Ninth Year of Service

RADIO ENGINEERING

XVII

Vol. IX OCTOBER 1929 No. 10

IN THIS ISSUE

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$2.00 per year

The Journal of the Radio Industry

Making it right for you

It's mighty versatile stuff, genuine laminated bakelite. The way it applies itself to the benefit of manufacturing is really astonishing. Ten chances to one it will work better in your product than some other material you're using now—such as metals, glass, porcelain, leather, rawhide, hard rubber, wood. And ten chances to one, Phenolite, Laminated Bakelite, will improve the quality of your product without decreasing your profits.

Our Service Engineering Department is an eager staff of chemists and engineers, ready to help you determine whether or not Phenolite will make fabrication easier, swifter, more economical, whether or not Phenolite will be likely to add to the measure of quality in quantity production. Our laboratories are where known requirements meet known performance. If your product is peculiar, all the better. Write for full information.

For every electrical and industrial use. Graded to your requirements. Adequate stock insures prompt delivery at all times.

NATIONAL VULCANIZED FIBRE

The electrical industry has discovered many instances where a very thin, very flexible fibre of high dielectric and bending strength is an absolute necessity—and in these cases they have discovered too that Peerless Insulation meets their needs.

PEERLESS INSULATION

PHENOLITE

Reg. U.S. Pat. Off.

Laminated BAKELITE

SHEETS : RODS : TUBES : SPECIAL SHAPES

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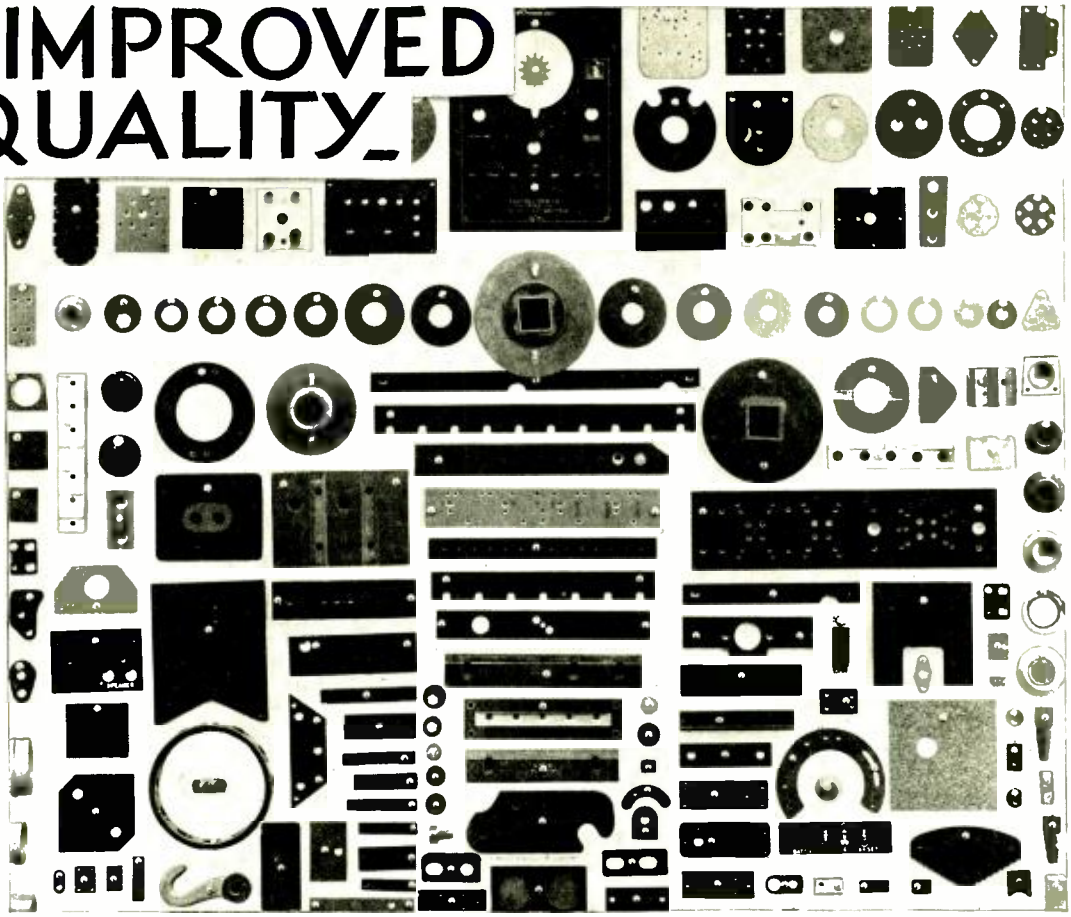

and WORKABILITY...

RESEARCH work never ends in the Formica laboratories. Materials and methods are constantly under study and occasionally something important develops.

Formica today is more easily workable, and at the same time better electrically than it was a few years ago.

The fact that leading American electrical organizations have used it without a break for 10 to 15 years is evidence that better insulation is not obtainable.

An exceptionally large equipment of fabricating machinery and a location near the center of industry makes prompt production and delivery of finished insulating parts possible.

Send your blue prints for quotations

THE FORMICA INSULATION COMPANY
4638 Spring Grove Avenue Cincinnati, Ohio

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RADIO ENGINEERING

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Vol. IX **October 1929** **Number 10**

Contents

Departments

The Advance of Radio

By Dr. Fulton Cutting
President, Colonial Radio Corporation

TO predict radio's future with any degree of assurance, it is necessary to review its history and carefully scrutinize the present trend, and even then the prophet is apt to be wrong. Radio is a constant surprise in itself. Subject to the imagination, research and effort of the scientific mind, its ultimate limitations are not even suspected today. We know what has been and what is, but we do not know how today's achievements may be eclipsed tomorrow.

The dynamic speaker, the screen-grid tube, the new type of engineering construction, the new developments of metallurgists and the amazing coordination of many other elements and factors have all brought about improvements and advances more rapidly than was ever expected. Radio has made faster strides in a shorter time than have ever been made in any other industry.

Today, with power at a high point, tone at a fine degree of actuality, beauty in keeping with the most luxurious of home appointments, value at a price never before made possible, it is easy to believe that radio has reached its final stage of development. Certainly it has achieved to the point where no one need longer wait for its future offerings.

I have no doubt that we will witness many changes in radio receivers as time goes on, but I do not hesitate to say that the purchaser of today's radio will derive a good measure of satisfaction from it for several years to come.

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52 Vanderbilt Ave.
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Yearly subscription rate $2.00 in U. S. and Canada; $3.00 in foreign countries.

A NEW ADDRESS

Is Provided for Sylvania Engineers

New, huge laboratories—for materials testing by more than ever exacting standards—for even more rigorous inspections of product—for even greater research—are provided for Sylvania Engineers in new huge Plant Number One.

Thirty-five thousand Sylvania Tubes per day. With twelve hundred employees and the newest of new production equipment.

And such light, air, ventilation—and employee comfort winter or summer—as raise this business structure far above the accepted definition of a factory.

All of which is important to Sylvania and to you in only one respect—that you shall have sufficient numbers of Sylvania Radio Tubes without sacrifice of a single factor of Sylvania standards of excellence.

While the administrative officials will continue in their own building, the entire Sylvania engineering staff has been installed in the new structure, thus coordinating under its huge roof, Engineering Research, Materials Test and Production Inspection divisions.

See Our Exhibit at the
EIGHTH ANNUAL CHICAGO
RADIO SHOW
COLISEUM, CHICAGO
October 21st to the 27th, inclusive
Booth No. 1-2, Section W

SYLVANIA PRODUCTS COMPANY
Emporium, Pennsylvania

Sylvania

RADIO TUBES

Licensed Under RCA Patents

MEMBER RMA

EDITORIAL

October, 1929

OUTSIDE PURCHASING

IS OUTSIDE purchasing speculative? Can a radio set manufacturer count on satisfactory delivery and engineering coordination when dealing with parts manufacturers? Such questions have often been raised.

A great number of manufacturers in the radio industry have worked up an entirely self-contained manufacturing structure—more or less self-reliant and in very few cases, drawing from the parts manufacturer. Everything is designed and fabricated according to the manufacturer's own pattern. In a sense, this may be very good practice, but, nevertheless, the fact remains that excessive plant space is required in the event that quantity production is a factor—and where is it not a factor in this new era of competition?

Undoubtedly, the largest manufacturers, with huge plants and numerous subsidiaries, will find little profit in dealing extensively with parts manufacturers; they are already equipped through their subsidiaries for handling design and fabrication. However, from the viewpoint of the smaller concerns turning out sets, outside purchasing appears not only a satisfactory procedure but decidedly advantageous.

Manufacturers of parts and accessories, who are, undeniably, specialists in their own respective fields, can often produce in quantity better units than can the set manufacturer. Proof lies in the fact that their efforts are directed in one particular channel of endeavor.

At one time the automotive industry was composed entirely of automobile manufacturers. Today, few parts are made in the automobile plants. The auto manufacturer has learned by actual experience over a period of many years that it is cheaper; from most every point of view, to purchase his parts and accessories on the outside and use every bit of available plant space for actual production assembly. Only recently, the builder of the most widely used car in the world turned to outside purchasing. Yet the company is self-contained.

The purchase of parts on the outside makes it possible to change a design, when necessary, without long and expensive delays in getting into production. This practice makes the production system decidedly more flexible and at the same time relieves the set manufacturer of a great deal of unnecessary burden and responsibility.

Obviously, when parts are purchased on the outside more plant space is made available for assembly purposes—or made available for emergency production purposes. Furthermore, this practice offers to the set manufacturer the services of scores of well-equipped and well-manned research organizations, with specialized knowledge and facilities. It saves on the cost of new machinery, it reduces large overhead costs of trained engineers and master machinists and it reduces labor costs as well.

The division of effort and time in the manufacture of parts and their assembly is reason enough for the contracting of parts on the outside. Let any extra effort and time be directed into other channels, such as distribution or production, and profits will show a decided increase.

Parts manufacturing is a highly competitive field. It is necessary, therefore, that these manufacturers meet the requirements of every field to which they cater. The pressure of this competition has forced the average parts manufacturer to narrow down his own operations to a few specialized lines. He, like other manufacturers, employs the most efficient production systems and the most modern machinery. With these aids he is able to meet the most rigid demands.

M. L. MUHLEMAN, *Editor.*

THE ADVANTAGES OF CONSTANT DEVELOPMENT WORK

Radio sets are constantly being improved. The condenser that meets all the requirements of the set of to-day may be obsolete in the set built for next year's market. The set manufacturer who uses Scovill-made condensers need never worry over his product being behind the times; rather may he be certain that Scovill electrical engineers, in close touch with the radio industry, will have new and improved condensers ready at the time the industry is ready for them.

This Scovill development work assures customers of condensers always slightly ahead of the market trend.

Scovill condensers and radio parts are manufactured under strict laboratory supervision. Telephone the nearest Scovill office.

