 feet in diameter and had arranged around its circumference 30 mirrors, each mirror being adjusted carefully at a slightly different angle from the preceding one, the angles being so arranged as to give the picture a ratio of 3 horizontally to 7 vertically, this being the ratio now used in the Baird receiving televisor, while the number of lines was 30.

The general arrangement of the miror drum is shown in the sketch, Figure 1. Each mirror reflects an image of the screen through the lens and on to the photo-electric cell. Due to the mirrors being tilted, the screen is divided into 30 strips, each sending out the varying current, which, after amplification, was transmitted to the B.B.C.'s transmitter at Brookman's Park over nearly 20 miles of land-line.



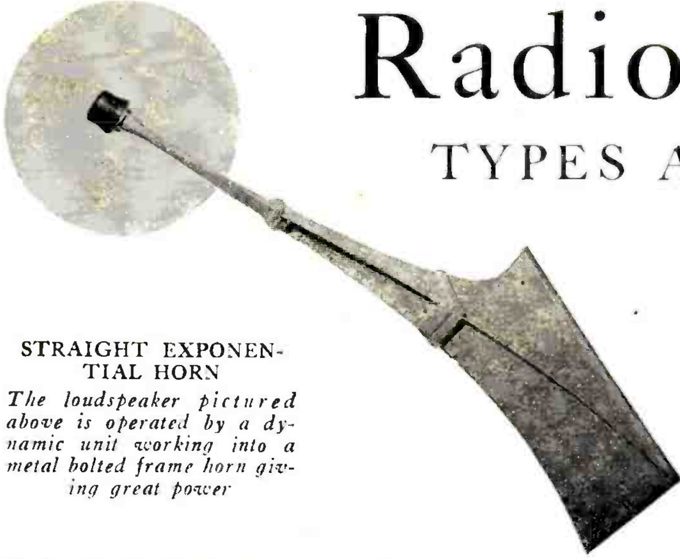
ARRANGEMENT OF THE PICK-UP

Figure 1. The television truck was located beside the track. By means of a large swivel mirror views of different parts of the track and stands were obtained by simply training the scanner on this mirror

One of the difficulties to be overcome was the accurate balancing of this line and the avoidance of interference from other telephone lines. The telephone line wires did not go direct to Brookman's Park, but went first to the studios at Long Acre in the center of London. Here the image was observed on a monitor televisor, and the operator at Long Acre kept in constant touch with the operator at the Epsom Race Course.

The televising of an outdoor scene of this sort presented considerable difficulties, as the horses would, in the normal course of events, be in the field of view for only an instant. This difficulty was to some extent mitigated by using the swivelling mirror seen in the accompanying illustrations. By moving this mirror it was possible to follow the movements of the horses to a certain degree, and also to take in at will different views of the race course.

The actual transmission took place at 2:45 in the afternoon, the national wavelength of the B.B.C. being used and the transmission extending over a half-hour period. While the television transmission was being sent out on the national wavelength, a running commentary was being transmitted on the regional wavelength, so that lookers-in were able both to see the race and listen to the simultaneous running commentary. The national wavelength is 261 meters, (*Continued on page* 812)



STRAIGHT EXPONENTIAL HORN

The loudspeaker pictured above is operated by a dynamic unit working into a metal bolted frame horn giving great power

Radio's Powerful

TYPES AND CHARACTER OF

Although most of us have generally reproducing sounds from their electrical with the various methods by which this of dynamic types, magnetic types, etc., actually meant by these terms and the following article

By E. E.

NO instrument in scientific history ever was developed so completely in so short a time, it is probable, as the modern loudspeaker. Even ten years ago radio fans *reached for the headphones* whenever anything really important was coming in. What loudspeakers existed were poor second to an ordinary telephone.

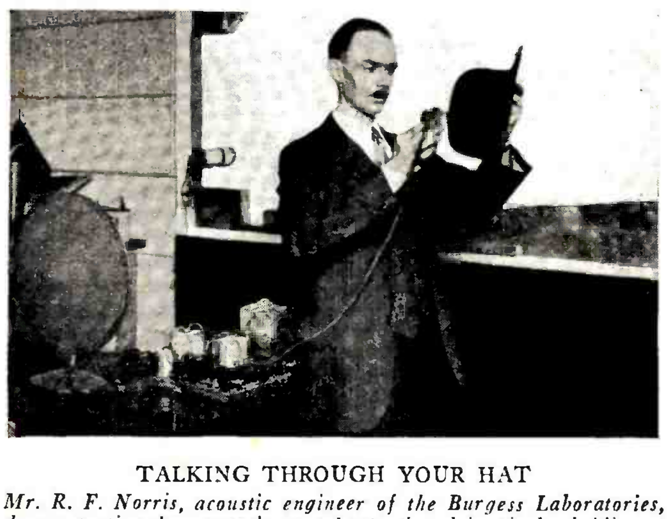
Nowadays this is changed so radically that the old days already seem as remote as pictures of knights riding around in tin suits with flags hung on their walking-sticks. Last year in Berlin the Siemens organization produced a loudspeaker of such enormous volume range that it delivered recognizable music twenty-five miles away, yet could be throttled down to a volume endurable in any ordinary room. A few weeks ago in New York City, Mr. H. A. Frederick of the Bell Telephone Laboratories demonstrated, before the Society of Motion Picture Engineers, loudspeaker equipment which reproduced the music of a full orchestra so perfectly that listeners out of sight would have had real difficulty in distinguishing the counterfeit from the real.

DYNAMIC SMALL HORN

This is the type of modified exponential horn used for home reproduction. It is easily mounted in a console cabinet

THEATRE SPEAKERS

These horns, in reality much larger than they seem to be in the photograph, are used in theatres for giving sound to the silver screen



TALKING THROUGH YOUR HAT

Mr. R. F. Norris, acoustic engineer of the Burgess Laboratories, demonstrating how sounds may be produced in air by holding a hat against the loudspeaker unit

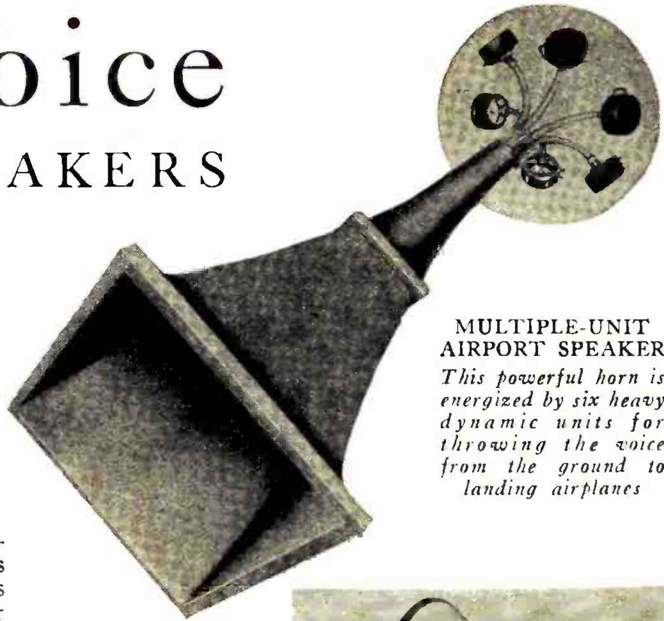
MODERN GIANT AND FORERUNNER

S. P. Grace, of the Bell Lab., holds replica of telephone of Alexander Graham Bell. At his left, a loudspeaking telephone as used in talking movies

Electric Voice

MODERN LOUDSPEAKERS

accepted the loudspeaker as a device for equivalent, not many laymen are familiar result has been accomplished. We speak with little understanding of what is principles of operation involved. The gives this information



MULTIPLE-UNIT AIRPORT SPEAKER

This powerful horn is energized by six heavy dynamic units for throwing the voice from the ground to landing airplanes

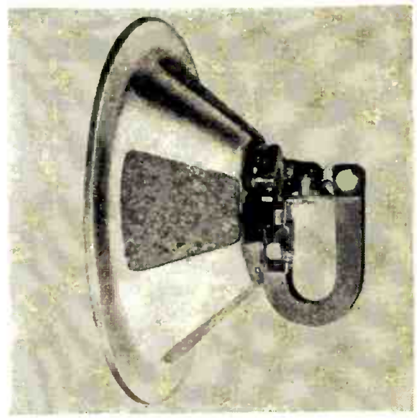
Free, Ph.D.

Like the majority of scientific developments, however, this one is never really finished. New demands are made continually on the loudspeaker art and still greater demands are to be expected. There was presented recently to our laboratories, for example, the problem of maintaining, in a gigantic auditorium, a uniform loudness of either speech or music in all parts of the hall—something which no present system of loudspeakers will do because the sound intensity necessary to reach the entire auditorium produces far too great loudness close to the loudspeakers, no matter where these are placed. This problem of even sound distribution in large rooms probably is the greatest present puzzle of loudspeaker designers and users, for the former defects of insufficient volume, of limited frequency range and of distortion already are largely cured.

If only a loudspeaker needs to be considered, for example, for use with home radio, the requirements are easy to formulate. The ideal loudspeaker must be able to impart considerable volumes of sound evenly to (*Continued on page* 796)

MAGNETIC CONE TYPE

Instead of a horn, this speaker uses a conical diaphragm for spreading sounds into the air. It uses a magnetic unit

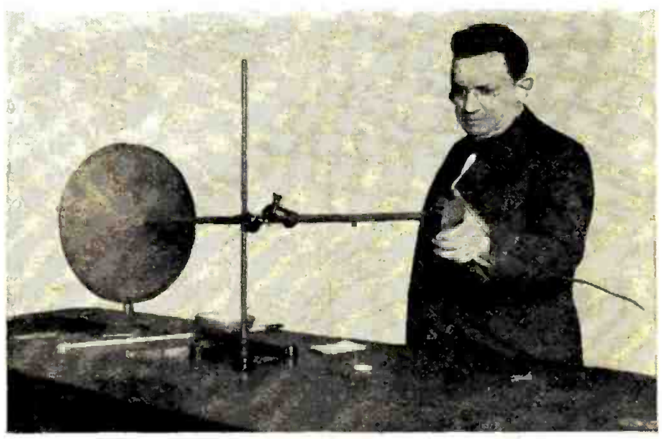


DYNAMIC CONE TYPE

Powerful cone reproducer using a cone working from an electro-magnetic unit equipped with a voice coil

LOUDSPEAKER WITHOUT A UNIT

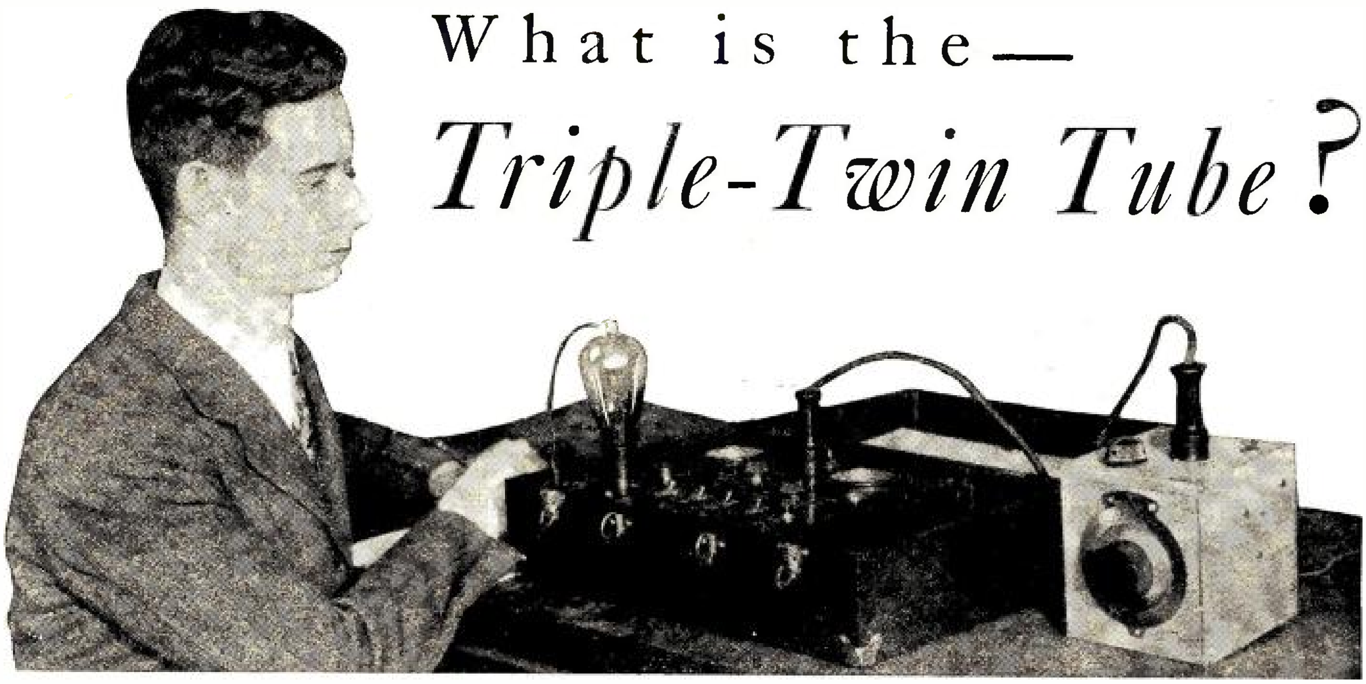
Workers finishing one process in the manufacture of the electrostatic loudspeaker, which operates on the principle of attraction and repulsion of electric charges



SOUND TRAVELS THROUGH SOLIDS

The author demonstrates this fact at N. Y. University by holding a unit to a metal rod, the other end of which in turn rests against a cone

What is the— *Triple-Twin Tube?*



A unique development in radio vacuum tubes that may do away with audio-frequency amplifiers, as well as detector tube, making possible two- and three-tube sets exclusive of the rectifier

By John M. Borst

THE tube family has been increased by another "child" of unique possibilities. The latest arrival is expected to do away with the audio amplifiers in broadcast receivers.

With a signal on the grid of 4 volts, r.m.s. value. it is said to deliver 4½ watts undistorted output to the loudspeaker. This is about equal to three and a half times the output of a pentode and about twelve times the power of a single –45.

Apart from replacing the audio amplifier, it will take the place of the detector as well. With a 10-volt carrier on the grid it will deliver its 4½ watts to the loudspeaker as in the case of the amplifier.

A receiver with this tube in the output does not need any interstage coupling devices. The saving in space permits a midget receiver to be made with only two or three tubes and a rectifier which can supply the quality of reproduction of present-day consoles.

The size and cost of the midgets can be further reduced for those who wish an economical instrument.

The tube was developed in the laboratories of the Cable Tube Corporation and will be known as the Speed type 295 tube. It is expected that it will not take very long for the manufacturers to use it in production, as the circuit does not necessitate any special parts. The load impedance necessary for maximum output is equal to the plate impedance of the tube, which is 4000 ohms. The transformers in present-day use are designed for this load so they may be used in the circuit as usual. The minimum distortion of the amplifier, as a whole, is about 5%, and this minimum is obtained with the same load as the maximum output.

The characteristic curves show that the tube, with the circuit designed for it, has a nearly straight frequency response curve from 30 cycles to 50.000 cycles. This quality makes it especially suitable for television.

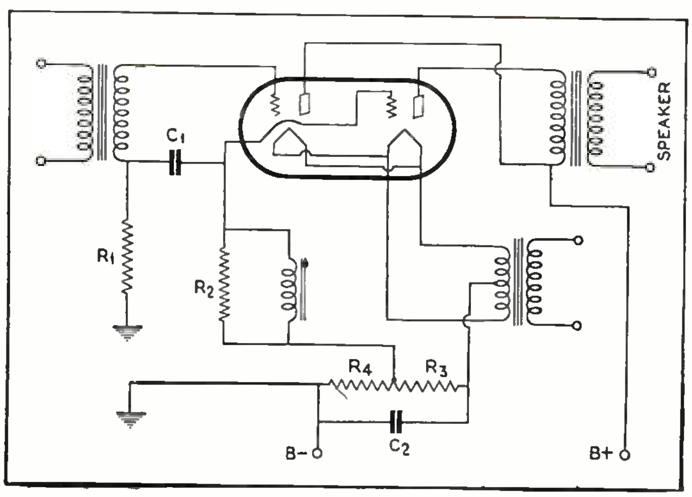
Construction of the Tube

The 295 consists of two triodes built in a single glass bulb. We all know that multiple tubes have been made in Germany a few years ago, but somehow they never became popular. The novelty of this tube is not the fact that it is a multiple one, but is in the circuit that goes with it.

In this article the two triodes which make up this tube will be called the first and second sections, or the input and output sections. The mounting of these two sections are entirely separate. so as to avoid static coupling as much as possible. The filaments are in parallel, and in order to insulate the different circuits, the input section is an indirectly heated tube and the output section is a heater type similar to the –50. The filament takes the standard 2½ volts a.c.

The two sections are coupled together in a "direct coupled" circuit. There is no need, however, of a double B battery. The cathode of the input section is connected to the grid of the output section. This is the only interstage connection inside the tube. This circuit would not deliver the 4½ watts power if it were not for the fact that the grid of the output section goes "positive." It does not affect, however, the quality of reproduction, because of the peculiarities in design of the circuit and the tube together, which we hope to make clear to the reader.

The tube fits in the standard five-prong socket. By inspection of the photograph it can easily be seen that the two triodes are so mounted that the fields do



AMPLIFIER CIRCUIT

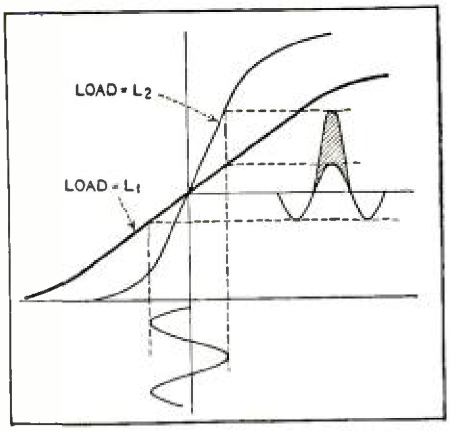
Figure 1. This diagram shows the connections for the tube when used as an amplifier

not interfere with each other. The cap on top of the tube is connected to the grid of the first section; both plates are brought out to the base of the tube.

Incidentally, the plate voltage for both sections is 250 volts. Although a direct coupling is used, the plates are at the same potential.

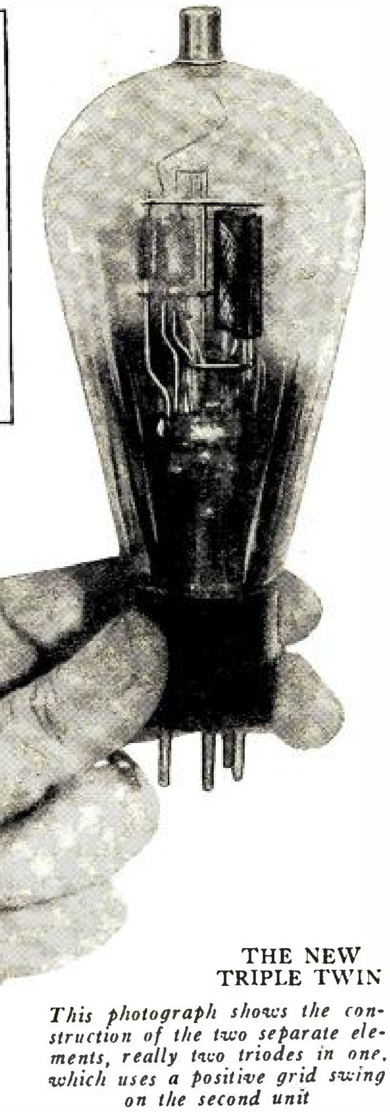
The Circuit Employed

Let us first discuss the working of the triple-twin tube as an amplifier. The circuit is shown in Figure 1. In the cathode lead—that is, in the plate circuit—there is a resistance R2 and an audio-frequency choke across it. The audio-frequency choke serves to provide a low resistance path for the direct-current component of the plate current. This does away with the loss of voltage in the coupling resistor R2. The direct-current component then goes through the choke, but the signal, at audio frequency, finds the choke a too high impedance path and most of it will flow through the resistance R2. For all practical purposes, we can say that the signal flows through R2 and this is the "load." In the circuit of Figure 1 this load is connected across the cathode and grid of the second section of the tube.



GRID CURRENT COMPENSATION

Figure 2. Dynamic characteristics for single tube at different loads. When a signal is impressed on the grid, the tube automatically varies its load so that a steepening characteristic is obtained for lowered load impedances



THE NEW TRIPLE TWIN

This photograph shows the construction of the two separate elements, really two triodes in one, which uses a positive grid swing on the second unit

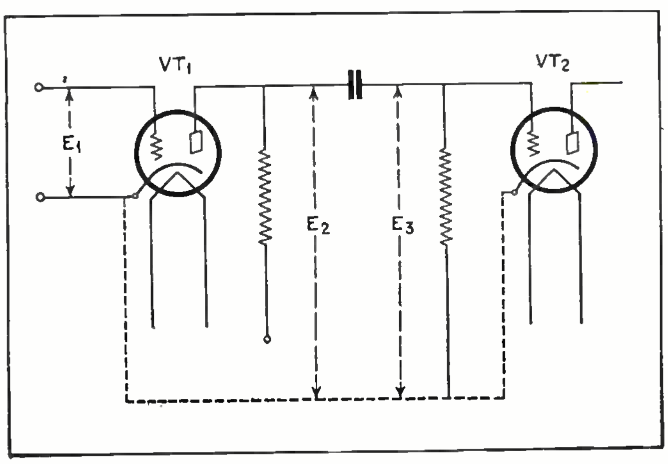
The bias to the first tube is provided by the voltage drop across the resistance R4, which carries the plate current of both the second and first tube. A small additional bias is obtained by the voltage drop across the choke. If we made the grid return (of the first section) to ground, as is usual in amplifier circuits, there would be a large resistance in the grid circuit. To provide a low-impedance return path to the cathode for the signal, the condenser C1, of 2 microfarads, is provided. This again necessitates the resistance R1, for without it the load would be short-circuited.

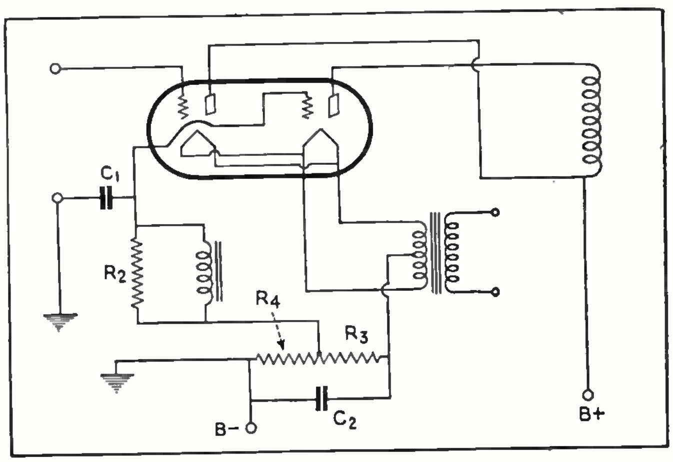
The signal is then amplified in the first section and develops an a.f. potential across the load which is connected to the grid and cathode of the next tube. However, the bias of the second tube is much smaller than that of the first. The grid of this tube, therefore, goes "positive" and it will draw current. One of the merits of the circuit is that this fact does not cause any distortion, for the circuit is so designed as to compensate for the additional current, which is drawn by the grid circuit.

We assume that the reader understands the causes for distortion in the ordinary coupled circuits, if the grid goes positive. In that case, current is drawn, and during that part of the cycle the impedance of the grid circuit changes and so the applied voltage, during that part of the cycle, drops, thus distorting the signal.

Let us draw the dynamic characteristic of a tube for a certain load L1 (see Figure 2). This represents the grid-voltage, plate-current curve for the tube (first section) when R2 is the load and the grid of the second section is still negative. Then at a certain point the grid becomes positive and makes the load impedance less. The dynamic characteristic then becomes steeper for this new load, L2, and it intersects the first one at the point where the conditions change.

When we now consider a sinusoidal signal, which is being impressed on the grid, we see that the part of the cycle which causes the second grid to go positive falls on the characteristic of L2 and that part causes a larger variation in plate current, thus providing additional current for (*Continued on page* 802)





RESISTANCE-COUPLED PHASE RELATIONS DETECTOR AND OUTPUT CIRCUIT

Figure 3. (Left) In standard resistance-coupled amplifiers the voltage E2 between the plate and cathode is 180 degrees out of phase when the signal voltage E1 is impressed between the grid and cathode. The voltage E3 is approximately 70 degrees advanced over E2 and about 110 degrees retarded behind E1. Figure 4. (Right) This is the electrical circuit diagram for using the triple twin tube as a combined detector and audio amplifier

Simple V. T. Voltmeter

With Coil and Condenser Matching Units

The vacuum-tube voltmeter described here represents an extremely useful instrument to have around in laboratory or shop. Units for use with this instrument, in matching coils and capacities, are also described

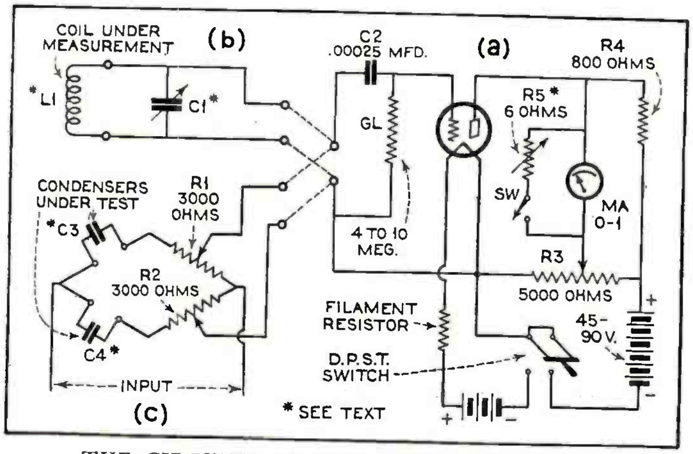
By Ransom M. Fiske

AN intelligent guess may have its place, but it certainly is not in the designing of radio circuits. A few years ago, when radio receivers had anywhere from three to a half dozen tuning controls, it was not necessary that condensers and coils have an exact value. Now, however, with single control, slight differences in capacities or inductances will make "just another radio" of a set that otherwise would have excellent sensitivity and selectivity. The equipment to be described, while not to be compared with the very expensive and highly accurate instruments available, is such that no one having use for it need be ashamed to add it to his laboratory. If care is taken in the construction and operation, truly excellent results can be obtained.

The theory of operation of the vacuum-tube voltmeter is easily understood. Assume that we have a tube connected in a conventional circuit such as Figure 1. The milliammeter in the plate circuit registers plate current under the existing conditions of plate and grid voltage. Now, if an alternating current is impressed on the grid, the plate current will vary up and down in accordance with the grid potential. The milliammeter will not pulsate, however, since its inertia will not allow rapid variation. The result is that the milliammeter will show the maximum of the plate current variation. The greater the alternating current voltage, within certain limits, applied to the grid, the greater will be the milliammeter reading. Such a device, being independent of frequency, is very valuable in making measurements at either audio or radio frequencies.

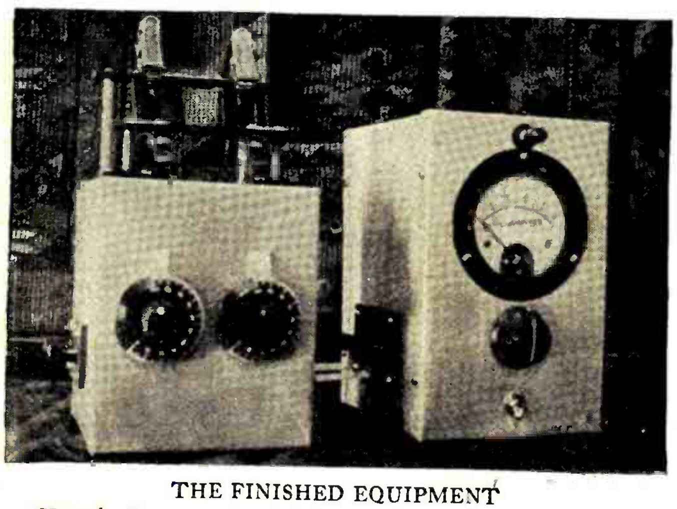
Figure 2 shows the schematic diagram of the vacuum-tube voltmeter and the related units for the measurement of inductance and capacity. Notice that the milliammeter is not connected in the same manner as shown in Figure 1. This method of connection is very important, as it greatly increases the sensitivity. It will be seen that a positive potential is applied to both sides of the meter through R4 on one side and part of R3 on the other. If R3 is adjusted a setting will be obtained where these potentials will balance and no current will flow through the meter. If an alternating current is now applied to the grid of the tube, the change in plate current will upset this balance and current will flow through the meter. A very slight change in plate current will produce a much greater deflection of the meter than if it were connected as shown in Figure 1. The meter shunt resistance (R5) may be mounted on the back of the meter, as, once adjusted, it is not touched again.

Figure 2b shows the circuit of the inductance measuring unit. The condenser (*Continued on page 792*)



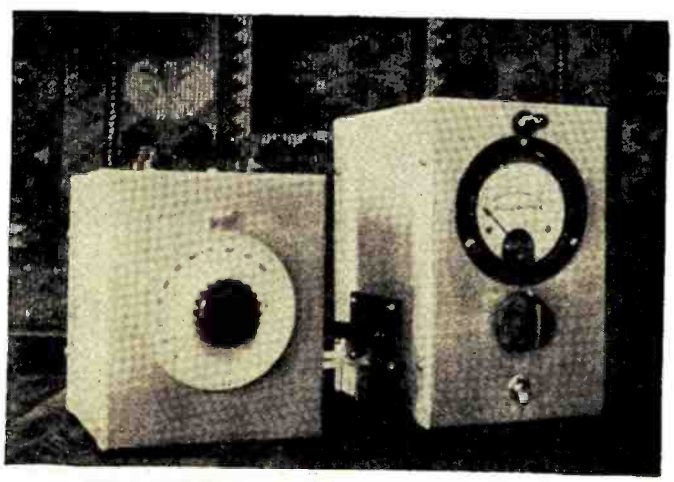
THE CIRCUITS OF THE UNITS DESCRIBED

Figure 2. (a) Shows the circuit employed in the voltmeter. The reasons for the resistors in the plate circuit are explained in the text. (b) The schematic circuit of the inductance matching unit and (c) of the condenser bridge unit



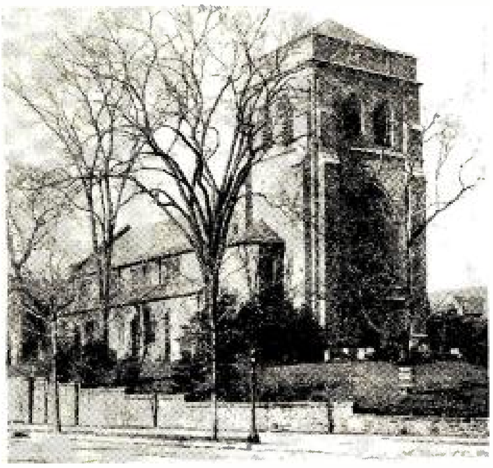
THE FINISHED EQUIPMENT

Here is the set-up for matching condensers. The v.t. voltmeter is at the right and the capacity bridge unit at the left. Two condensers to be matched are shown in position, held by clips above unit, for test



THE INDUCTANCE MATCHING SET-UP

The shield at the left incloses the equipment shown in the diagram of Figure 2b. The coils to be measured are connected between the clips on the top of the case. The instrument on the right is the v.t. voltmeter



Opening the Church Door to the Hard-of-Hearing

With the awakening realization that here in the United States there are probably three million people who are unable to participate in religious services because of impaired hearing, churches everywhere are evincing a keen interest in group hearing aid installations

By K. P. Royce*

THOUSANDS of people whose hearing is impaired are finding that the science of electrical communication has removed one more obstacle from their enjoyment of the normal contacts and opportunities open to their fellow beings.

Individual hearing aids have solved for them the problem of individual contacts. Here the source of sound is close by and is easily picked up by amplifying devices small enough to be carried around on the person or in a ladies' handbag.

But with such aids only, the hard of hearing would still be shut out from sound at a distance. This would mean that all those activities which human beings enjoy in groups would be denied to them. Lectures, speeches, sermons, music, meetings, classroom instruction, these and a host of similar gatherings in which the listener is at some distance from the source of sound would leave those with impaired hearing seriously handicapped.

To increase the amplification of the individual hearing device so that it would pick up the voice of a speaker at twenty or a hundred feet away would equally amplify all other sounds entering the microphone and mask the speaker's voice. The solution lay along other lines and has been found, not by equipping the individual, but by equipping the place of meeting for the individual.

Various forms of what might be called "group hearing aids" have become available. They are rapidly increasing in use. Now in churches, auditoriums, music halls, meeting rooms, and even schools, throughout the country, the equipment has become familiar and welcome to scores who have through this medium been released from the circle of stay-at-homes and are now able to listen comfortably.

THIS is the fifth consecutive article of a series devoted to the interests of the deaf. The earlier articles discussed the commercial types of individual hearing aids (November and December issues), a powerful portable hearing aid to be built at home (January) and a simple home-made amplifier attachment to enable the deaf to hear clearly over the telephone (February). The later articles will cover additional types of equipment, both commercial and home-made, to meet the various needs of those having impaired hearing.

These articles should be of tremendous interest, especially as much of the material is along lines on which little or no information has heretofore been available.

—The Editors.

As this type of hearing aid requires the installation of equipment in a building, the individual who needs it cannot furnish it himself, but rather he must look to building managers, to the directors of clubs, to the vestrymen of churches for it. In many progressive communities such organizations have had some form of hearing aid in use for a considerable time. As developments in communications have led to the perfection of hearing systems, the old equipment has become comparatively primitive and is being replaced by the new. Other organizations, realizing the service it performs, are furnishing it for the first time. Now architects, foreseeing the need, often provide for the installations in their original plans.

A recent installation, at the Reformed Church, Bronxville, N. Y., was made in accordance with the plans of the architect, Harry Leslie Walker, of New York. As in many buildings with stone floors, so here the plans allowing for conduit and outlets, simplified the installation and resulted in economy.

This church seats about 650 people. The system it uses is the Western Electric audiphone and its associated equipment, distributed by the Graybar Electric Company. As installed, it consists of a transmitter (microphone) and its power supply, an amplifier, and a number of receivers (headphones) which are equipped with potentiometers to permit of individual volume control.

The transmitter is very sensitive, being of the carbon granule type. It was

ONE OF THE HEADPHONE EXTENSIONS

In the Reformed Church, Bronxville, N. Y., outlets are provided in several pews where those who are hard of hearing may plug in individual headphones

*Graybar Electric Co., Inc.

—AND NOT ONLY IN CHURCHES

In the directors' room of one large organization hearing equipment is installed to aid two board members of impaired hearing to take an active and normal part in the proceedings

at first located on top of the pulpit which is the customary place for it. Listeners reported that even with amplification at its lowest, the volume at the receivers was too great. It was then placed on a shelf in the pulpit about two feet from the ground. However, the volume was still too great and the transmitter has finally been located at a concealed point about 15 feet in front of the pulpit. Obviously, with such a powerful system, speakers having a voice much less resonant than that possessed by Dr. John H. Powell of the Reformed Church may still be assured of adequate amplification.

The transmitter is furnished with six feet of braided wire which connect it with the apparatus box. If a longer connection is necessary, the wire can terminate in a connecting block which is furnished with the set.

A.C. Operated

A current supply of approximately 50 milliamperes flows through the transmitter when it is connected in circuit. The apparatus box contains a switch for the transmitter circuit. Although the box at the Reformed Church is located in the basement, both it and the amplifier are small enough to be placed within the pulpit if desired.

The single stage amplifier operates on a 50- to 60-cycle a.c. power supply of 105 to 120 volts. Its power consumption is approximately 40 watts. While the amplifier itself is supplied with a switch, a magnetic switch can be furnished by which both the amplifier and transmitter power supply can be operated from a remote point.

The amplifier contains two power tubes of the type that is familiar to radio technicians as the Western Electric "E" tube. One is used as the rectifier to supply plate current and the other as the amplifier tube.

The amplifier is equipped with input and output transformers designed to match the impedance of the transformer and of the output circuit, making it more faithful and efficient. The output transformer is tapped to allow matching the impedance of a small or large number of telephone sets.

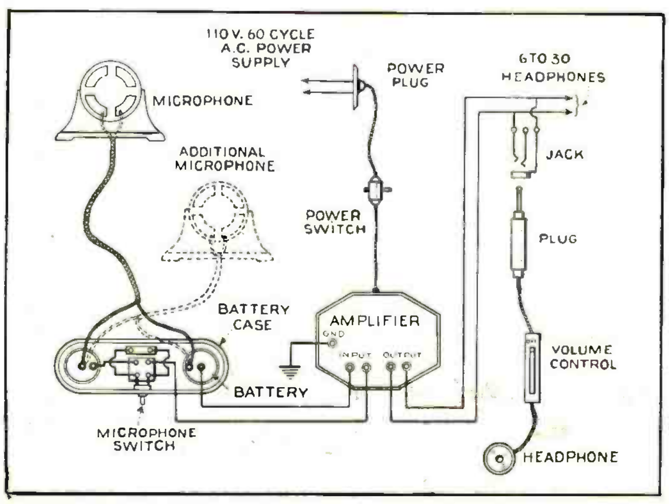
While the specifications of the system state that it will operate 30 headphones, in actual experience as many as 100 receivers have been used successfully, although there is some decrease in volume level with an increase in the number of receivers.