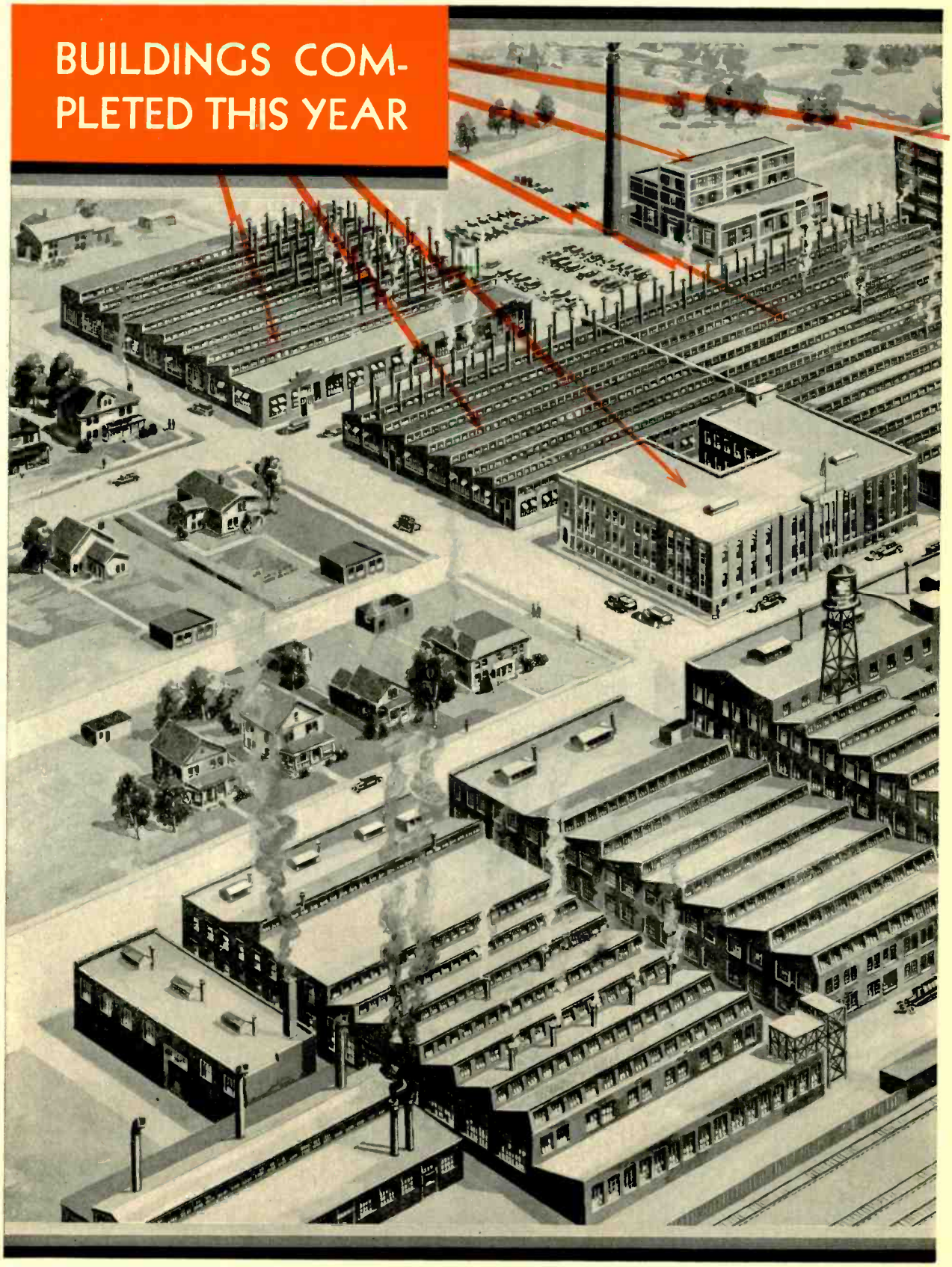
SCOVILL

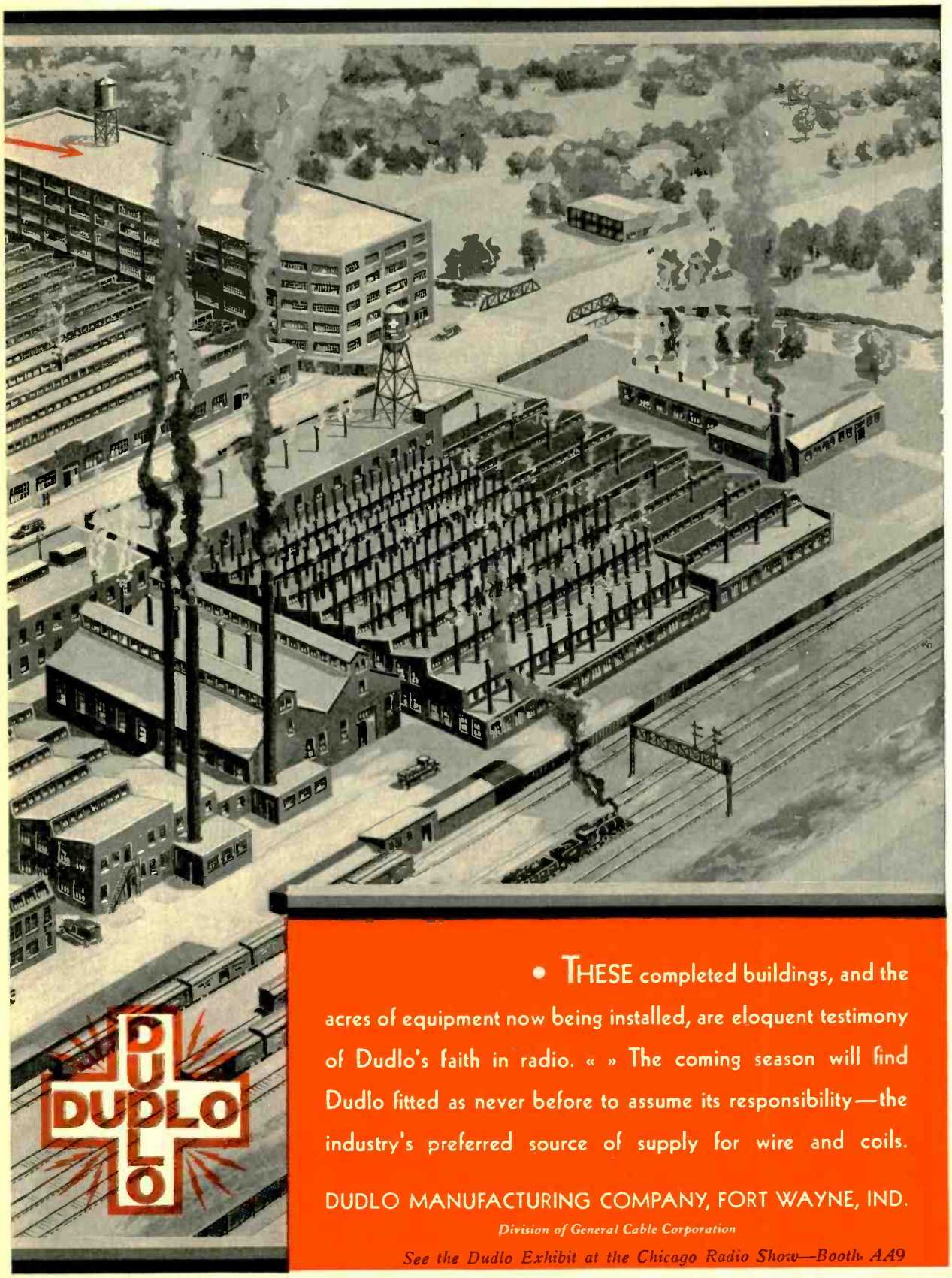
MANUFACTURING COMPANY

WATERBURY, CONNECTICUT

New York Providence Los Angeles Atlanta
Chicago Cleveland Cincinnati Detroit
Boston Philadelphia San Francisco
In Europe — The Hague, Holland

SCOVILL MEMBER COPPER & BRASS RESEARCH ASSOCIATION





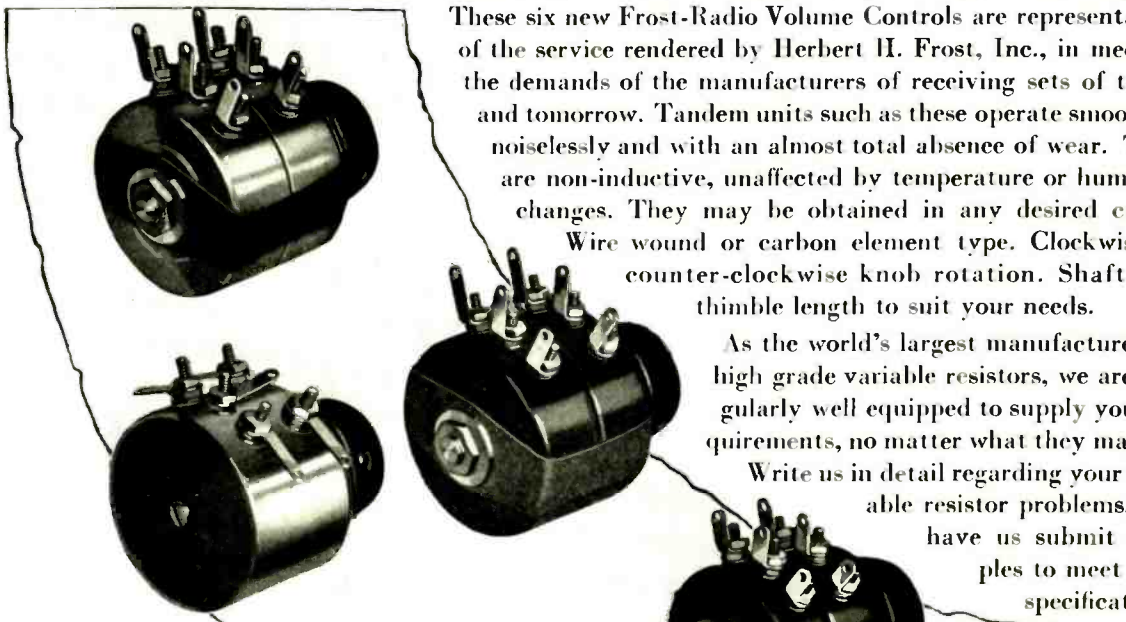
• THESE completed buildings, and the acres of equipment now being installed, are eloquent testimony of Dudlo's faith in radio. « » The coming season will find Dudlo fitted as never before to assume its responsibility—the industry's preferred source of supply for wire and coils.

DUDLO MANUFACTURING COMPANY, FORT WAYNE, IND.

Division of General Cable Corporation

See the Dudlo Exhibit at the Chicago Radio Show—Booth AA9

ANNOUNCING SIX NEW FROST TANDEM UNITS



These six new Frost-Radio Volume Controls are representative of the service rendered by Herbert H. Frost, Inc., in meeting the demands of the manufacturers of receiving sets of today and tomorrow. Tandem units such as these operate smoothly, noiselessly and with an almost total absence of wear. They are non-inductive, unaffected by temperature or humidity changes. They may be obtained in any desired curve. Wire wound or carbon element type. Clockwise or counter-clockwise knob rotation. Shaft and thimble length to suit your needs.

As the world's largest manufacturers of high grade variable resistors, we are singularly well equipped to supply your requirements, no matter what they may be. Write us in detail regarding your variable resistor problems, and have us submit samples to meet your specifications.

Brief data on six tandem units illustrated

A. No. 280-280. Combination metal shell wire wound and composition elements. Wire wound up to 15,000 ohms. Composition, 5,000 to 1 megohm. Rheostat or potentiometer type in either unit. Units insulated from each other. Diameter, 1 11/16 in. Depth of shell, 1 3/8 in.

B. No. 890. Double depth metal shell unit in rheostat or potentiometer type. Rotors in same electrical connection. Composition elements, 5,000 ohms to 1 megohm in each unit. Diameter, 1 7/8 in. Depth of shell, 1 3/16 in.

C. No. 1880-1880. Same as 280-280 except all bakelite.

D. No. 200-200. Metal shell type wire wound resistors with resistances from 5 ohms to 10,000 ohms. Split windings. Rheostat or potentiometer types. Units insulated. Diameter, 1 7/16 in. Depth of shell, 1 1/2 in.

E. No. 2880-2880. Bakelite shell composition element only. Resistance range from 5,000 ohms to 1 megohm. All curves. Potentiometer or rheostat types. Units insulated from each other. Diameter, 1 1/2 in. Depth of shell, 1 1/8 in.

F. No. 590-590. Metal shell, composition element only. Resistances from 5,000 ohms to 1 megohm. All curves. Potentiometer or rheostat types. Units insulated from each other. Diameter, 1 5/16 in. Depth of shell, 1 1/8 in.

HERBERT H. FROST, INC.

Main Offices and Factory **ELKHART, IND.** 160 North La Salle Street Chicago

is Out!

Newspapers From Coast to Coast Herald the Entry of a New Giant Into the Tube Business . . .

National Union Radio Corporation

takes its place beside R. C. A. and Cunningham . . . experts now forecast the end of present chaotic trade practices

On August 23rd at 4:10 P. M. the final papers were signed . . . a clerk released the news to 1100 newspapers . . . the National Union Radio Corporation had at last become a fact!

The radio editors of a big New York paper describe it as "The most important radio news this year."

A prominent jobber from Chicago wired—
"National Union will do much to stabilize the radio tube business."

Retailers the country over are greeting the news with enthusiasm.

National Union with a capacity of 75,000 tubes a day becomes one of the three largest manufacturers of radio tubes in the world.

Capitalized at $16,000,000, lack of money will not handicap its development.

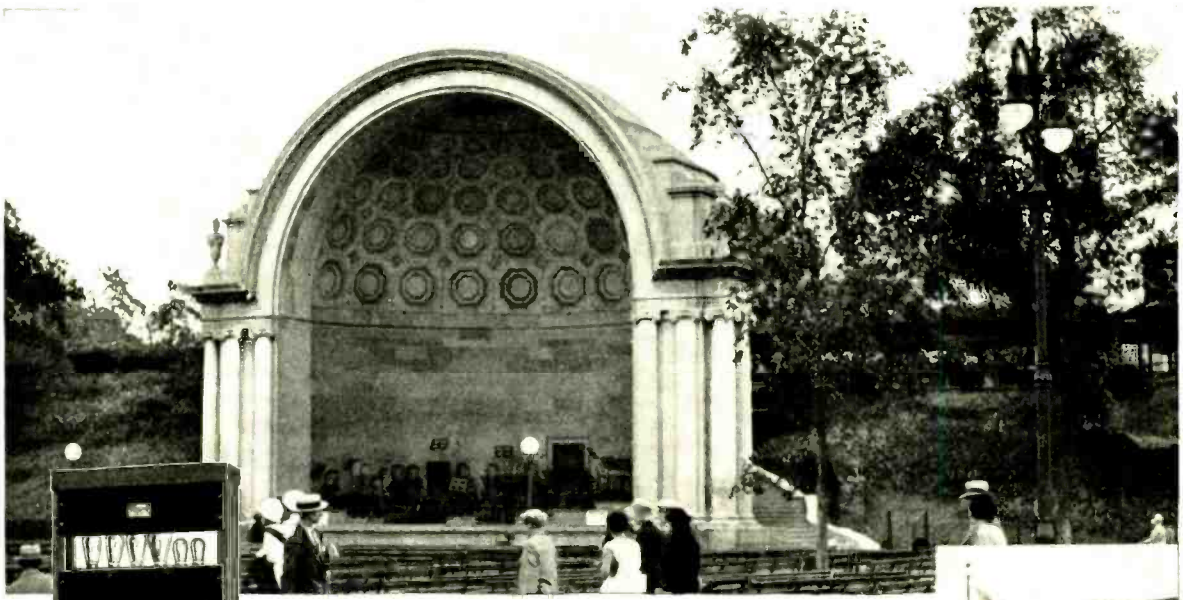
Directed by a group of the country's ablest radio executives, it should quickly win a position at the head of the radio industry.

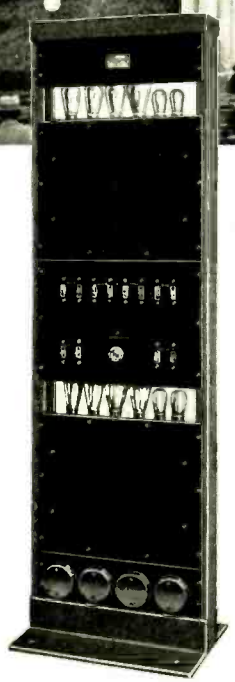
Through a reciprocal agreement with R. C. A., National Union will have the benefit of every important existing radio patent.

Look for big things from this new organization. Look for the fairest trade practices in the business. Look for the finest tubes science can devise.

More big news will follow during the next few months. Watch the next issue of this magazine.

RADIO CORPORATION





2-V PAM 19

New York Parks are PAM Equipped

In Central Park, New York, programs such as Goldman's Band, speeches originating in the bandstand, etc., are picked up and amplified by a PAM amplifier similar to that illustrated at the left and fed over wires to twenty-five municipal parks in other sections of the city.

One of New York's Parks

In each of these other parks is installed a 2-V PAM-19, shown above, which supplies reproducers located at proper points, thus permitting simultaneous quality reproduction at widely separated points.

The parks in your city are logical prospects for a similar type of equipment.

Have you seen your park authorities?

A new 16-page bulletin giving mechanical and electrical characteristics, representative installations and many new PAM amplifiers will be sent upon receipt of 10 cents in stamps to cover postage. When writing ask for bulletin No. RE-5.

Main Office:
Canton, Mass.

Samson Electric Co.
MANUFACTURERS SINCE 1882
MEMBER RMA

Factories at Canton and Watertown, Mass.

THE SENIOR

LOCAL STATIC!

—brings Profits to Dealers who Sell

THE JUNIOR

Produced by the manufacturers of the Muter Ultra-Dynamic Speaker — the new speaker of glorious tone. Write for details today on the sales possibilities this speaker offers you in replacements for old sets equipped with the magnetic type.

Muter

MUTER DEPENDABLE INTERFERENCE FILTERS!

CLEAR, perfect music coming from the speaker. And then, suddenly — crackle — sizzle — roar! Probably only a nearby motor or electrical appliance. But fatal, just the same, to radio enjoyment.

Every local disturbance of this sort means a prospect for you. Help your customers — and yourself — by selling them MUTER DEPENDABLE INTERFERENCE FILTERS to remove the nuisance of man-made static.

Made in two types

1. *The Junior:* For direct connection to radio set. Capacity type, with large factor of safety for use on 110 volt A.C. Priced at $5.00.
2. *The Senior:* For use in connection with electrical or mechanical devices causing local disturbances. Capacity inductance — rated for use on 110 volt A.C., on devices not exceeding 5 amp. current draw. The senior may also be used in the same manner as the Junior, in direct connection with the radio set, offering an additional inductance to eliminate disturbances. Priced at $7.50.

Write now for full information on this profit making filter.

LESLIE F. MUTER COMPANY

8440 South Chicago Avenue Chicago, Ill.

Unequalled Value in the Jewell Pattern 199

EVERY test necessary for effective radio servicing, including screen grid receivers, is met perfectly by the Jewell Pattern 199, *the lowest priced, high quality set analyzer on the market.*

Pattern 199's are built to the most exacting standards. The large 3¾ inch Jewell Instruments have been proved on thousands of exacting industrial applications. The bakelite panel and silver contact switches indicate the high quality of construction throughout.

In addition, the Pattern 199 is backed by the most complete and thorough radio data service available, including complete test data on sets of leading radio manufacturers. Jewell Analysis Charts make it easy to record test data systematically for convenient comparison and analysis.

Thousands of dealers are converting service liabilities into profits through use of the Pattern 199. Order one from your jobber today.

List price, $97.50 Dealers' net price, $73.12

29 YEARS MAKING GOOD INSTRUMENTS

JEWELL

199 Set Analyzer

Write for catalog sheet which describes the Jewell Pattern 409, a four-instrument set analyzer for expert servicemen, the the Jewell Pattern 210 Tube Checker, and complete line of Jewell Radio Instruments.

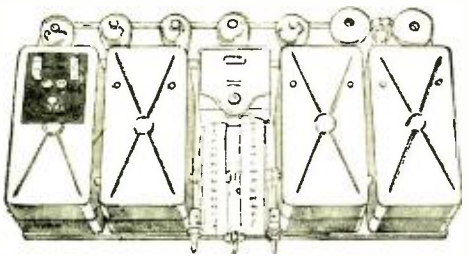
Jewell Electrical Instrument Company
1650 Walnut Street, Chicago, Illinois

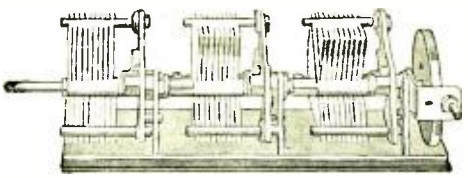
Please send us your booklet, "Instructions for Servicing Radio Receivers," and literature covering Jewell High Grade Radio Service Instruments.

Name----------

Address----------

ALUMINUM
for finer reception





BETTER tone timbre, greater selectivity, closer tuning, are highly desirable qualities that Aluminum shields bring to radio reception.

Aluminum shielding reduces interference. It eliminates electrostatic and electro-magnetic interaction.

It makes possible more compact design and adds less weight to the set than any other metal. It is very workable and presents few limitations of sizes and shapes.

Accuracy and uniformity beyond anything ever previously attained can be secured in variable condenser blades by the use of Aluminum.

The Company produces a special sheet Aluminum for this purpose with gauge tolerance of .001 in thickness, and with the total variation within one sheet limited to .0005 inch.

This material is available to Radio set manufacturers either in sheet or in finished form.

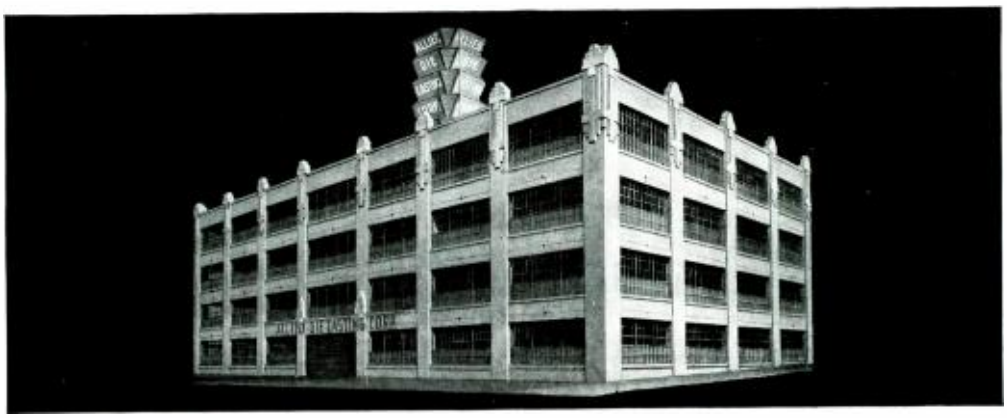
ALCOA

Aluminum Die Castings combine lightness, strength, accuracy and high conductivity. They have equal strength with less than half the weight of other casting materials.

Inquiry is solicited concerning the use of Aluminum Die Castings for loud speaker frames and bases, condensers and condenser frames, drum dials, chassis and cabinets, and for Aluminum in any other form.

ALUMINUM COMPANY OF AMERICA
2468 Oliver Building, Pittsburgh, Pa.
Offices in 19 Principal American Cities

The Model Die-Casting Plant !



Announcing

THE MOST MODERN DIE-CASTING PLANT

In Structure—Equipment—Methods and Personnel Allied sets a new standard for the industry.

The opening of the newly constructed plant of the Allied Die-Casting Corporation places at the disposal of all users of die castings, the many advantages possible through the combination of every modern facility.

This large plant, the newest and most up-to-date of its kind today, is devoted to two services. The more economical and more efficient production of finer die castings - - - and - - - the production of the most modern die casting machinery and its' installation and servicing in manufacturing plants.

This new, model plant offers to manufacturers an unsurpassed organization for the manufacture of exceptionally delicate, intricate and involved die castings, in which strength, accuracy and fine finish are inherent qualities.

The new Allied building has been deliberately planned, designed and built for just one purpose - - - to permit the most economical production of high quality die castings, by embodying every natural and physical advantage in its construction.

To this model structure has been added equipment chosen after exhaustive tests—only. None but the finest has been used. The great capacity of these high speed tools will be utilized to the utmost in the hands of skilled Allied artisans, producing the natural result when experienced workmen use fine tools.

As to methods—for many years Allied has successfully die cast parts that had been declared impossible to the art. These methods are now continued in the new plant under ideal conditions that make possible even greater developments in the science of die casting.

The Allied personnel is progressive. Old in die casting experience—but young in ability to accept new problems and new facts, to discard old costly methods and to be constantly alert to any factor that will make it possible to produce better die castings more efficiently and at lower cost.

The entire Allied model organization, as well as the staff of engineers, which has been so successful in the solution of production and die casting problems for some of the largest industries in the country, is at your command for consultation at any time.

PRESIDENT.

ALLIED DIE-CASTING CORP.

Long Island City, N. Y.

ALLIED DIE-CAST

The Model Die-Casting Plant !

DRILL CHUCKS Ettco TAPPERS

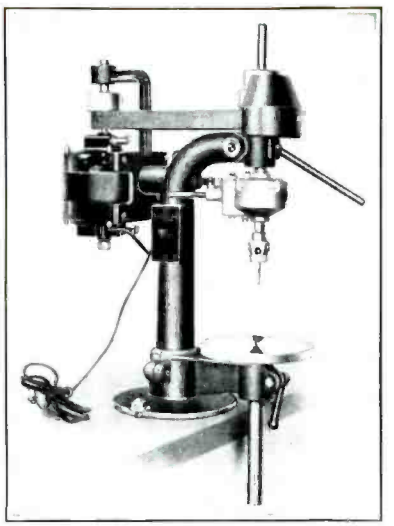
Used in the new Allied factory

High Speed Sensitive Tapping Attachment (above)

is simple—nothing to adjust—if the tap sticks or hits bottom the Ettco slips—the same action coming out. No clash of a positive clutch—just the smooth action of the patented leather lined cone clutch. Sensitive—speedy —satisfactory.

No. 1—Tapping attachment 3/16" in steel ¼" in C.I.	$35.00
No. 2—Tapping attachment 5/16" in steel ⅜" in C.I.	50.00
No. 3—Tapping attachment ¼" in steel ⅝" in C.I.	80.00

Including Chuck and 1, 2, 3 or 4 Morse Taper Shank



Electric Vertical Tapping Machine (above)

110 Volt—60 Cycle—Single Phase	$95.00
110 Volt or 220 Volt D.C. or 220 Volt A.C.	100.00

Write us

Drill Chuck
Self tightening — Hand operated

None of us have time to fiddle around with a key any more.

Another thing—why stand for chewed-up drill shanks?

The Ettco eliminated these things ten years ago.

No. 1-A	Capacity 0 to ¼—$5.50
No. 1½-A	" 0 to 5/16— 6.00
No. 2-A	" 0 to ⅜— 6.50
No. 3-A	" 0 to ½— 9.00
No. 3½-A	" ⅛ to ⅝—11.00
No. 1 M.T. Shank	.75
No. 2 M.T. Shank	.75
No. 3 M.T. Shank	1.00
No. 4 M.T. Shank	1.50

Also fitted with collars for your portable tools

These Prices subject to Consumer's Discount of 10%

ETTCO TOOL CO., INC.

594 Johnson Avenue, Brooklyn, N. Y.

Why MARVIN *Radio Tubes*
Serve Better — Live Longer

MARVIN Radio Tubes are Master-built by skilled engineers in the thoroughly modern factory shown above.

The finest of automatic processes produce MARVIN Tubes in quantity. Quality is insured by the exceptional testing methods installed by an engineering staff second to none in the industry.

The engineering departments of radio manufacturers and distributors are invited to test MARVIN quality in comparison with all other tubes. No matter how comprehensive or rigid the tests, we are confident of the result. You will be convinced that MARVIN Radio Tubes

"Serve Better and Live Longer."

MARVIN
MASTER-BUILT
RADIO TUBES

A section of the thoroughly modern Marvin factory, where Master-Built Tubes are produced.

MARVIN
RADIO TUBE
CORPORATION
Irvington, N. J.

Sales Office
225 Broadway
New York City

"In The Air" or "On The Air"
CLASS TELLS

Success may be judged by many standards, and you will discover how relative the term is, as applied to Radio, when you tie up with CARDWELL Condensers and compare Performance with what you considered was Success before.

The CARDWELL line is intended to, and does, meet a demand for the utmost in condenser value and efficiency. It includes transmitting condensers for broadcasting stations, commercial transmitters and amateur uses, and receiving condensers of several types and many capacities. The CARDWELL Taper Plate Condenser—unbelievably rigid and vibrationless—is incomparable for short wave receivers.

CARDWELL Condensers are not dressed up to delight the eye but are designed to do a job, and upon their preeminent ability to do that job is based the reputation of the CARDWELL.

CARDWELL CONDENSERS

"The Standard of Comparison"

THE ALLEN D. CARDWELL MANUFACTURING CORPORATION
81 PROSPECT STREET ✣ ✣ BROOKLYN, NEW YORK

Why LINE BALLAST CLAROSTAT ?

EVERY engineer knows by now the importance of automatic line voltage regulation, both from the engineering and the merchandising standpoints.

And most engineers know that the *Line Ballast Clarostat* is standard equipment in more radio assemblies than any other type of automatic line voltage regulator.

But very few engineers know even now why the *Line Ballast Clarostat* is the most popular form of automatic line voltage regulator. And so, at this time, we present our case, briefly:

1. The *Line Ballast Clarostat* is foolproof. No breakable glass bulb, delicate filament, gas, liquids or other factors to cause trouble. Instead, it is a husky, metal-clad, neat cartridge, containing a wire winding on a mica and metal framework. Positively nothing to break or wear out.

2. The *Line Ballast Clarostat* provides immediate voltage regulation—without the 3 to 4 minute lag found in many other types, which fail to protect against usual fluctuations.

3. The *Line Ballast Clarostat* as installed in the usual radio cabinet or power unit casing, is free from resistance variations due to drafts. On the other hand, its ventilated resistance unit provides marked advantages over the glass-enclosed types in the matter of rapid, positive and predetermined response.

(actual size)

4. The *Line Ballast Clarostat* employs a perfected resistance wire that cannot peel, crack or oxidize. Therefore, the unit will provide a life far in excess of that of the usual radio assembly.

5. The *Line Ballast Clarostat* is not offered as a cure-all. Instead, it is designed and produced for a specific power transformer. It is fitted to a definite transformer and load. And that explains why it maintains secondary voltages well within 5% even though line voltage may vary over 30%.

And there is yet more to be told, but space forbids. Therefore—

DESIGNERS AND MANUFACTURERS—

***Write** for engineering data regarding line voltage problems in general and the Line Ballast Clarostat in particular. Better still, send us a power transformer wound with 80 or 85 volt primary employed in your production sets, and we shall design a suitable cartridge for same.*

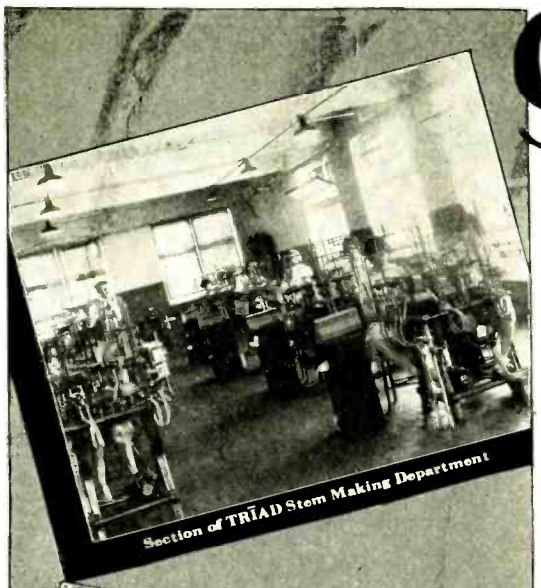
Clarostat Manufacturing Company, *Inc.*

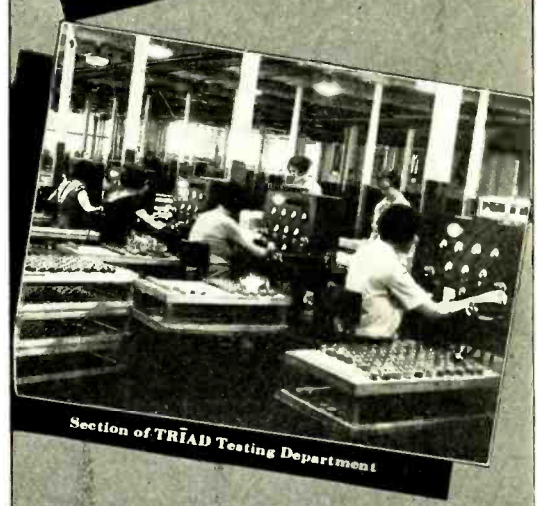
Specialists in Radio Aids

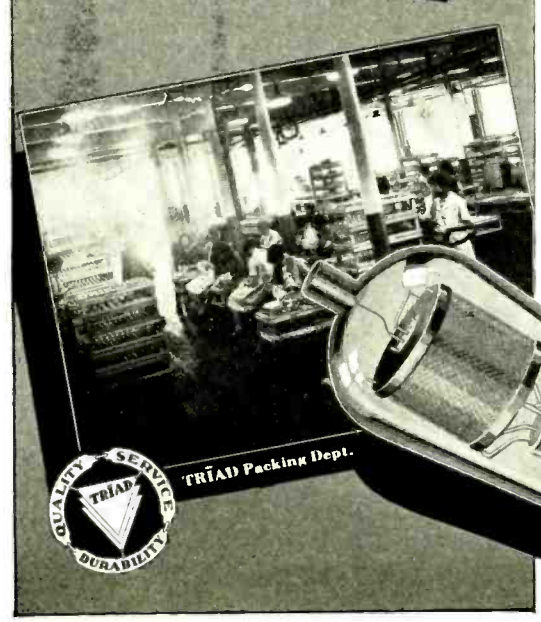
MEMBER R.M.A.

289 North Sixth Street : : Brooklyn, N. Y.

Remember—there's a CLAROSTAT *for Every Purpose*


Section of TRĪAD Stem Making Department


Section of TRĪAD Testing Department


TRĪAD Packing Dept.

9 Final Tests ... to assure *perfection*

Naturally — every TRĪAD Tube is constantly, rigorously tested throughout the entire manufacturing process — a special test follows every individual operation. Yet TRĪAD does *more than that!* When completed, each TRĪAD Tube is subjected to nine *additional* and *final* tests for vital characteristics — tests so stringent that nothing short of absolute perfection can survive them! This infinite care in manufacture has won for TRĪADS their reputation for superior quality — and has made possible that guarantee that goes with every TRĪAD Tube—a minimum of six months' satisfactory service or a proper adjustment. You can rely on TRĪADS — the tubes backed by an actual Insurance Certificate!

Call your jobber or write us direct for complete TRĪAD *information.*

TRĪAD MFG. CO., Inc., Pawtucket, R. I.

Tune in on the TRĪADORS every FRIDAY evening, 8 to 8:30 Eastern Standard Time, over WJZ and associated NBC Stations.