The jacks for the headphone plugs are located under the seats. This is the most convenient place because passage through the pew is not obstructed by the cords once the receivers are plugged in. Enough cord is furnished so that the user can stand up during the service without removing the phone from his ear. The receivers themselves are like those worn by telephone operators. Lorgnette handles, which can be telescoped to any comfortable length, are also available. Women prefer these as they eliminate the necessity for removing hats and can be held inconspicuously to the ear.

The potentiometer which is part of the headphone set enables each user to control volume to suit his particular needs. Changing the volume on one receiver has no effect on the input reaching the other receivers. The potentiometer is of high resistance and is designed to be held in the hand.

Many Buildings Equipped

More than 200 of these systems have been installed throughout the country in the last three years. The first installation was an experimental one made by Bell Telephone Laboratories in 1924 at the convention of the American Federation of Organizations for the Hard of Hearing in Washington, D. C. It was arranged to provide for 200 (*Continued on page* 806)



CONNECTION DIAGRAM

Schematic layout of a complete installation

THE MICROPHONE PICK-UP IN THE PULPIT

The inconspicuous microphone (in circle) may be left on the pulpit or concealed nearby. This view shows the early installation in the Reformed Church, Bronxville, N. Y. Later the microphone was placed in a concealed position fifteen feet from the pulpit

RECENT DEVELOPMENTS IN THE DESIGN OF

Electro-static Loudspeakers

A method of determining self-resonant conditions in stretched diaphragms used in the latest electro-static speakers, along with methods for coupling these speakers to the output circuit of an audio-frequency amplifier are described in this second and concluding article

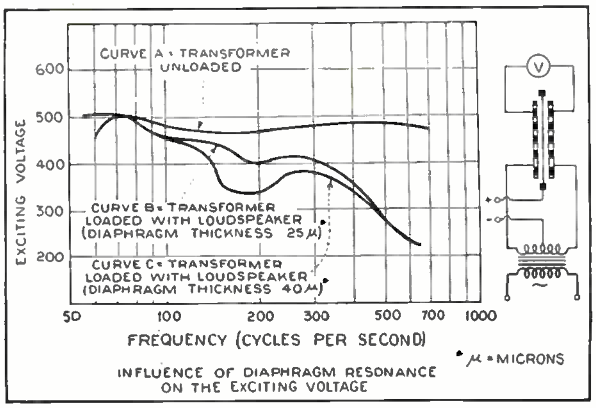
By Hans Vogt

Part Two

THE already well-known method of making sound figures on vibrating diaphragms by sprinkling sand over the diaphragm while in an oscillating condition often reveals interesting facts about its frequency characteristics. It has already been observed that with the formation of concentric circles on the diaphragm of an electro-static loudspeaker during these tests, it is accompanied by an undesirable increased sound reproduction at certain frequencies. The apparent increase in power input connected therewith can easily be proven by measuring the alternating voltage of the electrical excited and undamped oscillating diaphragm. In Figure 1, as shown in the curves B and C. the voltage rupture at a frequency of about 190 cycles per second can only be explained by a voltage in opposite phase caused by a diaphragm oscillating strongly at this fundamental note. It is interesting to note. also, that in thicker diaphragms these resonance effects are more pronounced (curve C).

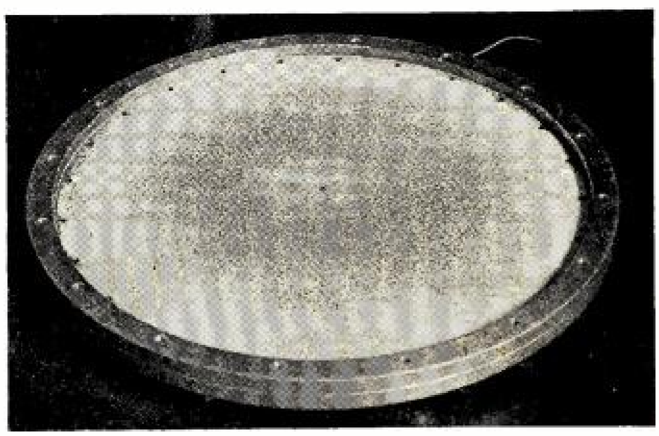
This counter-voltage. which was probably measured for the first time, may be compared with the electro-magnetic counter E.M.F. of a dynamo. Figures 2 and 3 show such "sound" figures of electrostatically excited. tensioned diaphragms of 380 mm. diameter, obtained by the use of sand. Figure 2 shows the fundamental note, Figure 3 the oscillating form belonging to the third harmonic. At the dark points, the diaphragms effect the maximum amplitude. These undesirable diaphragm resonances were considerably minimized, at the points of the fixed electrodes facing those parts of the diaphragm which showed a considerable amplitude in both resonance cases, by enlarging the width of the ribs so that the air passed in and out with difficulty at these points, causing an additional damping on the oscillating diaphragm. Figure 4 shows a fixed electrode seen from above and permits the easy recognition of the enlarged ribs towards the center of the diaphragm and at a point between the edge and center.

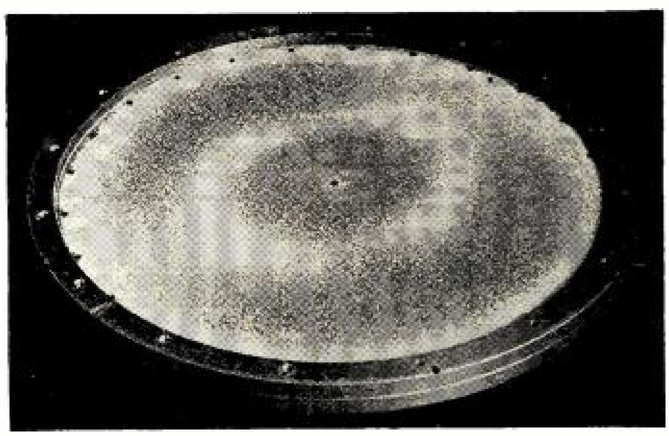
The electrical excitation of such a three-electrode system dimensioned. for normal use. takes place as follows: In the first place the polarization voltage is applied. In the case of the three-electrode system the density of the electrical field between the electrodes at the narrowest points, at an air distance of 0.4 mm. and at a direct voltage of 1500 volts, amounts to 37.5 kv. per cm. In view of the fact that the distortion factor is to be kept at a minimum (if possible below 5%), the alternating voltage must, if possible, not exceed a quarter of this value and amounts to a maximum of about 500 volts, effective. In the condition of oscillation, the values of the field density increase, therefore, at a full output to about 5 kv. per cm. The wattless bias is simply produced by the rectification of a high alternating voltage. The acoustically-modulated voltage supplies an amplifying tube. The connection, of the electrostatic sound producer to the amplifier, can be effected either direct or by means of a transformer, according to the amount of the plate voltage of the amplifying tube. The three-electrode system can



FREQUENCY CHARACTERISTICS

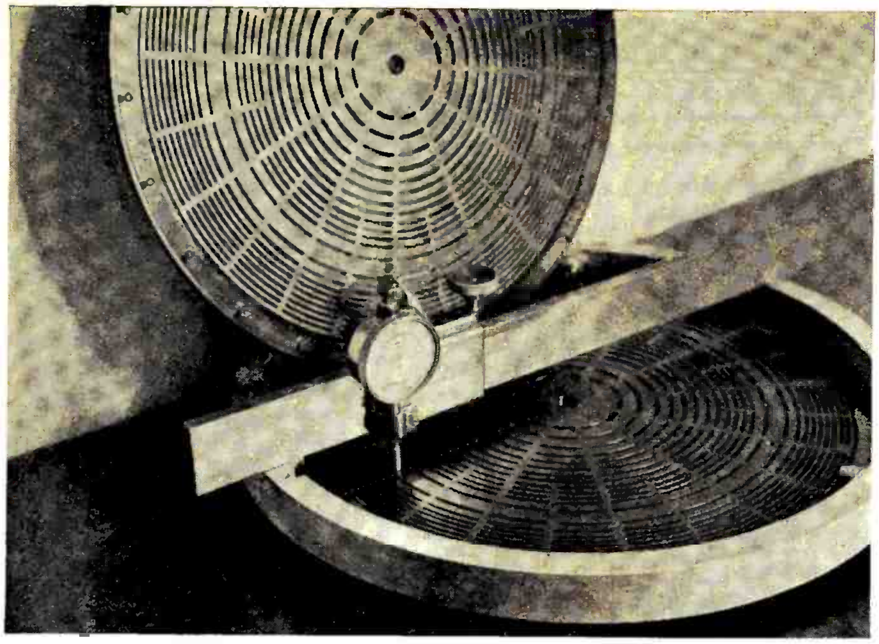
Figure 1. The three curves show variation in frequency characteristic with diaphragms at various thicknesses





SAND-SOUND FIGURES ON STRETCHED DIAPHRAGMS

By setting the diaphragms in motion electro-statically, the frequency characteristics may be quickly studied. Figure 2, left, shows the formation obtained at the fundamental note of the diaphragm. Figure 3, right, shows the form obtained from the resonance of the third harmonic



CORRECTING ELECTRODES

Figure 4. In these outer electrodes the spacing of the holes between the ribs has been decreased at certain radii to produce damping and eliminate resonance at troublesome frequencies

be considered as a double condenser, the capacity of which (measured in the position of rest) amounts, in the model, to about .0022 mfds. These capacities can be used either in series or in parallel. As the values of the bias of the alternating voltage and those of the capacities are known, the adaptation of the system to any desired conditions is possible by simple mathematical consideration.

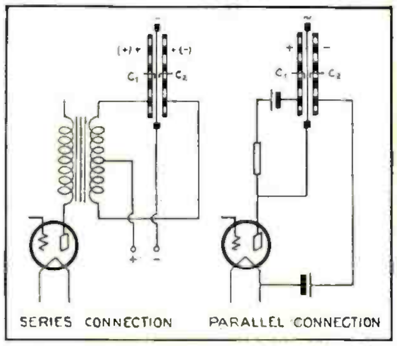
Series and Parallel Circuits

Figure 5 shows two types of circuits, the example *a* refers to a circuit in series of the capacities c_1 and c_2, the total capacity is therefore half, .0005 mfd. The fixed electrodes are connected with the bias. A transformer supplies the essential alternating voltage, which is fed to the fixed electrodes. The example *b* shows a circuit in parallel. In this case the capacities are connected in parallel with the amplifying tube or with the plate-coupling resistance. The capacity load on the generator now amounts to .0022 mfd. The fixed electrodes have an opposing bias, the alternating voltages are fed to the diaphragm. In comparison with the usual tube resistances and for economical reasons (omission of the transformer) the circuit in parallel mentioned in the example *b* is frequently given preference. Also combined circuits may be employed.

In the case of an oscillating capacity the result would be an increased reproduction of the higher frequencies. In order to obtain a constant sound effect, therefore such an adaptation must be made, so that the alternating voltage at the loudspeaker with increased frequency, becomes smaller in a certain proportion. It is only possible in this way to avoid the high tones being reproduced too strongly and the deep tones too weakly, a disadvantage which together with a high distortion has been disclosed in all previously known loudspeakers. Figure 6 shows, as an example, the course of the alternating voltage on a resistance-coupled amplifier, without loading (curve a) and with loading by a three-electrode system (.0022 mfd.) of the embodiment described (curve b).

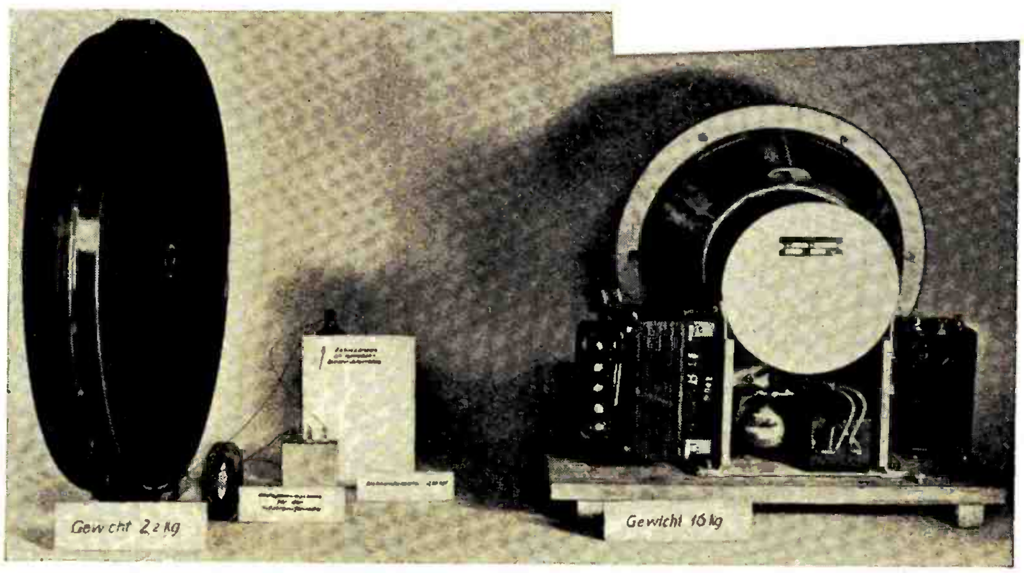
Sound Pressure Curves

In Figure 7 two sound-pressure curves are shown of the arrangement in question. The three-electrode system was connected to an output stage according to Figure 6



CHARACTERISTIC CIRCUITS

Figure 5. Left, a series arrangement of the capacities C1 and C2 when used in the output circuit of a tube with a transformer. Right, parallel circuit for connecting through a resistance to the plate circuit of an output tube



THE ELECTRO-STATIC AND THE ELECTRO-DYNAMIC

Figure 8. Left, the comparative size of the new electro-static speaker and accompanying coupling and power apparatus. Right, modern type of electro-dynamic speaker with large transformers and coupling devices

SUPERHETERODYNE Innovations

This new twelve-tube receiver is intended for the fan who demands the unusual in sensitivity along with other good qualities. It includes push-pull arrangements of both audio stages and the second detector

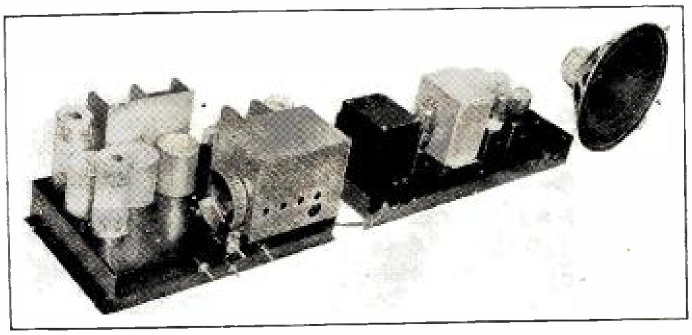
By McMurdo Silver*

IN the September, 1931, issue of RADIO NEWS the author described a superheterodyne tuner, compensated audio-amplifier combination, designed primarily for use under the most unfavorable reception conditions and by radio users to whom expense was no consideration, providing only that they could get the very best possible reception. It was felt that little if anything could be done to improve its performance. However, from that class of radio fans who always want the "ne plus ultra" of design and performance continued to come inquiries as to what gadgets could be added to it to make it just a wee mite better. Consistently they have been told nothing could be beneficially added, for the writer has never been one to favor adding gadgets just for their own sake—he has always held that any and every part or tube in a radio receiver must perform its full function if its inclusion was to be justified. But this continual stream of inquiries about extra gadgets has stimulated experiment in the S-M laboratories to see if there were any that would help at all. It has been found that the tone quality could be somewhat improved by certain changes and additions, and, hence, the new twelve-tube model to be described herewith.

Essentially it is the same as the 716-683 combination, except for the use of a push-pull second detector, two push-pull audio stages, with a simplified method of obtaining the dual tone control feature, and, of course, a considerable number of mechanical changes. The receiver is illustrated, mounted in a cabinet in Figure 1, removed in Figure 2, and its bottom view in Figure 3. The schematic circuit diagram appears in Figure 4, and the sensitivity, selectivity and electrical fidelity curves in Figures 5, 6 and 7 respectively.

The assembly will be seen to consist of three units—the tuner, the audio amplifier and power supply, and the electrodynamic speaker unit, all interconnected by means of suitable cables having plug and socket terminations.

The tuner circuit is seen at the left of the diagram of Figure 4. It consists of a dual pre-selector circuit coupled through a small common inductance just below critical coupling, or just below where the curve would ordinarily broaden out, feeding a type -51 vario-mu screen-grid r.f. amplifier stage. This r.f. stage in turn feeds a type -24 first detector through a tuned transformer, to the



THE RECEIVER UNITS

Figure 2. The tuner chassis is separate from the amplifier-power supply. This facilitates mounting in a moderate size cabinet, yet avoids undue crowding which would result in combining both on one chassis

*President, Silver-Marshall, Inc.

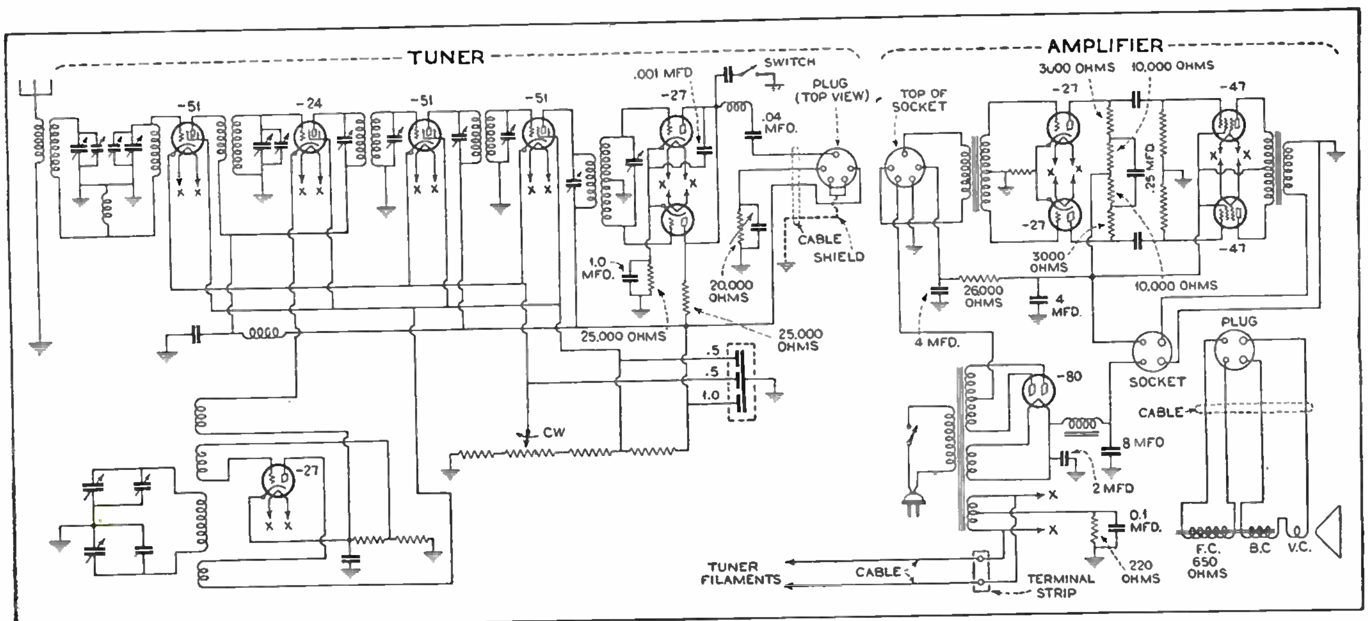
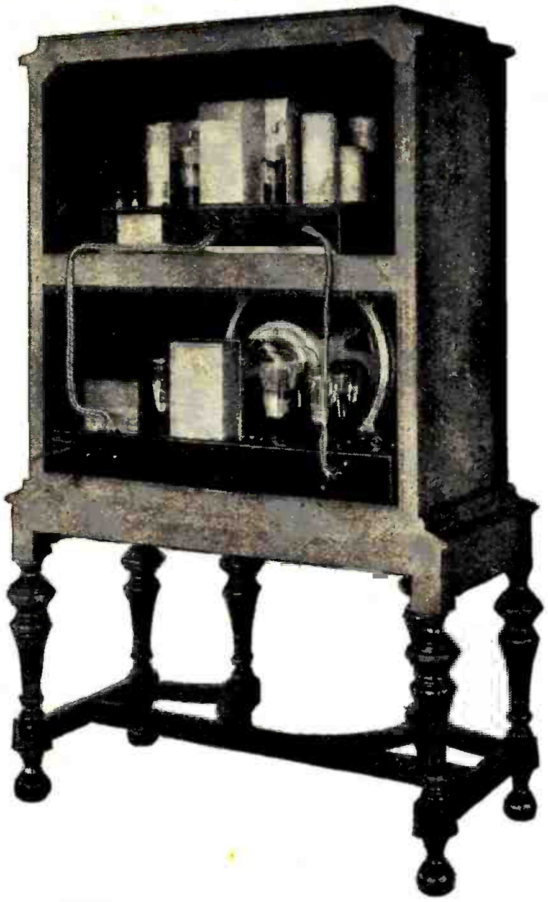


FIGURE 4. THE SCHEMATIC CIRCUIT DIAGRAM



THE RECEIVER IN ITS CABINET

Figure 1. An unusual feature is the center shelf, which is especially designed to prevent transmission of vibrations from speaker to tuner chassis. A combination of wood and celotex, separated by a dead airspace, is employed

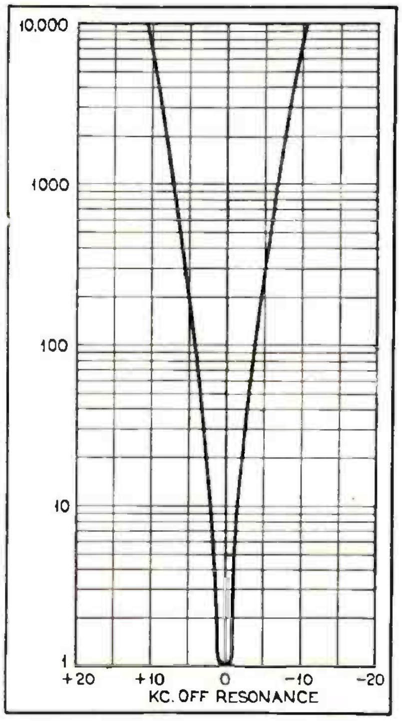
cathode circuit of which is coupled the extra stable tank-tuned oscillator. All four of the tuned circuits involved are tuned by a four-gang condenser housed in the large shield at the right of Figure 2, with the individual trimmers accessible through holes in the front of the shield for alignment purposes. There is nothing extra special about these circuits, except that the plate current of the –27 oscillator is bled through the bias resistors for the –24 first detector to insure a more constant grid bias than would be had through pure automatic bias. That portion of the voltage drop used to bias the oscillator is taken across an un-bypassed resistor intentionally, this serving to hold the output of the oscillator desirably constant over its range. The rejector input circuit of the 716 has been abandoned due to its difficulty of alignment in the field.

Two stages of 175 kc. i.f. amplification are used, with type –51 tubes. Each stage employs a dual tuned i.f. transformer, such transformers providing a total of six tuned circuits in the i.f. amplifier. The third of these transformers has a tapped secondary to feed the grids of the push-pull detector stage. Volume is controlled by varying the control grid bias of the r.f. and the two i.f. tubes simultaneously by means of a potentiometer, with a minimum fixed bias obtained by a resistor in series with the potentiometer in the bleeder circuit. By-passing and isolation of the necessary points is provided, as can be seen from the diagram.

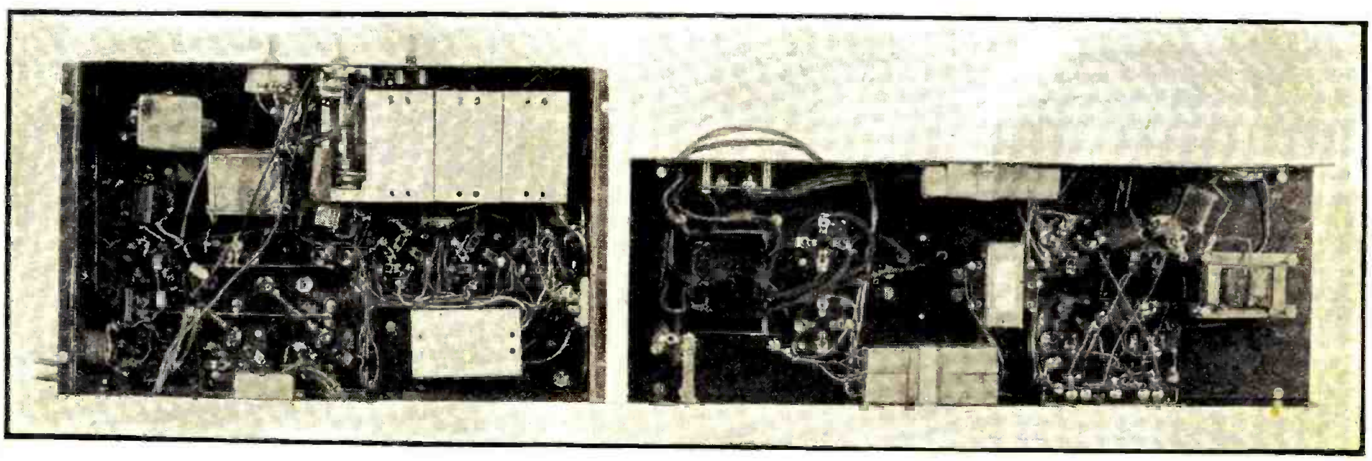
Push-Pull Second Detector

The second detector system employs two –27 tubes in push-pull, for increased handling capacity and reduction of harmonic distortion. At first glance, the circuit does not appear to be push-pull, since the two detector tube plates are tied together instead of going to opposite ends of a coupling transformer, as in a push-pull amplifier circuit. The connections shown in the diagram are correct, however, since the output of the detector tubes is pulsating d.c., there is no question of phase reversal involved. In fact, were a push-pull amplifier so biased as to rectify, there would be no output except that due to tube unbalance, since the plates would always be at the same potential, rather than opposite potential, as in an amplifier circuit. The detectors are biased by a 25,000-ohm resistor in their grid-plate returns, which is by-passed by a 1 mfd. condenser-essential, since the audio currents involved are in phase in their plate circuits, rather than out of phase and balancing, as in an amplifier circuit.

The detector plates are by-passed by a .001 mfd. condenser, and an r.f. choke is included in the plate lead. The switch SW and the condenser in series with it from detector plates to ground is the high-frequency or treble tone control, and will be covered later. The output from the tuner unit is through a cable terminating in a five-prong plug to be inserted in a socket on the amplifier chassis, and provides ground B + and detector output connections. An interesting feature is that though (*Continued on page* 807)



THE SELECTIVITY CURVE
FIGURE 6



THE VIEW BELOW DECKS

Figure 3. As the author explains, the rather unprofessional appearance of the tuner wiring is the result of an early model being used as the subject for this photograph

TOP VIEW OF THE FINISHED UNIT

Note the compact simplicity of the unit. The voltages or currents to be measured are connected to the two binding posts on the left, which are a new development and function either as plug jacks or regular binding posts

A Real UNIVERSAL Meter

Radio men have been looking forward for years to the development of a really universal meter, and here it is—an a.c.-d.c. meter unit which provides eleven voltage and current measurement ranges

***By* J. van Lienden**

IT sounds too good to be true, but the universal meter which is shown in the photographs on this page actually serves for all a.c. and d.c. measurements one wants to make on a receiver.

The new rectifier type milliammeter makes it possible to obtain all voltage ranges and current ranges with but one meter if the proper multipliers are provided. The rectifier type meter has been used before as an a.c.-d.c. voltmeter, but in the equipment described here, designed by the engineering department of the Shallcross Manufacturing Company, there are also milliammeter ranges available for a.c. and d.c. To be sure, for these current ranges the instrument has a rather high resistance, but for measurements in the plate circuit of a tube or in the power pack, in short, in all high-resistance circuits, it will be accurate enough. One should not try to use it in a low-resistance circuit, as, for instance, in measuring microphone current.

The ranges provided with this instrument are 0-5 volts, 0-10 volts, 0-50 volts, 0-250 volts, 0-500 volts and 0-1000 volts, both a.c. and d.c. All these ranges have a sensitivity of 1000 ohms per volt. This is somewhat unusual, for most a.c. voltmeters now in use draw a rather heavy current. The current ranges for both a.c. and d.c. are 0-1 ma., 0-5 ma., 0-25 ma., 0-100 ma. and 0-500 ma. The milliammeter operates on the voltage-drop principle; the shunts are so chosen that there is a potential difference of 5 volts across them at full-scale deflection.

The circuit is shown in Figure 1. The rectifier and the meter have an internal resistance of 5000 ohms; therefore it is necessary to put a 5000-ohm resistance in series with the d.c. meter so that the same multipliers can be used. The little resistance on the back of the meter must be connected across it when it is used on d.c. but not when it is used as an a.c. meter. This is automatically taken care of by the a.c.-d.c. switch.

It will be seen that when the switches are set for current readings there are different shunts available across the 5-volt voltmeter. On the lowest range (1 ma.) there is no shunt needed and the point on the selector switch was not connected in the original design. However, we see no reason for keeping the 5000 ohms in the circuit in this case, so in the model described here, a connection to the switch is provided which short circuits this resistance when using the 1 ma. range. Therefore, on this range the meter has a low resistance.

For safety a push-button has been provided. While the button is up, the voltmeter ranges are increased by 100 volts. The current ranges are also increased. Both these changes are provided for by a single button.

Constructional Details

All instruments are mounted on a panel 5¾ inches by 8¾ inches by 1/6 inch thick. The (*Continued on page* 800)

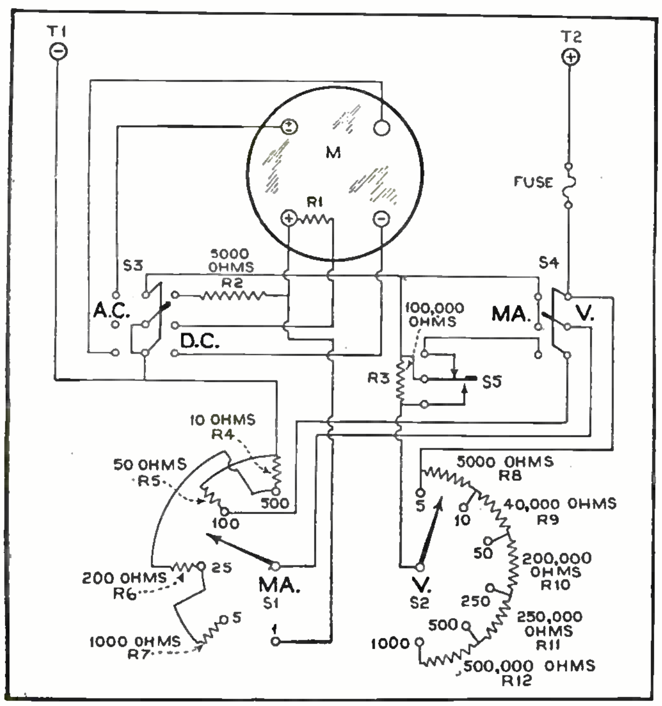
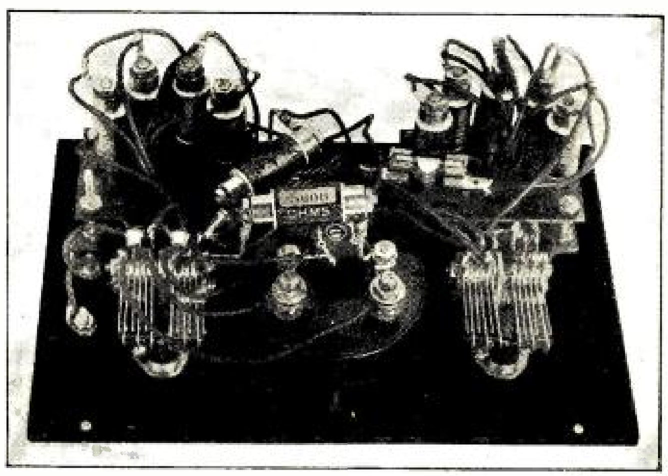


FIGURE 1. THE SCHEMATIC DIAGRAM

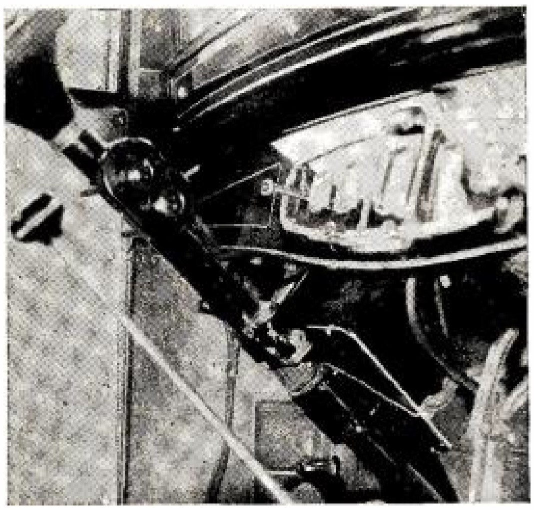


UNDER THE PANEL

All parts are directly or indirectly mounted on this panel. The details of the panel and of the subpanels used for mounting the resistors are shown in Figures 2, 3 and 4

SIMPLICITY OF INSTALLATION A FEATURE OF

New Motor Radio Design



RECEIVER AND REMOTE CONTROL
The receiver clamp and mounting plate provide a choice of fourteen positions for mounting

Here are given instructions on installing and adjusting the automobile radio set which was described last month. Much of the information given applies equally well to the installation of any auto radio

By Justus W. Berge

Part Two

THE method of mounting the entire receiver on the steering post of a car is one outstanding feature which marks the Marquette Motor Radio as a real advance in automobile radio design, since it eliminates the necessity of drilling holes for the mounting of the receiver proper or of cutting away parts of the floor of a car for this purpose.

The enameled-steel case in which the receiver chassis is mounted is composed of two parts. One of these parts covers the top of the chassis and also the sides, leaving the bottom exposed to view. The second part of the case is a bottom plate which is fastened to the flanged bases of both the chassis and the top cover by four screws and also to the clamp on the steering post.

Set Mounts on Steering Column

This bottom plate has fifteen holes in it, as shown in Figure 2. Since the clamp has four evenly spaced holes, it can be fastened to any given set of four holes in two different ways, so as to provide either horizontal or vertical mounting for the receiver. The five different positions of mounting the receiver, as shown on Figure 2, therefore become ten. By turning the plate over and attaching the clamp to the opposite side, four more positions are obtained. This gives a total of fourteen different positions in which the receiver can be attached to the steering post. In some cars it will be found that certain integral parts of the car are in the way of one kind of mounting or another. One of the fourteen will permit the installation of the receiver without being in the way of any car parts. Difficulties sometimes arise through close proximity of one-shot grease systems as used in some cars or a combination spark coil and ignition switch which is fastened to the dashboard. Sometimes a ventilator handle is too close at hand. In all of these cases the receiver can be mounted without coming too near any of these parts. A patent for this method of mounting a receiver is pending.

The clamp which holds the chassis to the steering post is felt lined, to relieve the receiver of as much shock as possible, and has a layer of rubber which comes in direct contact with the steering post. This prevents the receiver from slipping. The bottom and top parts of the clamp are held together by four machine screws which allow adequate leeway to compensate for different steering post diameters.

On one side of the case are three holes through which the compensating condensers can be adjusted after the receiver has been installed. This is a necessity, since the capacity between the antenna and the body of the car greatly varies in different installations, and this affects the line-up of the r.f. stages.

A tube shield which is fitted over the housing of the center coil effectively shields the r.f. and detector tubes from each other and thereby eliminates any possible tendency towards oscillation.

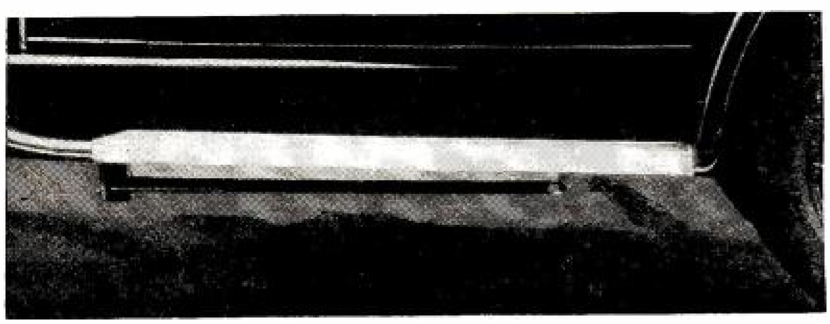
Concerning the sensitivity, in the heart of New York City, WLW comes in with good strength. On one occasion WFAA in Dallas, Texas, was received with volume enough to be heard above traffic noises. The tone produced by the dynamic speaker is comparable with that obtained on a good receiver designed for the home.

Something of the receiving qualities of the receiver can be imagined when one finds that it produces a signal in the Holland Tunnel, a gigantic steel tube under the Hudson River. The sensitivity of the receiver pulls through a few of New York's higher power transmitters, inside the tunnel. Under steel elevated structures, a few of the stations fade slightly, but some still come pounding through with practically their full strength.

Getting Set Ready

Having covered the design features of the receiver, now we will go into its installation and operation, including such points as noise elimination in the motor and proper antenna installation. The different points to be covered in this article are not solely confined to the Marquette installations, but many are applicable to the installation of any kind of automobile radio receiver.

The sequence of steps in the installation as presented is very important. This is due to the fact that conditions

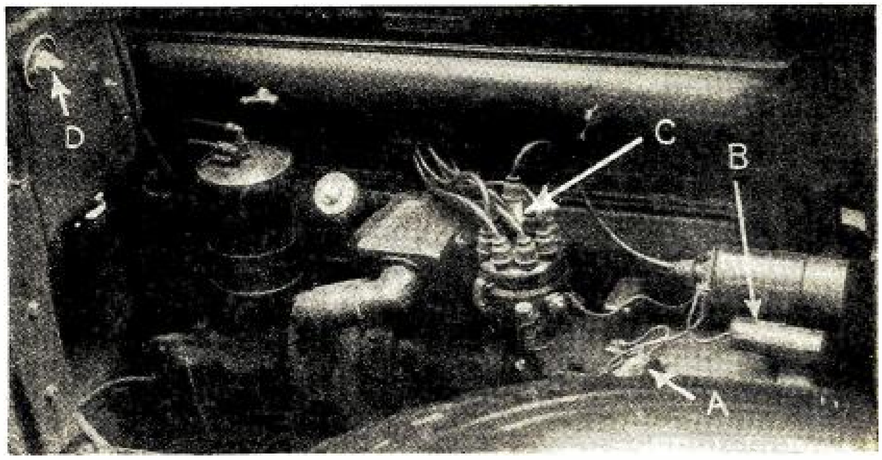


THE STEP TYPE ANTENNA
This antenna takes the form of a plate which mounts on the under side of the running board. It is provided with a splash guard and flexible mountings, and is weatherproofed

as encountered in step four might influence the work done in step five, etc. It is absolutely necessary to do the things in the right order of procedure if a perfect installation is desired.

The first thing to do is to test the receiver before installation. Place the proper tubes in their respective sockets. In the case of the Marquette receiver. three –36 tubes are placed in the two r.f. and detector sockets, one –37 is put in the first audio socket and two –38 tubes go in the final audio push-pull stage. The sockets are plainly marked with the type number of the tubes they take.

The receiver is placed in its steel case and propped up on the driver's seat. A wire is thrown over the top of the car or placed alongside of it to serve as a temporary aerial and connected to the antenna lead coming from the receiver. The batteries are also temporarily connected, by means of the cable. as follows: Yellow, B plus; green, B minus; red, A plus; and black, A minus. With the plugging in of the speaker, the set-up for test is ready.



ELIMINATING ENGINE NOISE

This shows the two by-pass condensers (A and B), the distributor suppressor (C) and the loudspeaker mounting screw (D). In this Buick model the pan on the top of the motor effectively shields the spark plugs and wiring so that no spark plug suppressors are required

The purpose of this operation is to make sure that the receiver is working properly and that the tubes are all good. It is indeed aggravating to have to demount a receiver after care had been taken in its installation only to find that one of the tubes is defective or perhaps that the remote control belt was not placed properly in its grooved pulley.

Installation Procedure

With the receiver in perfect working order under test, the actual installation work can begin.

The chassis is removed from its steel case and the large clamp is detached from the bottom of the case. Then the bottom is again attached to the case just as though the chassis were inside.

Since the receiver is to be mounted on the steering post. underneath the front dashboard and over the brake and clutch pedals, the dummy case should be tried in various positions in that area to determine which of the fourteen different positions in which the receiver can be mounted will be used. Any of these different methods of mountings can be effected by fastening the clamp to the steel base plate by means of four screws through the corresponding holes in each, which line up properly after the position desired is ascertained. The receiver should be placed so that the remote control cable comes out either on the left, right or top when facing the receiver from the driver's seat.

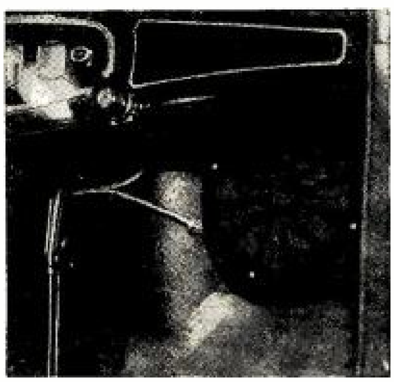
Care should be taken that the receiver is mounted as far up on the steering post as possible without coming in contact with any of the equipment fastened to the dashboard. By doing this. it lessens the danger of the set being in the way when the feet are applied to either the brake or clutch pedal.

A strip of rubber taken from an old inner tube should be placed between the felt in the clamp and the steering post. This acts as an additional shock absorber and also keeps the receiver from slipping on the post. The felt pieces should also be glued to the inner faces of the clamp.

The next consideration is the remote control. which should be handled very carefully prior to being permanently installed. to avoid sharp bends or kinks in the cable. It should be placed on the steering post between the steering wheel and dashboard. The remote cable at the point it enters the receiver should not be bent at an angle, but should be rounded in a circle to permit the free movement of the wire within.

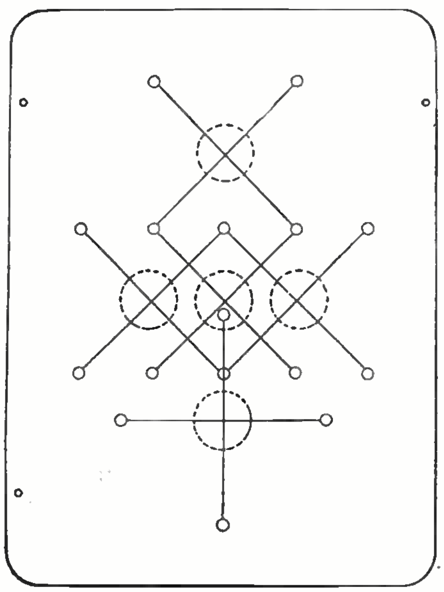
Before fastening down the four screws which hold the remote control to the steering post, the tuning knob should be rotated a few times. If the movement is not free, the entire control may have become twisted from its ordinary position and it should be turned either right or left, depending on which way it is twisted. The remote control is then fastened permanently to the post.

The dynamic speaker is then mounted in position. This is mounted on the bulkhead, above the footboard and on the passenger side of the front compartment of the car. The speaker is placed in tentative positions inside the car until a position is found where it will not interfere with any equipment on the motor side of the bulkhead or with a passenger's feet.



LOUDSPEAKER IN POSITION

Mounted on the bulkhead, the speaker does not interfere with foot room yet permits free distribution of the sound



THE MOUNTING PLATE

Figure 2. The sixteen holes in the base plate of the chassis provide for a wide variety of mounting positions. The intersecting lines and circles indicate five positions. Reversing the plate provides others

A hole to take the ⅜-inch rod on the speaker is then drilled and the speaker mounted with the transformer on the speaker on the side nearest the receiver, so that the speaker cord will easily reach the plug coming from the set.

At the plug end of the shielded speaker cord, the shield is extended into a heavy wire. This should be fastened down to any convenient screw on the chassis of the car for grounding purposes.

Battery Connections

The heavy battery cable with red and black insulated wires extending from it is connected directly to the storage battery of the car. It should not be cut if it is too long, since the ends of the wires are specially treated to be fastened under screws of the car battery connections.

It has been found that by connecting the red lead (positive) either to the car ammeter or to some other positive part of the wiring of the car and the black lead (negative) to the chassis of the (*Continued on page* 805)

Using Graphs *and* Charts *in* Modern Radio Practice

Ordinary formulas for the calculation of the design for coils used in radio are sometimes extremely complicated and involved. Many amateur designers shy at these formulas and lose much time with cut-and-try methods. This article presents satisfactory solutions through simple alignment charts

Part Three

THE formula for the inductance of a single-layer coil has always been difficult and inconvenient for calculation by the average man. The knowledge of the form-factor is needed to work it out, and this form-factor depends on the number of turns which is being sought. The result is usually a cut-and-try method; one generally has to repeat the work a number of times to obtain a satisfactory answer.

Previously, when alignment charts were made, they usually followed this formula, and while they eliminated some amount of calculating, they did not do away with the cut-and-try method. It was still necessary to guess at a form-factor, which is likely to be found all wrong.

However, it can be done in a much better way. The formula can be transformed into a more convenient one which expresses the relation between the form-factor and the inductance, diameter and turns per inch. The problem can then be solved at once, without repeating.

This expression has been put in the form of an alignment chart in Figure 1. With the aid of a ruler any one can design his coils from this chart without the need of calculations of any kind.

The use of this alignment chart is best explained by an example. Suppose an inductance of 240 microhenries is desired; it is to be wound on a form 2 inches in diameter, with number 28 enameled wire. In the table, below, it is found that this wire winds 74 turns to the inch.

(1) Draw a line from 240 on the inductance scale (extreme right) to 2 on the diameter scale (extreme left) and note the point of intersection on the turning scale (center). (2) Draw a second line from 74 on the turns-per-inch scale through the newly found intersection and find the form-factor on the f (A) scale to be 2.25. (3) A third straight line from 2 on the diameter scale through 2.25 on the f (B) scale intersects the length scale at 7/8 inch, which is the length of the coil. (4) The last line, from 7/8 on the length scale through 74 on the turns-per-inch (B) scale, indicates the number of turns as 65.

NUMBER OF TURNS PER INCH				
B. & S. GAUGE	DOUBLE SILK	SINGLE COTTON	DOUBLE COTTON	ENAM.
14	–	15.6	13.6	15.2
15	16.3	16.1	15.1	17.0
16	18.2	17.9	16.7	19.1
17	20.3	19.9	18.2	21.5
18	22.6	22.1	20.2	23.9
19	25.1	24.4	22.2	26.8
20	27.8	27.0	24.3	30.1
21	30.8	29.8	26.7	33.7
22	34.2	33.0	29.2	37.7
23	37.7	36.2	31.6	42.3
24	41.6	39.8	34.4	47.1
25	45.8	43.6	37.2	52.9
26	50.5	47.8	40.1	59.1
27	55.5	52.0	43.1	66.2
28	60.9	56.8	46.2	74.1
29	67.1	61.3	49.2	83.3
30	73.2	66.5	52.5	92.2
31	79.3	71.9	55.8	103.4
32	86.5	77.2	58.9	115.6
33	93.6	82.8	62.1	129.3
34	101.0	88.4	65.3	144.9
35	108.5	94.3	68.4	162.3
36	116.2	100.0	71.4	181.8
37	124.2	105.8	74.3	202.4
38	132.2	111.6	77.1	227.7
39	140.2	117.2	79.8	252.5
40	148.3	122.8	82.3	280.1

TABLE 1

It can be shown that the most efficient coil has a form factor of 2.46. As the efficiency does not fall off very rapidly on both sides of this value, we can accept as the best range for the form-factor from 1.5 to 4.

Those who wish to design their coils starting with a definite form-factor can still do so with the aid of the same chart. Example: Let us consider the same coil as before, but suppose the form-factor, 2.25, had been decided upon instead of the size of wire. Then in operation (2), the line is drawn starting from 2.25 on f(A) through the point on the turning scale and produced so that we find 74 turns per inch as the proper spacing. The table of wire sizes shows that either number 28 enameled or number 37 d.c.c. can be used. All the other operations are the same as in the previous example.

From the four quantities, inductance, turns per inch and form-factor, the designer can choose any three, but no more than three. The fourth quantity is then determined and will be found by the use of the chart.

Transformation of the formula.

This chart was obtained from the well-known equation:

$$L = 4\pi^2 n^2 \frac{a^2}{b} K \text{ cgs. units} \qquad (1)$$

where a is the radius of the coil in centimeters,
b is the length of the coil in centimeters
n is the number of turns
K is Nagoaka's constant

In Circular 74 of the Bureau of Standards this equation is transformed into the more convenient form:

$$L = \frac{(2a)^3 m^2}{\dfrac{1000}{\pi^2 K} \cdot \dfrac{2a}{b}} \text{ microhenries} \qquad (2)$$

where m is the number of turns per centimeter.

Let us call the denominator F, then

$$F = \frac{(2a)^3 m^2}{L} \qquad (3)$$

or, expressing all measurements in inches:

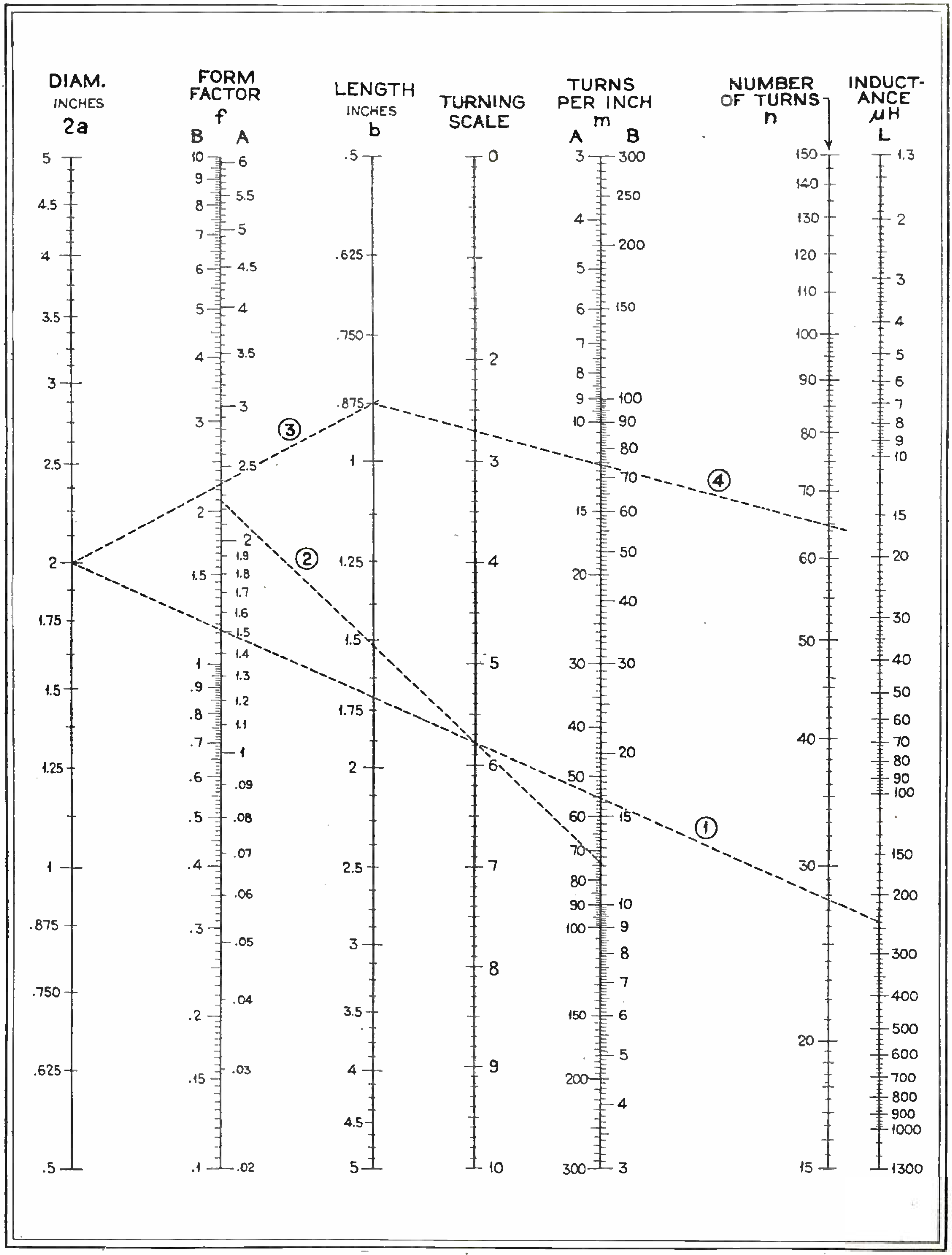
$$F = 2.54 \frac{(2a)^3 m^2}{L}$$

In Circular 74 a curve shows the relation between F and the form-factor 2a/b. When the form-factor is once found, the problem is really solved; multiplying diameter by the form-factor gives the length of the coil, and multiplying this by the number of turns per inch gives the total number of turns. In eliminating all calculation we wish to do this with the aid of the chart.

We see then that the problem consists of making four charts in one, all similar to those described last month. It was shown then that any calculation which consists of multiplications and divisions only can be performed by a logarithmic chart with parallel scales.

Some of the factors have to be raised to the second and third power and some quantities (*Continued on page* 803)

The Design of Single-layer Solenoid Coils



HOW MANY TURNS?

Figure 1. This chart and a ruler are all you need for the design of single-layer coils. Its range is sufficient to include the broadcast band and the short waves down to approximately 20 meters. The inductance in microhenries for a certain frequency is found from the chart in the February issue

The "*Complete*" Service Unit

The editors have at last found a serviceman's unit which closely approaches the ideal as a set tester, tube checker, oscillator and universal meter for measuring voltage, current, resistance and capacity

By W. Gerber

Part One

WITH the present trend leaning toward ultra-sensitive variable-mu and pentode receivers, the modern serviceman requires more elaborate servicing equipment than heretofore necessary. Servicing instruments like the set analyzer, tube checker, oscillator and ohmmeter are absolute necessities. Transportation of these individual servicing instruments is not practical, due to their weight and bulk. As a contrast, the compact servicing device described in this article offers a direct solution to this problem. A brief outline of its more prominent features is as follows:

(1) A set analyzer, capable of giving a thorough test on all receivers, including those which employ pentode, variable-mu and automobile type tubes, without the use of any adapters. R.F. pentode tests are provided for, too.

(2) An a.c.-operated tube checker, capable of testing pentode -47's, variable-mu -35's or -51's and 6-volt auto tubes. Provision is also made for testing Arcturus 15-volt tubes and Kellogg top-heater tubes, adapters only being necessary for testing the second plate of -80 rectifiers, pentode and screen-grid tubes. Three distinct readings indicate the condition of the tube. They are: normal plate current, grid bias and oscillation, the latter reading being particularly desirable for matching r.f. tubes.

(3) An a.c.-operated oscillator, having three fixed fundamental frequencies.

(4) A three-range output meter of the crystal rectifier type.

(5) An ohmmeter of two ranges: 150,000 and 15,000 ohms.

(6) A capacity tester which utilizes the a.c. line and a.c. meter for measurements.

(7) A d.c. volt-milliammeter the voltage ranges of which have a resistance of 1000 ohms per volt. These ranges are 10, 100, 250, 500 and 1000 volts. The milliammeter ranges are 1, 10, 50 and 100 ma.

(8) An a.c. volt-ammeter having four voltage ranges of 3, 15, 150 and 1200 volts, and one ammeter range of 3 amperes.

In the following paragraphs will be found a detailed explanation on the construction and operation of this modern, compact servicing instrument.

The Housing Problem

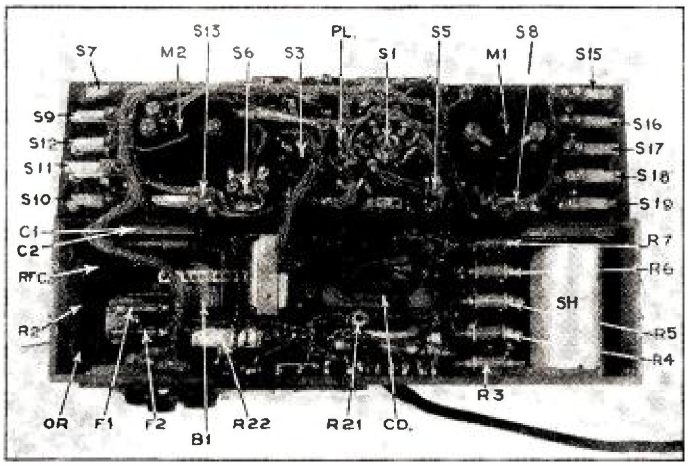
Considering the fact that most servicemen prefer to carry numerous tubes and tools with them, the author designed the carrying tray with such dimensions that it will fit in a nineteen-inch suitcase. Figure 6 gives complete dimensions of the tray, which can be made of either ¼-inch oak or mahogany. A coat of oak stain finished off with ordinary furniture wax will improve the appearance.

The main panel is of ¼-inch bakelite, the connection panel of 3/16-inch bakelite. Both panels are factory drilled and engraved to give them a professional appearance. Figure 2 (a) gives the layout of the main panel and Figure 2 (b) the layout of the connection panel.

Some readers may prefer to increase the dimensions of panels and tray in order to simplify construction and wiring. However, compactness is a highly desirable feature and, with proper care in planning and wiring, the dimensions given here will provide adequate space.

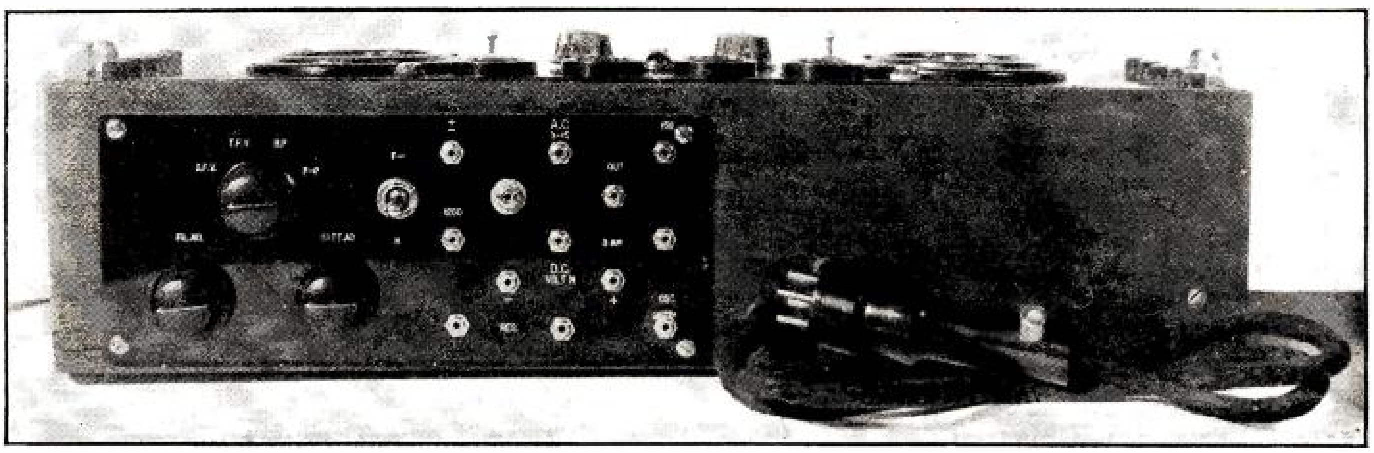
Mounting of Parts

Mounting of parts should be carried out in such a manner that they will occupy a minimum of space, and will not interfere with their neighboring parts in any way. Approximate



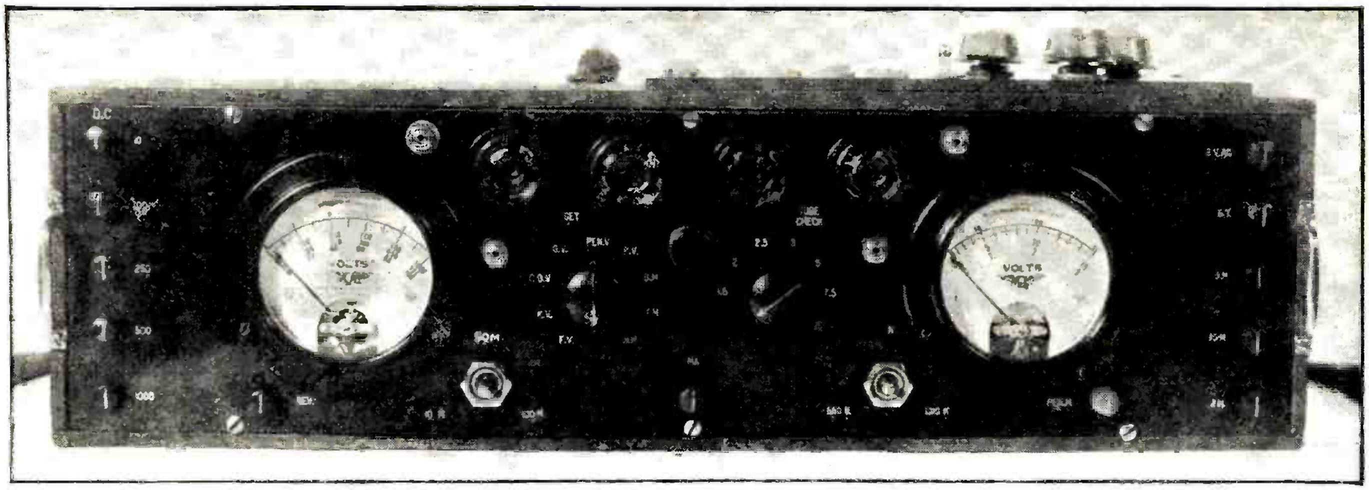
THE INSIDE VIEW

Here the top panel has been removed from the tray. Below is shown the inside of the tray and above it the under side of the panel



THE REAR VIEW

To use the unit as a universal meter for external measurements, the circuits to be measured are plugged into the tip jacks on this rear panel. For correct panel engraving, see Figure 2



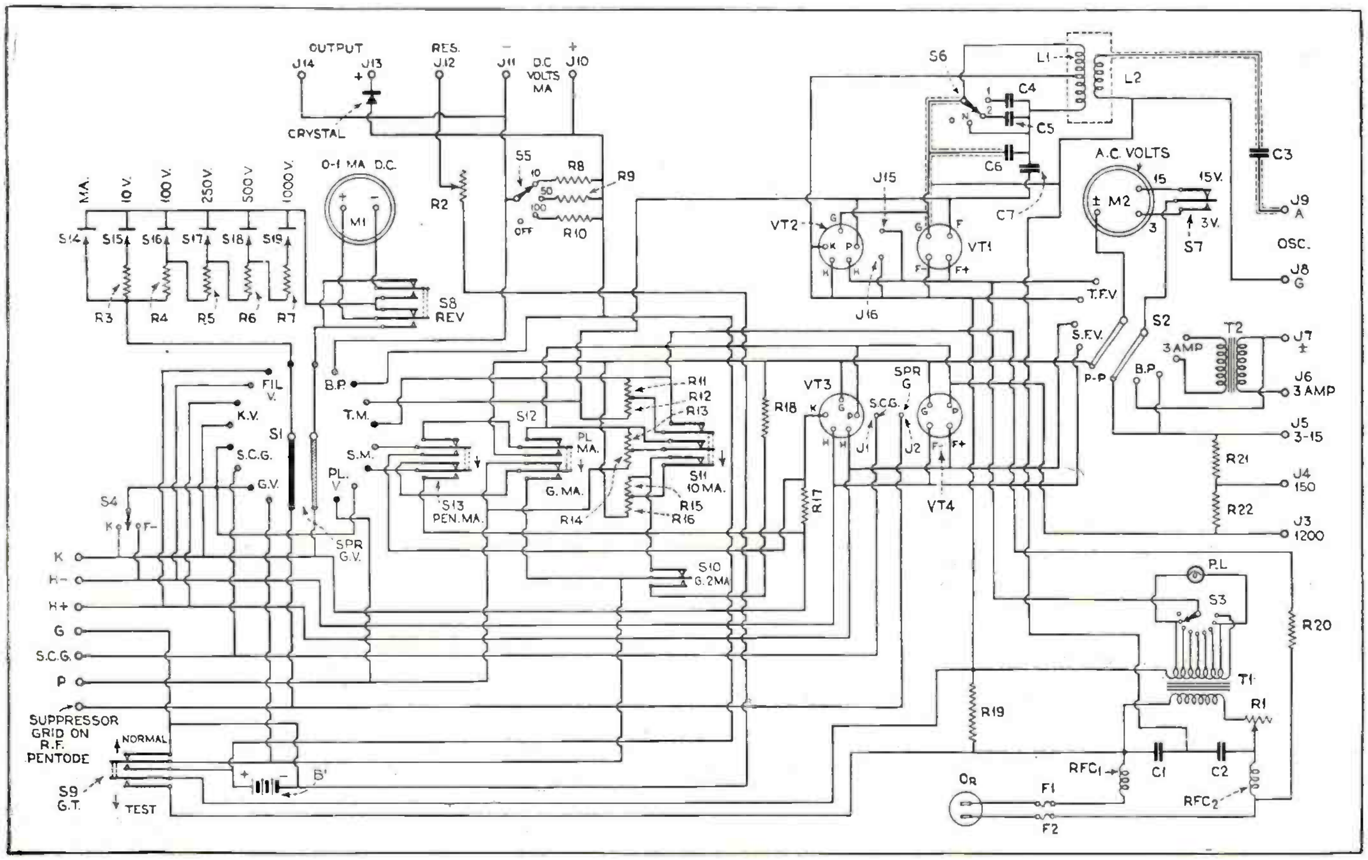
THE TOP PANEL VIEW

Each control is suitably engraved to facilitate use of the unit. Some slight changes in engraving were made in a later model. The correct engraving will be found in the panel layout drawing, Figure 2

position of parts may be obtained by referring to the various photographs. Large and heavy parts should be mounted on the bottom of the wooden tray and securely fastened thereto. Holes for the mounting of parts on the underside of the main panel should be drilled by the constructor himself, 3/16 inch deep. Use a 1/8-inch drill and thread a 6/32 screw into the hole. This method leaves the face of the panel free from unsightly screw heads, which would destroy its professional appearance. A small niche made 3/16 inch from the cutting point of the drill will enable the constructor to tell when the hole is the correct depth. The hole will be 3/16 inch deep when the niche is level with the panel.

The push-button switches can be made of old phone jacks with their frames removed. In this case Jewel locking buttons should be used. These buttons may be obtained from any radio supply store. The author prefers the push-button method of switching because it is only necessary to set the selector switch S1 and push a certain button to get the desired reading. If the constructor finds enough space underneath the panel he may prefer to use the standard Yaxley switches.

The 1 5/16-inch hole at the right end of the tray is for the a.c. outlet of the tube checker. The two fuses F1 and F2, chokes RFC1 and RFC2, filament-adjusting rheostat R1 and the by-pass condensers C1 and C2 should be mounted as close to the a.c. outlet as space will permit. The shield of the oscillator coil L1 may be fastened to the back of the wooden tray by means of three 1-inch machine screws. Although almost any coil shield might be used, the author found that a Grebe screen-grid shield suited the dimensional requirements exactly. It has three angle brackets which should be turned inward and the coil fastened thereto. A threaded hole will be found in each bracket. If the three 1-inch (*Continued on page* 811)



THE SCHEMATIC CIRCUIT DIAGRAM

Figure 1. Referring to the symbol numbers on the various parts in the photographs will aid in an understanding of the numerous circuits involved

Electric Filter Design

The importance of electric wave filters in radio communication both in transmitter and receiver design cannot be overestimated. The following article, third of a comprehensive series, deals with considerations of low-pass filters, insertion loss, "Q," coil construction, etc.

By C. A. Johnson*

Part Three

A LOW-PASS filter, as the name implies, permits alternating electric currents of frequencies below a certain value, f_c, called the "cut-off" frequency, to flow through it with very little loss, while currents having frequencies higher than this value are attenuated. That is, most of the energy associated with the higher frequencies, or tones, is not absorbed by the filter but reflected back to the generator from which it came; on the other hand, the energy carried by the lower frequency currents is absorbed and passed on to the load, being decreased only by the dissipation due to resistance in the filter.

As pointed out in the first article of this series, one important use for low-pass filters in radio engineering is to prevent "hum" and other interference from the power supply from reaching the filament and plate circuits. For example, Figure 1 shows a low-pass filter as used in a typical power supply for radio receivers. Two low-pass filter sections are used so that any of the 60-cycle current which passes the rectifier tube will be highly suppressed before reaching the filaments or plates of the tubes. The filter will also reduce interference, caused by sudden changes in the line voltage, to a low value. This is true because any sudden change in the line voltage, produced by opening or closing switches, etc., causes transient voltages to be set up in the line, and it may be shown by Fourier's Integral Analysis that these transient waves behave exactly as if they were made up of a great number of steady waves of higher frequencies which, of course, the low-pass filter will not pass.

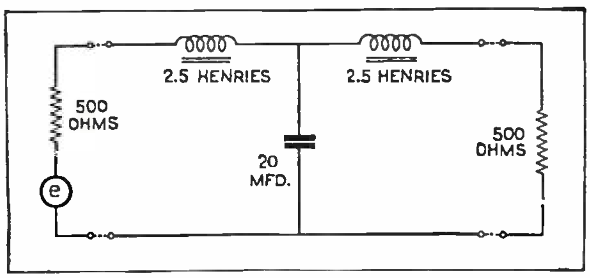
Low-pass filters are extensively used in suppressing the harmonics of oscillators used in testing circuits. They are also frequently used, together with high-pass filters, in constructing band-pass filters when the band of frequencies it is desired to transmit is more than one octave.

When describing the performance of filters it is common to refer to a curve showing its insertion loss plotted as a function of frequency. As explained in the previous paper, the insertion loss in decibels is 20 times the common logarithm of the absolute value of the ratio of the current flowing in the line before the filter is inserted, to the current flowing in the load after the filter is inserted. To illustrate, suppose we wish to insert the low-pass filter shown in Figure 2 in a 500-ohm transmission line. According to Ohm's law, the current flowing in the line before the filter is inserted is

$$I_0 = \frac{e}{1000} \text{ amperes} \qquad (1)$$

where the generator potential, e (or open-circuit voltage of the line) is in volts.

After the filter is inserted, we can compute the value of e which is necessary to cause 1 ampere to flow in the output circuit[1], then the insertion loss is 20 times the $\log_{10} |I_0|$ (since the current in the load, after inserting the filter, is assumed to be unity).



ELECTRICAL FILTER "CONSTANTS"

Figure 2. Here is a low-pass filter whose insertion loss characteristic is shown in Figure 5. The electrical circuit constants are given in the diagram

In actual practice it is hardly necessary to compute the insertion loss of filters unless a very close prediction of the performance of the filter is required, because a fair approximation to the actual performance can be obtained from transfer-loss computations or charts which will be described shortly. However, to illustrate the method of mesh computing a filter, the insertion loss will be computed for two frequencies in detail; the reader may become familiar with the method by performing the computations at other frequencies and checking his results against the curve, Figure 5.

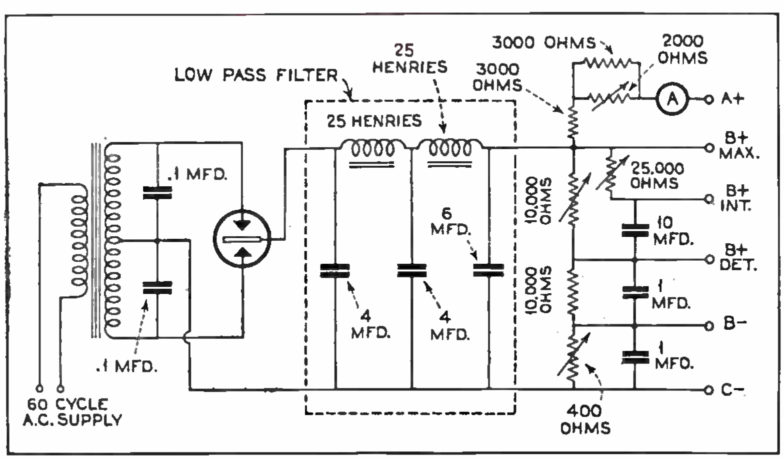
In computing the characteristics of filters, exactly, we cannot neglect the fact that all coils and condensers used in the filter have a straight resistance as well as a reactance to alternating currents, and it is customary to refer to the "Q" of an impedance arm as the ratio of the reactance to the resistance of that arm, or to the dissipation constant, d, which is the reciprocal of "Q." For example, if a coil has a reactance of $2\pi fL$ and a certain effective resistance, R_{eff}, at the frequency f, then the "Q" of the coil at that frequency is

$$Q = \frac{2\pi fL}{R_{eff}} \qquad (2a)$$

$$\text{and } d = \frac{1}{Q} \qquad (2b)$$

where L is the inductance of the coil in henries. The condensers used in a filter usually have "Q's" which are much higher than the coils and are ordinarily neglected in actual practice. A "Q" of 2 will be assumed for the coils in the filter shown in Figure 2 and the "Q" of the condenser will be neglected.

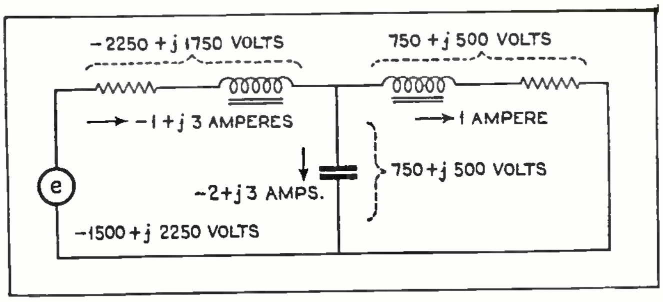
We shall mesh compute the filter at the cut-off frequency first. The theoretical cut-off frequency of this type of low-pass filter is



TYPICAL LOW-PASS FILTER

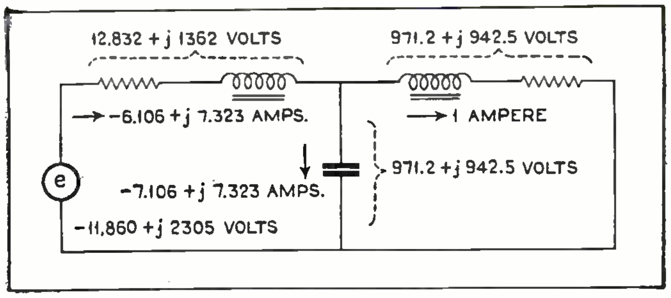
Figure 1. Typical power supply unit incorporating a low-pass filter

*N. Y. University.