TRĪAD
INSURED
RADIO TUBES

See the TRĪAD Display — Chicago Radio Exposition Oct. 21-27, Booth 6 — Section Z

9 FINAL TESTS

Below are listed the nine *final* tests for vital characteristics to which every TRĪAD Tube is subjected.

1 Gas
2 Emission
3 Filament Current
4 Plate Current
5 Oscillation
6 Grid Voltage
7 Mutual Conductance
8 Plate Impedance
9 Amplification Constant

What every Radio Dealer should know about his tube business

By J. J. Steinharter
President
Cable Radio Tube Corporation

IN 1927, 30,000 dealers sold 33,662,247 tubes—an average of 1123 tubes per dealer.

In 1928, 31,000 dealers sold 61,552,846 tubes—an average of 1985 tubes per dealer.

In 1929, 39,000 dealers will sell 100,000,000—AN AVERAGE OF 2564 TUBES PER DEALER!

(Courtesy "Radio Broadcast")

The tube business is growing—more sets, more tubes per set, new type tubes, more tube sales per dealer. Are you getting your share? Of course, half the story is in the line you carry.

Is It A Quality Line?

SPEED tubes are triple-tested . . . first quality tubes. Made by a company making tubes

J. J. STEINHARTER

since 1924. SPEED executives served an apprenticeship of over 20 years in incandescent lamp manufacture.

Is It A Complete Line?

SPEED Tubes include types 201A, 199, X140, WD11, WD-12, 200AA, 112A, 171A, 171-AC, 245, 210A, 250, 226, 227, 280, 281, 224AC.

Is It A Progressive Line?

SPEED had a 224AC type in 1928. SPEED'S 227 has been perfected to heat in 5 seconds—by test. SPEED adopted solid carbonized plates months ago. SPEED'S new manufacturing equipment is the very latest and best. SPEED raw materials are A1.

Is It A Well-Advertised Line?

SPEED Tubes are advertised in full pages in the Saturday Evening Post . . . in all the leading trade and fan radio magazines . . . in great newspapers from coast to coast . . . with direct mail, counter cards, window displays and every dealer help.

Is It A Profit Line?

SPEED'S Quality makes for satisfaction, sales and resales. SPEED'S return policy is most liberal. SPEED'S discounts are right. SPEED is the tube for profit.

REMEMBER 100,000,000 TUBES THIS YEAR!

Get Your Share—Handle The Right Line

Franchises Are Going Fast

As we say in consumer advertising

"STEP RIGHT UP AND CALL FOR SPEED"

LIKE A SHIP *without* A RUDDER . . .

the "control" is gone . . . not powerless . . . but rudderless . . . no longer does she respond to the helmsman.

Your radio without a good resistance device like the CENTRALAB resistance, doesn't respond to the slightest touch of the "helmsman."

You steer your way through the ether by fits and starts . . . augmenting the "static storms" by internal "self-inflicted" noises.

Better be sure that your radio is "Centralab" equipped.

This shows the exclusive rocking disc construction of Centralab volume control. "R" is the resistance. Contact disc "D" has only a rocking action on the resistance. Pressure arm "P" together with shaft and bushing is fully insulated.

The tailor uses the same principle as Centralab. He does not want to ruin the garment by placing the iron on it so he places a cloth in between. Centralab controls cannot ruin the resistance because the rocking disc is in between the pressure arm and the resistance.

This is the action of the usual wire wound control after it has been in use for some time . . . like dragging a stick over a cobblestone pavement.

"Volume Control Voltage Controls & Their Uses"

is the title of an interesting pamphlet that is yours for the asking.

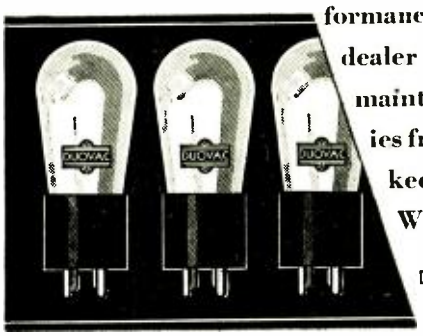
Centralab

CENTRAL RADIO LABORATORIES

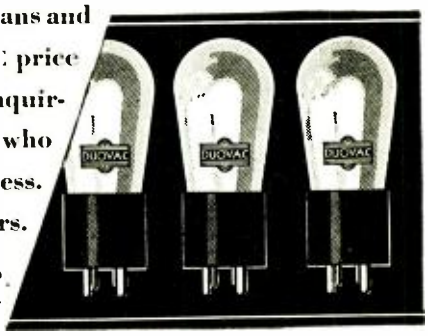
20 Keefe Ave. Milwaukee, Wis.

COMPARE
COMPARE
COMPARE
COMPARE

WHEN we say that DUOVAC Precision Radio Tubes are made by a new and better process we are ready to back up our statements with facts. And the outstanding fact is that DUOVACS are made in the world's most modern radio tube plant—representing the last word in tube-making machinery. Every piece of apparatus is NEW. Much of it was specially designed. All of it was planned with one object:—the production by precision methods, of radio tubes of absolute uniformity. DUOVAC uniformity sets a new standard of excellence in radio tubes. We invite comparison of the DUOVAC plant, of DUOVAC performance, of DUOVAC advertising plans and dealer cooperation and of DUOVAC price maintenance policy. We invite inquiries from distributors and dealers who keep in step with radio progress. Write today for particulars.



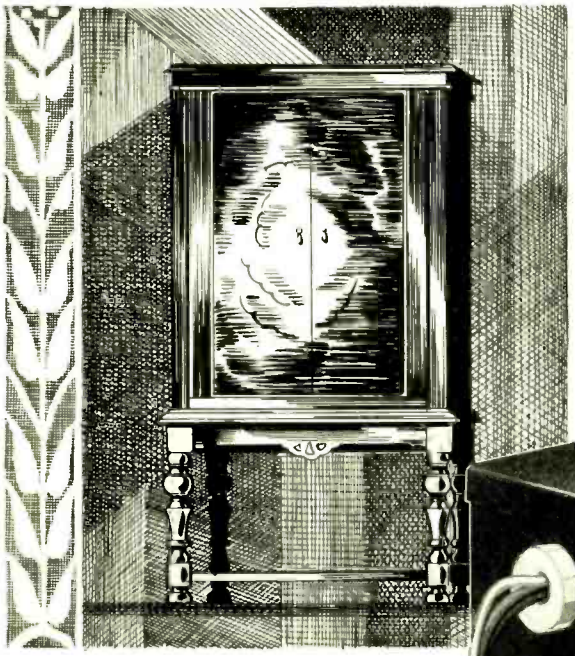
DUOVAC RADIO TUBE CORP.
360 FURMAN STREET
BROOKLYN, NEW YORK



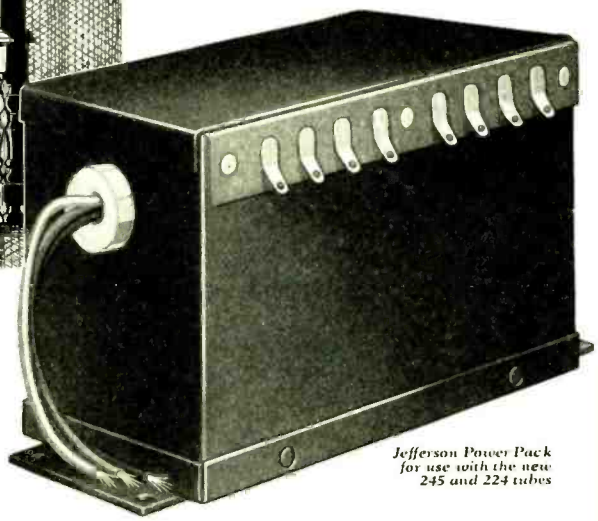
DUOVAC

The *Precision Radio Tube

*PRECISION—The quality of being precise, strictly accurate—identical.—Standard Dictionary



PERFECTED for your new power tube set . . . . .



Jefferson Power Pack for use with the new 245 and 224 tubes

Engineering Co-operation

Jefferson engineers, pioneers in the field of transformer development, are ready to assist in solving your transformer and choke problems. In our own modern research laboratories—or working with your engineers—Jefferson engineers can offer valuable aid in the design of your audio and power equipment.

Protection in Peak Periods

The Jefferson world-wide reputation for quality transformers and integrity in trade relations, combined with tremendous production capacity, is your assurance of a reliable source of supply. During last year's peak season, although besieged with outside business, not one of our customers was forced to seek another source of supply. Deliveries were made promptly under all conditions — production schedules protected.

Jefferson . . . . Transformers and Chokes

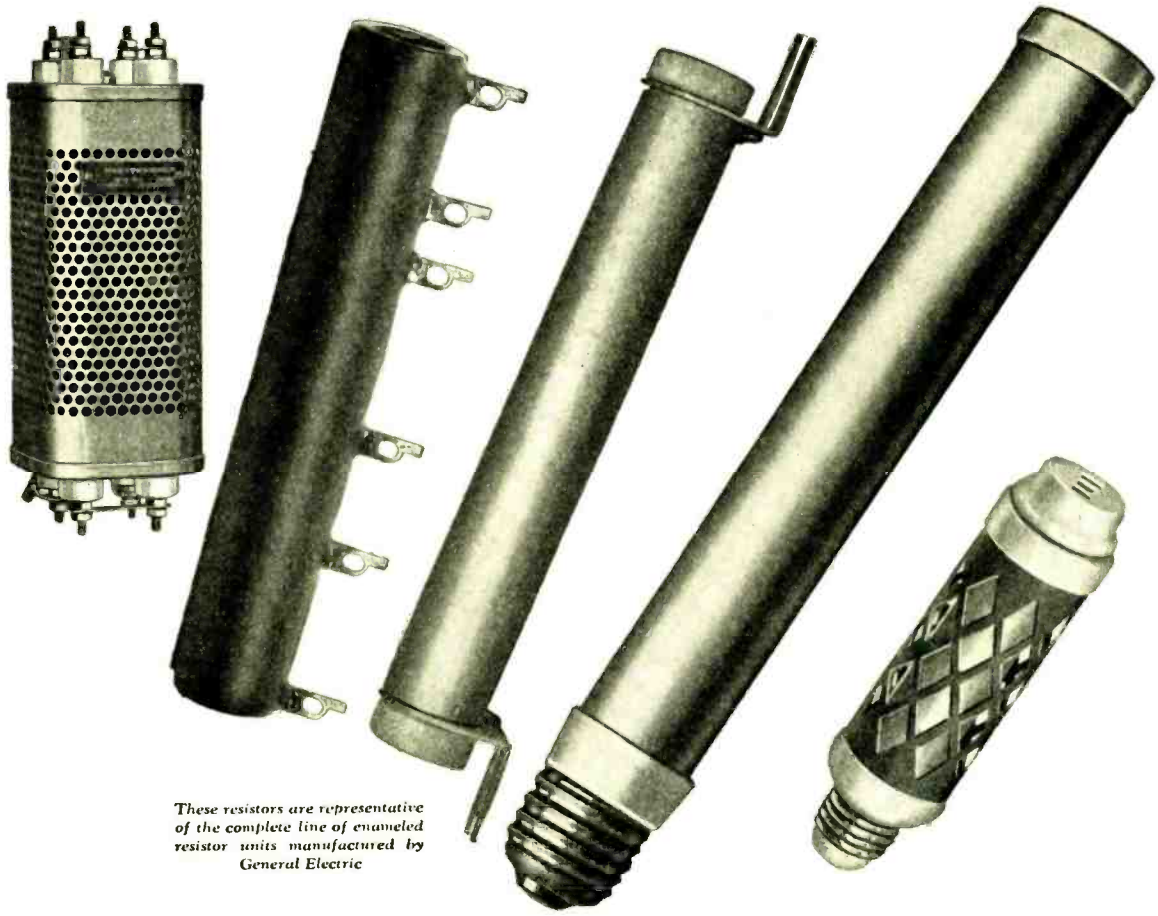
Foreseeing the present trend toward the use of new power tubes in receiving sets, Jefferson engineers have perfected a special transformer—and a wide choice of choke units—for coordinate use with the new 245 power tube and the 224 shield grid tube. Likewise, Jefferson audio transformers have been improved in design to make use of all the potentialities of these new tubes. Complete electrical specifications and quotations will be furnished reliable set manufacturers on request.

JEFFERSON ELECTRIC COMPANY
1592 South Laflin Street Chicago, Illinois

JEFFERSON

AUDIO and POWER TRANSFORMERS and CHOKES

(9481)



These resistors are representative of the complete line of enameled resistor units manufactured by General Electric

Permanent Resistance

With positive connections between conductors and leads—no clamp connections being employed—and with a low temperature coefficient, these G-E Type CR9006 resistor units are remarkable for their permanence. They are moisture-proof, flame-proof, and acid-resistant.

The conductors are embedded in enamel so strong that the resistors are not damaged by normal handling.

If you are confronted with conditions requiring resistors of these characteristics, it will pay you to ask the nearest G-E office for complete details.

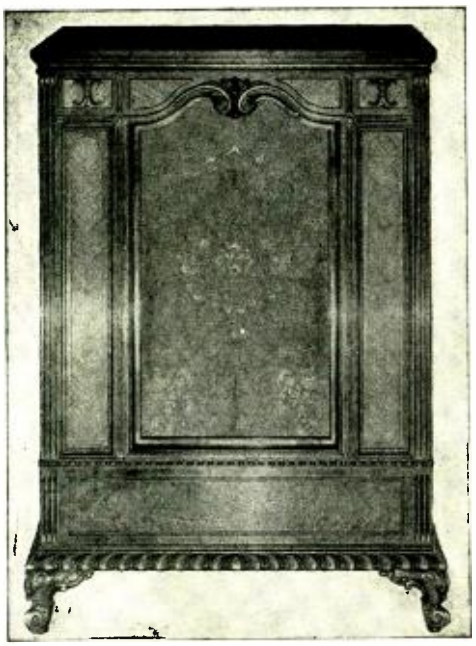
301-44

JOIN US IN THE GENERAL ELECTRIC HOUR, BROADCAST EVERY SATURDAY AT 9 P.M., E.S.T. ON A NATION-WIDE N.B.C. NETWORK

GENERAL ELECTRIC

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y., SALES OFFICES IN PRINCIPAL CITIES

THE LEADERS STANDARDIZE ON DURHAM RESISTANCES



Kolster Model K-45 using Electric Tuning and Remote Control and housed in a cabinet of extraordinary beauty.

KOLSTER

. . . another leader who standardizes on DURHAM RESISTORS and POWEROHMS

KOLSTER!—another great name in radio—another great leader who has set the pace in quality receivers for many years—another leader who has long recognized the superiority of the metallized principle upon which DURHAM Resistors and Powerohms are manufactured. Yes, KOLSTER is another of America's quality receivers which standardizes on Durham resistance units . . . because they are absolutely unfailing both in accuracy and uniformity. DURHAMS may cost a slight fraction more than average resistances, but their aid to quality reception is well worth the slight difference in price. Furthermore, their presence in a receiver is a guide to the quality of other parts. Write for engineering data sheets, samples for testing and complete literature. Please state ratings in which you are interested.

DURHAM Metallized RESISTORS and POWEROHMS are available for every practical resistance purpose in radio and television circuits, 500 to 200,000 ohms in power types; 1 to 100 Megohms in resistor types; ratings for all limited power requirements; standard, pigtail or special tips.