VOLTAGE AND CURRENT DISTRIBUTION

Figure 3. This diagram shows the distribution of currents and voltages in the low-pass filter given in Figure 2 at the theoretical cut-off frequency. The insertion loss at this frequency is 8.64 decibels



SIXTY-CYCLE CURRENTS AND VOLTAGES

Figure 4. In this diagram the distribution of voltages and currents in the filter of Figure 2 are given at 60 cycles. The insertion loss at this frequency equals 21.6 decibels

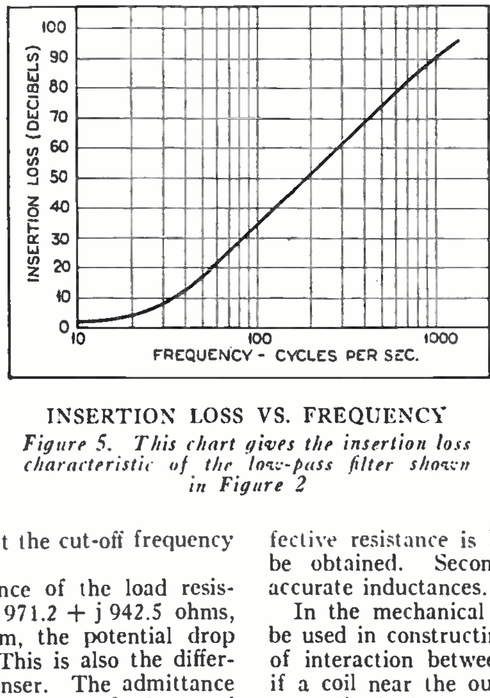
$$f_C = \frac{1}{\pi\sqrt{LC}} = \frac{1}{\pi\sqrt{5 \times 20 \times 10^{-6}}} = 31.83 \text{ cycles} \quad (3)$$

where the L and C refer to the total series inductance in henries and total shunt capacity in farads, respectively. Starting at the output end, we add the impedance of the line to the impedance of the last coil. The impedance[2] of 2.5 henries at 31.83 cycles is 250 + j 500 ohms; adding the 500-ohm load resistance, we have 750 + j 500. Now, since we are assuming 1 ampere to be flowing in the load, the potential drop across the coil and load resistance is 750 + j 500 volts, which is also the drop across the condenser. The admittance of the condenser is $j\,\omega C = j\,4000 \times 10^{-6}$ mhos, so that the current flowing through it is the product of the potential drop across it by the admittance or $(750 + j\,500) \times j\,4000 \times 10^{-6} = -2.000 + j\,3.000$ amperes. The total current flowing from the generator, according to Kirchhoff's second law, is the sum of the current flowing through the condenser plus that through the load or $1 + (-2.000 + j\,3.000) = -1.000 + j\,3.000$ amperes. Now since the impedance of the 500-ohm input line and the first series coil is 750 + j 500 ohms, the drop in potential across them is $(750 + j\,500) \times (-1.000 + j\,3.00) = -2250 + j\,1750$ volts. Adding this to the potential drop across the condenser, according to Kirchhoff's first law, the potential e, necessary to cause 1 ampere to flow in the load, is $-1500 + j\,2250$ volts. Now if this same potential is connected directly to the load, without the filter in the line, I_0 amperes would flow, and in this case

$$I_0 = \left[\frac{-1500 + j\,2250}{1000}\right] = 2.704 \text{ amperes} \quad (4)$$

The insertion loss at 31.83 cycles is then

$$20 \log_{10} 2.704 = 8.64 \text{ decibels} \quad (5)$$



INSERTION LOSS VS. FREQUENCY

Figure 5. This chart gives the insertion loss characteristic of the low-pass filter shown in Figure 2

The distribution of voltages and curves at the cut-off frequency (31.83 cycles) is shown in Figure 3.

At 60 cycles per second the impedance of the load resistance plus the last series inductance is 971.2 + j 942.5 ohms, and since 1 ampere flows through them, the potential drop across them is 971.2 + j 942.5 volts. This is also the difference in potential across the shunt condenser. The admittance of the condenser at this frequency is $j\,7540 \times 10^{-6}$ mhos, and the current flowing through the condenser is $(971.2 + j\,942.5) \times (+j\,7540 \times 10^{-6}) = -7.106 + j\,7.323$ amperes. Then the current flowing from the generator is $1 + (-7.106 + j\,7.323) = -6.106 + j\,7.323$ amperes. The impedance of the input resistance plus the first series coil is 971.2 + j 942.5 ohms, and the drop in potential across them is the product of their impedance by the current flowing through them or $(971.2 + j\,942.5) \times (-6.106 + j\,7.323) = 12{,}832 + j\,1362$ volts. The potential, or e.m.f., of the generator is then the sum of this potential drop plus the drop across the condenser, or $-11{,}860 + j\,2305$ volts. Then the current I_0 which would flow in the line due to this e.m.f., if the filter were not inserted, is

$$I_0 = \left[\frac{-11.860 + j\,2305}{1000}\right] = 12.08 \text{ amperes} \quad (6)$$

and the insertion loss at 60 cycles per second is

$$20 \log_{10} 12.08 = 21.6 \text{ decibels} \quad (7)$$

The distribution of currents and voltages in the filter at 60 cycles per second is shown in Figure 4, and the computed insertion loss as a function of frequency is shown graphically in Figure 5.

It may be seen from the curve that while the theoretical cut-off was 31.8 cycles, the actual cut-off may be said to be much lower, say about 15 cycles. After all, the cut-off of a filter has meaning only when we specify how much attenuation distortion[3] is allowable to the passed frequencies. In the example just worked out, the cut-off is at 15 cycles if we allow 3 db. distortion, or it is at 31 cycles if we allow 8.6 db. distortion.

If the filter is constructed using coils after having the values of "Q" assumed in the computations, and if the filter is measured between 500 ohm resistances as assumed in the computations, the measured characteristics should check exactly with the computed characteristics, because the reflection and interaction losses have been taken into account in the mesh computation.

It is obvious that the engineer cannot construct acceptable electric-wave filters unless he is able to procure good coils and condensers. In fact, this often proves to be the stumbling block for the engineer and it cannot be too greatly emphasized that great care be used in the specification of coils and condensers to be used in the filter. There is great difficulty in securing coils suitable for filter work for two reasons. First, the design must be such that the effective resistance is low enough so that acceptable "Q's" can be obtained. Second, it is difficult to secure sufficiently accurate inductances.

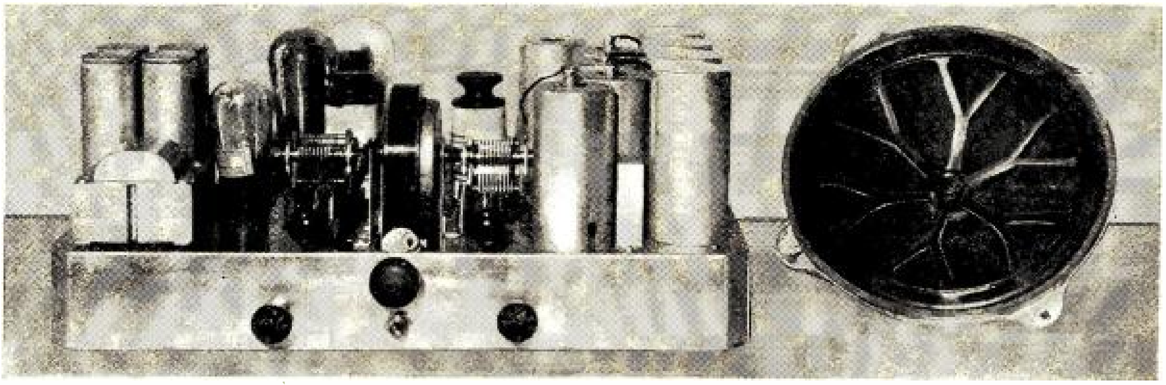
In the mechanical design of filters, considerable care must be used in constructing them so that there will be a minimum of interaction between the coils of the filter. For example, if a coil near the output of the filter is mounted so that its magnetic field cuts through the magnetic field of a coil near the input of the filter the predicted loss will not be obtained because of the pick-up from one part of the filter to another. In general, the coils should be shielded from one another and the shields made as large as practicable, because eddy current and hysteresis losses in the shields will lower the "Q" of the coils.

Low-pass filters consist of three different types. The constant k type has a single series coil and a shunt condenser. This is the type that has just been (*Continued on page* 815)

NOTE 1.—The assumption of one ampere flowing in the output circuit is a purely arbitrary convenience.

NOTE 2.—In the previous article it was stated that the impedance of an inductance coil was given by the formula

$$Z = \frac{\omega L}{Q} + j\,\omega L \text{ where } \omega = 2\pi f)$$



A CLOSE-UP FRONT VIEW

Center knob is the single tuning control, but for extreme precision auxiliary verniers on each of the tuning condensers are adjustable from the front panel by means of the two upper knobs

New All-Wave "Super"

Features High-Gain Design

This month the author continues his discussion of this new custom-built receiver, pointing out some additional features which contribute to the real DX-ability demonstrated by this receiver

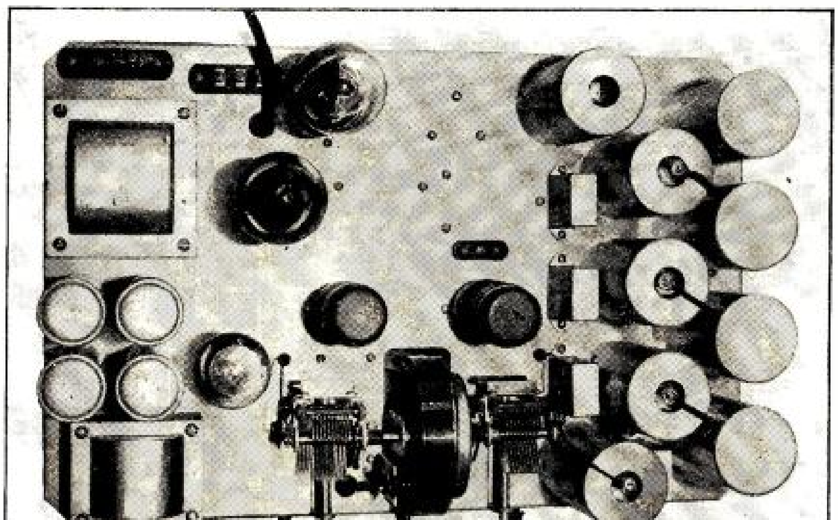
By Lewis W. Martin*

Part Two

THE interchangeable plug-in coils used in the "Comet" receiver are wound on treated isolantite forms. This material offers very low dielectric losses, which are now important especially at high frequencies. In addition, its extremely stable physical characteristics insure constant inductance, with consequent reliability of dial calibration, which is very important at short waves where the tuning is necessarily quite critical. The wavelength coil for the lower broadcast frequencies has a very high inductance value, and this is secured by a "two bank" winding of the same "Litz" wire used in the intermediate coils. This results in a low-loss winding, with attendant high gain and selectivity.

A type -24-A screen-grid tube is used as a first detector or "mixing" tube. Its high detector sensitivity, as well as its high output impedance, make it ideal for this purpose, as it works into the high impedance tuned plate coil of the first intermediate transformer. A further advantage of this tube is its high input (grid) impedance with correspondingly low effective input (grid) capacity, which together reduce the damping on the tuned input circuit and permit a larger wavelength range with a given coil and tuning condenser.

The second detector is also a -24-A type screen-grid tube working as a plate circuit rectifier. Its control grid is automatically biased by a cathode resistor, resulting in substantially linear power detection. In addition to audio frequencies, there is also a large component of intermediate frequency present in its plate circuit. This i.f. component is filtered out by means of a two-stage low-pass filter consisting of two 85 millihenry r.f. chokes and three .00025 by-pass condensers. These two filter stages are separately shielded from each other. This elaborate filtering is extremely important, as otherwise the i.f. component would also be amplified by the output pentode and would appear in its output circuit, causing overall feedback to the input of the receiver, resulting in great instability and seriously limiting the usable amount of intermediate amplification.



TOP VIEW OF THE CHASSIS

Note how the power supply and filter equipment is isolated from the detector and i.f. circuits by placement at the extreme left end of the chassis

The type -47 pentode is used in the audio output stage. This tube makes an ideal combination with a screen-grid tube operated as a linear power detector. Such a detector, resistance-capacity coupled, easily provides sufficient input voltage to the grid of the pentode, thus obviating the need both for transformers and an intermediate audio stage. The resistance-capacity coupling between power detector and output tube preserves the fidelity of the detector output and results in exceptionally clean and (*Cont. on page* 808)

*Hammarlund-Roberts, Inc.

Mathematics in Radio

Calculus and Its Application in Radio

By J. E. Smith*

Part Fifteen

BEFORE showing an application of the derivative to radio, a few of the simple formulas for differentiation of standard forms will now be shown and discussed below in the following illustrations:

1. $\frac{dx}{dx} = 1$

Here we have expressed in the form of a formula that the derivative of a variable with respect to itself is unity.

2. $\frac{d(u + v - w)}{dx} = \frac{du}{dx} + \frac{dv}{dx} - \frac{dw}{dx}$

Here the derivative of the algebraic sum of a number of functions is equal to the algebraic sum of their derivatives.

3. $\frac{d(cv)}{dx} = \frac{c\,dv}{dx}$ where c = a constant.

The derivative of the product of a constant and a function is equal to the product of the constant and the derivative of the function.

It will be well at this time to point out the application of this particular function. Let us take the formula y = ax, which gives us a product of a constant "a," and a function "x." Plotting the graph of such an expression will show more clearly the relations involved. Assuming a value of "a" to be equal to 2, we have:

If x = 0 the corresponding value of y = 0

If x = 1 the corresponding value of y = 2

If x = 2 the corresponding value of y = 4

If x = 3 the corresponding value of y = 6
" x = 4 " y = 8
" x = 5 " y = 10 and so on.

Plotting these values on "graph" paper, the straight line of Figure 11 is obtained. Now, further investigation of this expression shows from Figure 12 that the point P can be represented as follows:

(I) y = cx

and then the point Q can be represented:

(II) $y + \Delta y = c(x + \Delta x) = cx + c\Delta x$

Applying the same procedure as outlined in the previous installment, and subtracting (I) from (II), we have:

$$y + \Delta y = cx + c\Delta x$$
$$y = cx$$

(III) Subtracting $\Delta y = c\Delta x$

Dividing by the increment x,

$$\frac{\Delta y}{\Delta x} = c$$

Now, referring to Figures 13 and 14, it is noticed that when Q approaches P, x will approach zero as a limit and that limit is called the derivative $\frac{dy}{dx}$. But it will be noticed also that as Q approaches P, the angle "a" remains the same; therefore, the ratio of the side opposite to the side adjacent, which is the tangent of "a," is always the same or is a constant "c." Therefore, $\frac{dy}{dx} = c$ or with reference to (I) above, the derivative of the constant c, times the function x, is equal to c.

This results from the two fundamental formulas expressed in (3) and (1) above where v equals x.

4. $\frac{d(uv)}{dx} = u\frac{dv}{dx} + v\frac{du}{dx}$

Here, the derivative of the product of two functions is equal to the first function, times the derivative of the second, plus the second function, times the derivative of the first.

5. $\frac{dv^n}{dx} = nv^{n-1}\frac{dv}{dx}$

Here, the derivative of a function with a constant exponent is equal to the product of the exponent, the function with the exponent diminished by one, times the derivative of the function.

HEREWITH is presented the fifteenth of a series of instruction articles on mathematics, emphasizing especially its application to radio. The articles which have appeared thus far are:

WHAT HAS GONE BEFORE

*President National Radio Institute.

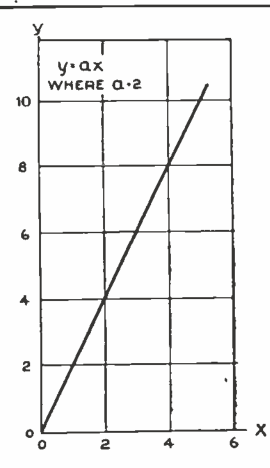


FIG. 11

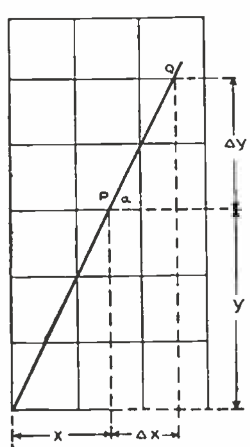


FIG. 12

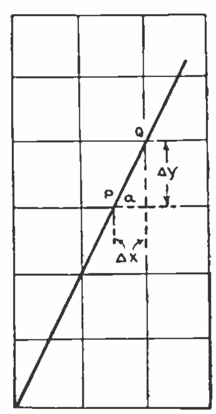


FIG. 13

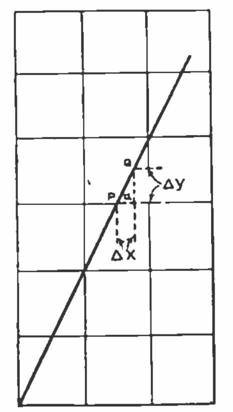


FIG. 14

With the Experimenters

Low Resistance Measurement; Auto Antenna; Line Voltage Compensator; One-Tube Receiver; All-Purpose Oscillator; Secret Radio Communication

Conducted by

S. Gordon Taylor

Measuring Low Resistances

It sometimes happens that one has a low resistance which he desires to measure with a fair degree of accuracy. The following method was devised to measure resistance values between .001 and 2 ohms, with the same accuracy as that of the meters used. This method requires only simple apparatus which most experimenters possess.

Referring to the circuit of Figure 1, a and b are two heavy binding posts, between which the unknown resistance is connected. A steady current is sent through this by one cell of a storage

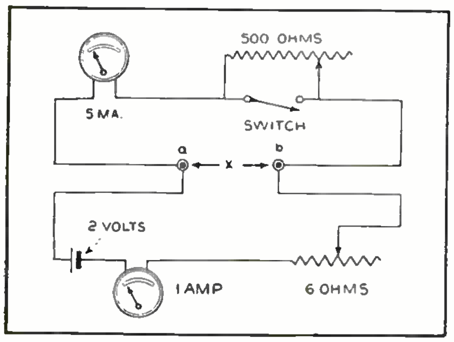


FIGURE 1

tery, an ammeter having a range of 0-1 ampere, and the rheostat, all connected in series. To measure the difference of potential, we have used a milliammeter with a 5 ma. scale connected up in series with a 500-ohm resistance coil having adjustable clips. This coil is supplied with a short-circuiting switch

0-1 MILLAMMETER		
RESISTOR	OHMS	
	MINIMUM	MAXIMUM
27.5	.00137	.0275
200	.01	.2
2000	.1	2.
0-5 MILLAMMETER		
10.569	.0010	.05
500.	.05	2.5

so that for resistance below .05 ohm the coil may be cut out.

By knowing the resistance of the milliammeter circuit from a to b, both with S open and closed, we can get the fall of potential between a and b by multiplying the reading of the milliammeter (in amperes) by this resistance.

To calculate resistance of x:

Let E = e.m.f., a to b; C = milliammeter current (in amperes); R = resistance of milliammeter circuit, a to b; r = unknown resistance x; A = current in the ammeter.

We have these formulas:

$$C = \frac{E}{R} \text{ or } E = CR \text{ or } r = \frac{E}{A}$$

Substituting for E we get

$$r = \frac{CR}{A} = \frac{C_{ma} R}{1000A}$$

where C_{ma} = current in milliamperes.

With the circuit connected up for measuring resistance, since no change in readings of A can be detected with a full-scale variation in milliammeter, no correction need be made in above formulæ, due to the current used by the milli-

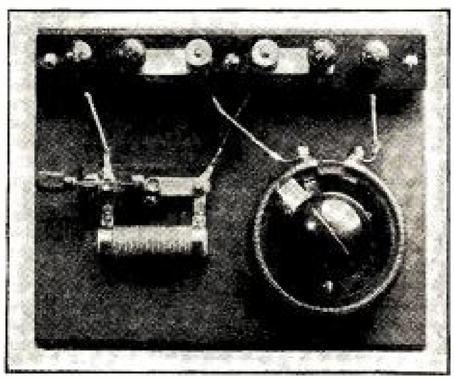


FIGURE 2

ammeter circuit.

The 5 ma. scale is used to simplify the apparatus. A meter with a 1 ma. scale

(Continued on page 809)

Auto-Radio Antenna

An extremely simple antenna for an automobile-radio can be made and installed in about fifteen minutes—at a cost of a few cents.

This antenna consists simply of a few feet of fine copper wire (enameled), somewhere between 30 and 36 gauge, which is sewed into the upholstery on the under side of the roof. The method is

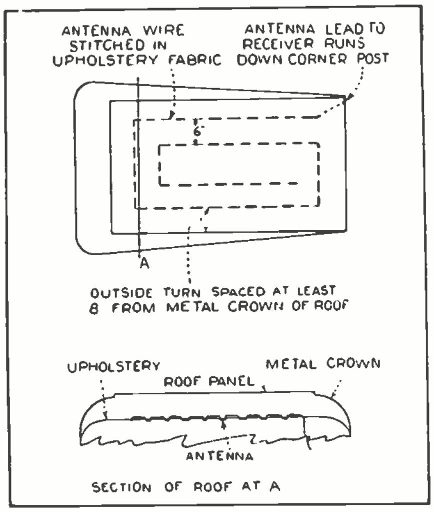


FIGURE 3

to thread the end of the wire through the eye of an ordinary darning needle and then, using a basting stitch, with the wire as the thread, sew it into the fabric. Each stitch should be about two inches long, about 1⅞ inches of this being above the upholstery fabric and only about ⅛ inch showing from the under side. This makes the wire practically invisible.

The length of the wire used will depend upon the receiver used. In one of the RADIO NEWS test cars (Essex coach), equipped with a Marquette Motor Radio, about 22 feet of wire was used, in the form of a rectangular spiral, as shown in Figure 3. This provided more than adequate pick-up—so much. in fact. that on local stations the push-pull pentodes in the output stage are overloaded even with the volume control near the low side.

This scheme works best in cars which do not use chicken netting to reinforce the roof upholstery. However, it is so simple to install that it is worth a trial in any car in which a radio is being installed, because it offers the quadruple advantages of high effectiveness, inconspicuousness, negligible cost and easy installation.

Simple Line Voltage Compensator

Either low or high line voltages may be compensated by connecting a small step-down transformer in the supply line to the radio set as shown in Figure 4. It

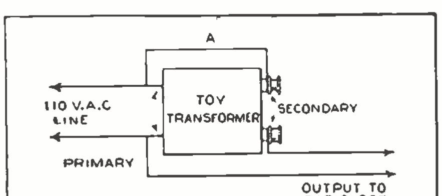


FIGURE 4

will be noticed from a study of this circuit that the voltage supply to the radio set includes that from the 110-volt line plus or minus the voltage developed at the output terminals of the step-down transformer. In effect, this secondary winding is connected in series between the line and the radio set.

The line is connected directly to the primary of the step-down transformer. One side of the line is also connected to one terminal of the secondary by means of the connection A. The other side of the line is connected direct to the radio set, as is also the terminal of the secondary which is not connected to the line.

Where the line voltage is high, the secondary of the step-down transformer is connected in such a way as to "buck" the line voltage, thus reducing it by the voltage of the secondary. When the line voltage is low, the secondary is connected so that its voltage will add to that of the line. To determine whether the transformer secondary is connected to "buck" or "add," a 110-volt lamp is connected to the output in place of the radio set. With this lamp in the circuit, the transformer secondary connections are first connected one way and then reversed. The connection which results in maximum brilliancy of the lamp shows the transformer adding to the line voltage and vice versa.

For this purpose, either a bell-ringing transformer or a toy transformer may be used. Toy transformers are best because they are usually provided with secondary taps to permit a choice of output voltages. Moreover, these transformers are always rated as to power. This latter is not true of bell-ringing transformers and some of the latter type are designed for such low power as to be useless for the purpose described here. In any event. the transformer secondary voltage should be sufficient to provide the necessary compensation required in any particular case. The transformer used should have a rating of at least ten watts.

WILLIAM WAGNER,
Cincinnati, O.

One-Tube A.C. Receiver

This simple receiver, the circuit of which is shown in Figure 5, is built in a cigar box. The type -37 automobile tube and the Pilot Wasp coil are mounted in a pair of UY sockets on top of the box. A bell-ringing transformer used for lighting the tube filament was originally placed inside the box but had to be removed and fastened on the end of the box to eliminate hum from magnetic coupling with the choke. The .00025 variable condenser is an old circular plate type of compact construction.

A dry rectifier bank taken from an Elkon EBH unit is used. With the 7500-ohm resistor in series, this rectifier delivers 70 volts d.c. and the actual voltage applied at the plate of the tube is 55 volts. The circuit is self-explanatory and all values are given except for the filament resistor. The value of this will depend on the bell-ringing transformer used.

As a safety precaution, the receiver is not grounded to the power line, consequently it will work only when the live wire is connected to the plate and the set grounded.

It will be noted that no antenna is employed. This is unnecessary, as advantage is taken of the double ground system provided by the actual ground and the ground through the power supply line. This receiver has been bringing in stations in the Bay district on a 24-inch cone speaker but is too feeble for good tone quality under these conditions. Using headphones, I have tuned in WLW

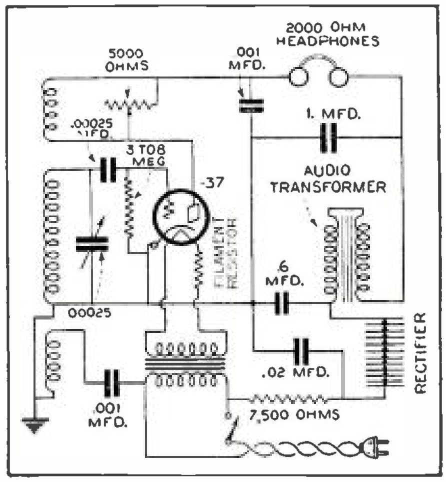


FIGURE 5

and other distant stations late at night (or early in the morning). As with every one-tube set, the tone is good with headphones. I have tried using short-wave coils, but they have not been very promising on this particular set.

H. A. HARRIS,
Santa Rosa, California.

An All-Purpose Oscillator

An article by C. K. Krause appeared under the above head in the October issue. page 303. Through an oversight in the circuit diagram, the filament circuit of the left-hand tube was not connected to that of the right-hand tube and the A—supply. This omission and its correction were so obvious that it is doubtful whether any trouble was caused to builders of this equipment.

A less obvious point is brought out in letters received from several readers, stating that the oscillator would not work when the switch was thrown to connect the 0-1 ma. meter as a grid-dip meter. This trouble may be experienced where the tube employed in the r.f. circuit is a weak oscillator. The remedy is found in removing the 2500 resistor from the meter circuit and connecting it in the lead from the lower right-hand switch-point (in the circuit diagram) to the A+ side of the filament circuit and battery. This change results in the resistor being in the meter circuit only when the meter is used as a filament voltmeter, at which time the resistor serves as the multiplier.

Secret Radio Communication

Am enclosing circuit diagrams for a simple tuning system which permits secret radio communication without resorting to the use of code words or complicated mechanical or electrical synchronizing systems. The plan outlined here should be of advantage in police work as

(*Continued on page* 814)

Backstage in Broadcasting

Chatty bits of news on what is happening before the microphone. Personal interviews with broadcast artists and executives. Trends and developments in studio technique

By
Samuel Kaufman

MARCH is here! With it comes thoughts of spring—of flowers, sunshine and serenity. But all will not be serene this season in the offerings of broadcasters. The approaching Presidential campaign will be the occasion of the booming of political guns, verbal warfare and din of campaign battles before the radio microphone. Without any doubt, this year will see radio used more extensively for political broadcasts than in any previous Presidential year. True, the choice hours of both networks and leading independent stations throughout the United States are already sold to commercial sponsors. Nevertheless, it is certain that these accounts will willingly relinquish their time to major campaign tilts. This, incidentally, will be the third Presidential campaign to be fought over the air waves. In 1924 the record-breaking conventions of the two major parties and the subsequent campaigning and election returns were heard by the nation via earphones and crystal sets. The 1928 campaign saw radio playing a still greater rôle in the Hoover-Smith race. This year, the greatest radio audience in history will follow the phases of the campaign via the most modern receivers.

F. W. Wile

BY the time you read this item you will already have heard the first series of broadcasts from the General Conference on Disarmament at Geneva by Frederic William Wile over the CBS. Wile, the chain's commentator on political affairs in Washington and a one-time NBC broadcaster, sailed for Europe with the American delegation to the conference. This is the chain's second coverage of an international conference through its trans-Atlantic facilities, Wile having blazed the trail when he represented the chain at the London Naval Conference in 1930. Throughout his series of broadcasts he plans to bring to the microphone delegates of leading foreign countries. Wile is a member of the editorial staff of the Washington *Star*, and his writings are widely syndicated. Preceding his return to the United States at the end of the World War, Wile spent nineteen years in Europe as the representative of American and British newspapers.

SINCE the "Sisters of the Skillet," Ed. East and Ralph Dumke, began broadcasting hints for housewives over the NBC a little over a year ago, more than 30,000 domestic problems have been submitted to them. We are told that most of the questions they have answered have had to do with "preventing husbands from snoring, moths from eating, weight from increasing, and shoulder blades from protruding." The "Sisters" gross some 500 pounds between them. They keep a complete filing system of questions and answers, and they claim they are in a position to attack any problem with efficiency. They employ a filing clerk who spends eight hours each day taking care of their mail.

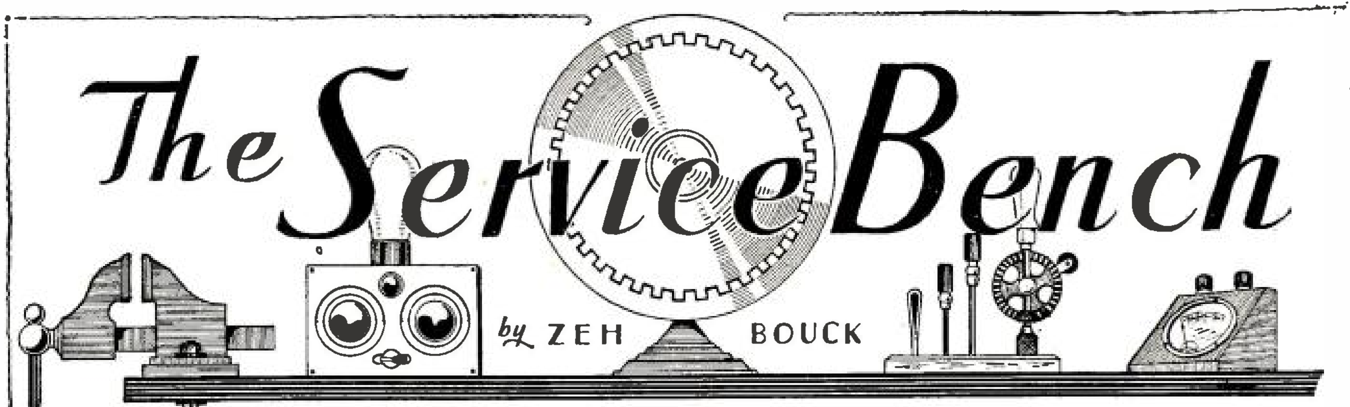
Ralph Dumke and Ed. East

FOR the purpose of conducting its Sunday international broadcasts the CBS retains a European representative whose duty it is to contact and bring to the microphone the most prominent men on the continent. Cesar Saerchinger, the CBS representative, maintains headquarters in London but makes frequent rounds of other nations to bring men of world-wide note to American listeners. He is persistent and keeps after elusive men until they consent to broadcast. In the instance of George Bernard Shaw, Mr. Saerchinger had to telephone the noted author once each week for an entire year until he was finally brought to the microphone. Saerchinger recently visited the United States to confer with CBS executives. He told the writer that he expects 1932 to set new high records in quality and quantity of international programs.

Gertrude Berg

THE second anniversary of Gertrude Berg's successful series, "The Rise of the Goldbergs," was celebrated with an appropriate "open house" party in the cozy atmosphere of Studio "L" of the NBC in New York. This is the famous studio furnished in the manner of a tasteful living room. Through the portals of the studio reserved for world-famed speakers and artists and others who might not feel wholly at home in the usual radio studio, passed many of the most prominent names in radio. The fictional radio husband of "Mollie Goldberg" and the real husband of Gertrude Berg chatted together as they nibbled cakes and sipped coffee. It was a great party and, according to the popularity the daily feature is attaining, it should be followed by many more anniversaries.

THE growth of chain broadcasting in the United States has been tremendous. When the NBC was launched the event was merely observed as an interesting experiment. But from the mere handful of stations at the inception, the network grew rapidly until it reached its present gigantic proportions, spanning the nation in a gigantic spider-web fashion. When the CBS was launched, subsequent to the NBC's birth, the spirit of competition spurred them both onward to the present sterling entertainment rating of both.



Service Business Methods—Pepping Up Tube Sales—Radio Insurance—Standardized Resistor Replacements—Service Kinks—Induced AC Hum—Stromberg-Carlson Trouble

Open for Business—And How to Get It!

ROGER H. HERTEL, owner and manager of Hertel's Radio Store in Clay Center, Nebraska, and a consistent contributor to *The Service Bench*, generalizes, from his personal experience, on the ways and means of drumming up radio sales and service.

FRONT OF MATCH CASE

Figure 1. A paper of matches provides a good advertising medium for the serviceman. On one side the name of a featured product—

"While I sell Atwater Kent radios, it is the service end of the business that I stress. Queer as it may seem, a person advertising as a serviceman, and going into homes as such, *can often work up a larger retail radio business than the ordinary dealer*. By doing expert radio-service work, you convince your clients of one thing, namely, the fact that you *know your business*. With their confidence won, it is a matter of finding out what they want or need, and suggesting what they should buy. Either immediately or eventually you are assured of a sale wherever you have stimulated confidence.

"As I am employed seven hours and a quarter every day in broadcasting station KMMJ, I must utilize every available bit of spare time in the direction of my sales and service enterprise. I have working for me two high-school boys who do most of my missionary work. These fellows make a house-to-house canvass of the town. Each of them carries, in a brief-case, advertising matter, notebook and free inspection cards. After indulging in a bit of non-consequential personal chatter, they bring up the subject of radio reception. They ask about interference, and describe the work we are doing down at the store to alleviate this nuisance in Clay Center. They refer to National Radio Week, and in the course of the conversation note the prospect's name, address, 'phone number, type of radio and general condition of tubes and aerial. If everything is okay with the radio, a few pertinent questions regarding the more general electrical appliances for home use often results in a sale.

"Aside from giving the serviceman the opportunity of making about five free inspections per day, the accumulated information tells him where trouble is likely to exist, its probable cause and the tools required for its repair. It is a highly practical way of handing out circulars and building up a thoroughly 'live' mailing list.

"Make sure your home-town newspaper editor knows you. Drop in to chat with him every week or so. Give him plenty of radio news to publish. When you talk to the high school, make a new installation, or go to Squedunk for a special meeting, attend a dealers' convention—*be sure it gets into the local paper!* Write all the radio articles you can for free publication. Run a small advertisement in the paper every week! If you live in a territory where there are several small cities in the county, run ads in all papers. They don't cost much and will bring in farm trade, as well as trade from the nearby towns.

"It pays to run a 'slide' in your local theatre and others in your general territory. If possible, secure an educational radio film. R.C.A. puts out a most interesting one-thousand-foot reel called 'The Four Corners of the Earth.' It is furnished free and your local theatre manager will generally be glad to run it gratis—as it is of a genuine educational nature. It will stimulate the tube replacement business.

"One of our best advertising bets are paper matches with a story on the cover. We pass these out ourselves, and also arrange for their distribution by several local restaurants. Cigar and stationery stores are also good and logical outlets. We also have a small 'sticker' with space for filling in date sold, customer, test and check, which goes with every tube or set we sell—a gesture that stimulates confidence, and a gentle reminder of where reliable radios, parts and service may be had."

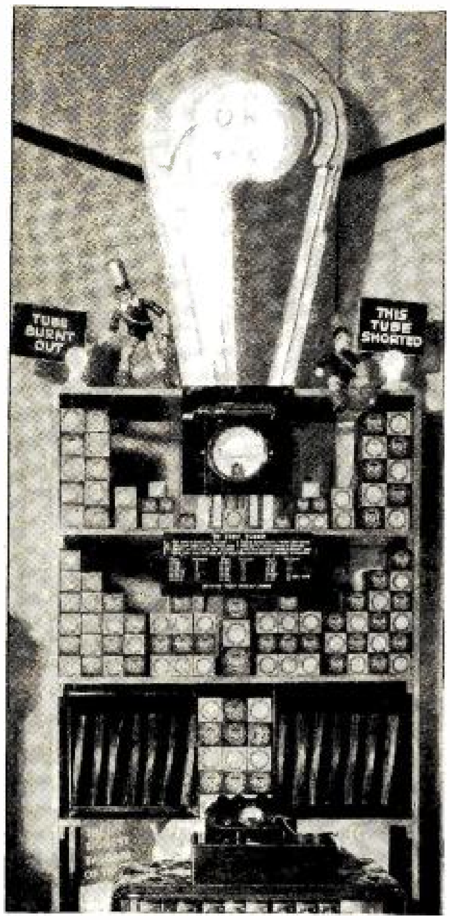
REVERSE OF MATCH CASE

Figure 2. On the other, your own message. Local cigar stores and restaurants will be glad to distribute these little reminders for you

Tube-Selling Display for the Service Shop

The accompanying photograph illustrates a spectacular form of automatic tube tester. When the filament is open, a blue lamp illuminates a sign reading "Tube burned out." A red lamp warns "Tube shorted" when the grid shorts either to filament or plate. If none of these defects exists a white light flashes behind a sign reading "O.K. to test," indicating that the tube under inspection may be placed in the usual type of counter tube tester, the meter of which has been disconnected and a giant twelve-inch meter substituted.