DURHAM METALLIZED

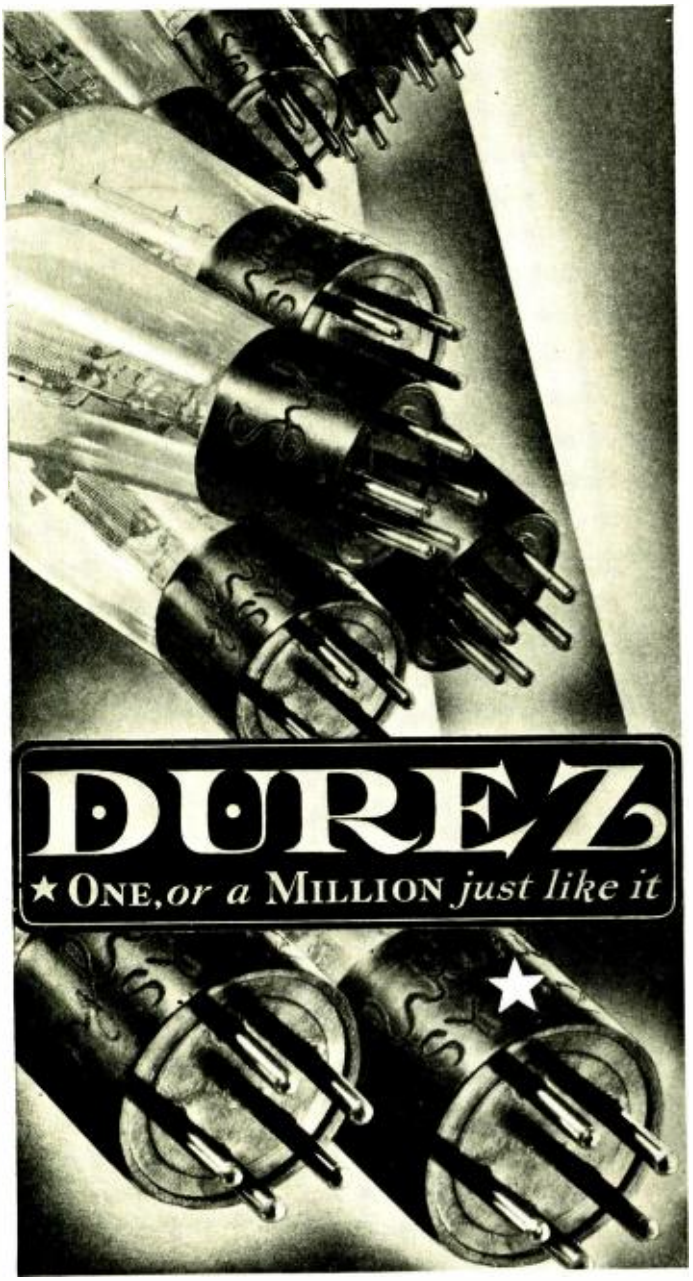
RESISTORS & POWEROHMS

INTERNATIONAL RESISTANCE CO.

2006 Chestnut Street, Philadelphia, Pa.

A better base—a better tube...

make yours with DUREZ!



Change! There's the radio industry in a word! In a month, the new method may be outworn. With a single shipment, the material you thought more than satisfactory proves inadequate. . . . In their search for the best, many radio manufacturers have abandoned other materials, and switched to Durez—with uniform success!

The Sylvania Products Company of Emporium, Pa., known over the country through their effective broadcasting as makers of Sylvania Radio Tubes, is one concern that changed for the better. The toughness of Durez, its durability, its workability and efficiency were carefully analyzed. They probed its economy under modern production methods. . . . The inquiry proved Durez superior in every way.

Durez has remarkable insulating qualities. It is tough, non-brittle. Hard as flint. Resists acids, heat, moisture, gases, alkalines. Durez is simple and easy to mold. One operation, and the part is complete—without any burnishing, polishing, or tooling whatever. Studs may be inserted; holes, threads, intricate designing cared for in the one molding process!

Perhaps you're having trouble in the basing operation with material you now use. Is it strong enough? Can it resist destructive agencies sufficiently? Is it economical? And—this is important from a competitive standpoint—is it *modern?* Durez, with its wide range of beautiful colors, will brighten up your product, freshen it, modernize it—economically!

Tell us what you make. We'll tell you how to make it better—with Durez. General Plastics, Inc., 105 Walck Road, North Tonawanda, N. Y. Also New York, Chicago, San Francisco, Los Angeles.

☼

Write for this free booklet, "Do It With Durez." Contains complete information about Durez—physical and dielectric properties, color ranges, and possible applications.

Tone quality is the yardstick

CONSTANTLY the objective of the radio industry has been better *tone quality*. For successive years all known features of the radio set have been improved and exploited, but today *tone quality* definitely measures the success of any radio receiver. The industry's success now rests on *tone quality* and its future promise of progress rests on *tone quality*.

Many of the industry's leading manufacturers depend for their superiority on the tone quality of Jensen Electro-Dynamic Speakers.

In each case the laboratories of these manufacturers, in collaboration with Peter L. Jensen, adapted these speakers to their specific needs. Dealers who sell these sets pin their faith in making the sale on the superior tone quality and shrewd dealers insist on sets equipped with Jensen Electro-Dynamic Speakers.

Write us for the names of Jensen equipped sets and for information regarding the Jensen Auditorium, Concert and Standard Electro-Dynamic Speakers. Prices from $25 to $100 (including both units and cabinet models). Attractive trade discounts.

Jensen
ELECTRO-DYNAMIC SPEAKERS
LICENSED UNDER LEKTOPHONE PATENTS

JENSEN RADIO MANUFACTURING CO. · 6601 S. Laramie Ave., Chicago, Ill. · 212 Ninth St., Oakland, Cal.

Every master musician knows—

Let any renowned concert artist become careless . . . let a single sour note creep into one of his golden-toned offerings . . . and the world would tell him about it. People who didn't know a note of music would inform him of the discord in no uncertain terms.

For the world is getting tone-conscious. It may not know *why* but it knows *whether* music is right. Every audience today is a discriminating audience.

Likewise the radio receiver which meets public approval today must satisfy keen, discriminating ears. A few cents "shaved" on transformers only means a handicap to your selling organization. The radio buying public now judges *price* by *tone quality.*

Sangamo "A" Line Transformers are built for the custom set maker or manufacturer who wants a "tone" advantage against competition and who is willing to make production economies anywhere but on the "audio end."

The cost is slightly higher but is more than offset by the increased salability of the receiver.

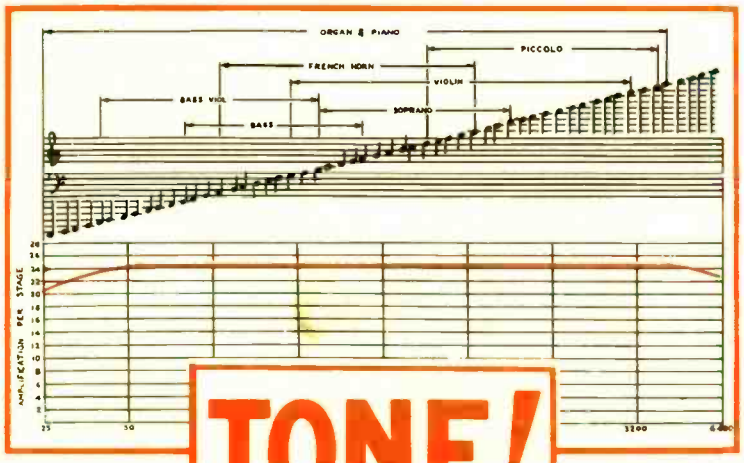
SANGAMO ELECTRIC CO.

SPRINGFIELD, ILLINOIS, U. S. A.

Manufacturers of Precision Electrical Apparatus for 30 Years

SANGAMO

See reverse side



TONE!

Curve of Type "A" Sangamo Straight Audio Transformer showing uniformity of amplification at all audible frequencies.

"A" Line Transformers

Type A straight audio amplification. List price..... $10.00

Type B Push-pull Input Transformer for all tubes. List price..... $12.00

Type C-171 Push-pull Output, for 171 or 250 type power tubes with cone speaker. List price. $12.00

Type D-210, same as C except for 210 and 112 power tubes. List price... $12.00

Type H-171, Push-pull Output for 171 or 250 power tubes for Dynamic Speaker. List price..... $12.00

Type G-210, same as type H except for 210 and 112 tubes. List price. $12.00

Type F Plate Impedance for use as a choke to prevent oscillation and for impedance coupled amplifiers. List price..... $5.00

Unusual facilities for furnishing transformers with or without cases ready for mounting and quick assembly with the receiver. Prices on application.

PIN THIS TO YOUR LETTERHEAD AND MAIL

SANGAMO ELECTRIC CO.
SPRINGFIELD, ILLINOIS, U. S. A., DEPT. 103

SANGAMO

I am interested in engineering data regarding your transformers and condensers.

SANGAMO Condensers

No item can cost so little and cause so much trouble in a receiver as a fixed condenser. This fact is especially appreciated by the manufacturer with an eye to the service problem. Likewise, experience has shown that a fixed condenser is not necessarily a good condenser just because it is molded in Bakelite.

The immunity to thermal changes and to mechanical damage rendered by the Bakelite enclosure is supplemented in Sangamo Condensers by accurate rating and sound construction of the mica condenser within the Bakelite casting.

The standard line of Sangamo Fixed Condensers leaves the factory tested to maximum variation of 10%. Also furnished with closer ratings and in high voltage types.

NEW! Condensers *for* Manufacturers

While the Sangamo Condensers shown *at the top of the page* have always been popular with manufacturers, there has been a demand for condensers of the same quality, of a size and shape more suitable for factory set design and production. For manufacturers' use only, we have designed the Sangamo "Illini." The connecting lugs may be bent to any position required without impairing the condenser.

Prices on request

IMPRESSIONS *and* EXPRESSIONS

By

AUSTIN C. LESCARBOURA

Will There Be a Tube Shortage?

As the radio industry swings into its peak season, there is considerable concern among the jobbing and retailing fraternity with regard to the supply of vacuum tubes. Will there be a tube shortage is the question being asked on all sides.

Personally, we believe there will be a tube shortage in certain types, due not only to an unforeseen demand, not only to the limited production caused by certain difficulties, but mainly due to inferior tubes which will soon be spotted and virtually blacklisted.

Even at this early date, long before the market gets into full swing, the commonplace —27 or better type a-c. tube is becoming scarce—at least good tubes of this type, with a satisfactory mimimum of hum. The —24 or a-c. screen-grid tube is none too plentiful, and large screen-grid set manufacturers are tying up every possible source of supply so as to have ample tubes for their set deliveries. The —45 is another tube which is none too plentiful just now.

We believe there will be a shortage of *good tubes*, for the present radio sets are far more critical in the matter of tubes than were the sets of yesterday. Hum factor is receiving far more critical consideration than six months ago, with the result that many a-c. heater tubes heretofore considered satisfactory, are now being barred by set manufacturers and the trade, thereby causing a shortage for a type of which there should be ample tubes.

What the industry needs now and for the next few months is *quality* more than quantity in the matter of vacuum tubes to meet requirements. There are too few good tubes and too many bad tubes. And the demand exceeds the supply in the matter of quality tubes.

For the Sake of a Few Pennies!

Among the several inglorious wrecks that are strewn along the pathway of radio progress, there is no sadder than the —99 type dry battery tube. Here was a practicable idea which, properly exploited, would have provided a successful radio set for the farm and rural home. Instead, the manufacturers sought to economize in every possible way in the production of this tube, to the end that it became truly cheap in worth as well as in price.

The real inside story of the —99 tube is one of inadequate filament on the one hand, and excessive residual gas on the other. The minute thoriated tungsten employed in that tube had such a limited amount of active material to begin with, that any remaining gas following exhausting and seal-off would soon neutralize same and render the tube inoperative. And that is precisely what happened in 9 out of 10 of these tubes.

Now on the other hand, if molybdenum had been used in place of the gassy nickel for the plates and grids, as well as support wires, the residual gas would have been reduced to an absolute minimum, and the limited amount of thorium or active material would be permitted to do its work. It might cost anywhere from 15 to 25 cents to replace the nickel parts with molybdenum parts. And yet the tube manufacturers, bent on competing on a price rather than a quality basis, never made use of molybdenum. We have seen —99 tubes made with molybdenum parts perform satisfactorily well in excess of a thousand hours, with no apparent falling off of emission.

That Belated Television Debut

From all talk and little action, television affairs seem to have shifted during the past twelve months to all action and little talk. And yet much is going on these days behind a cloak of modesty. In fact, we venture to predict that practical television equipment for average home use will be on the market before Christmas, together with a satisfactory television broadcasting service covering at least the eastern portion of the United States.

Television workers have found the problems far beyond their expectations. Those who predicted the broadcasting of news events, complete plays, and combination sight and sound programs, have long since come to know the rashness of their claims. Nevertheless, it is generally believed that the simplest kind of television pictures, even if no more than understandable silhouette action, will be sufficient for the inauguration of the television era. Serious television workers are of the opinion that the sooner television is placed on the market, the quicker it will develop. Furthermore, there is little use in trying to evolve the perfect system in the laboratory, for, as with broadcasting, the art is much too complicated for the restricted efforts of any man or group of men to solve. Rather it is a question of universal cooperation, and the art must become a natural evolution in actual practice.

Don't think that television is dead. Far from it, television is simply working rather than talking. And within the next ninety days, we shall witness the debut of everyday television, or the transplanting of an experiment from the laboratory to everyday conditions.

How About Short Waves?

Is the radio industry paying sufficient attention to short-wave reception and its possibilities? Personally, we think not. At any rate, here is a subject worthy of serious consideration and discussion.

During the past few years, rapid strides have been made in short-wave radio telephony. There was a time not so long ago when the short-wave spectrum was confined wholly to radio telegraph traffic, but today there are many broadcast relay services in operation, not to overlook the interesting amateur radio telephone conversations. In other words, there is ample material to listen to, even for one without the slightest knowledge of the telegraph code.

The amazing feature about short-wave reception is, of course, the distance spanned. Stations a thousand miles away come in pounding even during broad daylight. A simple four-tube, short-wave receiver brings in the British and Dutch short-wave broadcasting programs for the listener-in located in almost any part of the United States. And static seems to have very little effect on short-wave signals, for even when normal broadcasting is impossible due to an electrical storm a few miles away, the short-wave signals come pounding across the ocean with practically no interference.

Now it is our opinion that radio manufacturers are overlooking a good bet in short-wave radio reception. We believe that a really good set with brand new engineering—something beyond the present screen-grid r-f. amplifier, regenerative detector, and two audio stages—would go big.

The Grid-Suppressor Circuit†

Discussion of Regenerative Amplifier from Viewpoint of Transmission and Oscillation Characteristic

*By Sylvan Harris**

ON account of the complicated phenomena encountered in regenerative amplifiers such as the grid-suppressor type, any rigid theory of their operation must necessarily be quite involved, unless only a single stage of the amplifier were under consideration. The cascading of several stages, however, leads to complications due to the interaction of these stages, the causes of which are often quite obscure. A rational explanation of the mechanism of the amplifier may, however, be secured by considering the amplifier in the light of two characteristics, one of which *determines* the amplification, and other of which *limits* it. The former might be termed the *transmission characteristic* and the latter the *oscillation characteristic*.