This device has proved itself a remarkable stimulus to tube sales. Everything is simple, open and above board. The



A SPECTACULAR TUBE TEST

Figure 3. Set up in the service shop or show room, this device will pay for itself in increased tube sales

customer may even test his own tubes. The small stock of tubes is arranged attractively, and represents fifteen different types.

This device also makes a particularly attractive window display, and customers may be taken into the store window in order to have their tubes tested—providing an animated window that is sure to gather crowds. After this, the display may be placed either on the sales counter or in the service shop. It is a genuine interest attracter and sales getter.

In the interest of the tube business, the Western Michigan Music Company, Victor distributors for Grand Rapids, will be glad to supply dealers and servicemen with a diagram of connections.

The cost is not prohibitive in consideration of its advertising value. The case costs $20, the giant tube $15, the giant meter $27, the counter tube checker $12.90, preliminary tester $15, wiring $10—a net total of $99.90.

Selling Radio Insurance

Servicemen, more and more, are considering the serious business of getting business. *Knowing all the circuits by heart* won't do you any good *unless* the ailing sets make a circuit from the home to *your* shop and back again. H. G. Wood, of West Webster, N. Y., turns in a good idea:

"This is just another way of overcoming the disastrous effects produced on the radio serviceman by Old Man Depression. A very effective one I find it. And even though the old man may be trying to let up on us, servicemen, especially those who are just setting up in business, will find my suggestion a profitable one.

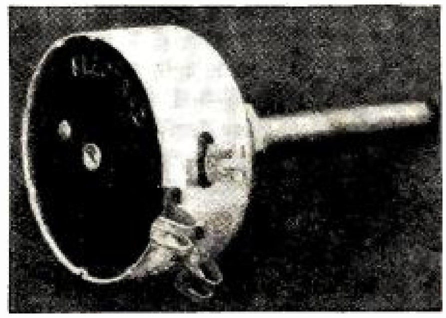
"About eight months ago my service business began to fall off a bit. I had never been overwhelmed with service calls—and now I could hardly make ends meet. I set about to overcome this condition, and today I'm convinced that servicing isn't such a bad business after all. I had our neighborhood printer make me up some cards stating that the undersigned would guarantee to keep the insured's radio working for a period of one year. This service includes all labor charges, service calls, re-erection of aerials, all test work and replacement of parts—tubes, transformers, condensers, etc. No additional charge of any kind is to be made, except the list price of parts used in making replacements. This is really a form of insurance and is equally attractive to the customer and serviceman. The serviceman is certain to make the difference between wholesale and list prices on all the parts required for the set insured, over the period of insurance.

"I find it very easy to sell these cards to my steady customers for $2.50. Through them I am able to dispose of many more, thus increasing my business and acquiring new customers whose trade I am sure of for at least one year. Very few set owners pay out less than this insurance price for service in twelve months, so the radio serviceman, with any sales ability at all, should experience little difficulty in selling many of these cards. Each one sold brings me in many profits during the year."

Standardizing Volume Control and Resistor Replacements

With the rapid development of portable radio testing devices and set analyzers, there has been a consistent trend towards the practice of servicing receivers without removing them from the premises of the owner. This procedure saves time and money, eliminates unnecessary inconveniences and inspires the customer's confidence in the serviceman.

In the past, however, while it was immediately possible to locate resistor defects, it was not feasible to carry a complete stock of the many different types of fixed and variable resistors required to complete repairs. Therefore the time saved by using a modern analyzer was



REPLACEMENT VOLUME CONTROL

Figure 5. This almost universal type of volume control may be used for replacement purposes in many different types of receivers

more or less wasted in returning to the shop for the necessary resistors or volume controls—or in transporting the receiver itself to the work-bench.

Today this condition has been alleviated to a great extent by the development of universally applicable resistor replacement parts. For example, Electrad is marketing a single volume control which can be used in 133 different commercial receivers. Through intelligent design, a total of five different replacement volume controls can be applied to over 343 commercial receivers. Seven additional controls take care of practically all other volume control requirements, such as reverse potentiometer pentode-plate-tone control, variable-mu reverse potentiometer ground-cathode control, etc. In other words, the serviceman who carries these twelve replacement units in his kit can be almost certain of replacing a faulty volume control. As a matter of fact, two or three types will suffice him in all but very exceptional instances.

Voltage dividers and other fixed resistors, such as bias resistors, etc., have presented another and comparable problem to the radio serviceman. Obviously, it is impractical to carry a complete line of all the individual resistors required in the modern receiver. To do so would require a truck instead of a kit. The design of fixed resistors with similar versatility has

(*Continued on page* 813)

A MODEL SERVICE SHOP

Figure 4. The service headquarters of Charles Ogilvy, Ltd., Ottawa, Canada—Mr. LaPointe in charge. Plenty of light contributes to efficient servicing

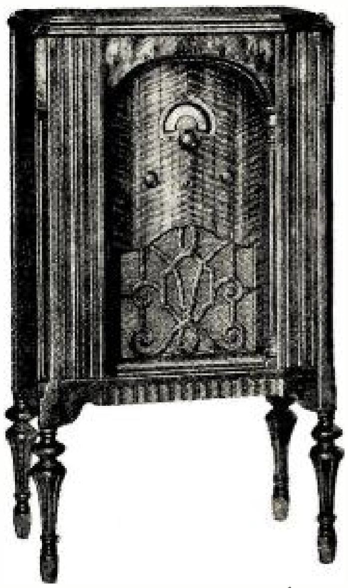
What's New in Radio

A department devoted to the description of the latest developments in radio equipment. Radio servicemen, experimenters, dealers and set builders will find these items of service in conducting their work

Conducted by
The Technical Staff

Console Receiver

Description—A new line of tuned radio-frequency and superheterodyne receivers which includes both mantel type and console models. The accompanying photo shows a nine-tube superheterodyne receiver utilizing riator and static minimizer and a ten-inch

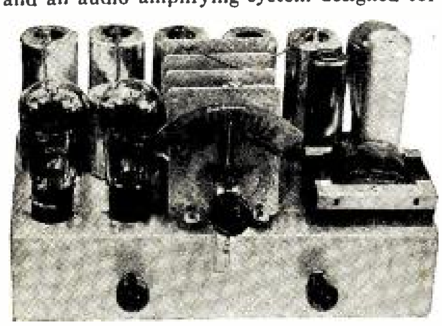


auditorium type dynamic speaker. The tubes employed are: three –35 type, one –24 type, two –27 type, two pentode type and an –80 type rectifier tube. The dimensions of the American walnut cabinet are 38 inches high by 21½ inches wide by 13 inches deep.

Maker—High Frequency Laboratories, 3900 N. Claremont Ave., Chicago, Ill.

Radio Receiver

Description—The accompanying illustration shows an eight-tube a.c. superheterodyne chassis. It utilizes seven tuned circuits, a high-gain antenna circuit, power detection and an audio amplifying system designed for



handling auditorium volume. With the vacuum tubes employed for this receiver are two multi-mu type tubes and two pentode type power tubes.

Maker—Freed Television & Radio Corp., 22 Wilbur Ave., Long Island City, N. Y.

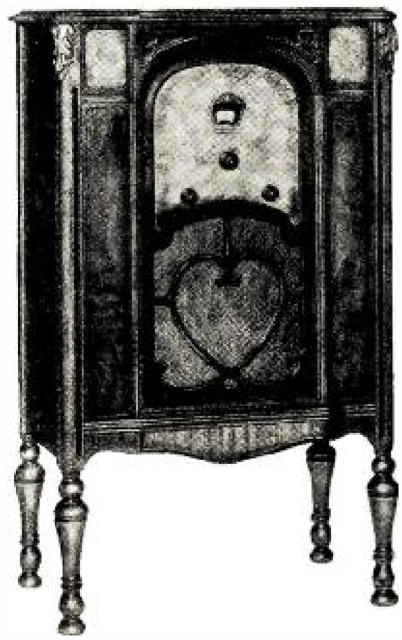
Lightning Arrester

Description—A new resistor type lightning arrester has recently been introduced. It measures 2 inches in length and weighs only one ounce. The arrester is enclosed in a bakelite shell, the design of which permits the use of the same size and type resistance parts employed in larger units.

Maker—Belden Manufacturing Company, 4689 W. Van Buren St., Chicago, Ill.

Console Receiver

Description—The Fada Lowboy console model 63 receiver is especially designed for European use. By means of a single switch it is possible to change from a waveband of 200 to 550 meters to the long waves between 1000 and 2000 meters. The tubes utilized are as follows: two type –35 multi-mu, one

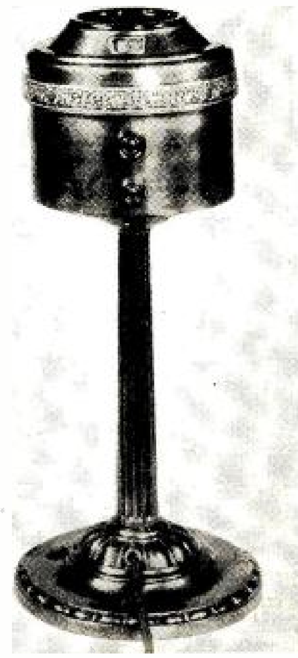


type –24 screen grid, one type –47 pentode, and one type –80 rectifying tube. This set features tone control, phonograph tip connections and dynamic speaker. In addition to this receiver the new line of sets for export trade includes a total of ten models and four chassis. Several of these models are available for operation on five different voltages and frequencies.

Maker—F. A. D. Andrea, Inc., Long Island City, N. Y.

Remote Control

Description—A remote-control unit which provides complete tuning and volume control for any radio receiver, from any point within a radius of 30 feet from the receiver. It resembles a smoking stand in appearance and is connected to the radio receiver by means of a 30-foot flexible extension cord. The unit contains no motors or mechanical appliances, but instead constitutes a frequency changer by means of which any station tuned in is converted to the fixed frequency to which the receiver is permanently tuned. In addition to serving as a remote control, the unit provides the advantage of single control, regardless of the number of tuning controls on the radio set. It is also said to increase both the selectivity and sen-

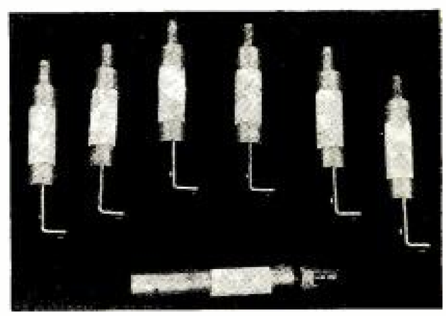


sitivity of the receiver and may be used with either tuned r.f. or superheterodyne receivers.

Maker—General Motors Corp., Dayton, Ohio.

Auto Suppressors

Description—This motor radio noise suppressor outfit shown here for a six-cylinder car comprises six spark plug suppressors, one for each spark plug, and a suppressor for connection to the common cable of the distributor. These suppressor units are mois-



ture-proof, rugged and capable of withstanding heavy mechanical shocks. The capacity of these resistors is extremely low, less than 0.5 micro-microfarads, and the resistance is 15,000 ohms or an optional value, as desired. The suppressors are available singly or in any desired quantity.

Maker—Lynch Mfg. Company, Inc., 1775 Broadway, New York City.

Midget Vernier Dial

Description—A midget type vernier dial, three inches in diameter, especially adapted for small size radio receiving and transmit-

(*Continued on page* 816)

Radio Physics Course

This series deals with the study of the physical aspects of radio phenomena. It contains information of particular value to physics teachers and students in high schools and colleges. The Question Box aids teachers in laying out current class assignments

By Alfred A. Ghirardi*

Lesson Eight

CURRENT can flow in a circuit only as a result of the application of electromotive force. Whenever a current flows through a resistance there must be a difference of electrical potential (p.d.) or pressure between the ends of that resistance tending to make the current (electrons) flow through it. This difference of potential is equal to the product of the current in amperes times the resistance in ohms. In practice, when a source of e.m.f. is applied to a circuit containing resistances, the part of the e.m.f. used up in sending the current through each resistance is called the *"voltage drop"* or *"fall of potential"* through that resistance. Both of these expressions are commonly used. In some devices the voltage drop occurring in resistance is made use of to reduce voltages which may be too high, as in the case of filament and plate circuit resistors in vacuum tube circuits as shown in (A) and (B) of Figure 1. In other cases the current is made to flow through a resistance purposely in order to create a difference of potential for some definite use as in the case of C bias resistors in electric radio receivers, shown in (C) of Figure 1. As the current flows from A to B through the resistance, there is a fall of potential from A to B. Therefore point B is at a lower potential than point A. That is, B is negative with respect to A. In other cases, the voltage drop in resistors is objectionable, and is kept low by keeping the resistance of the circuit as low as possible. It is the *pressure* and not the *current* that is used up in maintaining a flow of electricity (electrons) through a circuit.

The end to which the current flows is at a lower electrical potential (—) than the end from which it flows (+). This condition is shown in (D) of Figure 1 which represents an output-divider resistance employed in B eliminators used in electric radio receivers. This is made up of several resistors connected as shown, or else a single resistor with taps taken off the resistance wire at various places. The current flows out of the B elimintor at A, and back into the B eliminator at B. Thus A is the positive terminal (point of highest potential). We will assume that all of the current flows down through the resistance from A to B. There will be a fall of potential from A to C equal to the resistance in ohms from A to C multiplied by the current in amperes flowing through (E = I × R). Point C is at a lower electric potential than point A by this amount. Similarly point D is at a lower potential than C by an amount equal to the fall of potential from C to D (I × R). Point B is at a lower potential than point D by an amount equal to the resistance B multiplied by the current flowing through it. We will assume that the resistances have been so chosen that the potentials at these points are as indicated in the diagram, *i.e.*, 180, 90 and 45 volts. The fall of potential along the resistance may be indicated graphically by the sloping line EF whose vertical height above the horizontal axis line at any point indicates the potential at that point. Notice how the electrical potential decreases as we go from end A to end B of the resistance.

The fall of potential through a resistance may be looked upon somewhat similarly to the case of the fall or drop in pressure of water flowing through a pipe. The friction between the individual molecules of water and between the water and the inside surface of the pipe causes a gradual loss of pressure along the pipe.

Electricity flowing through a conductor is really a source of power because it can be made to do work if it is made to flow through suitable apparatus. A familiar application of this is in the use of electricity to drive electric motors of all kinds. Power is the rate of doing work. In considering power we consider not only the amount of work done but also the length of time during which it is done, that is, the *time rate*. It requires more power to do a certain amount of work in a short interval of time than in a longer time.

The unit of electric power is the *watt*. The watt is the

Where to Borrow, Rent or Buy 16 MM. Educational Films

A 64-PAGE directory which includes hundreds of sources of 16 mm. educational films for both sound and silent motion pictures has just been issued. This list is undoubtedly the most complete available, inasmuch as it is strictly unbiased and includes films for sale, rent and loan. Believing that this booklet will be of unusual value to those concerned with the use of motion pictures in education, RADIO NEWS has arranged with the publisher to provide copies, without charge, to readers who may desire them. Simply address your request on school letterheads to Department E, RADIO NEWS, 350 Hudson Street, New York City, N. Y.

*Radio Technical Pub. Co., Publishers Radio Physics Course.

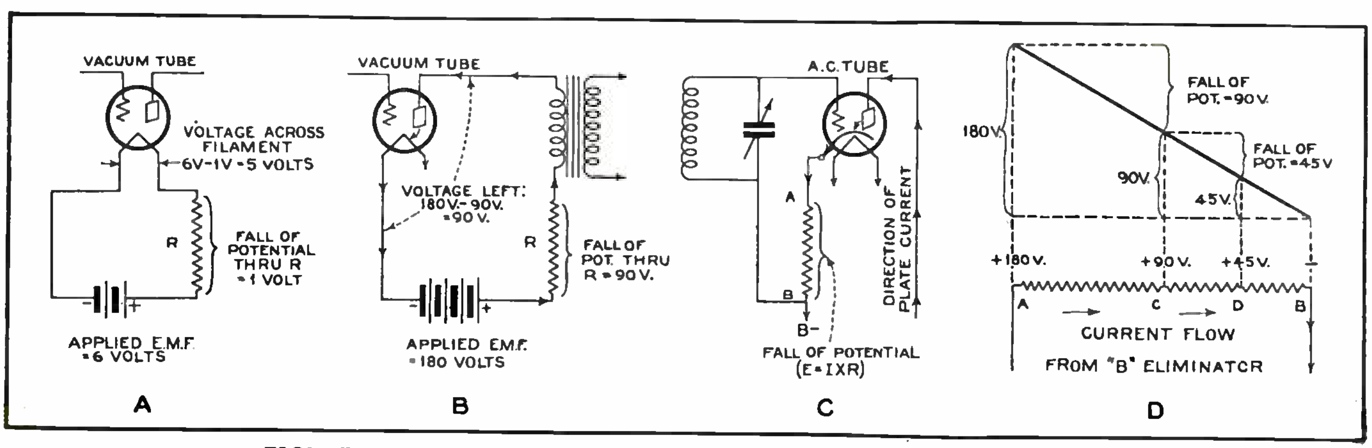


FIGURE 1. EXAMPLES OF FALL OF POTENTIAL ALONG A RESISTANCE

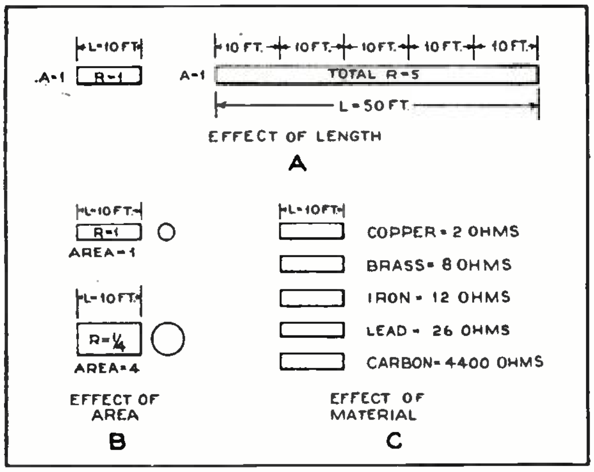
power in a circuit in which one ampere is flowing under a pressure of one volt. The number of watts in a circuit is equal to the volts multiplied by the amperes.

$$W = E \times I \qquad (1)$$

Thus, the filament of a 224 type vacuum tube has flowing through it 1.75 amperes under a pressure of 2.5 volts in order to heat it to a red heat. The filament is therefore using electric power at the rate of 2.5 × 1.75 = 4.37 watts.

The watt is a rather small unit of electrical power for use in practical work. The *kilowatt* (kw.) equaling 1000 watts is used when expressing larger amounts of power. To change watts to kilowatts divide by 1000. To change kilowatts to watts, multiply by 1000. 764 watts (or nearly ¾ kilowatt) equal one horsepower. This relation is useful to remember.

Equation (1) enables us to calculate watts if the voltage and current are known. There are two other



RESISTANCE DEPENDS ON THE LENGTH, AREA AND MATERIAL. FIGURE 2

convenient forms of this power equation which can be easily derived from this one. These enable us to calculate the electric power used up in sending current through a resistance. The electric power used up in this manner is converted into heat. The ordinary incandescent lamp filament or vacuum tube filament are common illustrations of the practical application of this. Current sent through the filament against its resistance, produces enough heat to raise the temperature of the filament to a point where it gives off light. The heat is probably produced by the collision of the moving free electrons with the many atoms in their path. The energy of the moving electrons is thus converted into heat energy which raises the temperature of the conductor. The heating effect of electric current is also made use of in the electric stove, electric iron, electric furnace, etc.

From Ohm's law we have $I = \frac{E}{R}$.

Substituting this value of I for I in the power equation (1), we obtain:

$$W = E \times I = E \times \frac{E}{R} = \frac{E^2}{R} \qquad (2)$$

This gives an expression for the electrical power in terms of the voltage and resistance.

From a former equation we have $E = I \times R$.

Substituting this value of E for E in the power equation (1), we obtain:

$$W = E \times I = I \times R \times I = I^2R \qquad (3)$$

Examination of this last equation shows that in a circuit in which the resistance is kept constant, the electric power consumed in forcing current through it is proportional to the square of the current. For instance, if we consider the filament of a –01A type vacuum tube again, its resistance is 20 ohms. Its normal current is .25 ampere. This heats the filament to a dull red heat. If now we (*Continued on page* 804)

Question Box

PHYSICS and science instructors will find these review questions and the "quiz" questions below useful as reading assignments for their classes. For other readers the questions provide an interesting pastime and permit a check on the reader's grasp of the material presented in the various articles in this issue.

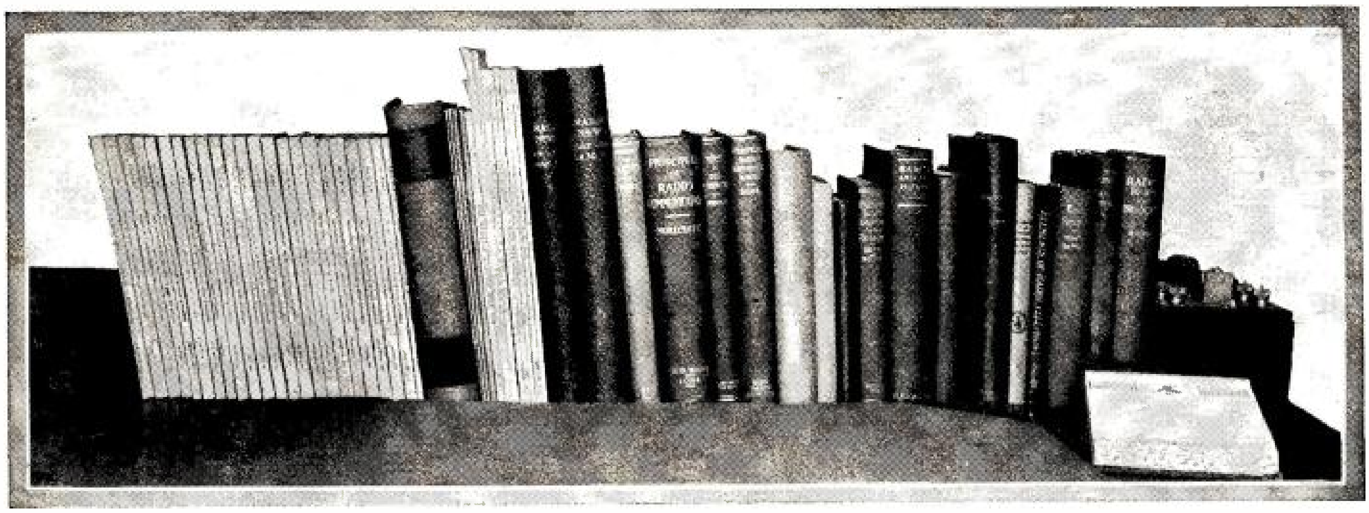
The "Review Questions" cover material in this month's installment of the Radio Physics Course. The "General Quiz" questions are based on other articles in this issue as follows: "Walking" Transmitters, Radio's Powerful Electric Voice, Simple V.T. Voltmeter, Superheterodyne Innovations, Electric Filter Design, Radio Surgery, New All-Wave Superheterodyne, The March of Television, New Motor Radio Design, Televising Horse Races.

Review Questions

1. *Knowing the value of a resistor and the amount of current flowing through it, how can the voltage across it be calculated?*
2. *What is meant by the common expression "voltage drop"?*
3. *What is the unit of electrical power?*
4. *What power is consumed in the filament of a –01A tube, operating under normal voltage?*
5. *What current is drawn by a 50-watt lamp in a 110-volt circuit?*
6. *What are the two essential requirements to obtain a flow of electric current?*
7. *What two factors determine the amount of current flowing in a circuit?*
8. *What electrical term do the initials A. W. G. represent?*
9. *If a copper wire has a diameter of ¼ inch, what is its area in circular mils?*
10. *What is meant by the term "specific resistance"?*
11. *Give two important reasons why copper is so extensively used as a conductor of electricity.*

General Quiz on This Issue

1. *What practical purpose is served by the two resistors connected in the plate-meter circuit of some vacuum-tube voltmeters?*
2. *What advantages are claimed for isolantite as a form for r.f. coils?*
3. *For what purpose is a push-pull second detector employed in one of the latest superheterodynes?*
4. *Describe two distinct types of antennas for motor car radio installations.*
5. *What important parts are played by mirrors in some recent television experiments?*
6. *What new development makes possible play-by-play broadcasts of a golf game?*
7. *What is the "transfer loss" in filter circuits?*
8. *How long ago did the first practical demonstration of transmitting images and writing over wires take place? In what country? Who was the inventor of the system?*
9. *Explain the main differences between a "dynamic" and an electro-magnetic loudspeaker.*
10. *Who invented the scanning disk?*
11. *How are ultra-short waves used in medicine?*



Radio Science Abstracts

Radio engineers, laboratory and research workers will find this department helpful in reviewing important current radio literature, technical books and Institute and Club proceedings

Conducted by
Howard Rhodes

Radio Construction and Repairing, by James A. Moyer and John F. Wostrel. Third edition. Published by McGraw-Hill Book Company, Inc.

Servicemen, amateurs and radio experimenters will find this book useful. The first edition was published in 1927. This latest edition brings the text up to date by including much additional data on superheterodynes, tone control systems, short-wave receivers for code and for television reception. The text is elementary in treatment, all the explanations being qualitative—there isn't a single equation in the entire book.

One of the longest chapters in the book is that on the testing and repairing of receivers. It includes a complete list of causes of interference and the usual chart of "troubles" and "cures." Several commercial testing units are illustrated and their use in repairing is described in detail.

The chapter on television is based largely on the system of transmission and reception used by station W1XAV of the Shortwave and Television Laboratory of Boston, Mass. Unfortunately, the text describes the 48-line system in particular, whereas most stations have now changed over to 60 lines. The change is not serious, however, for the technical details are accurate for any number of pictures or lines per picture.

As a whole, the text is a reasonably complete review of all parts of radio-receiver circuits, describing how they work and how they can be repaired or tested. It will prove more helpful than an ordinary book on "service," since the reader learns more of the principles underlying the operation of receiver circuits.

Radio and Education. The Proceedings of the First Assembly of the National Advisory Council on Radio in Education, 1931, edited by Levering Tyson. Published by the University of Chicago Press.

The National Advisory Council on Radio in Education is attempting to assemble and disseminate facts about radio in education and to induce qualified authorities in various fields to devise radio programs that will prove contributions to educational broadcasting. This book contains all the addresses given at the first assembly of the National Advisory Council during the week of May 21, 1931. It includes addresses by such well-known figures as Damrosch, Millikan, Goldsmith, and others. The program of the Assembly was designed to cover the complicated field of educational broadcasting and most of the addresses were delivered by individuals experienced in the broadcasting of educational features. As a result we have a book that deals with facts rather than mere opinions, a book that represents a complete and accurate summary of educational radio, its history, problems, and future possibilities. As Dr. Goldsmith stated in his address, "education *is* communication," and it behooves us to analyze, systematically and interestingly, the rôle which radio may take in disseminating knowledge.

The successful application of radio's possibilities as an educational medium will not be attained unless its unique characteristics are carefully studied by educators, so that they may utilize this new educational tool to its fullest capabilities. More concrete, trustworthy information is to be found in this book than has heretofore been available. It is essentially a text on radio and education. Its value to teachers as well as broadcasters should be obvious.

Please Stand By. A novel by Madeleine Loeb and David Schenker. Published by the Mohawk Press, Inc.

"Canned music. Served hot, sealed, and delivered. Guaranteed to brighten the home. . . . The great American canning industry par excellence."

Such is the opening of this novel on studio life and the problem of producing programs that listeners will like and which will also sell glue or canned peaches or—anything. It is a story of "the American broadcasting system, supported by Big Business, who holds the moneybags and whose advertising managers always feel that they know more about programs and scripts than any program department ever will know." It is a story of advertisers who want something "different" in the way of a program and who end up by hiring a jazz orchestra and a crooner who play and sing *very special* arrangements of popular ditties! The program ends by being the same as dozens of others, but the advertiser is satisfied—and the station gets the contract.

The theme of the book is a love affair (can anyone tell me why I should be reviewing a love story?) around which is woven the experiences and ballyhoo through which the program and press departments must go to land and keep a broadcasting contract.

The story ends happily. "She took Donald's hand and forgot Manuel. Let him have his shadow success. This was the real thing." You didn't expect it to end *unhappily*, did you?

Review of articles appearing in the January, 1932, issue of the Proceedings of the Institute of Radio Engineers

An Untuned Radio-Frequency Amplifier, by F. W. Schor.

This article outlines the theory and performance of untuned r.f. amplifying transformers for use with screen-grid tubes. Experimental data is given on many different types of transformers: some used tuned primaries or secondaries, and others untuned windings wound on silicon-steel cores. The transformer giving the most uniform gain was one using single-layer primary and secondary windings wound on opposite legs of a finely laminated, silicon-steel core; a gain of about 10 was obtained over practically the entire broadcast band. Other transformers had gain characteristics which were as high as 50 at 550 kc. but which dropped to about 8 at 1500 kc.

An Experimental Study of the Tetrode as a Modulated Radio-Frequency Amplifier, by H. A. Robinson.

The advantages and limitations of the tetrode employed as a modulated radio-frequency amplifier are considered and the results of an experimental study made upon one type of screen-grid tube are given. Oscillograms and characteristics are presented from which the operation of the type UX-865 tetrode can be predicted under varied operating conditions and for several methods of modulation. The method of graphical analysis is employed to determine the relative effects of the circuit parameters and electrode voltages upon the performance of the tetrode as a modulated amplifier.

A method of modulation is described in which the modulating signal voltage is introduced in both the screen-grid and plate circuits, eliminating the detrimental effects of secondary emission and permitting the complete modulation of the radio-frequency carrier with a negligible degree of distortion, the tetrode performing in a manner similar to that of a neutralized triode.

An Experimental Study of Regenerative Ultra Short-Wave Oscillators, by William H. Wenstrom.

This paper gives a quantitative account of the operating performance for two representative oscillator circuits, one of the single-tube type and the other the two-tube balanced type. Wavelength (approximately 3 meters) was measured by two independent methods. Efficiency and stability were measured under various plate, grid and filament conditions. Normal efficiency values ranged from 20 percent to 40 percent. Under most conditions, the two oscillator circuits were about equally efficient. Frequency variations were less than 1 percent, while output variations rarely exceeded 2 percent.

Theory of Design and Calibration of Vibrating-Reed Indicators for Radio Range Beacons, by G. L. Davies.

This paper gives a general treatment of the design of vibrating reeds. The expression for the frequency of a loaded uniform reed, computed by a method equivalent to one given by Rayleigh, checks very closely with that obtained by Drysdale and Jolley for a similar reed. Design equations are given for uniform reeds and for the type used in the reed indicator. From the results of both theory and experiment, the effect of the various factors of design and operation upon the reed frequency is discussed and the calibration procedure, necessary to take account of these factors, is outlined.

Effect of Shore-Station Location Upon Signals, by R. A. Heising.

Experiments are described for ascertaining the attenuation suffered by the unreflected wave in traversing relatively small amounts of land between the seashore and hypothetical inland sites. The results show 8 to 12 db. attenuation for 1 mile inland, with greater attenuation thereafter for unfavorable terrain. Swampy ground produces small attenuation.

Review of Contemporary Periodical Literature

Audio-Frequency Compensation Methods, by Julius G. Aceves. Electronics, December, 1931.

An excellent article on methods for deigning audio-frequency circuits to compensate sideband attenuation or loudspeaker characteristics and therefore improve the overall fidelity. A number of circuits are given indicating how compensating circuits can be introduced in the audio-frequency amplifier. A note accompanying the article states that the material is taken from the chapter on Audio Amplification which forms part of a Handbook for Radio Engineers, to be published by the McGraw-Hill Company.

A New Selenium Tube, by G. F. Metcalf and A. J. King. Electronics, December, 1931.

The authors describe a new selenium cell mounted in a vacuum. Its average resistance at 100 foot-candles is 750,000 ohms, its dark resistance 6 megohms. It is designed for voltages up to 125 volts a.c. or d.c. and the maximum current output is .5 ma. Circuits are given, showing how the tube may be used to control a thyratron. Other curves show that the output falls off very rapidly with frequency, due to the time lag of selenium. At .05 lumens per sq. in., the output at 5000 cycles is one-fifth the output at 500 cycles; with an illumination of .2 lumen per sq. in. the ratio is about four to one. The cell is especially sensitive to red light.

The Dynatron Oscillator, by F. M. Colebrook. Experimental Wireless and Wireless Engineer, England. November, 1931.

Practical details are given for using a screen-grid tube as a dynatron oscillator. The upper frequency limit of the ordinary dynatron is stated to be 15 megacycles (20 meters). By the use of a new type dynatron circuit, Figure 1, the upper frequency limit is raised to 50 megacycles (5.5 meters).

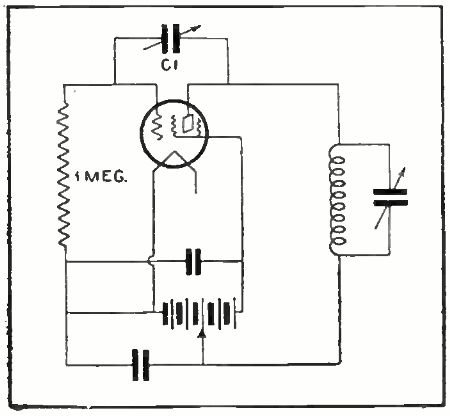


FIGURE 1

In Figure 1 the condenser C1, between plate and control filament, is about 100 mmfd.; if the circuit is to be used to generate audio frequencies, C1 will have values about 5000 mmfd. It is best to start with a low value for C1 and gradually increase it until oscillations begin. To obtain the upper limit of frequency the plate circuit load will simply be the wire connecting the plate to the A battery. Up to about 7 meters the frequency is determined by the LC constant of the tuned circuit.

A Self-Stopping Thyratron Circuit, by Herbert J. Reich. Electronics, December, 1931.

A characteristic of the thyratron is that once the discharge starts, it cannot be stopped by any variations of the control-grid voltage. A grid-glow tube connected in accordance with the author's suggestions will perform the function of automatically stopping the anode current.

Acoustics and Its Relation to Seating in Auditoriums. Projection Engineering, November, 1931.

An excellent article on theatre acoustics. A typical theatre is analyzed, showing the effect of the size of the audience on the acoustic characteristics of the auditorium. The article includes useful tables of absorption coefficients.

Distortion in Valve Characteristics, by G. S. C. Lucas. Experimental Wireless and Wireless Engineer, November, 1931.

This article gives methods of determining the amount of distortion produced by a power amplifier under any conditions of load or voltage; the method is applicable to any type of tube, including the pentode. If we use the following notation:

A = d.c. plate current
B = I_{max} of fundamental
C = I_{max} of 2nd harmonic
D = I_{max} of 3rd harmonic
E = I_{max} of 4th harmonic

then the percentage harmonic distortion will be:

$$\%\ 2nd = \frac{C}{B} \times 100$$

$$\%\ 3rd = \frac{D}{B} \times 100$$

$$\%\ 4th = \frac{E}{B} \times 100$$

The values of A, B, C, D and E are obtained from the dynamic tube characteristic and are as follows:

$$A = \frac{\frac{1}{2}(I_{max} + I_{min}) + I_o + I_2 + I_3}{4}$$

$$B = \tfrac{1}{4}\sqrt{2}(I_2 - I_3) + \tfrac{1}{4}(I_{max} - I_{min})$$

$$C = A + E - I_o$$

$$D = \frac{I_{max} - I_{min} - 2B}{2}$$

$$E = \frac{2A - I_2 - I_3}{2}$$

In the above equations the various currents are taken from the dynamic characteristic (see Figure 2) and have the following values:

I_{max} = The maximum value to which the current rises. It is the plate current corresponding to a grid voltage equal to the normal grid bias minus the peak value of the a.c. signal voltage E_{ac}

I_2 = The plate current corresponding to a grid voltage equal to the normal bias minus $(E_{ac}/\sqrt{2})$

I_3 = The plate current corresponding to a grid voltage equal to the normal bias plus $(E_{ac}/\sqrt{2})$

I_o = Normal no-signal plate current

I_{min} = The plate current corresponding to a grid voltage equal to the normal grid bias plus the peak value of E_{ac}

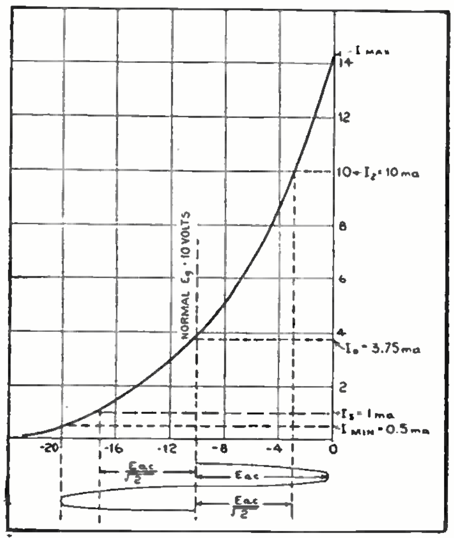


FIGURE 2

These various currents are indicated in Figure 2. For this particular curve: I_{max} = 14.3 ma; I_2 = 10 ma; I_3 = 1 ma; I_o = 3.75 ma; I_{min} = .5 ma.

By determining the values of these currents and substituting in the various equations the distortion for any load condition can be determined. In applying this method to pentode tubes some of the quantities may be negative; this shows a difference in phase. The negative sign *must* be retained in solv-

(*Continued on page* 816)

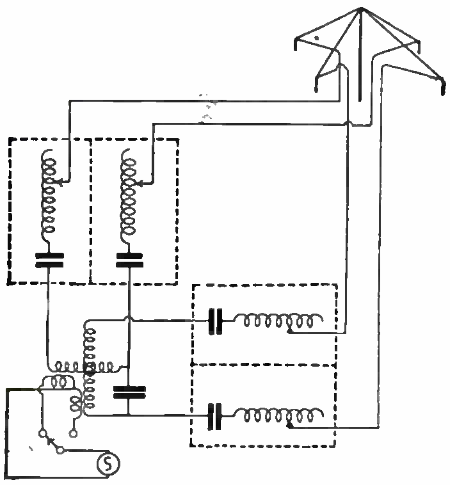
Latest Radio Patents

A description of the outstanding patented inventions on radio, television, acoustics and electronics as they are granted by the United States Patent Office. This information will be found a handy radio reference for inventors, engineers, set designers and production men in establishing the dates of record, as well as describing the important radio inventions

Conducted by

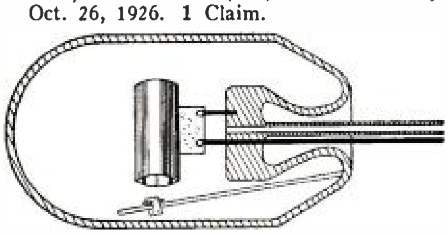
Ben J. Chromy*

1,833,735. RADIO SIGNALING SYSTEM. IRVING F. BYRNES, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. Filed Aug. 7, 1928. Serial No. 298,120. 10 Claims.



1. In a signalling system employing a goniometer having intersecting secondary windings and a primary winding the method of overcoming the effect of inherent capacity existing between the secondary windings which includes the step of introducing an electromotive force into each of the secondary windings in opposed relation to the electromotive force in said winding resulting from said inherent capacity.

1,833,117. METHOD AND ARRANGEMENT FOR DISPERSING MAGNESIUM IN VACUUM TUBES. SIEGMUND LOEWE, Berlin, Germany. Filed Oct. 27, 1827, Serial No. 229,104, and in Germany Oct. 26, 1926. 1 Claim.

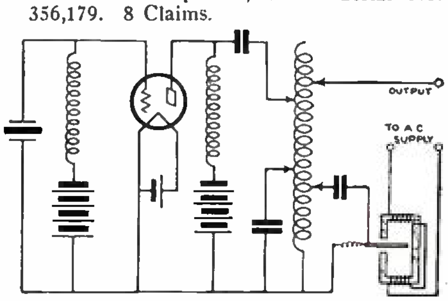


An electrical device having an electrode in an evacuated container, a movable mica strip within said container, said strip being supported at its lower end by said container, a vaporizable metal carried by the upper end of said strip whereby said vaporizable metal may be moved into contact with said electrode by tilting said container.

1,829,965. RADIO RECEIVING SYSTEM. DEWEY T. SIMONDS, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. Filed Oct. 8, 1925. Serial No. 61,356. 10 Claims.

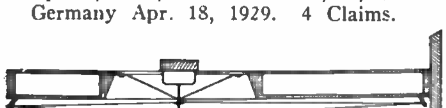
1. The combination in a radio receiving set, of a resonant receiving circuit having an effective frequency range of 500,000 to 1,100,000 cycles, a local source of oscillations, means for combining oscillations from said local source with oscillations received in said receiving circuit to produce beat currents of substantially 300,000 cycles, said source of oscillations having an effective frequency range such that said beat currents are produced throughout the effective frequency range of the receiving circuit, and means including a circuit tuned to said last named frequency for amplifying and detecting the beat currents thus produced.

1,831,933. FREQUENCY MODULATION SYSTEM. ALBERT H. TAYLOR, Washington, D. C., assignor to Wired Radio, Inc., New York, N. Y., a Corporation of Delaware. Filed Apr. 12, 1929. Serial No. 356,179. 8 Claims.



8. In a frequency modulation system, a thermionic tube, input and output circuits therefor, a piezo electric crystal element connected in said input circuit, means for tuning said output circuit, and means for periodically varying said tuning means.

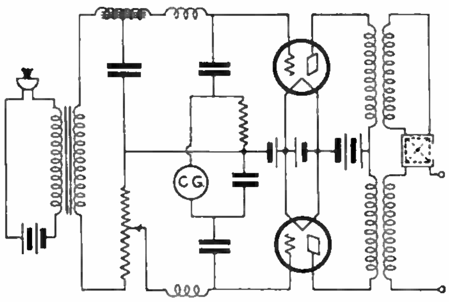
1,829,910. LOUDSPEAKER. CHAKIR MIDHAT, Berlin-Eichkamp, Germany. Filed Apr. 7, 1930, Serial No. 442,430, and in Germany Apr. 18, 1929. 4 Claims.



1. A loudspeaker, comprising, in combination, a large-sized diaphragm, a resonance box surrounding said diaphragm on all sides like a baffle-board, a plurality of strings stretched over said resonance box, and a driving unit adapted to cause said diaphragm, as well as said strings, to oscillate, substantially as set forth.

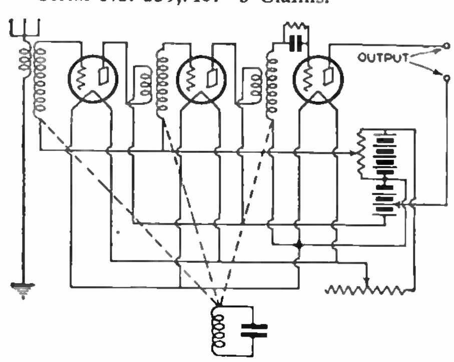
1,831,516. MODULATING SYSTEM AND METHOD. RALPH B. STEWART, Washington, D. C. Filed Jan. 10, 1928. Serial No. 245,750. 25 Claims.

1. In the art of wave modulation, the method of segregating the upper and lower side-bands into separate circuits, which consists in producing two carrier currents having quadrature phase relation, modulating one of said carrier currents by signalling currents, modulating the other carrier current by signalling currents in phase quadrature to the first mentioned signalling currents, and supplying modulated currents from both carrier currents to two output circuits having the two modulated currents supplied to one circuit reversed in relative phase with respect to the modulated currents supplied to the other circuit.



14. In combination, a source of speech frequency current containing frequency components essential to intelligible speech, and means comprising a static impedance network for deriving from said source substantially equal two-phase currents with the component currents in each phase of substantially equal amplitudes for the same applied voltage.

1,831,519. RADIO RECEIVING SYSTEM. FOSTER J. TRAINOR, Daytona Beach, Fla., assignor of one-half to A. J. Malby, Daytona Beach, Fla. Filed Dec. 13, 1927. Serial No. 239,713. 5 Claims.



1. In a radio receiving system, the combination of a plurality of cascaded audions, a plurality of radio frequency transformers, the secondaries of which are connected to the grids of said audions, a tuning circuit comprising a single tuning coil and a variable condenser, said secondaries and tuning coil being inductively coupled.

1,833,074. SOUND REPRODUCING APPARATUS. LEON V. FOSTER, Irondequoit,

(*Continued on page 816*)

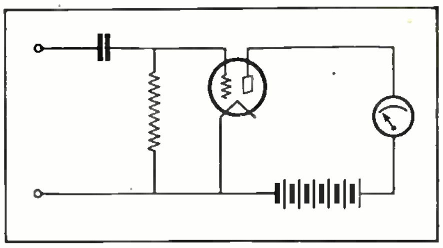
*Patent Attorney, National Press Building, Washington, D. C.

Simple V. T. Voltmeter

(Continued from page 762)

C1 may be of nearly any size on hand. The one in the equipment illustrated is .00025 mfd. maximum capacity. A small condenser will enable you to obtain greater accuracy in matching inductances, but if too small it will not be practical if inductances of high value, such as intermediate frequency transformers, are to be matched. It has been found convenient to mount two Fahnestock clips on top of the case to accommodate the coils to be tested.

In constructing the capacity bridge unit (Figure 2c) care must be used to keep the sides or arms of the bridge circuit as nearly equal, physically, as possible. You may want to match very small capacities at some time and if the bridge is unbalanced in construction a high percentage of error may result. Be particularly careful if the unit is built in a metal box. Keep the connections from one input lead to the two condensers equal in length. Keep the wires from the other input lead to the two resistance arms equal in length. Do likewise with the leads between the resistance arms and the capacity arms. Keep similar wires equidistant from any metal so that unequal capacities, no matter how slight, will not be introduced into the argument.



VOLTMETER CIRCUIT

Figure 1. This is the fundamental circuit employed in all vacuum tube voltmeters

The method of connecting the condensers should be that which will be most convenient for the type of condensers that will be most frequently tested. In the equipment illustrated, the two spring clips toward the front are mounted solidly on the bakelite strip. The two toward the rear are on flexible leads.

Other constructional details should be obvious from inspection of the diagram. All three units could be constructed in one case if desired, provided the necessary switching arrangement is included to connect either the bridge circuit (Figure 2c) or the tank circuit (Figure 2b) as needed. It is advisable, however, to keep the vacuum tube voltmeter separate so that it may be easily used for other purposes. It is not necessary to use any shielding. The instruments illustrated were built in aluminum cases for permanency and eye value.

The choice of the tube is not important. In this instance a 201-A is used merely because there was a surplus of this type on hand.

Before using the vacuum-tube voltmeter it will be necessary to properly adjust the meter shunt resistance R5. Before connecting plate and filament supply, R5 should be adjusted so that very little resistance is connected across the meter. Then with the tube operating, R3 should be adjusted till the meter indicates zero. Now open the switch which disconnects the shunt R5 and *very carefully* readjust R3 until the meter shows full scale deflection. Then close the switch again, shunting the meter, and *carefully* adjust R5 so that the meter indicates 0.1 milliampere. This arbitrary adjustment is convenient because the meter when shunted now reads from zero to 10 ma. Always, when starting to use the equipment, adjust R3 for zero reading *with the shunt connected* and then disconnect the shunt, readjusting carefully for zero with R3 if necessary.

Matching coils is a simple and rapid operation. One coil, of the number to be matched, is taken as a standard and the others matched to it. Connect the condenser unit C1 to the v.t. voltmeter. Adjust the meter to zero reading. Connect the standard coil across the condenser unit. Now set up an r.f. oscillator near enough so that a weak r.f. current will be induced in the tank circuit L1 C1. (The oscillator must, of course, be oscillating at a frequency within the limits to which L1 C1 will tune.) Adjust C1 until the greatest deflection is obtained on the meter. This indicates resonance between the oscillator and the circuit L1 C1. Keep the coupling between the oscillator and the coil being tested low enough so that maximum deflection at resonance is about half scale. Now, without changing any adjustments, substitute another coil for the one that was taken as standard. If the inductance value of this coil is the same as the standard, no adjustment of C1 will be necessary to obtain resonance. If additional capacity is needed, the inductance is below standard. Likewise, if less capacity is needed, the inductance is above standard. The inductance may be easily altered by spreading the turns of wire slightly if the inductance value is too high or crowding them together somewhat if too low. If the difference is too great to be corrected by this means, it will be necessary to remove or add a few turns.

In measuring capacities, a source of audio-frequency input to the bridge circuit is needed. This may be supplied by a beat-frequency oscillator or by a straight audio-frequency oscillator. The bridge unit should be connected to the v.t. voltmeter and the latter adjusted to zero reading as heretofore. Condensers may then be connected in the two capacity arms of the bridge and the input applied. Adjust R1 and R2 until the bridge circuit balances as indicated by zero reading on the meter (lack of balance is indicated by a deflection of the meter). Keep the moving contacts away from the common ends of R1 and R2, as when in that position it is evident there is no input to the v.t. voltmeter. This might lead to the false conclusion that balance had been obtained. If, when balance is obtained, the dials on R1 and R2 show the same reading, the two condensers are of the same capacity. An input, to the bridge, of a frequency in the order of 1,000 cycles per second has been found very satisfactory, especially in connection with the measurement of small capacities.

Before depending too much on the bridge it might be well to check its accuracy. Connect two condensers that are assumed to be of the same value. When balance is obtained suppose R1 reads five divisions higher than R2. Now transpose the two condensers and again balance the bridge. If R2 now reads five divisions higher than R1, it shows the bridge is accurate and the difference is in the condensers under test. Inaccuracy in the bridge will have to be corrected by changing the length or spacing of the wires in the bridge circuit.

Summary

Care and pains in the construction of this equipment will be well repaid in the satisfaction of becoming well acquainted with the coils and condensers with which you are working. Use caution in adjusting the vacuum-tube voltmeter. The milliammeter may be burned out through carelessness.

"Walking" Transmitters

(*Continued from page 751*)

announcer's description of an event and convey it by wire to the broadcasting rooms in New York.

N.B.C. employs standard R.C.A. short-wave receiving sets having a redesigned audio-amplifier system for this purpose. The sets have a single stage of tuned-radio-frequency ahead of a regenerative detector, which in turn is followed by two well-balanced stages of audio amplification. Output from this set is fed directly to the line circuit with, of course, the usual monitoring equipment at the receiving set.

In cases where more than one transmitter is employed or announcers are situated at vantage points within the reach of wire circuits, and several announcers are conveying the description of an event, an interlocking system of communication enables each announcer to hear his colleague and to pick up the description without the loss of a fraction of a second.

One of the outstanding examples of such a broadcast was the description of the army air maneuvers over New York City last spring. Remote radio equipment was installed in two army planes, one following the squadron of over 600 planes, and another cruising over the city. In each plane was an announcer. Announcers were also stationed at Curtiss Field, Valley Stream, L. I., atop of the Medical Center building, in the tower of the Empire State Building and at the Battery. Each announcer was able to communicate with the other, and at the same time to hear the description from whatever point of vantage was in service. A master switchboard installed at the N.B.C. Building enabled William Burke Miller, director of special events broadcasts for the company, to direct the entire broadcast without actually seeing a single one of the planes.

Countless other events have been broadcast to the radio listeners through these portable remote transmitters.

Considerable time is usually required in setting up the remote radio apparatus for special broadcasts, as frequently local conditions make transmission difficult. Nine engineers worked two weeks on the set-up for the Hampton Roads broadcast. First came the survey of locations for the land equipment, seeking a spot clear of interference either from power lines or heavily traveled roads. Greater distances between origin and pick-up points were achieved during this event than in any previous broadcasts of the sort.

Since these broadcasts listeners have heard countless events which might never have been broadcast, had it not been for the development of remote radio installations. It has been possible to follow the collegiate shell races down the Hudson and Connecticut rivers, from both train and yacht tender; to hear a word picture of the international yacht races; to visualize the sensation of diving under water aboard a submarine, through an announcer's voice; to "see" an event from the air; to escape from a purposely sunken submarine and to follow both professional and amateur golfers about a difficult course.

All of these special events broadcasts are marking strides in the progress of broadcasting. Figures recently released by the Columbia Broadcasting System reveal that almost ninety per cent. of all major sports events during the first six months of 1931 were covered by short-wave transmission from the point of origin. The remote radio transmitter which began as a parachute jump experiment has passed through a period of rapid transition, and has resulted in a remarkable advancement.

Radio Surgery

(Continued from page 756)

been developed by Victor Tomberg, a Viennese physicist. This method which does not use even the needle is treated in detail at the end of this article.

High-frequency currents of the characteristics which are necessary for these purposes can be produced practically in three ways:

1. By the spark gap oscillator (Tesla).
2. By the oscillating arc (Poulsen).
3. By tube oscillators, especially short-wave tubes.

Of those three methods for the production of high-frequency currents the first one, with the aid of spark gap oscillators, has been the simplest and least expensive in construction.

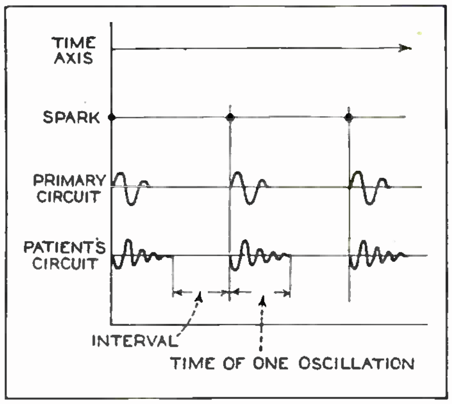


FIGURE 4

The method of high-frequency production by the spark method is shown in Figure 3.

In this type of modern apparatus which is built symmetrically and grounded, the patient may be connected to the ground. It is then entirely possible to touch the patient without getting an electric shock. In earlier constructions which are in lesser use today, the patient had to be carefully insulated from any connection to ground potential. The wavelength of this type apparatus lies usually between 200 and 700 meters. Within these limits the spark gaps work steadily and the efficiency of the generator circuit is high.

The oscillations produced by electronic tubes or by the Poulsen-arc are undamped and uninterrupted. A greater input energy is therefore possible. But the cost of this type apparatus is higher.

The arc-light, as a high-frequency generator, has, in the form of the Poulsen-arc, to be excluded from consideration, as it is too inconstant and unreliable to be placed in the hand of a physician. The arc is inclined to extinguish itself and therefore interferes in the treatment which, after all, has to be kept under constant operating condition.

The development of the ultra-short wave technic has made possible a new method, using quasi-optical waves, for operating purposes. This method, though still in its state of development, gives reason for great hopes.

At about 50,000,000 (fifty million) cycles per second, corresponding to a wavelength of about 6 meters, frequencies are generated which are undamped and of such an energy that a second connection, of the patient with the high-frequency apparatus, is unnecessary even for cutting purposes.

The second connection of the patient can be considered his capacity-against-ground, which is high enough at these frequencies as to be satisfactory for these operations.

Insulating is difficult at these frequencies. The handle in which the high-frequency scalpel is fastened is made of quartz. The needle itself consists of a small scalpel, a little longer than one inch and about 3/16 inch wide.

Figure 5 shows a schematic diagram of an apparatus for producing the ultra-short waves used. It can be used unipolar, bipolar or with condenser electrodes.

It is a particular problem to develop an apparatus which works on ultra-short waves with sufficient energy. The apparatus works on the push-pull principle. The diagram is self-explanatory. Chokes are placed between the grid and filament connections so as to control any outflow of short-wave energy over an undesired path and, at the same time, to avoid overheating of the oscillator tubes.

These tubes work upon a primary circuit with a tuning condenser so as to regulate the frequency, within certain limits. A greater variation can be performed by the change of the coils, which consist only of a few turns of wire.

Tomberg has designed a special system with which it is possible to use the high-frequency created in the oscillator at any place satisfactorily distant from the short-wave generator.

This energy conductor system consists of a three-conductor system. One of the wires is maintained at ground potential, while in the two others standing waves are generated by the short-wave oscillator. This energy conductor is therefore tuned for the same wavelength.

Such a system is practically free from radiation. It is possible with this system to treat several patients at different places in one hospital with one single oscillator.

Now, what are some of these effects which can be produced by the influence of these short radio waves upon biological tissues?

By the investigations started independently of each other, in America by Schereschewsky in 1926, Schliephake in Jena, Tomberg and Stieboeck (1929) in Vienna, it was shown that characteristic changes take place in organ substances brought between the plates of an electric condenser. This condenser, together with the organic material in between its plates building the dielectric of this condenser, is a part of an oscillating circuit tuned for very high frequencies. The tuning into resonance can be performed by making small changes in a self-induction which mainly consists of one simple winding of round or square form (see Figure 7) or also by changing the capacity of the patient-condenser.

Primarily, heat is produced in the organs by the hundreds of thousands of oscillations each atom, between the condensers, has to endure. Actually this heat production is only a part of the many complicated reactions which take place in biological tissues under the influence of short waves. The biological reaction is dependent upon the heat, the wavelength, the specific conductivity and other specific factors of the substance, its dielectric constant, dissociation, the dimensions of the condenser field, of the energy supplied, and many more.

Each wavelength seems to have one especially effective and large influence in connection with subjective substances. There exists a certain dependency between this effect and the conductivity and dielectric constant of the material. The maximum of this curve, however, is pretty flat and it is therefore possible to use a rather large frequency band for a specific reaction upon certain substances. For instance, blood is heated most at a wavelength of about 2½ meters. A solution of albumen coagulates best by a wavelength of about 1 meter, physiological salt solution is heated most at a wavelength of 3.2 meters, etc.

The heat created by short-wave fields is, in its *statu nascendi*, different from ordinary heat. In any of the usual heating processes the heat penetrates from the outside to the inside of the heated object. Dependent upon the thermic conductivity of the treated object the advancing of the heating process towards the inside of the body declines along an exponential curve. With the condenser method, however, the reaction is different. Here, at the same time, in each molecule of the treated object the same increase of temperature is created by the high-frequency field if the field intensity remains constant. The temperature increase, therefore, is the result of a power center molecularly directed.

A solution of albumen coagulates under ordinary conditions at about 75 degrees centigrade. In the condenser field, however, the effect of coagulation already takes place at a temperature as low as 60 degrees centigrade. These temperatures have been measured with a thermocouple immersed in the solution. Furthermore, many bacteria grow best just at the normal body temperature. Raising of this temperature, as by fever, kills those bacteria. A bacteria culture, however, placed between the condenser plates of this ultra-short-wave field is killed at ordinary body temperatures.

The facts mentioned above show just a few possibilities for the application of high-frequency currents to biology, medicine and other departments of applied science heretofore not in direct contact with the radio field. It is possible to perform, without any direct contact with the condenser electrodes, reactions of various kinds in an entirely new way.

According to the new method the condenser electrodes are designed to build only small points. These electrodes are brought as near as possible to the part of the body which is to be treated internally. The electrodes are placed in insulating material so as to avoid any direct passage of the current as such.

In the Figures 9 and 11 typical forms of the effect of the application of short waves by condenser method are illustrated on living animals. A frog and a chicken are shown which have been both subjected to short waves. Parts of the spinal cord of the frog and the brain of the chicken have been placed within the condenser field.

With the frog, the electrodes were applied to the side of the head and the spine. The transmitter was working on 3.8 meters wavelength and had an output energy of 40 watts. The current intensity in the operating circuit was about 4 amperes.

A thin pencil of high-frequency radiation was sent through the tissue with the aid of two small condenser electrodes. In the path of such ray, a part of the spinal cord of the frog was laying. Due to its chemical and physiological characteristics, the heat effect of the radio waves upon the spinal cord is an extensive one. The ray of heat influenced the spinal cord in such a way that after an exposure for about 10 minutes the *entire left part of the frog was paralyzed!*

This partial paralyzation of the frog is shown by the effect that one of his legs remained stretched out constantly and does not move upon stimulation. The entire right side of the frog was undamaged.

In addition to the effect of the applied condenser electrodes the frog was stimulated by a periodical discharge of faradic current applied to him separately with the aid of two more electrodes. These periodically altered currents were produced with an oscillating neon lamp. At the one leg of the frog a writing lever was attached which acted upon a Kymograph (a glazed white paper which is covered with lamp-black. This paper was placed on a cylinder turn-

(*Continued on page* 797)

Radio's Powerful Electric Voice

(Continued from page 759)

the surrounding air and it must convert perfectly into this sound the electric oscillations delivered by the amplifier.

Considered as a converter of energy, every loudspeaker is really two converters in one. First, it must convert the electric oscillations into mechanical ones, which is the duty of the voice coil and field in a modern dynamic loudspeaker or of the magnetic drive in the electromagnetic type. Second, some other device must convert the mechanical vibrations thus generated into sound waves in the air. Two alternative devices now are prominent for this: a large diaphragm, usually conical, which drives the air directly, or a small diaphragm, usually metallic, at the small end of an air-filled horn.

This last difference corresponds to the types commonly called cone loudspeakers and horn loudspeakers, respectively. Either kind can be fitted with either electromagnetic driving units or electrodynamic ones, so that there really are four chief types of loudspeaker which are or have been of prime importance: the electromagnetic cones, the electromagnetic horns, the electrodynamic cones and the electrodynamic horns. The last two, with their names often shortened to "dynamic," seem now to be most in favor, with the cone type most popular for homes and other small units, while the horn type is favored for theatres and other installations on a large scale.

Several other types of drive besides the electromagnetic and electrodynamic have been tried or suggested, and other types of sound radiator in addition to horn and cone are possible. Some of these other possibilities, such as the electrostatic loudspeakers or the piezo-electric ones, are by no means unpromising. A few years ago electromagnetic loudspeakers were the rule. Now they are virtually ousted by the electrodynamic ones. Perhaps the latter are destined to be superseded, in their turn, by something else.

The driving unit of the already old-fashioned electromagnetic loudspeaker was merely a variant on Bell's original telephones. An iron disk, bar or other magnetic object to serve as an armature was placed in the magnetic field of a permanent magnet or an electromagnet, usually the former. The oscillating currents corresponding to the sounds then were impressed on this magnetic field in some way so that they varied it. The simplest way is that used in standard telephone receivers, where these currents circulate in small coils surrounding the magnetic pole pieces. When the magnetic induction of the current opposes the field of the magnet the total magnetic force acting on the diaphragm or other armature is lessened. When the current reinforces this magnet the total magnetic force is increased. Thus the diaphragm of a telephone receiver is set into back-and-forth vibration. Vibrations from these types of armature can be communicated, by levers or otherwise, to a sound-radiating diaphragm or cone.

It is possible, too, to let the currents carrying the sound signals circulate around the moving armature instead of around the fixed magnet, thus weakening or strengthening the magnetic response of the armature instead of the magnetism of the field, but causing the final mechanical vibrations in a substantially similar way. The essential of the magnetic loudspeaker, however it may be applied, is the interaction between varying currents corresponding to the sounds and otherwise unvarying mechanical forces between two or more magnetic poles.

The essential principle of the electrodynamic loudspeakers, now so much more popular, is not very different. Instead of magnets of iron or similar materials, the thing which provides the fixed force against which the sound currents are to act is an electromagnetic field, generated, for example, by a direct current circulating in a coil of wire. In this unchanging electromagnetic field there is placed a small light coil of wire which is free to vibrate. Through this, often called the "voice coil," the currents that carry the sound message are made to circulate. When they pass in one direction the voice coil is displaced backward, let us assume, with reference to the electromagnetic field and the mounting of the loudspeaker. When the current moves in the reverse direction the voice coil is displaced forward. The result is that the voice coil is set into vibration in more or less exact correspondence with the oscillations of current flowing through it. This vibration then may be communicated directly or by levers to any kind of vibrating sound emitter—a horn diaphragm, for example, or a directly radiating cone.

There is no apparent limit to the volume of sound that can be produced by either of these methods, if the vibrating coils, magnets and so on be made large enough, if enough power be used to drive them and if the radiating surfaces, whether one or many, be large enough to emit the sound into the air. The German loudspeaker already mentioned, which apparently holds at present the world's record for loudness, is reported to operate on this electrodynamic principle, the moving coil being fastened to a large, stiff diaphragm of special light-weight metal. One of the best loudspeakers ever produced, both in quality and loudness, that devised several years ago by Dr. C. W. Hewlett of the General Electric Company, uses a single large voice-coil, itself built as a diaphragm between two coils which provide the electromagnetic field, but unfortunately requiring a very large field current for its operation.

Frequency Range

The chief practical difficulties of small loudspeakers, whether of electromagnetic or electrodynamic type, always has been that of covering a wide enough range of frequencies. Mr. Leopold Stokowski, the distinguished director of the Philadelphia Orchestra, has reported tests showing that frequencies up to 8000 cycles a second are necessary for adequate reproduction of the music of violins or trumpets, and frequencies to 13,000 cycles for certain other instruments, including the oboe, the snare drums and the piano. At the lower end, the deepest organ notes require good reproduction down to 60 cycles and preferably to 30. To encompass this wide range with any single loudspeaker always has been difficult. Failure to do so even reasonably well probably is the reason for the decline of the electromagnetic principle in favor of the electrodynamic one.

Next to the difficulties about frequency range, loudspeakers of all types have been most seriously handicapped by the other kind of frequency trouble called distortion. The trouble is that loudspeakers, unfortunately, cannot be built of empty air, but must be made of wood or metal or other solid substances.

Anyone can experiment on this for himself. Take a small Swiss music box out of its wooden case or provide any other thing that produces more or less regular sound vibrations—even a detached loudspeaker unit operated by a radio receiver or a phonograph but without its cone or diaphragm. Touch this music box or vibrating loudspeaker unit to a number of different articles, such as a

(Continued on page 798)

Radio Surgery

(*Continued from page 795*)

ing with constant speed). Upon this Kymograph the jerking of the frog leg was recorded, together with the time during which the oscillator worked and the time which elapsed during the experiment.

The line a in Figure 10 is the line of time. The line b gives information about the starting and stopping of the high-frequency oscillator. (The thick, wide line gives the time during which the short-wave oscillator works.) During the entire experiment an intermittent stimulation with the faradic current was continued. Curve c is the record of the characteristic motion of the frog leg.

Going from the right to the left, we find that the stimulation of the stimulated frog leg is pretty large as long as the short-wave apparatus is not put into action. Then the white line starts, a sign that the generator has been switched on. The jerking becomes less and less and finally stops entirely. A part of the body is temporarily paralyzed.

The white line stops, showing that the oscillator has been switched off. During the whole time the stimulating current runs continuously, and soon the paralyzation ceases. The motion starts again, however, with an intensity which is only half of that as it had been at the beginning of the experiment. The short-wave apparatus is put into action and for the second time a paralyzation of one-half of the body takes place. After a certain time elapses, with opened short-wave current, smaller motions start once more. After the third application, they cease entirely, although the stimulating current is still running, the periodic paralyzation has been turned into a chronic one.

A similar electric operation of the nervous and brain centers was performed on the chicken shown in Figure 11. With this animal the paralyzation of the brain is shown by a typical chronic deficiency of certain reactions. The chicken squatted down for weeks and weeks in a twisted position until it was killed for the purpose of an anatomical investigation. It had no desire to eat or drink and remained in the one place in the characteristic position shown. This behavior of the chicken is characteristic for a brainless animal. It is, however, essential that the operation was performed without any loss of blood and that no exterior parts of the head had been damaged.

By the intelligent co-operation of medically trained physicists and surgeons with some understanding of physics it will be possible to attack the problem of incurable diseases from an entirely new angle in a serious and scientific way, provided that the necessary funds can be raised.

Physics in the science of medicine, and especially now the application of the science and art of ultra-short-wave technics, have added a new hope to medicine. These electric waves offer, as proven by early animal experiments, unusual advantages for medicine, and especially for surgery. By the development and improvement of the methods and technical appliances they may, perhaps, in the near future, together with other physical, medical and chemical developments, with radium, light and X-ray technics, provide a valuable new factor for the fight against the scourge of all humanity: the incurable diseases.

Radio-Equipped Ambulance

WASHINGTON, D. C.—Radio-equipped ambulance, designed to operate with the police station to minimize delay in receiving news of accidents, has been placed in service by Casualty Hospital here.

Radio's Powerful Electric Voice

(Continued from page 796)

derby hat, an empty cigar box or a brass cymbal like those used in orchestras. Very different sounds will be emitted by the hat, the cigar box and the cymbal, even if the sounds put into them are the same. The tones from the hat will sound thick and muffled, those from the cymbal will be shrill and tinny, only those from the cigar box will sound reasonably natural.

Resonant Frequencies

These differences are due, of course, to the fact that the hat, the cymbal and the cigar box all have their own natural frequencies of vibration which are set up by the sound waves fed into these articles, just as the natural frequencies of a bell are set up by striking it. Whatever material be used for the cone or diaphragm of a loudspeaker and however this material is shaped, damped or otherwise controlled, there are likely to persist in it some of these tendencies to natural vibration. It is these which are chiefly responsible for the so-called resonance peaks of most loudspeakers at certain frequencies, indicating a tendency of each particular instrument to exaggerate certain ones among a series of mixed tones being fed into it and to depress others so that the whole tone series is distorted.

Not all of the "saw-tooth" appearance of the average loudspeaker curve at different frequencies is due, however, to real resonance peaks. Many of these apparently serious faults exist only in the method of measurement, not in the loudspeaker. They are results of interaction between the vibrations of the loudspeaker and the echoing sound waves set up in the test room, as may be proved easily by testing the same speaker in another test room or even by moving its position in the same room, by swinging it on a pendulum or moving it on a rotating table. Neither complete removal of these acoustic difficulties in loudspeaker testing nor complete correction for the errors introduced is easy, but it may be asserted confidently that many loudspeakers are a great deal better in reality than they get credit for being in the conventional tests.

Two loudspeaker accessories designed to help prevent distortion and to extend the response at the lower frequencies are the "baffle" on cone speakers and the widely flaring, "exponential" horn now usual in loudspeakers of that type. The acoustic theory of exponential horns is well known; they provide the easiest way to load the moving diaphragm uniformly at all frequencies with a mass of air which the diaphragm can drive like a flaring piston and convert into a sound-radiating area as large as the mouth of the horn.

The Sound Baffle

The flat plate or baffle still frequently used on cone loudspeakers is of much less certain utility. The theory is that the baffle "supports" the sound wave for a half wavelength or more as this wave leaves the cone. Since sound travels in air under ordinary circumstances something more than 1000 feet a second, one wavelength of a 64-cycle organ tone is about 16 feet, which would suggest a baffle of at least that diameter, to be efficient. In fact, little benefit is gained by baffles more than three or four feet in diameter. It is probable that conventioned baffle theory, like much else in conventional acoustics, is woefully incomplete and that the real benefits of baffles are due to keeping the emitted sound wave from reacting with the sound waves coming from the backs of open cone loudspeakers and perhaps to some additional smoothing effects, as yet unanalyzed, on the interaction between the loudspeaker and the room in which it is working.

However this may be, carefully designed and constructed loudspeakers of the electrodynamic type, if not of other types, can be made to reproduce very low tones or very high ones and to do so with little distortion. What has not been possible hitherto is to devise a single loudspeaker to cover, adequately, the whole frequency range desired by the musicians, from 30 to 13,000 cycles per second. This is the reason for the expedient, now frequently employed, of two separate loudspeakers mounted together, one for the high frequencies, the other for the low ones.

Often the loudspeaker for the lower frequencies is an open cone with the electrodynamic drive and radiating directly into the air. The one for the higher frequencies may be a small metallic diaphragm driving a narrow exponential horn. Many other combinations of horns, cones or other radiators are possible and are about equally successful. Electric filters usually are provided to select the higher frequencies exclusively for one loudspeaker and the lower frequencies for the other one. Other electric filters may be used to smooth out any lack of an exact "match" between the two loudspeakers in the range of intermediate frequencies where both are operating.

With adequate design of the two loudspeakers and their associated circuits, this two-speaker device probably is the present high point of the loudspeaker art. Only perfectionists, perhaps, would demand more, but it is the good fortune of radio that perfectionists never have been lacking among its devotees. That is one reason why radio has advanced so fast.

Future Possibilities

Many possibilities have been urged as chances of additional improvement. One is what might be called the mechanical amplifier, in which the electric movement of the loudspeaker produces only a small amount of mechanical energy which then controls much larger mechanical forces much as the relatively feeble hand of the engineer uses the throttle to control the vast power of a locomotive. One device of this type is the frictional loudspeaker; another is the air-valve one.

In the frictional instrument tiny variations of electrostatic attraction corresponding to voltage variations from the amplifier are used to increase or decrease the friction between a rotating cylinder, usually of some smooth and uniform variety of stone, and a metal band which encircles it and inside which it turns. Thus the frictional drag between cylinder and metal band increases or decreases in correspondence with the voice currents. The back-and-forth vibrations of the metal band thus produced are much more powerful than the original electrostatic impulses, the extra energy being part of the power used to rotate the cylinder. Loudspeakers have been built on this principle, but operating difficulties in the precise adjustment of the stone cylinder and the metal band seem to have proved almost insuperable.

The air-valve loudspeakers, exemplified in the Hoovenaire device, also are mechanical amplifiers which use an electromagnetic or electrodynamic drive to work a small vibrating valve which turns on or off a stream of compressed air, much as the vibrating light valve of a talking-motion picture camera turns on or off the light beam in correspondence with the oscillations from the amplifier. The successive jets or pulses of escaping air set up sound waves from the horn of the loudspeaker in almost exactly the same way that a cornet player produces a tone by making a series of separate air puffs through his lips. Loudspeakers of this type have proved capable of great volume with comparatively small use of electric power, but the frequency ranges obtained have not been entirely satisfactory.

At the last meeting of the Acoustical Society of America, in Cleveland, Mr. C. B. Sawyer of the Brush Laboratories of that city demonstrated a new loudspeaker based on the piezo-electric effect, the property of some kinds of crystals, notably those of Rochelle salt, to shrink or swell in one or more directions when the crystal is subjected to electric forces. It is this same piezo-electric property of quartz crystals which is now used to keep constant the frequencies of broadcast transmitters. In the piezo-electric loudspeaker crystals of Rochelle salt twist under electric forces so that mechanical vibrations, corresponding to the electric oscillations, are produced and passed on to a vibrating diaphragm or cone. The device is still relatively undeveloped and has at least one serious defect, which is that the piezo-electric force varies considerably with temperature.

Still another suggestion for loudspeaker drives is magnetostriction, which is the slight contraction and expansion of iron when magnetized or demagnetized. An iron bar, for example, may be surrounded by a wire coil carrying the varying current from the amplifier. The iron bar then will be set into corresponding mechanical oscillations of small extent but relatively enormous force. Connecting such a magnetostriction bar to a vibrating cone or diaphragm produces a loudspeaker, but these devices, also, are still too little developed and tested for sure conclusions about them.

Electrostatic Principles

Of the many relatively unused principles possible for loudspeaker operation, the one which seems most promising is that of electrostatic attraction exerted directly on the vibrating element, which might be, for example, the whole side of a room.