The transmission characteristic is represented by the well-known formula

$$K = \omega L_2 \left[\frac{\left(\frac{\omega M}{r_p}\right)\mu}{r_2 + \frac{\omega^2 M^2}{r_p}} \right] \qquad (1)$$

in which the symbols have the customary meanings. The amplification of any amplifier stage may be calculated by means of this formula provided the resistance component of the tube is assumed to be removed from the tube and incorporated in R_2, and the reactance component of the tube impedance is considered as an additional element of the tuned circuit. When this is done the tube can be considered truly as a potentially operated device.

Referring to Fig. 1A, R is the grid-suppressor resistance; the input impedance of the tube can be represented[1] by a capacity c_g in series with a resistance r_g. The voltage impressed upon the input of the tube is the potential difference between G and F. The parallel circuit formed by R, r_g and c_g in parallel with C can be considered equivalent to a simple series circuit such as shown in Fig. 1B, between G and F. The voltage which is amplified by the tube is then the P. D. between G and F of Fig. 1B. The tube is now considered as taking no power from the tuned circuit.

The impedance GF (Fig. 1A) is given by

$$Z' = R' + j\,\frac{1}{\omega C'} \qquad (2)$$

$$R' = \frac{R + r_g}{(R + r_g)^2\,\omega^2\,C^2 + \left(1 + \frac{C}{c_g}\right)^2} \qquad (3)$$

$$C' = \frac{(c_g + C)^2 + (R + r_g)^2\,\omega^2\,c_g^2\,C^2}{(c_g + C) + (R + r_g)^2\,\omega^2\,c_g^2\,C} \qquad (4)$$

In equation (4) the terms involving the resistances are small compared with the others, so that C′ is approximately $C + c_g$. The resistance R′ is the resistance introduced into the tuned circuit by the input impedance of the tube and by the grid-suppressor. In the expression for R′ the first term of the denominator may be neglected, so that R′ is approximately

$$R' = \frac{R + r_g}{\left(1 + \frac{C}{c_g}\right)^2} \qquad (5)$$

The value of r_g for an inductive load in the plate circuit is given by Miller as $-L_p/\mu\ c_{gp}/r_p\ (c_{gp} + c_{gp})^2$ and $-L_p\mu c_{gp}/r_p\ (c_{gf} + c_{gp})^2$ and c_g is given by $c_{gf} + c_{gp}$ both of which are independent of frequency.

With this information we can now determine the amplification equation. The secondary current is given by

$$I_2 = \frac{\left(\frac{\omega M}{r_p}\right)\mu E_g}{r_2 + \frac{R + r_g}{\left(1 + \frac{C}{c_g}\right)^2} + \frac{\omega^2 M^2}{r_p}} \qquad (6)$$

neglecting the primary circuit reactance. The denominator of this fraction is the resistance of the coupled circuit referred to the secondary. It is seen that in addition to the resistance of the coil and the resistance reflected from the primary circuit, there is a term which depends upon the values of the grid-suppressor and the input consistants of the tube.

Now, the voltage drop between G and F of Fig. 1B is the product of the impedance of that leg of the network and the secondary current I_2.

Performing this operation and putting $\omega L_2 = 1/\omega\ (C + c_g)$ there is obtained

$$K = \frac{Z_{GF}\, I_2}{E_g} \qquad (7)$$

$$= \frac{\left(\frac{\omega M}{r_p}\right)\mu}{r_2 + \frac{\omega^2 M^2}{r_p} + \frac{R + r_g}{\left(1 + \frac{C}{c_g}\right)^2}} \times \omega L_2 \times \sqrt{\omega^2 \left[\frac{R + r_g}{\left(1 + \frac{C}{c_g}\right)^2}\right]^2 (C + c_g)^2 + 1}$$

The first term under the radical is small compared with unity, so that the voltage amplification per stage is given, very nearly, by

$$K = \frac{\left(\frac{\omega M}{r_p}\right)\mu\,\omega L_2}{r_2 + \frac{\omega^2 M^2}{r_2} + \frac{R + r_g}{\left(1 + \frac{C}{c_g}\right)}} \qquad (8)$$

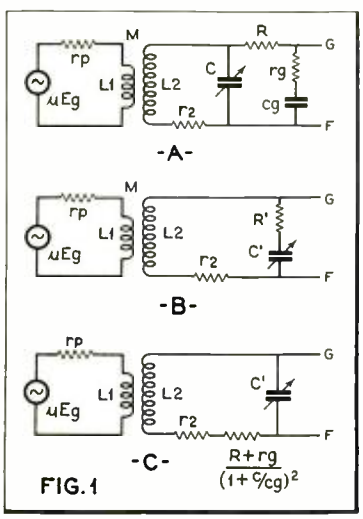
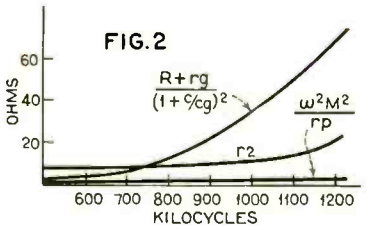


FIG. 1

† *Delivered before the Radio Club of America.*

* *Engineering Laboratories, Kolster Radio Corp.*

[1] *J. M. Miller, S. 351, Bureau of Standards.*

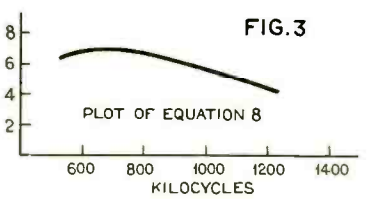


This is the amplification equation of the circuit of Fig.1C, which may, therefore, be regarded as the approximately equivalent circuit of the amplifier. The manner in which the three components of the equivalent resistance vary with frequency is shown in Fig. 2, which has been calculated for a typical case. Likewise, in Fig. 3, there is shown a curve of voltage amplification, calculated by equation (8).

The effect of the grid-suppressor and the input impedance of the tube is therefore seen to be equivalent to introducing a rather large resistance into the tuned circuit, thus reducing the amplification considerably, even at low frequencies. The amplification increases with frequency up to a point beyond which the third resistance term in equation (8) increases so rapidly that the amplification begins to decrease. The frequency at which the amplification is maximum depends upon the values of the various circuit elements.

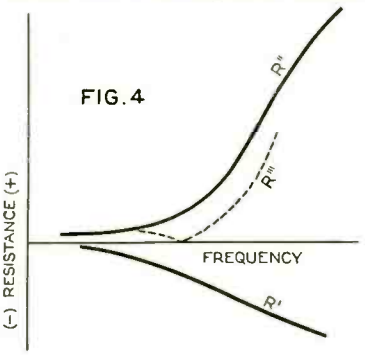
An inspection of Fig. 2 shows that, for values of grid-suppressor commonly used, the "true" resistance of the tuned circuit plays an important part only at the lower frequencies, and that at 1500 kc. the resistance due to the grid-suppressor and the tube impedance may be as much as four or five times the "true" tuned circuit resistance. The reflected resistance, likewise, is small, and at high frequencies it may even be omitted from consideration in most cases.

It is clear, from what has gone before, that unless something were done to neutralize the greater part of this resistance, indicated by the denominator of equation (8), very little amplification would be obtained, and the selectivity would certainly fall far short of commercial requirements. The resistance is partially neutralized by the feedback *within* each stage, (i.e., from plate to grid of the same stage), as indicated by the fact that r_g is intrinsically negative; but this is not sufficient since r_g is of the order of only several hundred ohms (negative), while R may be from four to ten times as great.



When several stages are connected in cascade, a feedback current is established from *stage to stage*, which assists in neutralizing the circuit resistance. It is this stage to stage feedback which mainly determines the "oscillation characteristic" and limits the possible amplification. The plates and grids are coupled through a capacity c_{gp}, and were it not for the transformers, these capacities would all be in series. The coupling capacity between a given stage and those preceding it would then decrease arithmetically on passing from stage to stage, whereas the amplification from stage to stage increases geometrically. The power fed back would be attenuated more slowly than a signal applied to the input would be amplified. Consequently, on passing from stage to stage, a stage would eventually be reached in which the power fed back would be greater than the input circuit losses, and self-oscillation would result. From this it follows that the amplification of any stage cannot exceed the attenuation per stage of the feedback current.

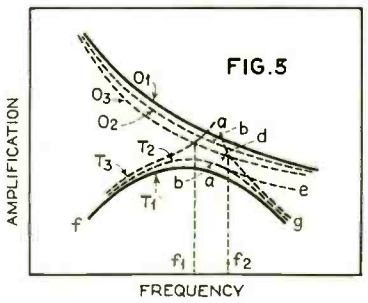
This manner of viewing the problem has been applied by A. W. Hull to



the determination of the maximum amplification obtainable in a tuned impedance coupled amplifier employing screen-grid tubes. However, the situation is considerably more complicated in circuits employing tubes which have appreciable internal capacities, since any or all of the stages may be sources of feedback currents; and furthermore, the phases of the currents will vary not only with frequency, but also from point to point in the circuits. However, it is known that the limiting amplification decreases with frequency in a manner somewhat as indicated by the "O" curves of Fig. 5.

The overall feedback increases steadily with frequency, having the effect of introducing into the tuned circuits a negative resistance, as indicated by the curve R' of Fig. 4. In that illustration, R'' represents the total circuit resistance before cascading (i.e., the denominator of equation (8), or the sum of the curves of Fig. 2), and R''' is the resulting resistance after cascading.

In Fig. 5, the "T" curve is the "transmission characteristic:" this must not intersect the "O" curve if self-oscilla-



tion is to be avoided. The separation between the curves is the *margin of stability*. a-a represents the margin of stability of an amplifier having the characteristics O_1 and T_1. If the grid-suppressor is reduced permitting an increase of feedback, O_1 is lowered to O_2. The regenerative effect is now greater and, due to the apparent reduction of circuit resistance, T_1 becomes T_2. The margin of stability is now b-b. Upon further reducing the grid-suppressor the new amplification curve T_3 intersects the new oscillation characteristic O_3. The margin of stability is now zero over a portion of the tuning range, and oscillations occur between the frequencies f_1 and f_2. At f and g, Fig. 5, the regenerative effect is small, therefore, changes made in the attenuation of the feedback, such as reducing the grid-suppressor, mainly effect the portion of the curve near the peak. This is illustrated in Fig. 6, which shows amplification curves taken on an amplifier for various values of grid-suppressor. The circuit constants were adjusted to make the peak occur near the middle of the tuning range.

The peak of the curve may be made to occur anywhere within the tuning range or may even be made to occur outside of the range. As Fig. 6 indicates, reducing the grid-suppressor moves the peak slightly toward the higher frequencies. This effect is small and is of little value in design. The initial effect of cascading, however, shifts the peak considerably to a higher frequency, as can be seen by comparing Figs. 3 and 6. Increasing the mutual inductance of the transformers moves the peak toward the lower frequencies and, as can be seen by equation (8) increases the amplification as well. This may, however, require an increase of grid-suppressor in order to maintain stability, depending upon the initial margin of stability. It is possible to keep the net circuit resistance low (i.e., the R''' curve of Fig. 4), by employing loose coupling and at the same time keeping the grid-suppressor small, but the amplification will also be small. By the time the coupling has been loosened sufficiently to afford the required low resistance (or the required selectivity) the amplification will have either fallen below the commercial requirement, or the amplifier will have been made unstable in order to maintain this amplification. On the other hand, it is possible to employ a substantial coup-

ling and obtain considerable amplification, and, at the same time, obtain the required selectivity by properly adjusting the regenerative effect throughout the tuning range.

There are several means of increasing the amplification at the higher frequencies, other than moving the peak of the curve to that region. One means is to shunt the grid-suppressor by a small fixed condenser, reducing the attenuation of the feedback as the frequency increases. The effect of such an arrangement is shown in Fig. 7. In amplifiers which are unshielded the effect may be created by the capacity between the transformers, or between the stators of the tuning condensers, or by a small amount of inductive coupling between the stages.

It is a simple matter to compute the amplification of a single stage without considering the regenerative effects produced by cascading, but this by itself would be of no value. It was necessary therefore, in order to test the theory, to devise a method of measuring the regenerative effect. An agreement between the amplification curve obtained experimentally and the computed curve would then afford simultaneous proof of the validity of both the theory of operation of the amplifier and of the method of measurement.

The method used for measuring the voltage amplification was the usual one of impressing at the input of the amplifier a known r-f. voltage (obtained as a voltage drop in a small resistor) and measuring the output voltage with a calibrated vacuum tube voltmeter. The detector tube of the radio receiver was used as the V. T. V. M. The ratio of the two voltages then gave the voltage amplification.

In any given stage of the amplifier the voltage amplification is proportional to the voltage drop in C, Fig. 1c, and hence to the current flowing through it. This current is given by

$$I'_2 = \frac{\left(\frac{\omega M}{r_p}\right) \mu E_g}{R_2} \qquad (9)$$

where R_2 is the apparent value of the total circuit resistance, including the effects of cascading. Now, if without making any other changes, a small resistance be added to the circuit, the secondary current becomes

$$I''_2 = \frac{\left(\frac{\omega M}{r_p}\right) \mu E_g}{R_2 + r} \qquad (10)$$

The ratio of these two equations furnishes

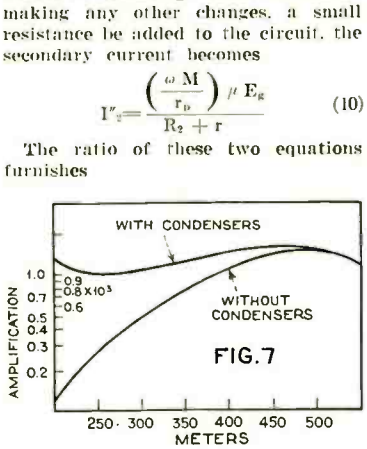


FIG.7

$$R_2 = \frac{r}{\left(\frac{I'_2}{I''_2}\right) - 1} = \frac{r}{\left(\frac{K'}{K''}\right) - 1} \qquad (11)$$

in which K′ and K″ are the voltage amplifications, as measured, before and after inserting the resistance r. The resistance R_2 is the sum of four components, viz.,

$$R_2 = r_2 + \frac{R + r_g}{\left(1 + \frac{C}{c_g}\right)^2} + R_3 + \frac{\omega^2 M^2}{r_p} \qquad (12)$$

in which R_3 is the negative resistance added to the circuit due to the feedback resulting from cascading the stages. This resistance may now be substituted for the denominator of equation (8) and the amplification of the stage computed.

A set of curves showing the variation of R_2 with wavelength is shown in Fig. 8, for various values of grid-suppressor resistance. It is to be noted that the wavelength at which zero resistance occurs is in agreement with the wavelength at which oscillations occur, as indicated in Fig. 6. Fig. 8, however, applies only to a single stage of the amplifier.

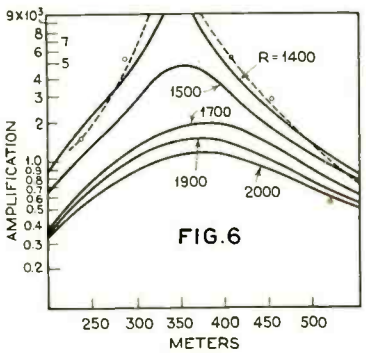


FIG.6

Due to the fact that the feedback originating in the fourth stage can feed back through three stages, and that originating in the third stage can feed back through two stages, and so on, it is clear that the regeneration conditions cannot be the same in all stages.

This is in addition to the fact that the feedback currents vary in their phase relations both with frequency and from point to point in the amplifier. From all this it follows that R_2 will differ from stage to stage despite the fact that the circuit elements in all the stages may be identical. Fig. 9 shows this variation from stage to stage of an experimental amplifier. In computing the amplification, therefore, it is necessary to separately measure R_2 for each stage, and then to separately calculate the amplification for each stage. The overall amplification can then be obtained by multiplying the stages together.