Experts in acoustics are demanding more and more insistently from the loudspeaker art the device already mentioned which will distribute sound evenly in an auditorium or other large room, instead of emitting all of it from a relatively few extremely loud sources like the conventional theatrical loudspeakers. To accomplish this by using many small loudspeakers of present types distributed widely over the room is perhaps not impossible but has serious operating difficulties in keeping the whole group of loudspeakers in exact balance and in maintaining exact phase relations and non-interference in the distributed sound. A better solution would be to make large areas of walls or ceiling into one plate of an electric condenser and to make these wall areas vibrate by varying the electrostatic attraction between them and the other condenser plate, another surface a few millimeters underneath.

Small electrostatic loudspeakers of this type have been built by many experimenters but usually with only moderate success. Two difficulties appear to be most serious. One is the rapidity with which the electrostatic attraction decreases as the vibrating plate moves away from the fixed one, as move it must if much sound is to be radiated. This trouble is said to have been eliminated, in part, by recent German designs in which the vibrating plate is between two oppositely charged grids so that the deficiency in driving force as the plate leaves one grid is compensated by other forces as it approaches the other one.

The other chief obstacle of the electrostatic principle seems to be difficulty of keeping the electric forces and the distance between the

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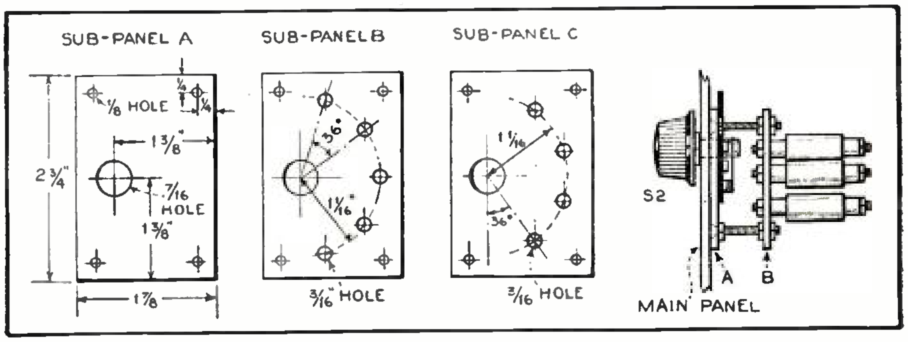
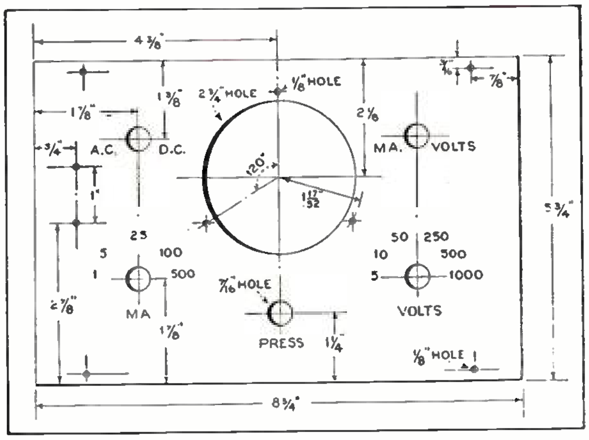
A Real Universal Meter

(*Continued from page 769*)

specifications for drilling and engraving are shown in Figure 2. The next problem is: where can the resistors be mounted? It is both unsightly and wasteful of space to have mounting screws visible on the panel. The method evolved for mounting the voltmeter and milliammeter resistors is shown in detail in Figure 4 and avoids these complications nicely. It will be noted that the five voltmeter resistors are mounted on the





PANEL SPECIFICATIONS AND ASSEMBLY DETAIL

Figure 2, left, shows the complete drilling layout for the panel. Figure 3 gives the specifications for the sub-panels used in mounting the resistors and Figure 4, above, shows the details of one of the resistor assemblies

subpanel B (see Figure 3). This subpanel is mounted on a second subpanel A, and the latter is supported by clamping it between the switch S2 and the main panel. The milliammeter resistors are mounted in the same manner under switch S1. This method has the added advantage that the resistor terminals are immediately adjacent to the switch terminals. It will be found convenient to solder the connecting wires from the switches and upper resistor terminals before these assemblies are mounted on the main panel, all leads to other circuits being brought down through the large holes in subpanels B and C.

Two of the three remaining resistors, R2 and R3, are supported by the wiring, while R1, which is furnished with the meter, is mounted directly on the rear of the meter. The fuse block may be conveniently and rigidly mounted on one of the screws supporting subpanel B.

The reader is warned not to press the key unless he is sure that the switches are set right. This is especially important when measuring voltages or currents of large values.

Parts List

M—Weston a.c.-d.c. Universal type 301 meter
R1—Furnished with the meter
R12—500,000-ohm Shallcross "Super Akra-Ohm" resistor
R11—250,000-ohm Shallcross "Super Akra-Ohm" resistor
R10—200,000-ohm Shallcross "Super Akra-Ohm" resistor
R3—100,000-ohm Shallcross "Super Akra-Ohm" resistor
R9—40,000-ohm Shallcross "Super Akra-Ohm" resistor

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Radio's Electric Voice

(*Continued from page 799*)

plates uniform enough so that the moving plate vibrates as a whole instead of vibrating in sections like a bell and thus creating distortion. There have been troubles, too, in persuading electrostatic loudspeakers to yield enough sound energy for large rooms and in finding suitable materials for the fixed and vibrating plates, but none of these difficulties, not even the chief ones of variable force and sectional vibration, seem to be theoretically insuperable.

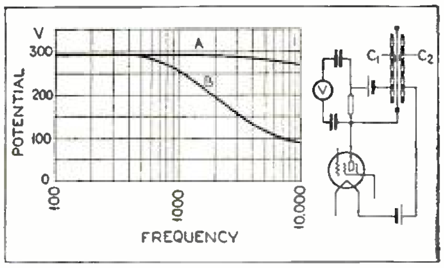
Loudspeakers, if two are used, now cover a satisfactory frequency range, at least until microphones and phonograph recorders catch up with them. Properly used, they are capable of any range of sound volumes desired, from a whisper in the drawing room to the full volume of a band or a voice amplified to be heard twenty-five miles away. Distortion by loudspeakers is largely conquered—so far, at least, as this is possible without considering the acoustic interaction with the room in which the loudspeaker is to be heard.

Progress is still possible in simplicity and cheapness without sacrificing quality, and perhaps this is the kind of loudspeaker research most likely to be profitable to the individual inventor, but the great need of the art is for a better way to distribute sound evenly in large halls, without bursting the ear-drums of auditors in front seats so that those in rear ones can hear at all. This, it may be, is where the electrostatic loudspeakers can find their best utility.

Static Loudspeakers

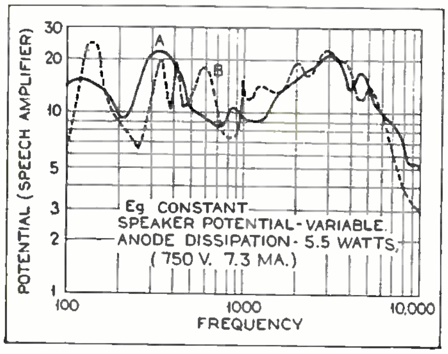
(Continued from page 766)

To summarize, it may be stated that technically usable loudspeaker systems can be produced with the employment of the electrostatic field, which are equivalent to the older magnetic systems, based on the variations of the magnetic field, but are considered superior in regard to quality of reproduction.



OUTPUT CIRCUIT CURVES

Figure 6. A shows output voltage without loudspeaker and B shows curve of output voltage when capacity load of loudspeaker is impressed



SOUND PRESSURE CURVES

Figure 7. Curve A was measured by the Gruetzmacher and Meyer method and curve B was measured directly in front of the loudspeaker which was hooked up in an output circuit as shown in Figure 15

A Universal Meter

(Continued from page 800)

R2, R8—5,000-ohm Shallcross "Super Akra-Ohm" resistor
R7—1,000-ohm Shallcross "Super Akra-Ohm" resistor
R6—200-ohm Shallcross "Super Akra-Ohm" resistor
R5—50-ohm Shallcross "Super Akra-Ohm" resistor
R4—10-ohm Shallcross "Super Akra-Ohm" resistor
S3, S4—Yaxley three-pole double-throw jack switches, type 763
S5—Yaxley single-pole double-throw push-button switch (safety key) type 2003
T1, T2—International Air Research combination plug-jacks binding posts, one red, one black
F—Littlefuse 1-ampere fuse with mounting
General Fabricating Company's drilled and engraved panel (see Figure 2)
General Fabricating Company's subpanels (see Figure 3)
Art Jewelry Case Corporation box, 5 inches by 8 inches by 3 inches deep, inside dimensions, 3/8-inch material

What Is the Triple-Twin Tube?

(*Continued from page 761*)

the grid current. In other words, this increase by the change in the characteristic is just equal to the current the grid draws and the current through the load R2 remains the same: a sinusoidal wave.

Of course, the compensation will not be exactly equal to the grid current unless the tube is carefully designed to do just that. Also, the load L2 varies during this half cycle; the more grid current, the lower the load, and we really would have to draw a whole family of curves.

The Phase Relation

So far we have only spoken about the compensation for grid current during a part of the cycle and did not consider whether the compensation came at the right part of the cycle. In order for it to do so, the plate current will have to be in phase with the voltage on the grid of the next tube. It is, in this particular circuit, but not in any of the other conventional circuits. If such a compensation was attempted with a standard hook-up, it would come at the negative half of the cycle and would make matters worse instead of better.

In Figure 3 is shown a standard resistance-coupled circuit. We all know that when during the positive half of the cycle the control grid of VT1 becomes less negative, the plate current will increase, and during the negative half it will decrease. The plate current is then in phase with the incoming signal on the grid.

Operating Characteristics

When the plate current increases, the voltage drop across the resistance R increases and the remaining part of the B-voltage is what is left for the tube, so the plate voltage drops when the plate current increases and it increases during the negative half of the cycle. The plate voltage, from cathode to plate, is opposite in phase to the grid voltage and the incoming signal. The voltage across the load R1 is in phase with the signal, but we do not usually connect that to the grid circuit of the tube. The latter circuit is generally coupled to the plate and cathode. The condenser in the resistance-coupled amplifier brings an additional phase difference. But it should be seen that, whatever type of coupling is used, the voltage on the grids of the two tubes will be out of phase and no compensating could be accomplished with the above described method.

Compensating Current

Now let us look at Figure 1. Here the voltage across the load R2 is in phase with the signal applied on the grid of the first tube. This signal is directly connected across the grid and the heater of the second tube, and therefore the voltages on the first and second grid are in phase. This shows that the increase in plate current, due to a change in the load, will come at the right time to compensate for the grid current.

It was found that R3 was necessary to eliminate hum. This one tube, with the circuit shown in Figure 1, is all that is needed for a phonograph pick-up. The output in the plate of the tube will be as much as the dynamic speaker can handle, if not too much.

The Detector Circuit

According to data supplied to us by the Cable Tube Company, the triple-twin tube will deliver 4½ watts to the speaker when used as a C-bias detector. To obtain this output the carrier has to be 10 volts.

In Figure 4 is shown the hook-up for the detector circuit. The difference between this and the amplifier circuit is mainly in the values of the components. The condenser C1 has now become .0005 mfd., which is a low impedance for the radio-frequency component. The signal across the load—that is, the audio component—which is applied to the second section of the tube, finds this condenser a high-impedance path. Therefore, the grid return can be connected to ground without short-circuiting the load.

In this case the resistor R4 is larger, so as to get the proper bias on the input section. The bias on the output section remains the same as in the amplifier.

In this case the grid will go positive again and there will be just the right amount of compensation, as described above, because of the shifting of the characteristic as soon as the grid draws current.

Other Applications

One of the great problems in television is to design an audio amplifier with a nearly straight-frequency characteristic. At present the audio-frequency band seems to go up to 50 kc. only, but soon this is expected to be increased. The frequency characteristic is substantially straight from 30 to 50,000 cycles. This should be a great help for designers of television receivers.

Photo-Cell Amplifiers

The plate circuit of the 295 tube draws 50 ma. The variation in plate current for a given change in grid voltage is larger than that of most tubes generally used for photo-electric cell amplifiers.

It seems to the writer that the triple-twin tube increases the possibilities of industrial applications of the photo-electric cell. With the greater amplification possible, relays do not have to be so delicate and can be made to control the power circuit directly.

In the sound-film industry, also, this new amplifier should find wide application. It would greatly simplify the construction of the amplifier in the projection booth, with less chance of breakdown, not to speak of the reduction in cost.

Engineering Data

By courtesy of the Cable engineers, we give below some of the characteristics which were obtained by experiments in their laboratory:

Filament voltage	2.5 volts a.c.	
Filament current	4 amperes	
Plate voltage, first section	250 volts	
Plate voltage, output section	250 volts	
Mutual conductance, first section	1150	approximately
Mutual conductance, output section	3700	approximately
Plate current	50 ma.	
Grid bias input	6 volts	
Plate impedance	4000 ohms	
Recommended load impedance	4000 ohms	
Maximum undistorted output	4.5 watts	

The minimum harmonic distortion is 5% at 4000 ohms. It is 8% at 2000 ohms and at 9800 ohms. This is the second and third harmonic combined. Note that the minimum distortion is at 4000 ohms, which is the impedance needed for maximum power output. There is no need for designing special transformers, as with the pentode. A standard output transformer designed for -45 type tubes or for -50 type tubes will do. It must be able, however, to stand the 50 ma. plate current.

In the diagram of Figure 1, R1 = .1 megohm, R2 = 12,500 ohms, R3 = 70 ohms, R4 = 210 ohms, approximately.

Graphs and Charts in Radio Practice

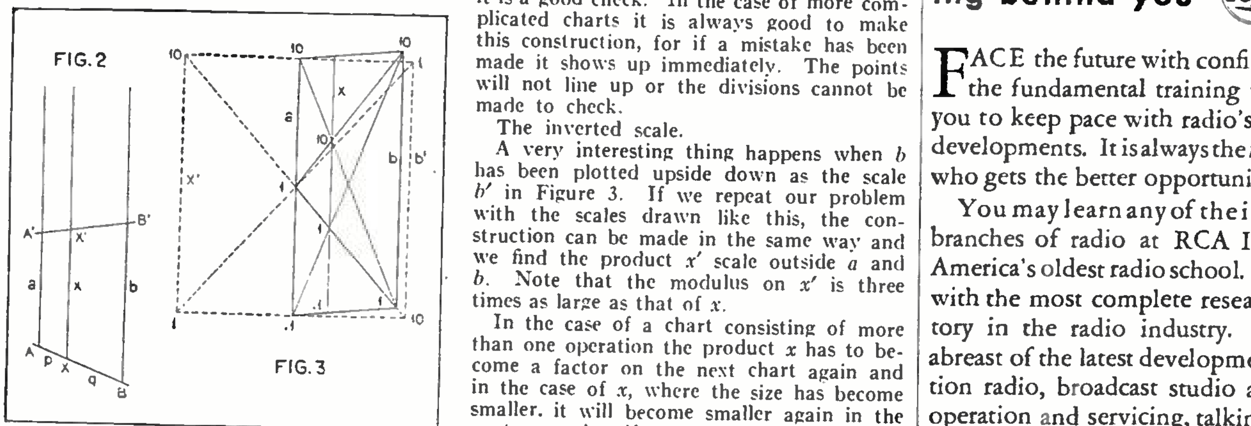
(*Continued from page 772*)

vary over a greater range than the others. This can be taken care of by regulating the distances between the scales as well as the size of the units.

We derived the formula for the chart with the scales placed at different distances. We shall now give it again, but in a more general way, taking into account also the size of the units.

In most textbooks on this subject one introduces the concept "modulus." To simplify the discussion and to make the reader familiar with the notation in standard textbooks it will be used in this article hereafter.

The modulus is the number of inches which constitute the length of one unit on the scale we are talking about. For instance, if we use a logarithmic scale of 1 cycle to the sheet (10 inches), the modulus is 10; and when we use another scale with 2 cycles in the same space, the modulus is 10/2 or 5.



THEORY OF ALIGNMENT CHART

Figure 2. Simple chart with scales at different distances. Figure 3. Construction of the third scale by the automatic method

In Figure 2 are shown three logarithmic scales, *a*, *x* and *b*. The moduli of these scales are respectively, M_a, M_x and M_b. If we draw any straight line intersecting these three scales there exists the relation

$$XX' = \frac{p(BB') + q(AA')}{p+q} \quad (4)$$

which was proven last month.

Substituting for AA′, XX′ and BB′ their respective values, $AA' = M_a$. log a, $XX' = M_x$, log x, $BB' = M_b$ log b, we obtain:

$$M_x \log x = \frac{M_a q}{p+q} \log a + \frac{M_b p}{p+q} \log b$$

or

$$\log x = \frac{\frac{M_a}{M_x} q}{p+q} \log a + \frac{\frac{M_b}{M_x} p}{p+q} \log b$$

removing logarithms.

$$X = \sqrt[p+q]{a^{qM_a/M_x}\, b^{pM_b/M_x}} \quad (5)$$

The product of two factors, raised to different powers, can be obtained by leaving the distances equal and properly choosing the moduli, or by leaving the moduli equal and choosing the right distances. It can also be obtained by making both distances and moduli different, and in each instance there will be one combination which is best.

The Automatic Method

For those who think this formula becomes too complicated it may be comforting to know that there is a graphical way out. For instance, in Figure 3 the scales *a* and *b* have been drawn, *a* with a modulus which is half that of *b*. Suppose we wish to construct a chart for the finding of the product *ab*. At which distance should the scale *x* be and what is the modulus?

Connect 1 on scale *a* with 10 on scale *b*, the product is 10; therefore this line should intersect the *x* scale at 10. Draw another line from 1 on scale *b* to 10 on scale *a*. This line should also go through the point 10 on *x*. Therefore the intersection gives us one point of *x* and a calibration point. When this process is repeated with the product 100 as in Figure 3, another point is found and another calibration point. This is all the information necessary to draw and calibrate *x*.

When the relations are simple, the geometric method should not be necessary, but it is a good check. In the case of more complicated charts it is always good to make this construction, for if a mistake has been made it shows up immediately. The points will not line up or the divisions cannot be made to check.

The inverted scale.

A very interesting thing happens when *b* has been plotted upside down as the scale *b′* in Figure 3. If we repeat our problem with the scales drawn like this, the construction can be made in the same way and we find the product *x′* scale outside *a* and *b*. Note that the modulus on *x′* is three times as large as that of *x*.

In the case of a chart consisting of more than one operation the product *x* has to become a factor on the next chart again and in the case of *x*, where the size has become smaller, it will become smaller again in the next operation if we use the same type of chart. This constant diminishing in size can be prevented by plotting one of the factors upside down, which gives us the product on full scale.

The principle can be easily understood algebraically also when we consider the chart consisting of scales *a*, *b′* and *x′*. We can consider that on *b′* is plotted the value of *1/b*. Then, since *a* is midway between *b′* and *x′*, any straight line cuts off values so that $a = x'/b$ or $x' = ab$.

In the previous examples we have only spoken of multiplications, but it should be easy to understand that the same charts can be used for division also.

These principles have been applied in the chart in Figure 1, which consists of one division and three multiplications. Some of the scales are used in two operations and it was a problem to fit them so that they would be suitable for both cases.

Operation 1: $x = (2a)^3/L$. Here the division was performed by plotting L upside down. The raising of 2*a* to the third power was accomplished by using a modulus for the diameter three times as large as the one for the inductance.

Operation 2: $F = xm^2$ or $x = F/m^2$. The moduli of F and *m* are equal, but the distance of F from *x* is twice as far as that of *m* to *x*.

Since F represents a complicated form, the calibration on this scale has been made directly in terms of the form factor *f*. The readings on both *f* and *m* scales should be made on the side marked A, for these same scales are used again and then we need another set of divisions B.

Operations 3 and 4 are both straight multiplications, such as shown in the dotted lines of Figure 3. The distances are equal in both cases.

Radio Physics Course

(Continued from page 787)

triple the voltage applied to this same filament so as to triple the current flowing through it, then the heat produced is 3 × 3 or nine times as much (varies as the square of the current). This of course would raise the temperature above the melting point of the filament wire, and it would melt.

The electrical power can be measured by measuring the current with an ammeter and the voltage with a voltmeter. The amperes and volts are then multiplied together to obtain the watts. The wattmeter is an electrical instrument for measuring the watts directly.

Relation of E.M.F., Resistance and Current

In every branch of electrical and radio work it is very important to have a clear understanding of the relation between e.m.f., resistance and current. The student must learn to look at any electric circuit as a combination of three factors. First, we have the e.m.f. which is able to cause a flow of current (electrons) if a conducting path is provided. Second, we have the conducting path, which offers a certain amount of resistance or opposition to the flow of current (electrons) depending entirely upon its material, length, cross-section area, and temperature. Third, we have the resulting flow of current, whose value depends upon the applied voltage and the resistance of the conducting path. Note that the resistance of the path really is independent of the voltage and the current. The resistance really depends upon the *physical* characteristics of the conducting circuit, *i.e.*, the material, the length, the area and the temperature. The current is the result of the application of the e.m.f. to the conducting circuit. The current depends upon the applied e.m.f. and the resistance. The e.m.f. depends on the amount of e.m.f. which is provided by the e.m.f. generating or producing device (battery, dynamo, etc.) applied to the current.

It has been stated several times that the resistance of any conductor depends upon its length, cross-section area, material and temperature. We will now study these factors in detail.

Length and Resistance

Just as a long pipe offers a greater resistance to the flow of water than a short one, so a long electrical conductor has a greater resistance than a short one. The resistance is *proportional* to the length. Thus a wire 50 feet long has five times the resistance of a similar wire ten feet long. This becomes evident when we realize that every 10-foot section of the 50-foot wire offers the same opposition (resistance) to the flow of electrons through it as the original 10-foot piece of wire does. Therefore the total resistance of the 50-foot piece is 5 times as much. This is shown in A of Figure 2. We may then state the rule:

The resistance of a conductor is directly proportional to its length.

Area and Resistance

Just as the internal diameter or cross-section area of a water pipe determines how much water can flow through it, so the cross-sectional area of a conductor determines its resistance to the flow of current (see B of Figure 2). The larger the diameter or cross-section area, the less will be its resistance. *Thus, the resistance of a conductor is inversely proportional to its cross-sectional area.* The areas of two similar circular conductors are proportional to the squares of their diameters. Hence the resistances of two wires of similar material and length are inversely proportional to their diameters squared. The larger the cross-section area of the wire, the more electrons there are available to flow past any point every second under the influence of a given applied e.m.f. Therefore the resistance to the electron flow must be less.

Wire Gauges

The standards by which the various sizes of wire are designated are called *wire gauges*. Unfortunately, several standards of wire gauges differing from each other have been adopted by various manufacturers and are in use.

In each gauge a particular number refers to a wire having a certain diameter, the gauge number *increasing* as the size of the wire *decreases*. The law by which this decrease occurs is not the same in the different gauges. In the United States, copper wire is usually designated by the Brown and Sharpe (sometimes called American) wire gauge. This is generally termed B. & S. G. or A. W. G. In the B. & S. gauge, the ratio of the *areas* for two successive gauge numbers is 1.26. The diameter of a wire may be measured accurately with a micrometer.

Circular Measure

When calculating the resistance of round wires for electrical purposes it is convenient to use a *circular* measure to express the cross-section area of the wire, rather than the old method of measuring the area of circles in square inches. A *mil* is a unit of length used in measuring the diameter of wires, and is equal to $\frac{1}{1000}$ inch; that is, 1 mil equals .001 inch.

The circular mil area of a wire is equal to its diameter in mils squared. For instance, No. 18 wire is .040 inch in diameter; that is, it has a diameter of 40 mils. Its circular mil area is 40 × 40 = 1600 circular mils.

Material and Resistance

It must be evident from our study of the electron theory, that since all materials have a different electron arrangement, the ease with which the free electrons can be made to drift along through the material (flow of current) by the application of an e.m.f. must vary with the different materials. That is, different materials have different resistance. The resistance of a piece of the material of certain definite length and cross-section area is called its *specific resistance*. In practical work it is common to express the specific resistance of a material as the certain number of ohms of resistance which a piece of this material of definite size of one foot long and one circular mil in cross-sectional area (mil-foot) will have. This is necessary in order to compare the resistances of the different materials on the basis of equal lengths and cross-section areas.

The fact that copper has a low specific resistance (see table of specific resistances) and is rather cheap makes it used more than any metal in electrical work. Aluminum is also a good conductor, but its specific resistance is higher than that of copper. However, it is lighter in weight and where this factor must be considered, it is used. Part (C) of Figure 2 shows the relative resistances of similar wires of various materials.

The values of specific resistance (k) in ohms per circular mil-foot for several common conducting metals and special resistance alloys are listed below. Notice that silver has the lowest resistance, and copper has but

(Continued on page 805)

New Motor Radio Design

(*Continued from page 771*)

car that ignition noise is materially increased. The A battery leads must therefore always be connected directly to the battery and not through the wiring or chassis of the car.

Although on a majority of the cars manufactured the negative of the storage battery is grounded to the chassis of the car, there are a few cars which have the positive grounded. This can be determined by the markings on the grounded terminal of the battery. Since the A negative on the receiver is grounded to the steel case, it would make no difference if the chassis of the set were grounded to the chassis of cars having the negative side of the battery grounded to the car chassis. However, if the positive of the battery is grounded, the insulation on the clamp and also on the remote control becomes important. The felt pads under the receiver clamp and the leather strips under the remote control unit provide this insulation. It is only necessary to make sure that no metal parts of the car touch the receiver case.

The A battery leads should be firmly secured under the car battery connection screws and the wires removed as far from the battery top as possible, even though the cable is treated to withstand the sulphuric acid which it may pick up from the battery.

Plate Voltage Supply

When this receiver was designed it was made to be used with three or four of the regulation 45-volt B batteries. Since then a unit has been placed upon the market which operates directly from the six-volt car storage battery, drawing 1.6 amperes and delivering 180 volts. This unit converts the six volts from the car battery into an alternating current, steps it up through a transformer, rectifies it with a type -71a tube and filters it for use on the receiver. Its cost is not much more than four good B batteries and a battery box. It is highly recommended for use with any automobile receiver.

If this unit is used, it can be placed in the tool box underneath the driver's seat with two connections going directly to the storage battery and the B battery cable connected to it with the yellow wire going to positive (high voltage) and the green wire going to negative terminals of the eliminator.

If batteries are to be used, they can either be placed in a trunk in back of the car if one is available or housed in a battery box which can be placed under the floor board alongside of the storage battery. No C batteries are needed with the Marquette Motor Radio, since it is entirely self-biased.

Eliminating Ignition Noise

The suppression of ignition noises is generally accepted as the bugaboo of auto radio reception. The elimination of motor noise is a thing which can be accomplished as easily as balancing the different sections of the tuning condenser of the receiver—something which must be done before maximum results and satisfaction can be obtained.

Ignition noise produced in the speaker is defined into two classes: noise picked up through the r.f. end of the receiver which can be cleared up and noise produced through the audio end which shows faulty construction or design in the receiver proper. This latter type of noise interference is not obtained with the Marquette set. To determine if the noise is produced in the r.f. or audio end, turn the set on and start the motor. In the case of most receivers, the volume control adjusts some part of the r.f. circuit. By decreasing the control to its lowest point and noticing if the level of the noise is still the same, it can be ascertained if the noise is r.f. or audio. It is r.f. when it diminishes as the volume control is turned down.

By running the A battery leads directly to the car battery, a good deal of the noise is eliminated. Now the spark plug suppressors, distributor suppressor and by-pass condenser supplied with the receiver are installed. A suppressor is placed on each spark plug and the ignition connection made to the suppressor. The distributor suppressor is installed by removing the center connection on the distributor, inserting the suppressor and making connection to the top of it.

The by-pass condenser is screwed to some

Radio Physics Course

(*Continued from page 804*)

a slight bit more. The lower cost of copper favors its use for electrical conductors instead of silver. Notice that the specially manufactured high-resistance alloys such as "Climax," "Excello" and "Nichrome" have from 30 to 60 times as much resistance as copper wire. These are employed especially to purposely place resistance in a circuit. German silver is an alloy of copper, nickel and zinc. The percent stated in the table below indicates the percentage of nickel.

If the specific resistance (k) in ohms per mil-foot of a material is known, it is easy to calculate the resistance of a round wire of that material by multiplying the specific resistance (k) by the length (L) of the wire in feet and dividing by the area (C.M.) of the wire in circular mils. The formula is:

$$R = \frac{kL}{C.M.} \qquad (4)$$

Specific Resistance in Ohms per Circular Mil-Foot at 20° C.

Copper (annealed)	10.35
Copper (hard drawn)	10.60
"Advance" (alloy)	294.
Aluminum	17.
Brass	42.
Carbon (coke, lampblack)	22,000.
"Climax" (alloy)	480.
"Constantin" (alloy)	294.
Excello (alloy)	552.
German Silver (18%)	198.
German Silver (30%) (Constantin)	294.
Gold	14.6
Graphite	4,300.
Iron (pure, annealed)	61.
Iron (cast)	435.
Ia Ia, hard (alloy)	300.
Lead	132.35
Manganin	264.
Mercury	576.
Molybdenum (drawn)	34.
Monel metal (alloy)	252.
Nichrome (alloy)	600.
Nickel	47.
Platinum	60.
Silver	9.56
Steel (soft, carbon)	96.
Steel (cast)	115.
Steel (transformer)	66.
Tantalum	93.
Therlo (alloy)	282.
Tin	69.
Tungsten (drawn)	34.
Zinc	35.

firm part of the car chassis near the generator by use of the lug with which it is equipped. The connection from the condenser is made to the single terminal of the generator, which is connected to the positive of the storage battery.

What success one has had in eliminating noise through the installation of the above-mentioned suppression kit can then be determined by test. In most cases, it will be found that the noise remaining at this point is not objectionable, since it disappears behind an incoming signal. However, some extreme cases will require some more attention and any of the following things can be tried:

A condenser (same as used on the generator) can be connected to the low voltage side of the spark coil and its other side grounded to the chassis. Do not mistake the heavy wire which comes from the spark coil and goes to the distributor head as one of the low-voltage sides.

If the negative side of the car battery is grounded to the chassis of the car, some noise can be eliminated by grounding the receiver chassis to the steering post by use of a heavy wire placed under a screw on the case of the set and fastened to a grounded metal part of the car.

In extreme cases, the spark coil may be placed too near to the receiver, in which event this coil can be moved to another part of the car.

If, after trying all of the above things, one is still not able to eliminate objectionable noise, it would be advisable to have the contact points in the distributor looked over.

The Antenna

An antenna placed in the roof of the car is best for all-around performance, but such a system is not adaptable to every model or make of car. In a roadster or touring car, where the top is put down on favorable days, the roof type of antenna does not work out so well, since it performs very poorly with the top down and the antenna in close proximity to the metal of the car.

Some sedans and similar models have grounded wire mesh as part of the roof construction. This can be determined by connecting a bell or buzzer to the side of the battery, which is not grounded, and connecting the other side to a long needle which is used to pierce the fabric of the roof. It should be tried in quite a few places. If there is a ring during the piercing process, the roof does contain a wire meshing and therefore prohibits the use of a roof antenna.

The antenna being manufactured commercially which is made to be placed under the running board is the one which has no "buts" or "don'ts." It works on any kind of car. The r.f. pick-up of the two systems varies slightly, with a shade the better for the roof antenna.

The wire connecting the receiver to the roof antenna should be kept an inch or more from any metal of the car. Except in the case of the running-board antenna which uses the capacity principle between the antenna and the car chassis, the closeness of the antenna wire to the metal of the car will greatly decrease the volume given by the receiver.

Balancing the Receiver

The installation having been completed, the receiver is now ready for balancing. This is done by tuning in a station around 50 on the dial, preferably a weak one, so that with the volume control turned well up the signal will be weak enough that a slight change in intensity can be noticed. By use of a screw driver placed through the holes on one side of the receiver case, the balancing screw of each section of the three-gang condenser may be rotated for maximum signal.

Opening Door to Hard-of-Hearing

(*Continued from page* 764)

listeners. Since then advances in the communication art have contributed many improvements to the system. The engineers have so refined and simplified it that its lowered cost has made it widely available and it is easy to install and maintain.

This type of group hearing aid is now called into use under many conditions to serve a great variety of purposes. A prominent executive in New York, for example, has a modified form of the system in his office. A transmitter on his desk, with a concealed amplifier, enables him to hold meetings in his office involving more people than would be possible if he depended only upon the individual type of hearing aid, which does not employ a vacuum tube. How advantageous he has found the system is indicated by the fact that installations have been made at two other meeting places which this executive attends. One is the board room of a large corporation in which he is a director and the other the trustees' room in a university of which he is a trustee.

A particularly interesting set-up of the system is to be found at the New York League for the Hard of Hearing. Here there are three complete systems. Ordinarily one is located in the board room with 12 instruments, one in the meeting room and another kept in reserve for special occasions. In the event of large gatherings, all three can be set up in one room. The three transmitters are placed on the rostrum and can feed from 100 to 200 instruments.

One of the most distant installations of this system is that at the Government School for the Deaf and Blind at Pasay, Manila, where all the pupils are Filipinos and Chinese. In many schools for the hard of hearing, group hearing aids are coming into use for teaching children with defective hearing the sound of words. They become proficient at lip reading, but are unable to pronounce words intelligently because they have no sound pattern to follow. With the group hearing system, they watch the teacher form syllables and words with her lips and simultaneously hear them, thus associating the words by sight and sound. Then, one at a time, they speak into the microphone and, by hearing their own efforts, can perfect their pronunciation.

The variety of places finding use for group hearing aids is constantly widening. Some recent installations indicative of this are at the Museum of Arts in Toledo, the Pease Auditorium in Michigan State College at Ypsilanti, Mich., the New York Academy of Medicine, and the Upper Montclair Women's Club in New Jersey.

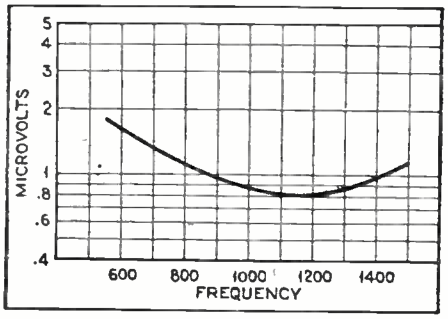
The day is not far distant when those handicapped with defective hearing will be able to walk confidently into any hall or meeting place knowing that provision has been made for them and that they can participate fully in one more phase of well-rounded living.

Superheterodyne Innovations

(*Continued from page 768*)

only one ground lead is brought out, it is connected to the prongs of the plug in such a way that as soon as the plug is pulled out, even though the power may still be on, the rectifier circuit is opened up, thus protecting all filter condensers.

The audio amplifier consists of a first stage having two –27 tubes in push-pull coupled to the detectors by a tuned transformer and feeding the two –47 output pentodes in push-pull through a combination of resistances and condensers. Power is supplied by an extra large power transformer, a type –80 rectifier and a filter system which employs the speaker field.



THE SENSITIVITY CURVE
FIGURE 5

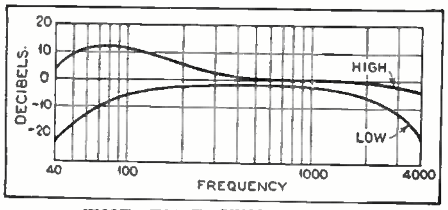
The audio transformer feeding the two –27 tubes is of the Clough tuned type, as can be seen from the d.c. feed to the detector plates through a 25,000-ohm resistor and the .04 mfd. condenser in series with its primary. This provides some of the bass accentuation, which is controlled by the 20,000-ohm rheostat shunting the .001 mfd. condenser in series with its primary return. Through careful proportioning of this transformer, the effects of its leakage reactance and distributed capacity are taken advantage of to provide a rise in the high frequency or treble range, and this is controlled by the switch SW and condenser in the detector plate circuit. This is all done at some expense in terms of audio gain; hence, the use of the push-pull first audio stage to make up for this loss. The resistance coupling to the pentodes tends to provide more bass accentuation. This is accomplished by shunting a portion of the plate resistors with a .25 mfd. condenser which operates to reduce the effective plate load with increasing frequency.

In practice, the range provided by the variable bass tone control is ample to take care not only of individual preferences in tone, but to make up for the loss of bass due to decreasing ear response as volume is turned down. The high-frequency accentuation is about 4 db. at 4,000 cycles with the switch SW open, and attenuation is about 15 db. at 4,000 cycles with the switch closed. Those who may ask why not make the treble control also variable are referred to the writer's article in the September, 1931, issue of Radio News. The combination of speaker and output transformer provides considerable treble compensation, necessary to balance out the effects of side band attenuation in the extremely sharp i.f. amplifier.

The power supply presents no features so unusual as to warrant special description, except for the heater or filament supply leads to the tuner, seen as the two heavy wires at the left of Figure 1. Due to the very heavy current drawn by the heaters of the tubes in the tuner—over 12 amperes—special precautions must be taken to prevent excessive voltage drop in the necessarily long heater leads between power unit and tuner, and this is taken care of by using a pair of number 10 stranded cables for interconnection, which are anchored to concealed binding posts accessible through apertures in the amplifier chassis. Plugs, one four-prong and one five-prong to prevent confusion, take care of all other connections between the tuner, amplifier and speaker.

Examining Figure 2, the tuner is seen at the left, the amplifier and power supply in the middle, and the speaker unit at the extreme right. In the large can upon the tuner chassis is the four-gang condenser, while behind it and to the right in an individual tube shield is the oscillator tube, to the left of which and also behind the condenser can are the r.f. and first detector tubes. At the rear of the tuner chassis are the two i.f. tubes, in separate compartments of the vertical shielding and to the left of this shielding are the two individual shields housing the push-pull detectors. Three i.f. transformers are clearly visible in the photograph. The graduations on the tuning dial are well spaced, the tuning condenser curve being such as to provide an extremely pleasing separation of low-wave stations on the dial. The four controls are, respectively, the volume control to the right, bass tone control to the left, tuning control upper center, and high-frequency tone control switch at the lower center. The on-off switch is carried on a cable projecting from the amplifier-power unit and is intended to be mounted in the side of the cabinet housing the entire assembly.

Upon the amplifier chassis, left to right, can be seen the power transformer, rectifier tube, the can housing some of the filter condensers and the audio choke, and the push-pull –47 and –27 tubes. The speaker unit requires no special comment other than to state that its in-put transformer is contained in the amplifier unit in order to prevent any loss of high frequencies due to the capacity of the leads to the speaker, and that it is especially compensated to provide an accentuated high-frequency response.



THE FIDELITY CURVE
Figure 7. The two curves show the variation in frequency response characteristics obtainable by means of the dual system of variable tone control

Looking at Figure 3, the underside view of the tuner looks somewhat sloppy, the photograph having been taken of an experimental model before its wiring was cabled and cleaned up. The four rectangular aluminum cans house the pre-selector, r.f. and oscillator coils. As a matter of fact, little further comment is required upon this assembly other than to call attention to the oscillator trimmer condenser at the lower right end of the chassis and the small coupling coil for the pre-selector stage visible on a line with the tone control and behind the pre-selector coil shields.

The power amplifier assembly is interesting principally in connection with the carefully worked out placing of the various transformers and the choke to avoid induction effects which would result in appreciable hum in the output. The peculiar mounting of the first audio transformer at the extreme right end of the amplifier chassis is, for instance, intentional—to prevent induction effects from the power transformer.

In Figure 5 appears the sensitivity curve of the receiver, this being a composite curve taken both upon original experimental models and on a number of production samples. It is seen to range between approximately one and two microvolts absolute, or in terms of microvolts per meter from about .3 to about .45 microvolts per meter. This sensitivity is extremely high and is considerably higher than can be utilized in the majority of locations. It is provided principally to satisfy the most extreme demands for distance-getting ability.

The selectivity curve of Figure 6 is interesting in that it shows a band width of 21 kc. 10,000 times down and adequate to provide absolute 10 kc. selectivity in any American location, particularly as the receiver is entirely free of cross modulation, harmonic or image frequency interference characteristics.

Figure 7 shows two overall fidelity curves, neither of which, however, represents the true antenna to ear fidelity. The upper curves show the maximum base accentuation that can be obtained, as well as the maximum treble accentuation. It will be noticed that the curve is down 4 db. at 4,000 cycles, this drop being more than compensated for by the speaker, which presents to the amplifier a load whose impedance rises with frequency rather than a purely constant load, which was the condition under which the fidelity measurements were taken. The lower curve shows the maximum base and treble attenuation possible. The drop of 20 db. at 4,000 cycles actually appears in the curve as about 4 db. greater than in practice due to the high-frequency compensation of the speaker. It is sufficiently well down, however, to satisfy the most rabid bass lover and to very considerably diminish background noise or other atmospheric disturbances which would interfere with the reception of weak stations in noisy locations. The bass attenuation is, of course, extreme, but it has been found that some few people actually enjoy a program with considerably attenuated bass response. Suffice to say, however, that the bass response can be varied to any level desired between the two extremes shown.

One more point is worthy of attention before closing. In Figure 1 it will be observed that the shelf upon which the tuner chassis rests in the cabinet is apparently about 2¼ inches thick. The shelf proper is actually only ⅝ inch thick, then comes an air pocket below it which is closed by a second shelf of ½ inch Celotex. This condition has been found to eliminate certain types of cabinet resonance, and particularly to prevent the serious transmission of vibrations from the loudspeaker unit to the tuner chassis.

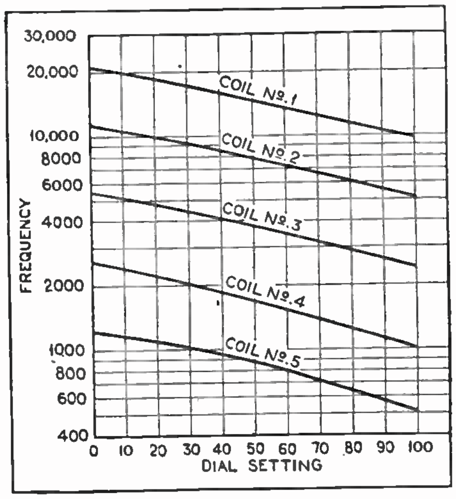
New "All-Wave" Super

(*Continued from page* 778)

faithful reproduction of speech and music. A tone control is provided in the plate circuit of the pentode which enables the listener to modify the response at the higher audio frequencies to suit.

An important feature of the "Comet" is the "long-wave" oscillator, which can be started and stopped by a switch on the panel. It consists of a –27 type tube and associated circuits and its output is loosely coupled capacitively to the grid of the second detector. Its circuits are adjusted to oscillate at 465 kc., which is the frequency for which the intermediate amplifier is tuned. Inasmuch as all incoming signals, of whatever frequency, are shifted to 465 kc. by the action of the oscillator and the first detector (or mixer), it will be evident that starting the 465 kc. oscillator will produce an audible beat note, since the signal (coming through the intermediate at approximately 465 kc.) and the output of the beat oscillator are both impressed on the grid of the second detector. Thus the "Comet" is ideal for c.w. reception—the pitch of the beat can be adjusted to suit by means of the left-hand vernier which controls the heterodyne oscillator. Although this feature is primarily intended for c.w. code reception, it is also extremely useful in searching for broadcast signals. It is normally quite easy to skip right over stations, especially when tuning in the very short waves. However, all chance of missing a station can be avoided by first turning on this long-wave oscillator. Then as the main tuning dial is slowly turned a whistle will be heard each time a carrier wave is crossed. When such a whistle is heard it is a simple matter to adjust the dial for zero beat (approximately), which makes the whistle low in pitch. This process automatically tunes in the signal very accurately. After turning off the oscillator, speech or music will be heard provided the carrier is that of a phone or broadcasting station.

The use of type –35 variable-mu tubes in the intermediate stages assures extremely smooth control of the amount of intermediate amplification between wide limits. The actual control consists of a tapered wire-wound variable resistance in series with the cathodes of the two intermediate amplifier tubes. By this means the loudspeaker output may be adjusted to suit, whether the signal be from a powerful nearby station or from a foreign station thousands of miles away.



THE TUNING CHART

Figure 5. Shows the tuning curve for each of the five sets of plug-in coils. Note that each curve overlaps the next, making an unbroken tuning range from slightly over 500 kc. to over 20,000 kc.

The receiver is substantially "single control." The left-hand vernier provides a precise adjustment for the oscillator tuning and proves very helpful when receiving the very short waves. The right-hand vernier controls the wavelength tuning and is most valuable in receiving the longer waves. Under ordinary op-

(*Continued on page* 809)

With the Experimenters

(*Continued from page 780*)

might be used. However, it has some disadvantages which Table 1 brings out. In computing the minimum resistance values (in Table 1) which could be measured with the different values of R, only the value of the smallest whole division in the scale was used. The scale in the 1 ma. meter being divided into 20 parts while the scale of the 5 ma. meter is divided into 50 parts, although both scales are of the same length. This, together with the fact that the resistance of the 1 ma. meter is nearly three times that of the other, makes the 5 ma. meter the more desirable one to use.

The above refers to the Weston 301 type of instrument.

It would also be necessary to use two multiplying resistances, one of 200 and the other of 2000 ohms in parallel, both with short-circuiting switches if the 1 ma. meter were used, to cover the entire resistance range from .0013 to 2 ohms.

One could easily connect up the apparatus as shown in Figure 1 without any special apparatus, but the results are apt to be unsatisfactory. To simplify matters the testing block shown in Figure 2. was constructed. It is made up in the breadboard type, as that method allows external meters to be used.

A walnut baseboard, 6 inches by 7.5 inches, was used. The binding post strip, 1 inch by 3/16 inch by 7½ inches long. was placed at the front and elevated by ½-inch rubber bushings. Since most mounted instruments have their connections at the back, this allowed very short connectors. Number 12 tinned bus wire was used, soldered to ordinary tinned lugs. The two central, heavy all-metal binding parts were connected to the adjoining posts in each side by copper strips, 1/16 inch by ½ inch. The 500-ohm adjustable resistance was connected to the short-circuiting switch as shown. It is not important to use heavy copper conductors in the milliammeter circuit but it is important to so make the connections that the resistance will be constant.

Make up two permanent short flexible connectors with U-shaped copper terminals soldered in each end. These are to connect up the ma. meter to the two right-hand parts. After this is done, measure the resistance between the two center binding posts, first with switch S closed and again with switch S open, with x out and battery circuit disconnected. Use a Wheatstone bridge for these measurements, if possible, as the accuracy of low-resistance measurements will depend largely on the accuracy of these two measurements. In order to simplify the formulæ $r = \frac{C_{ma} R}{1000A}$, the resistance of the multiplier should be adjusted so that with S open and the milliammeter in the circuit the resistance between the two center posts will be exactly 500 ohms.

Now in actual practice with any low resistance over .05 ohm connected between the two posts a and b, and with a 2-volt battery and 1-ampere meter in series connected to the two left-hand posts. adjust rheostat till A reads 1 ampere. Since R = 500, our equation becomes:

$$r = \frac{C_{ma}\, 500}{1000 \times 1} = \frac{C_{ma}}{2}$$

which formulæ is used for resistances between .05 and 2.5 ohms.

The resistance of the milliammeter circuit with S closed was found to be 10.5688 ohms as measured by a Wheatstone bridge.

In measuring resistances when it is necessary to use connections from center posts to the resistance, first short circuit the free end of the connectors and measure their resistance. This value is then subtracted from the measured value of x.

It can easily be proven that the greatest possible percent of error, due to instrument error, is approximately the sum of the percent of error of the meters used. Thus if the two meters are correct within 2%, the greatest possible error in measurement of resistance would be 4%; this would only be the case when one meter reads 2% too much and the other one 2% too little.

To check up the instrument error, connect up a standard 1-ohm resistance unit between posts a and b and from its

(*Continued on page 810*)

New All-Wave "Super"

(*Continued from page 808*)

erating conditions most stations can be tuned in with the main control alone, irrespective of vernier settings. When a station is heard it can then be tuned in precisely by means of the verniers. When a signal has been tuned in this manner other stations a few degrees above or below it can be tuned in solely by the use of the main control.

The range of this new receiver is limited only by the noise level. This is generally very high in the congested districts of large cities. Also in such locations the field strength of signals from distant stations is greatly reduced by the presence of large steel frame buildings, power and communication wiring, etc. Nevertheless, excellent reception has been had with the "Comet" even under such adverse conditions. In the outskirts of cities, or in average suburban residential areas the results are quite different. Here the noise level is ordinarily much lower and the arriving signals stronger. Consequently in such localities reception from stations thousands of miles away is the rule rather than the exception. From such a location in the outskirts of New York City (but still several miles inside the city line) West Coast stations in the broadcast band were consistently received in the evening. Short-wave broadcasting from stations in Rome and London was regularly received during the day. Modulated code signals were heard from great distances, including Siam and Java, at 9:30 in the morning. With the aid of the long-wave (or intermediate frequency) oscillator, c.w. code signals could be copied from any distance. All of this was accomplished on the loudspeaker—phones were not even used for tuning—and in practically all cases the signals were audible throughout a four-room apartment. Substantially the same or even better results were obtained when the receiver was taken to a residential section of New Jersey.

March of Television

(*Continued from page 753*)

(as the widely heralded Kerr cell) to theatre television projection within the last year or two.

Among other things, Nipkow proposed stereoscopic television and the employment of infra-red rays at the transmitter. Both of these ideas were put into practice in England during the last few years, the latter attaining world-wide prominence as Baird's "noctovision." No greater compliment can be paid the great pioneer Nipkow than this simple truth: the method of his invention still remains, nearly fifty years later, the basic method of present television, and practically all of his various devices are used in one or other of the systems of today.

Nevertheless, full practical exploitation of Nipkow's suggestions had to wait on three developments in other fields of science. The selenium cell follows light changes too slowly for efficient television use. Something quite inertialess was needed, and it appeared as the photo-electric cell of Elster and Geitel in 1890. Similarly, the weak picture currents at the receiving end balked the early experimenters. This difficulty was removed by De Forest's invention, in 1907, of the triode amplifier. Finally, although the modulated arc-light receiver may still be the best system for the theatre, in small installations the gaseous glow tube is simpler and more efficient. This inertialess light was invented by Moore in 1910.

Later Progress

In the meantime there occurred other events, removed from the main current of television progress but nevertheless notable because they paved the way for modern developments. In 1891 Amstutz, an American, sent the first half-tone picture over a twenty-five mile line, using celluloid sheets etched in relief. In 1898 Szczepanik proposed color television, lately staged as a practical demonstration. In 1902 Korn sent the first photograph by wire, using at the transmitter a powerful Nernst lamp as the source of a narrow beam of light, which was directed through successive elements of the "negative" to a compensated selenium cell. In 1909 Kundsen sent the first line drawing by radio, using one metal plate at the spark transmitter, and at the receiver a second plate, covered with lampblack, on which the drawing was scratched by a coherer relay.

Not until after the World War did Nipkow's television principle bear actual fruit in the work of C. Francis Jenkins in America and John L. Baird in England. Even so, at first the images were very crude; they appeared only as outlines, showing no detail. In April, 1925, Baird transmitted vision of this sort over the distance of a few feet before the patrons of a London department store. The unimpressed subject was a ventriloquist's doll. In most of Baird's laboratory work a similar doll sat patiently before the transmitter.

Progress continued. One cloudy Saturday in June, 1925, a distinguished group of Washingtonians, assembled in the Jenkins laboratory on Connecticut Avenue, watched the flickering image of a toy windmill which was seen to revolve. The windmill itself was turning in Anacostia, five miles away, and radio was bridging the visual gap. During the following January, Baird demonstrated an improved television system before members of the Royal Institution assembled in London. They saw recognizable faces and were much impressed. Single faces have been prominent in many television experiments since, because they reproduce satisfactorily where a larger or more comprehensive scene would be hopelessly blurred.

In 1927 television *in the grand manner* was demonstrated in New York by the Bell Laboratories. This great research organization quite naturally eclipsed the best efforts of the two pioneers. The Bell screen was about two feet square; the faces and speech came in twenty miles by radio and three hundred by wire. The hundreds of able men who planned and built the Bell equipment made vast improvements in existing technique, but they discovered no new principles.

Cathode Rays

With the limitations of Nipkow's disk and other mechanical scanning methods ever more apparent, it is not strange that someone should have thought of using, in preference to mechanically directed light rays, the inertialess electron beam of a Braun cathode-ray oscillograph tube. Here again the idea roots in the past. It was familiar to the Germans Lux and Dieckmann in 1906, and came to the attention of the English-speaking world in 1908 through a letter to *Nature*. In June of that year Mr. Campbell-Swinton wrote: ". . . may I point out that . . . this part of the problem of distant electric vision can probably be solved by the employment of two beams of cathode rays (one at the transmitting and one at the receiving station) synchronously deflected by the varying fields of two electromagnets placed at right angles to one another and energised by two alternating currents of widely different frequencies so that the moving extremities of the two beams are caused to sweep synchronously over the whole of the required surfaces within the one-tenth of a second necessary to take advantage of visual persistence. Indeed, so far as the receiving apparatus is concerned, the moving cathode beam has only to be impinged on a sufficiently sensitive fluorescent screen, and given suitable variations in its intensity, to obtain the desired result." Cathode-ray receivers, now widely hailed as the last word in television, are thus in principle over twenty years old.

With the Experimenters

(*Continued from page* 809)

measured resistance determine the actual percent of error. If thought desirable, this percentage could be used in correcting future measurements.

Part of this error, however, may be due to inaccuracy in reading the instruments, especially with the cheaper sort, using rather coarse graduations and wide pointers.

List of Parts

1 ammeter, 0-1 ampere range
1 milliammeter, 0-5 ma. range
1 rheostat, 6-ohm, 1.5 amperes capacity
1 s.p.s.t. switch
1 Electrad 500-ohm resistance
6 binding posts
Hard rubber strip, 3/16 by 1 inch by 7½ inches
3 hard rubber bushings, ½ inch diameter, 7/16 inch high
Walnut base, 6 inches by 7½ inches

S. G. BROWN,
Willoughby, Ohio.

The "Complete" Service Unit

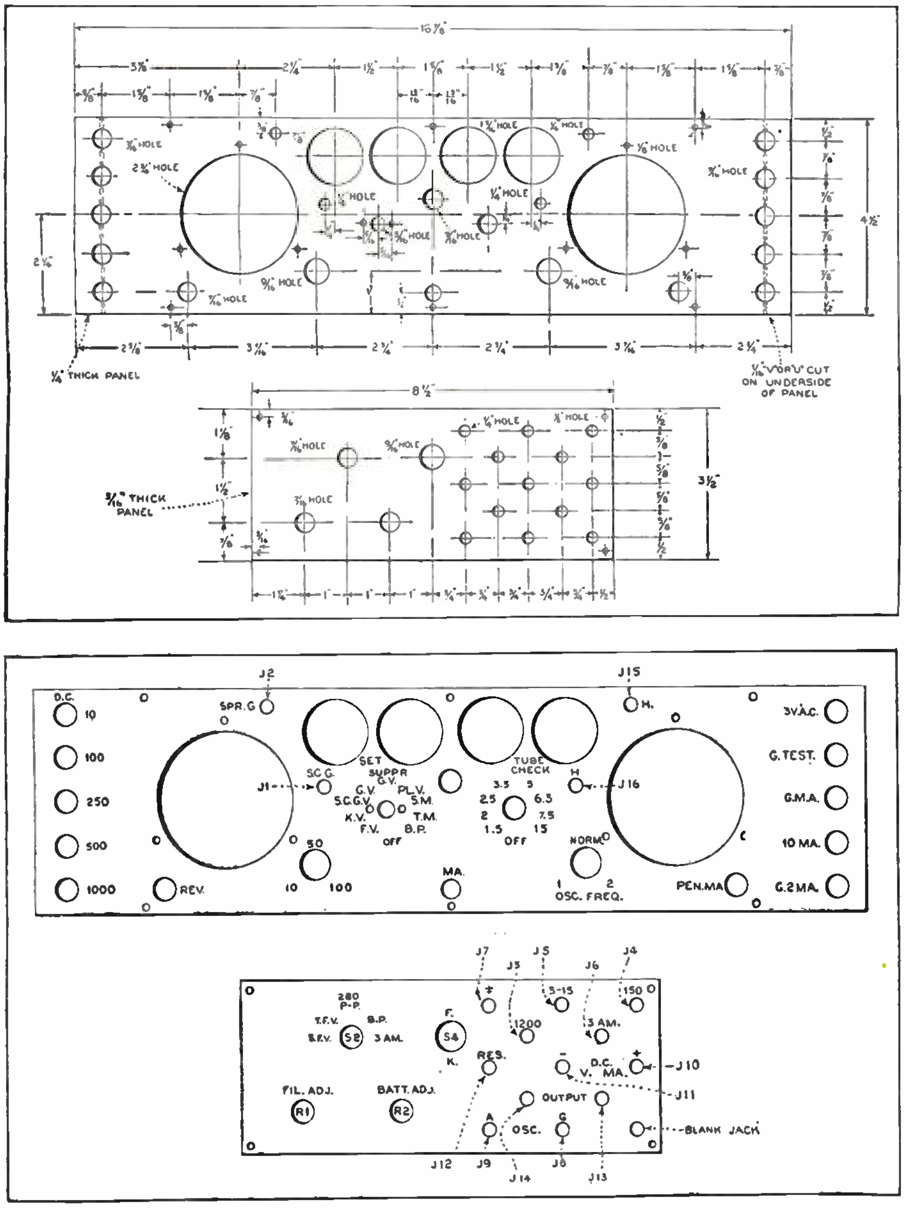
(*Continued from page 775*)

6/32 machine screws are spaced correctly, they will engage the threaded holes in the brackets.

It is not very practical to mount the voltmeter multiplier resistors on the underside of the main panel. A better plan is to mount them on the bottom of the wooden tray. A mounting block for these resistors can be made of a piece of 3/16-inch bakelite, 4⅜ inches long and 2 inches wide. Five grid-leak clips spaced 1 inch apart on each side of the panel will provide a rigid support for the resistors. This mounting block can be fastened to the bottom of the wooden try with 1-inch machine screws run through ½-inch metal sleeves.

The tube-checker filament transformer should be mounted in such a position that its magnetic field will not affect the readings of the a.c. meter. By reference to the photographs and careful planning the constructor can likewise mount the remaining current transformer, a.c. voltmeter multiplier resistors, crystal rectifier and C battery. Make sure that when the panel is in place none of its parts touch the parts on the tray.

Flexible color coded wire should be used for connections between the tray and panel. The toggle switch S4, a.c. selector switch S2, filament adjustment rheostat R1, ohmmeter zero adjustment rheostat R2 and the necessary tip jacks are all mounted on the connection panel which is fastened in the place provided for it on the back of the wooden tray.



THE DETAILED PANEL LAYOUTS

Figure 2. The drilling specifications; also the engraving. This engraving in some instances varies slightly from that shown in the photographs and it is suggested that the builders follow the engraving as shown in these drawings

Transformer Construction

Laminations from an old audio transformer or choke can be used as the core for the tube-checker filament transformer T1. Assuming that the laminations are of the "shell" type, the center leg of the complete core should not have an area of less than ¾ inch.

The primary of the transformer is wound with 660 turns of No. 28 enameled wire.

Each layer should be insulated with thin waxed paper. The secondary is wound with 90 turns of No. 18 enameled wire tapped at the 9th, 12th, 15th, 19th, 30th, 37th, 45th and 90th turns to obtain voltages of 1.5, 2, 2.5, 3.3, 5, 6.3, 7.5 and 15 volts, respectively. Make sure that the "window" space is at least ⅝ inch. This transformer, of course, was designed to operate from a 110-volt. 60-cycle line.

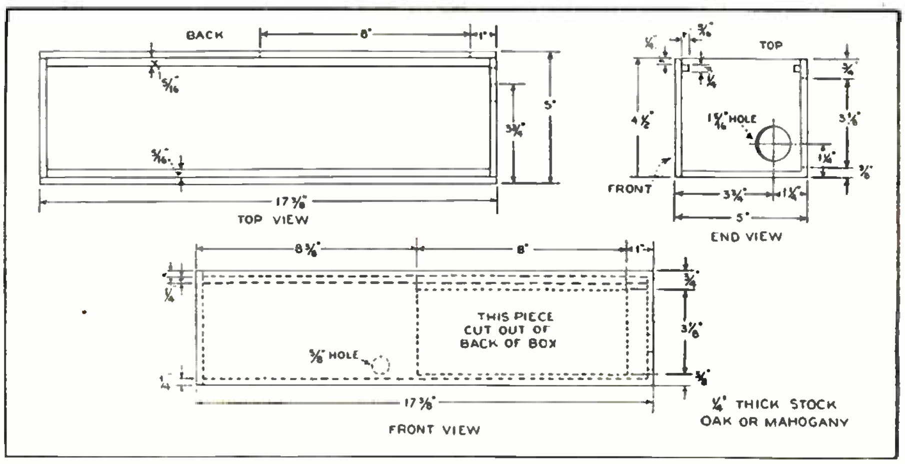


FIGURE 6. SPECIFICATIONS FOR THE WOOD TRAY

Televising a Horse Race

(*Continued from page 757*)

and the regional 356 meters, both wave-lengths being, of course, easily received throughout England, and, in fact, the B.B.C.'s transmission was well received over a considerable area in both France and Germany.

Many reports on the success of the trans-mission were received from amateurs throughout England.

Mr. Lamb of Worthing, about 70 miles from London, reported as follows:

"We watched first of all the jostling crowd opposite the grand stand, and occasionally a policeman keeping the people from climbing the rails. Then came the parade, and we realized the wonder of seeing by wireless, as each horse and jockey passed slowly by.

"After the parade we continued to watch the crowds of spectators until the start of the race, listening at the same time to the running commentary.

"Then came the most exciting part. We listened with strained ears as we realized that within a moment or so the horses would be at the winning post, towards which we were looking. We all crowded round the televisor and at that moment *Cameronian* flashed past, closely followed by *Orpen* and *Sandwich*.

"Of all the recent developments in television this broadcast of the Derby was, to my mind, the most wonderful."

Mr. Willis of Norwich, some 120 miles northwest of London, stated:

"We could see the course, the grand stand and the procession of horses before the race quite distinctly, in spite of interference. We could also see the horses flash past on the screen. This experiment was little short of sensational."

Other similar reports were received from amateurs in various parts of England.

The televising of the Derby marks a great step forward in the art of television. It is the definite entry of the televising of outdoor events; all kinds of outdoor scenes now come within the scope of the Baird daylight transmitter. Hitherto, scenes broadcast have been confined to studio transmissions, the persons televised having to be traversed by a moving spot of light, and only scenes of limited extent came within the scope of the television transmitter.

Three years ago television in daylight was demonstrated for the first time, the transmission taking place from the roof of the laboratories in Long Acre to a laboratory three floors below. Of this transmission Sir Ambrose Fleming, inventor of the Fleming valve, stated:

"The writer has had the opportunity of seeing in practical operation a very striking advance in the apparatus for television.

"In this vast improvement it is not necessary for the face or object, the image of which is to be transmitted for television, to be scanned by a brilliant beam of light traversing it, or to be flooded by powerful infra-red rays. The object whose image is to be transmitted can be simply placed in diffused daylight, just as if the ordinary photograph of it had to be taken. The transmitting apparatus is then placed near to the object, and the image of it appears on the screen at a distance, when proper synchronism is secured. The advantage of this important advance will be clear. It means that the face of a singer or speaker can be transmitted by television at the same time that the voice is being picked up by a microphone for ordinary radio broadcasting. It means a great step forward in the possibility of transmitting to a distance the image of moving objects or persons as seen in ordinary daylight.

"The television transmitter becomes, in fact, a more complicated kind of camera, in which the screen on which the image appears is not immediately behind the lens, but may be miles or hundreds of miles away."

Now these words are coming true. The electrical telescope has been actually used to show the finish of a horse race to lookers-in miles away from the race course.

The diagram of the arrangement is shown in Figure 2. The mirror drum and swiveling mirrors are contained in a mobile transmitter, the adjustment of the mirrors allowing the horses to be followed to a certain degree, and also giving an easy method of taking in parts of the race course, so that while the race was in progress lookers-in were allowed to see the grand stand, the "bookies" and the great crowd pressing along the rails.

The Service Bench

(*Continued from page 784*)

solved this problem. Electrad fixed replacement resistors are equipped with an adjustable sliding contact, so that the serviceman can readily set the clamp to obtain exactly the voltage desired. (As a matter of fact, the use of such a resistor is preferable to employing the fixed type, because it is possible to meet the voltage requirements of individual receivers which often vary considerably from that recommended for maximum efficiency.) Thus a handful of resistors, in different current-carrying capacities, with a few extra sliding clips, will perform a multiplicity of servicing jobs.

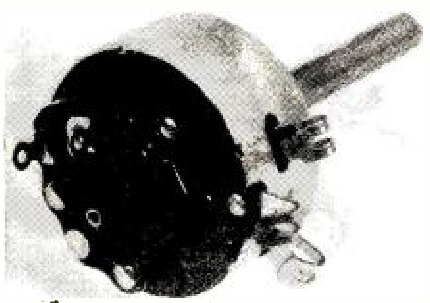


Figure 6. This type of volume control is employed in over one hundred different commercial receivers. Standardization increases the serviceman's profits and lessens his labors

Dealers as well as servicemen will appreciate the advantages of versatile replacement parts. Such modern units permit the dealer to carry fewer and more salable parts in stock, while enabling him to give better and prompter service to his customers.

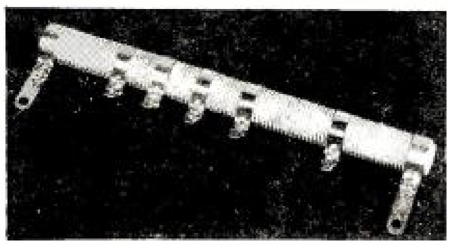


Figure 7. By the use of sliding clamps, resistors of this type may be substituted for any one of a vast number of resistors

For the convenience of servicemen, Electrad has prepared a replacement volume-control guide which supplies ready information as to the exact type of volume control required in any of the 343 standard receivers. This publication gives complete receiver circuits as well as other useful data. It may be obtained free by writing on a serviceman's letterhead to the RADIO NEWS Service Bench.

All In a Day's Work

William J. Struss, of the Witten Radio and Electric Company, Witten, South Dakota, sends in several items of interest to the serviceman isolated from conventional supply sources.

"When recently in urgent need of drum-dial cable, I went to our local butcher shop and obtained some of the cord used for tying up cold pressed meats. After a reasonable amount of washing and drying, it proved ideal.

"A good Litz wire of any desired number of strands can be made from the secondary winding of an old Ford spark-coil. Fasten the required number of strands of the correct length to a convenient tree or fence and hook the other end in the chuck of a hand-drill. Twist until adequate interlacing is secured."

Induced AC Hum

Hum, due to faulty components in the receiver itself, is today readily diagnosed and cured. Exterior induced hum still presents an interesting case to the ingenious serviceman. Harry J. Hooton, of the Radio Service Company, Beach Hill, W. Va., contributes the following on this topic:

"The writer experienced considerable trouble with a.c. hum when installing receivers near a 50,000-volt transmission line. In one instance there was apparently no remedy, for the antenna could be erected in only one direction—parallel with the high-tension line. Upon connecting the ground, the hum became so pronounced that it drowned out reception on several stations. One idea after another was tried and discarded, but it was impossible to operate the receiver with ground. We finally ran a fifty-foot counterpoise, with sensitivity equal to that of a good ground and practically a total reduction in hum level. When using an antenna system of this type it is desirable to string it directly under the antenna and as close to the ground as possible, although it works satisfactorily six to ten feet above the ground. It should be as well insulated as the antenna and equipped with the usual lightning arrester.

"The handiest thing in my tool kit is a bakelite screw-driver. It is used, of course, for trimming, adjusting, compensating, neutralizing, etc., with the set in operation without the danger of short circuits and the body capacity effects common with the ordinary tool. My bakelite screw-driver was sawed from a bakelite panel and dressed on an emery wheel."

Trouble in a Stromberg

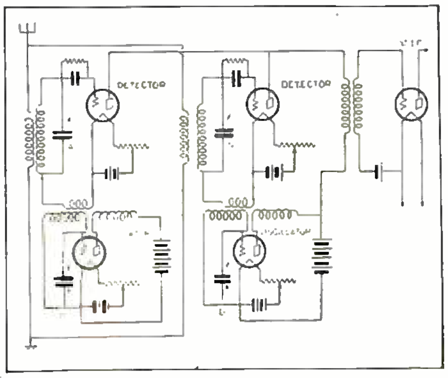
"While servicing a Stromberg-Carlson d.c. model, I ran into an unusual case. The diagnosis was simple, for the circuit check revealed a direct short between the detector plate and ground. Finding the exact cause, however, was a horse of a different shade. When the set was removed from the cabinet, it tested perfect! Upon being replaced, the short returned! Close inspection showed that the 1 mfd. condenser across the plate and ground was at fault. The metal case enclosing the condenser was connected to the grounded chassis. When the receiver was in the cabinet, the pressure caused the high-voltage side of the condenser to come in contact with the casing. Merely reversing the connections to the by-pass condenser cleared up the trouble.

"L. E. FISCHMAN,
Rudolph Wurlitzer Co."

With the Experimenters

(*Continued from page 781*)

well as in ship-to-shore communication. The principle involved is that of splitting up a message, transmitting parts of it on one frequency and other parts on a



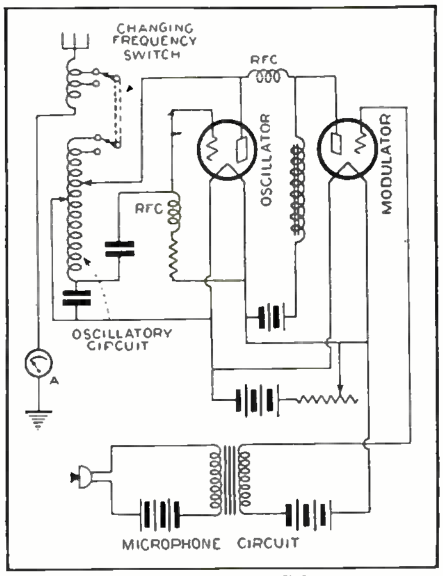


FIG. 6. THE DUPLEX EQUIPMENT

second frequency, the shift from one frequency to another being accomplished by means of a switch located within easy reach of the operator of the transmitter. At the receiving end, a superheterodyne circuit is employed, the basic circuits of which are shown in Figure 6. This receiver consists of two frequency changers or heterodyne circuits, each including its own oscillator and detector. One of these circuits is tuned to one of the frequencies of the transmitter and the other to the second frequency, and both circuits are connected to the same intermediate frequency amplifier. Thus signals on either frequency can be picked up without involving any switching arrangement at the receiving end.

In using this system, a police alarm might be transmitted as follows, the Roman type representing the transmission on one frequency and the italics the transmission on the second frequency: "Squad 40, District 10, investigate robbery of drug store at 4410 *North Racine Avenue.*" Anyone not equipped with a duplex receiver tuned to both of the transmitting frequencies employed could receive only one part of this message.

CLIFFORD CURTIS,
Chicago, Ill.

INDEX TO ADVERTISERS

Electric Filter Design

(*Continued from page 777*)

illustrated and shown in Figure 2. The two other types are derived from this type of filter and are called the series derived m-type filter and the shunt derived m-type filter.[1] These derived types of filters are designed to give a high loss to a group of frequencies above the transmission band. The loss characteristic rises very rapidly from the cut-off frequency to the frequency called the attenuation peak frequency (designated as f_∞), after which the loss tends to drop as the frequency increases. The derived types of filters, when used in tandem with the constant k type of filter, matched on an image impedance basis, make it possible to obtain a quick rise in the loss characteristic after passing the cut-off frequency.

Considerations in Filter Design Work

The electrical design of low-pass filters consists chiefly in doing the following things:

1. Make a thorough study of the loss requirements to be met and plot them on a frequency scale.
2. Determine the impedance characteristic of the line into which the filter must work so as to select the appropriate design constant "R," which is the resistance of the filter at zero frequency.
3. Select a tentative cut-off frequency, and attenuation peak-frequencies in case the derived types of filters are to be used.
4. Compute the U's and V's from the relation

$$\frac{Z_1}{4Z_2} = U + jV = -\left(\frac{f}{f_c}\right)^2 + jd\left(\frac{f}{f_c}\right)^2$$

(for the constant k type) .... (8)

or,

$$\left[\frac{Z_1}{4Z_2}\right]_m = (U + jV)_m = \frac{(d + j1)\,(a^2 - 1)}{d + j\left[1 - a^2\left(\frac{f_c}{f}\right)^2\right]}$$

(for the derived types) .... (9)

where f is the frequency at which the transfer loss is being found, f_c is the cut-off frequency, $d = \frac{1}{Q}$ = dissipation constant, $a = \frac{f_\infty}{f_c}$ where f_∞ is the frequency of infinite attenuation[5].

5. Determine the transfer loss, α, and the transfer phase shift, β, from the charts given in the first series of these articles. (In many cases we are not interested in the phase shift and β may then be neglected.)
6. If the loss requirements are met with at least 3 db. margin of safety, the values of the coils and condensers may be computed from the formulæ given in Fig. 6.

NOTE 3.—By the attenuation distortion of a low-pass filter we mean the difference between the loss at the upper edge of the transmitted band and the loss at zero frequency.

NOTE 4.—For the methods of deriving m-derived sections see Transmission Networks & Wave Filters by T. E. Shea, p. 244-270 (D. Van Nostrand Co.).

NOTE 5.—Actually of course it is not possible to get infinite attenuation in dissipation filters of this type. What is possible will be found by the charts when substituting f_{∞} for f in formulae (9).

Radio Science Abstracts

(*Continued from page* 789)

ing other equations in which the negative quantity may be substituted.

We have covered this method of harmonic analysis in considerable detail, for we feel the method outlined may prove very useful to engineers who have to work with tube circuits.

What's New in Radio

(*Continued from page* 785)

ting equipment and all types of portable radio apparatus where space is limited. It is easily and quickly attached without employ-

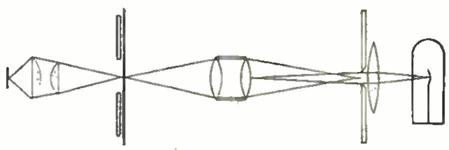
ing special tools. Type BMD is a dual-range instrument with a graduated scale of 0-100-0. The BMC model operates in a clockwise direction with scale reading 200-0.

Maker—National Company, Inc., 61 Sherman St., Malden, Mass.

Latest Radio Patents

(*Continued from page* 790)

N. Y., assignor to Bausch & Lomb Optical Company, Rochester, N. Y., a Corporation of New York. Filed June 29, 1929. Serial No. 374,711. 9 Claims.



1. Apparatus for reproducing sound comprising in combination a light source, a film bearing a sound record in position to be illuminated by said source, a light-sensitive cell and means defining a curved slit positioned between said film and said cell with the concave side of the slit facing the film.

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