Since the apparent resistance of the circuits, R_2, is a direct measure of the margin of stability, a set of curves such as shown in Fig. 9 or in Fig. 8 is of great value in determining manufacturing tolerances for the supression

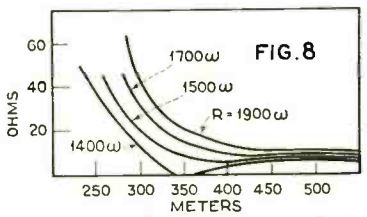


FIG.8

elements. In addition, Fig. 9 indicates that it may sometimes be desirable to design the various stages of the amplifier differently. For example, Fig. 9 indicates that the third stage has the smallest margin of stability. Slight changes in this stage may lead to self-oscillation; a more desirable condition would be obtained by slightly increasing the grid-suppressor of this stage and reducing that in the first or the fourth stage. In this particular amplifier the primary winding of the fourth transformer was "reversed" in order to point out the effect on the regeneration conditions of a phase reversal, giving to the fourth stage the largest margin of stability, whereas it would otherwise have the least.

The final amplification per stage, after cascading, is given by

$$K_f = \frac{\left(\frac{\omega M}{r_p}\right) \mu \omega L_2}{R_2} \qquad (13)$$

Dividing this by equation (8) there is obtained

$$K_r = \frac{r_2 + \frac{\omega^2 M^2}{r_p} + \frac{R + r_g}{(1 + C/c_g)^2}}{R_2} \qquad (14)$$

which gives the regenerative amplification obtained by cascading the stages.

By making measurements of R_2 in each stage, computing K for each stage by equation (13), and then multiplying the stages together, fair agreement with the experimental curve for R = 1400 ohms in Fig. 6 was obtained. This is indicated by the broken curve of Fig. 6.

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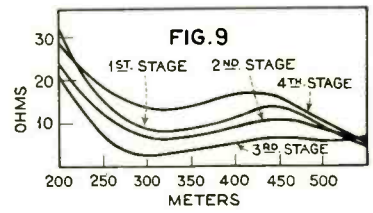


FIG.9

Simplifying "Straight Line" Condenser Design

Some Interesting Data on the Characteristics of S. L. C., S. L. W. and S. L. F. Condensers

By O. C. Roos

IN quite a few articles on S.L.F and S.L.W. condensers, the subject of the plate form is given an air of mystery. The necessity of adapting the condenser to coils of different self-capacitance is ignored. Writers have stated that 50% difference in this latter quantity is negligible and that anyway the coils can be made with less than 10% variation in self-capacitance.

The fact of the matter is that no S. L.F. or S.L.W. condenser can possibly be accurately designed for any resonant circuits without an auxiliary adjustable condenser to furnish a definite total "zero" capacitance, including wiring, tubes and stray condenser flux. There is need for designers to come out flatly with the proof that condenser plate shaping procedure is very easy in all cases. The simple law governing the range of the design curves should, therefore, be given a popular exposition.

Simple Design Method

As the designer of condensers of S.L. calibration, which are accurate to ¼% between 1500 and 500 kc., with widely different types of coil, I should like to point out that this very simple law for the range of the condenser has been developed so that it enables the engineer to set down his greatest and least condenser plate areas in advance, with rigorous exactitude.

It is well known that

$$P^2\,\theta^2 = 4K \qquad (1)$$

is the proper polar equation of a curve whose total "reversed" area is proportional to the reciprocal of θ^2. This is the required condition for S.L.F. design. What is generally overlooked, however, is that this total instantaneous capacitance ("area") in the circuit must always be considered as made up of the capacitance of the S.L.F. condenser plates formed from only a part of it—*plus stray capacitances* corresponding to the rest of the area of the curve. In Fig. 1 a so-called S.L.F. curve is given as a-b-c. It shows too little auxiliary or "zero" capacitance but can be straightened out to give the graph d-e-f by readjusting (increasing) this auxiliary capacitance.

A condenser separation of .025 inch gives 9.02 mmf. per square inch of electrodes in air; hence, it is easy to equate the stray or "zero" capacitance

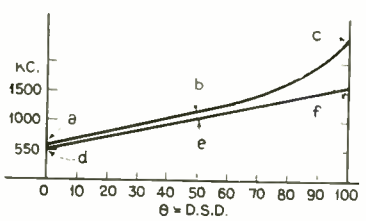


FIG. 1

False and correct straight line frequency calibration.

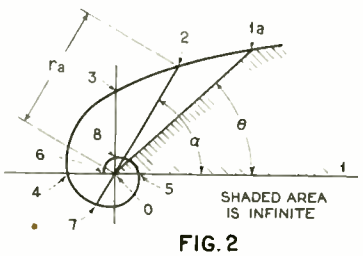


FIG. 2

Determination of S.L.F. plate shape.

C_o to a fictitious "area," A_o. Therefore, we have

$C_o = A/9$ in mmf. where A is given in square inches.

If we define the "graph" 2-4-5 in Fig. 2, giving the total area from $\theta = \infty^*$ to $\theta = \Psi + \alpha$ where α = angle 1-0-2 and Ψ angle of plate rotation, — so that

$$\text{Total area} = A = \frac{K}{(\alpha + \Psi)^2} \qquad (2)$$

we get a simple equation for building up the area in Fig. 2, in terms of the "zero" area, A_o—corresponding to C_o. We thus reach a total of 9 times this "area" by adding the plate-area calculated from equation (2)—which is, of course, 8 times this "zero" area A_o.

Now since the plate area plus the fictitious "area" A_o is proportional to total capacitance, it must operate between an initial angle α and a final angle $\alpha + \Psi$ on the curve in Fig. 2 and we must allow the "zero" capacitance, which is mostly outside of the condenser plates, to equal the capacitance corresponding to the highest frequency covered by the S.L.F. range.

"Reverse" Method

Since in Fig. 2 we have a curve whose area is swept out by the radius vector 0—2 as defined by equation (1), and since this radius vector covers a semi-revolution to reach the position 0—7, we have the usual 180-degree area for a rotor plate—never more. But mathematically the area after an infinite number of turns from $\theta = \theta$ to $\theta = \infty$ is merely finite as given above in equation (2). In fact it is

$$A = \frac{K}{\theta^2} \qquad (3)$$

where K is a constant, and since

$$f \sqrt{A} = D \qquad (4)$$

where D = dial reading and f = frequency in kc., we have

$$f = \frac{D\theta}{K} \qquad (5)$$

$$\text{Hence} \quad df = -\frac{D}{K}\,d\theta \qquad (6)$$

the law of growth along an S.L.F. graph.

The area A, means in this case the whole area of the enmeshed plates plus an equivalent "area" due to wiring, tubes, coils, stray capacitances, etc. It does not mean the area of the condenser plates alone.

Here the interest for the practical engineer is in the simplicity of this "reverse" method. We know that Fig. 2 is the curve given by equation (1). As the radius vector starts from the initial line 0—1 and traces out counterclockwise, the area bounded by the spiral 1a—2—3—4—7—8—6, etc. its angular displacement θ varies from $\theta = 0$ to $\theta = \infty$.

The area traced out from the position $\theta = 0$ to, say, θ = angle 1—0—2 is infinite, but the area traced out from the angular position 1—0—2—to $\theta = \infty$ is perfectly definite, as given by equation (3) above, where θ = angle 1—0—2. Thus all our troubles are solved by measuring areas from $\theta = \infty$ *backwards*. This is a more direct procedure than the usual method and it permits a determination of the wavelength of frequency range to be carried out in advance.

If we imagine a single pair of plates, rotor and stator, we may neglect any consideration of "cut-out" for the time being and it is then easy to show that there is a relation existing between the total angular travel of the rotor, the desired frequency range and that position of the radius

*Designating infinity throughout this article.

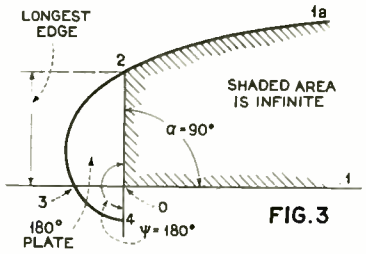


FIG.3

S.L.F. polar curve. fm/fn=3.

vector in Fig. 2 which gives, say, at 0—2, the longest radius to be used in the plate. In other words, if we cut the curve 1a—2—3—7—5 so that the rotor plates have 180 degrees of relative angular motion, we can select the correct initial edge line 7—0—2, in advance for this purpose as follows—noting that the "area" 1—5—0—2—1a can not be used; as it is infinite.

The problem now is to determine the relation between the initial angle 1—0—2, called α, the "angle of rotor travel," called ψ and the frequency range called g. Today, g generally varies between 2 and 4. Assuming $g=4$ we can apply the simple law

$$\alpha = \frac{\Psi}{g-1} \qquad (7)$$

Equation (7) means that, since $\Psi = 180$ degrees and $g=4$, $\alpha = 60$ degrees or the angle 1—0—2 in Fig. 2 must be 60 degrees to determine the longest radius 0—2 of the movable S.L.F. plate.

In Fig. 3 a 180-degree plate is shown with a 3 to 1 frequency range of 500 to 1500 meters (600 to 200 kc.)—hence,

$$\alpha = \Psi/2 = \frac{180}{2} = 90 \text{ degrees for the}$$

longest edge 0—2. In Fig. 4 a 90-degree plate is used with the same frequency range and, therefore, $\alpha = 45$ degrees, to get the longest edge 0—2.

The effect of "cutting-out" the stator plates to give room to the rotor shaft is roughly shown in Fig. 5. The circular stator sector 0—10—9—8—0 has to be made up, at any angular displacement 2—0—3 of the rotor, by an extra area 22—2—3—33—22 added beyond the outline given by the sector of Fig. 3. This added area is shown in Fig. 5 between the curve 2—3 and the new outline 22—33.

It is obvious that the percentage variation in the radii of the former and latter curves is greatest when Θ is greatest, i.e., when the "meshed" area is least (shortest wavelengths) and where we see the liability to error is greatest. Hence, we have the failure of most S.L.F. calibration "curves" at high frequencies, rather than at low.

It must now be obvious that the area of the condenser plate curve in Fig. 2 if taken from $\Theta = \alpha + \Psi$, where the capacitance area is least, to $\Theta = \infty$ where it is zero, covers all of the stray capacitance in the set. To design for this is the secret of an accurate calibration curve.

Just as in S.L.F design the area from $\Theta = \infty$ to $\Theta = C$ is finite, so in S.L.W. design (straight line wavelength) the same rules are found regarding greatest and least areas, *but reckoned from the opposite or initial line.* In other words, the area from $\Theta = 0$ (not $\Theta = \infty$ as in S.L.F work) to $\Theta = \Theta$ for an S.L.W. condenser $= K\Theta^2$ but the law given by equation (7) holds as before, i.e.,

$$\alpha = \frac{\Psi}{g-1}$$

where g = wavelength range = the reversed frequency range.

Here we see that the minimum capacitance C_0 from $\Theta = 0$ to $\Theta = \Theta$ is to be made up partially by stray capacitance effects and is equivalent to a "zero" fictitious area. By careful design the S.L.F and S.L.W errors at highest frequencies and shortest waves respectively, are less than ¼%. With broadcast reception above 2000 kc. this would not be too refined a degree of accuracy. On all S.L.W. condensers also, an adjustable separate vernier of from 20 to 50 mmf. maximum capacitance is necessary.

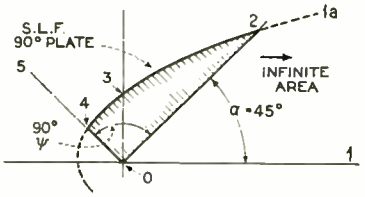


FIG.4

S.L.F. polar curve. f max/f min=3.

Limitations on "Straight Line" Plates Due to Extended Foreign Allocations

Before June 30, 1929, when the allocations adopted by the convention of Prague went into effect, there were about 92 foreign broadcast stations operating between 545 and 2525 meters, or, an average of 21 meters per station "separation." If we work this out in frequency separations, we find each station is "spaced" about 4.5 kc. from its neighbors on the average. This is bad for freedom in detuning; as the "listener-in" is never free from some type of heterodyning unless his set cuts sidebands on account of being a "razor-edge" tuner.

As a matter of fact, this annoyance has now been alleviated to a large extent by putting only 38 foreign broadcasting stations between 550 and 1875 meters or between 160 and 545 kc., giving about 10 kc. average station "frequency spacing" and about 35 meters average wavelength separation. It should be noted, however, that these new allocations are *not* by uniform "frequency spacings"—say, 10 kc.—as in the United States. They jump 44 kc. between two Moscow stations, 20 kc. between a Norway and a Denmark station and 17 kc. between the same Norway station, and one in Switzerland. So the designer cannot use a gear or equivalent reduction ratio to get *all* broadcasting stations *evenly* separated around, say, a 300 degree condenser dial revolution, used in operating an S.L.F. plate. We have not as yet "sold" foreign technicians this idea.

In checking up certain stations in Germany and Switzerland we find 108 meters difference in wavelength and between this same German and a Russian station there is only 5 meters difference in wavelength! So the engineer is "out-of-luck" in looking for an approximately constant value of wavelength station spacing in foreign allocations. This limits the usefulness of the S.L.W. condenser. We see that the S.L.W. condenser has been "scrapped" to all intents and purposes for broadcast reception by the Prague Convention in 1929.

To appreciate the peculiar coincidence in the selection of approximately 548 meters and kc. as the upper wave and lower frequency of the American broadcast range we may examine Figs. 6 and 7 between the points marked A and B on the curves where the abscissae are kc.—the ordinates or wavelengths suddenly start to "jump" at less than 547.7 kc. If the converse relation of wavelength for abscissae is studied, it is obvious that the jump in the ordinates or kc. will take place at the same figure of 547.7 meters. The two curves are meant to emphasize the fact that frequency in kc. and wavelength in meters when multiplied together always equal 300,000 whose square root is approximately 547.7.

The rate at which the ordinates of these curves are increasing for one unit decrease in the dial scale divisions, shown on the horizontal scales as wavelength or frequency, is closely proportional to $-1/(\text{D.S.D.})^2$

In other words, if the frequency at 50 D.S.D. or 500 kc. is decreased by 1 kc. the wavelength will increase a certain amount; since the negative sign in the above expression means that the resulting change is opposite in sense. But if we take 250 kc. and change it to 249 kc.—the change in wavelength will be 4 times as great;

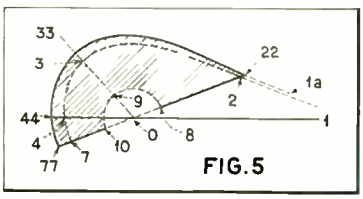


FIG.5

Area needed to compensate "c t. out" on "central" stator S.L. plates.

since 250 is one-half of 500 and its square, 62,500, is one-quarter of the square of 500, or 250,000.

The above ranges show that so long as there were 92 foreign broadcast stations alone which fitted into the wavelength range above 548 meters, they were bound to crowd the dial of an S.L.F. condenser—to 4.5 kc. per station. Thus, in Fig. 7, with S.L.F. abscissae, the wavelengths above 548 meters from A to B will be few, but relatively will waste the balance of the condenser dial space. Hence, when foreign stations are less than 10 kc. apart, we need to add to the S.L.F. plate for Fig. 6 from A to C, an S.L.W. plate for the long waves from A to B in Fig. 7. This latter range replaces the range A to B in Fig. 6.

Station Spacing and Dial Detuning Interval

Let us pause to note that the average experimenter and designer would be inclined to lose interest here in any other form of condenser plate than the S.L.F. on account of the corrective recommendations of the Prague convention in extending the useful broadcast range of the S.L.F. condenser down to 160 kc. It is far better, however, to understand the reasons which have lead certain manufacturers to use combinations of S.L.M. and S.L.C. (straight line capacitance or circular shape) plates than to ignore these principles.

If one has an understanding of the effect of every type of condenser plate on the way in which stations separated by various systems are "logged" on a dial, the whole question of sharpness of tuning or detuning is cleared up. The answers will coordinate the "natural spacing" system of 10 kc. frequency separation between all broadcast stations started in the United States and perhaps 100 kc. in the future for television stations at ultra-high frequencies.

Under certain conditions some convention may, in the future, have a set of stations whose frequencies progress geometrically, i.e., by, say, 102%—station A having 1000 kc.; B, 1020 kc.; C, 1040.2 kc., etc. This would require special condenser plate shapes to get

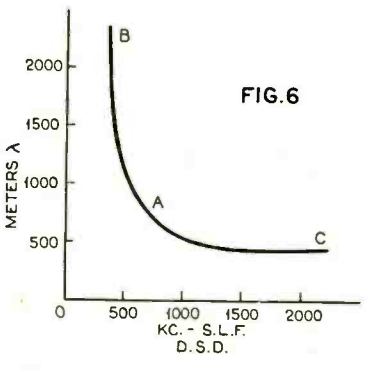


FIG. 6

Illustrating S.L.F. station crowding (A to B)

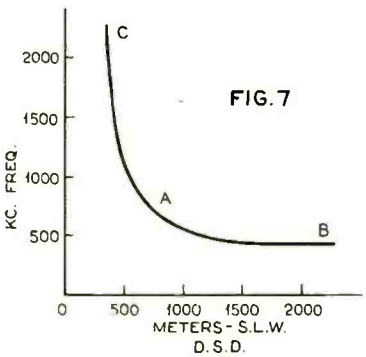


FIG. 7

Illustrating S.L.W. station crowding. (A to C).

the best results in station dial separation and best behavior of the dial detuning interval (D.D.I.). Although we have assumed this interval as that frequency band which reduces at each end the resonant energy to half, whereas in practice it should reduce it to about 10%, yet the laws inherent in the S.L.W. and other plates affect this D.D.I. in exactly the same way no matter which of the two above definitions we prefer.

The decrement of a circuit is defined as the ratio of the D.D.I. centered over the tuning-point under the first definition (having peak resonant energy) to the total or absolute D.S.D. (from true zero) at this tuning point, interpreted as frequency or wavelength. It is half this when S.L.C. plates are used. This is the only reason why the first definition has been used for the D.D.I.

Use of S.L.W. Plates to Prevent Crowding

We have seen why foreign allocations have crowded radio stations on the low frequency part below 548 kc. on an S.L.F. condenser, before the Prague Convention. A precisely similar argument applies to Fig. 7 for the use of an S.L.F. condenser on the short waves. If we use an S.L.W. condenser for this range it is so crowded that we waste most of the dial space, intended for long waves, by relatively large "spacing" of stations thereon. The remedy is to use S.L.F. plates for Fig. 7 between A and C for short waves and S.L.W. plates between A and B for longer waves. The analysis of both Figs. 6 and 7 thus points to one remedy: start the design for short wavelengths with an S.L.F. curve in the plate and finish for long waves with an S.L.W. curve.

To show the general preliminaries of a plate design combining more than one type of curve boundary edge, we may suppose that we are to use 50 degrees for S.L.F. and 130 degrees for S.L.W. It is of no consequence that American broadcast stations can all be handled by an S.L.F. plate—the lower frequencies under 548 kc. are irregularly allocated and, undoubtedly, will show some crowding on an S.L.F. condenser until eventually uniformly spaced 10 kc. apart. However, there are even now regions among the 38 broadcast stations below 548 kc. where an S.L.W. plate will reduce this crowding. To start the above design we will use 1500 to 750 kc. for S.L.F. calibration over 50 D.S.D. This gives 10 kc. per D.S.D. There remains 130 D.S.D. if we have a plate motion of 180 degrees, which we must now use as an S.L.W. plate segment. Let us next assume that 560 meters tunes in at 180 degrees. Then to reach 750 kc. or 400 meters at 50 degrees we have a difference of 160 meters corresponding to 130 degrees or D.S.D. This means a calibration density of 1.23 meters per D.S.D. and is very satisfactory at the short broadcast waves where the stations are separated by about 2 meters, but is not at all convenient at the long broadcast waves where each station has a wave which is longer, by 9 meters on the average, than its neighbor's.

In other words, it would be inadvisable for the civil authorities over radio channels to specify the standard 10-kc. frequency separation "down" the frequency scale indefinitely for any except broadcast stations. They would be wasting "space" on the wavelength scale of Fig. 6 and this waste becomes

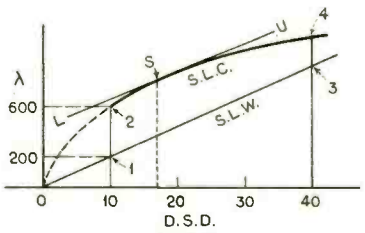


FIG. 8

S.L.C. vs. S.L.W. station "spreading" compared at same dial readings.

more serious, the lower the frequency. Telegraphic or beam-beacons with medium speed signals could be separated by 8 kc. or less.

For instance, if a 10-kc. decrease at 500 kc. gives a certain change in wavelength, the change at half this frequency will be 4 times as great! This means that at 250 kc., or 1200 meters, stations have about 36 meters separation for 10 kc. difference in frequency instead of about 9 meters separation around 500 meters.

It is necessary to have the author-condenser plate to cover the broadcast range. The experimenter who wants to use longer waves can not always use this form. However, for still shorter waves, which are bound to come into future broadcasting plans, the S.L.F. is the best as it has a valuable special property in "detuning" by the same amount, all stations at high frequencies.

Above Broadcast Band

It is necessary to have the authorities "space" transmitter wavelengths above 550 meters at, say, 40 meters

apart for certain telegraph work. This will produce less crowding at tuning points using S.L.W. but the detuning at such points to escape the adjacent station will begin to "overlap" the tuning point of the adjacent station selected for a signal or broadcast. This can be stated in another way rather more concretely.

Suppose that 1 per cent difference in wavelength or frequency is necessary to "tune out" a station at 600 meters. This allows the 610 and 590 meter stations under the above plan to be "tuned out" at 604 and 596 meters by 5-kc. adjustments respectively. Let us again try it at 1200 meters or 250 kc. The absolute frequency difference for detuning adjacent stations is here unchanged in spite of the larger capacitance used in tuning. Now, calling the relative change twice as great as before, we find the following difficulty: our 6 meters necessary difference for detuning stations has become practically 24 meters difference. In other words, when detuning our receiver by 2% or 5 kc. on S.L.F. plates, we have to pass over two adjacent station tuning points both above and below it. If we use an S.L.W. plate instead, even when stations average 40 meters apart, it does not completely avoid the trap but merely spreads the necessary detuning dial movement proportionally to the square of the wavelength of stations.

We can still, however, utilize the S.L.W. dial near the full capacitance position more efficiently for sharp detuning than is possible in the old fashioned S.L.C.—or straight line capacitance—condenser. This has not, however, prevented the addition of an S.L.C. segment in the rotor for spacing the longest wave stations further apart on the dial regardless of the widening of the D.D.I.

Such "spreading" of long-wave stations by very slow changes in capacitance is increasingly necessary beyond 500 meters. The S.L.C. plate is better than S.L.W. for this purpose. The greater the D.S.D. reading—say Θ degrees—the wider is this spreading in favor of the S.L.C. calibration.

Dial Detuning Interval

We must be careful to distinguish on the one hand between mere change of dial reading per unit change of wavelength, frequency or capacitance and, on the other hand, the dial detuning interval. Thus we see that the wavelength change at, say, point S in Fig. 8 is measured by the slope of the tangent LSU at point S but the D.D.I. is not so measured. The dial detuning interval denoted by "D" is, by definition, here taken to be the actual dial movement necessary to cut the highest energy in half, but the former or "natural spacing" is a ratio of two small changes, i. e., of the dial reading change to the "electrical change" usually a frequency change between stations. Since broadcast stations are arranged on a "straight line frequency" graph by the government, we are more interested in the frequency changes per D.S.D. illustrated in Fig. 8.

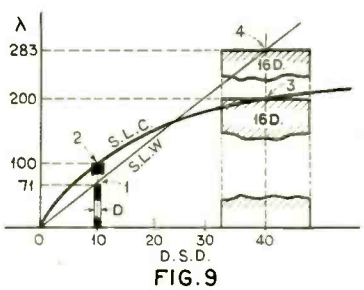


FIG. 9

S.L.C. vs. S.L.W. for detuning intervals.

Sharpness of tuning or detuning may be defined as the reciprocal of the decrement of a circuit at some particular frequency. If, for instance the decrement of a circuit is small, it means that the quantity "D," or double the dial movement from resonance to reduce resonance peak voltage 30%, is small and the sharpness of tuning is correspondingly great.

The above "D" is our old friend the "dial detuning interval" or D.D.I., for short. It may be .1 or .2 of a D.S.D. for sharp tuning, ie., .05 or 1 D.S.D. each side of the resonance point. If it is .1 and we have 10 D.S.D. on an S.L.F. condenser dial with an absolute dial frequency scale, i. e., "true zero" and not a mere "dial" or "masked" zero—the decrement is .1/10, or in frequency change ratio 1/100, assuming 10 kc. per D.S.D. This would also hold true in an S.L.W. condenser with any arbitrary wavelength difference for D.S.D., e. g., 10 meters. A D.D.I. of .1 D.S.D. at a reading of 10 D.S.D. would mean a decrement of 1/100 when judged by wavelengths. This is also true in the case of an S.L.C. condenser but the D.D.I. has to be halved to get the true decrement in this case. Under similar readings to the above two cases, we would obtain a decrement indication of 1/200; since small percentage changes in capacitance correspond to half such percentage changes in frequency or wavelength.

Sharpness of detuning, is related closely to "D", the dial detuning interval itself. It is measured by the reciprocal of the ratio of "D" to the dial reading at the D.S.D. in question. The smaller this ratio is, the sharper is the "detuning."

In an S.L.W. plate the dial change is D.S.D. per kc.—or what is very closely the same thing—the "natural spacing" (in D.S.D.) of stations—is proportional to Θ^2, but the same change in the S.L.C. plate with given values of D.S.D. is generally narrower, being proportional to $\Theta 3/2$. The ratio of these two quantities shows that the S.L.C. station spacing is $\Theta 1/2$ times narrower than the tuning at the same dial setting on an S.L.W. plate. This is illustrated by Fig. 8 where the S.L.W. and S.L.C. curves read 200 and 600, respectively, at D.S.D.

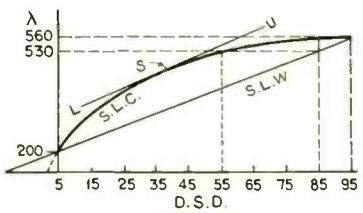


FIG. 10

S.L.C. vs. S.L.W. settings at same wavelength

Now, at point 2 in Fig. 8, on the S.L.C. calibration curve, corresponding to 10 D.S.D., the dial change in terms of kc. or station spacing is narrower than for point 1 having the same dial reading. We are here reading the curve "backwards," of course. When we pass to a reading of 40 D.S.D. at point 3 we have four times the dial reading and we may confidently say that the relative increase in station spacing at point 4 or the S.L.C. scale over point 3 on the S.L.W. scale is only one-half as great as the preceding case.

For a comparison of "dial detuning intervals," (D.D.I.) instead of station spacing dial intervals, we have Figs. 9 and 10. In the former we use S.L.C. and S.L.W. curves for comparison of the detuning intervals at points 1-2 or 3-4. These intervals are shown by shaded rectangles whose width represents the detuning interval and whose height is the wavelength ordinate of the calibration curve at that point.

A dial detuning interval "D" for S.L.W. calibration at point 1, when observed at point 2 becomes "2D"; since we will assume that the wavelength is 40% greater at 2 and the dial detuning interval is proportional to the square of the wavelength. Passing to points 3 and 4 with four times the capacitance and wavelength respectively, we find that the detuning interval at 3 is 8 times what it was at point 2. It varies as the "three-halves" power of the capacitance of S.L.C. dial reading and the "three-halves" power of 4 is 8. The dial detuning interval at point 4 is 16 or as it happens, equal to that for point 3.

This comparison, however, may be protested against as not a fair way of looking at the operation of the two types of condenser plate curves—considered as competitors for a segment design covering the longer waves. Why should we take the same D.S.D. on the two types? Should we not rather take positions giving the same wavelength? Very well then—such a comparison is made in Fig. 10. Here we have an S.L.C. and S.L.W. calibration curve running between 5 to 95 D.S.D. and 200 to 560 meters. It is obvious that we reach any given wavelength such as, say, 530 meters, more quickly on the S.L.C. curve. The latter gives us 530 meters at 55 D.S.D., whereas the S.L.W. reading for this wavelength is 85 D.S.D. These are the proper dial

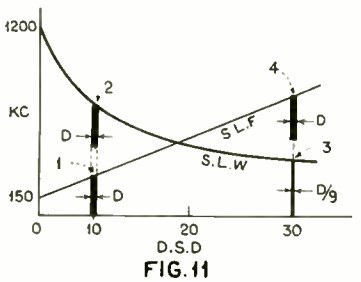


FIG.11

S.L.F. vs. S.L.W. for detuning.

readings at which to compare sharpness of tuning—or rather, detuning—for equal wavelengths.

The rate of change of the wavelength in terms of D.S.D. is constant all over the S.L.W. dial, but this is, of course, not true for the S.L.C. dial calibration. For example, in Fig. 10 we have taken 200 to 560 meters over 90 D.S.D. for an S.L.W. plate. Therefore, each D.S.D. has the same wavelength rate-of-change, which is 3 meters per D.S.D.

If we use an S.L.C. calibration over the same range, this must have at 200 meters a greater rate-of-change but will have at 560 meters, a smaller rate-of-change. At one point "S" on the S.L.C. dial both these rates-of-change are the same; they follow the slope of the tangent LST—i. e., 3 meters per D.S.D. They may start in at 4 meters or more and end up at 2 meters or less per D.S.D.

Sharpness of Detuning Versus Spreading of Stations

In tuning by variation of capacitance we always find by physical laws, that the dial detuning interval divided by the absolute dial reading in D.S.D. is proportional to the wavelength. This is true for S.L.C., S.L.W. and S.L.F. plates. We find on analysis, which a descriptive treatment like this may omit—that, in particular the S.L.F. calibration scale has as a result of the above law a property which no other has. The amount of dial reading change, with sensibly constant resistance needed to cut the signal in half, is the same all over the scale!

What importance has this fact for the broadcast listener? Simply this—you can tune out any broadcast station at any range from 500 to 1500 kc.—or any other S.L.F. range—by the same angular dial movement, say, of one D.S.D. This is true practically always—if the coil resistance doesn't increase much with frequency—any more than 10%; since the condenser resistance simultaneously decreases.

The S.L.F. scale has this advantage over both the S.L.C. and S.L.W. scales from the standpoint of uniform dial change in detuning stations. In fact, the much touted Duddell "logarithmic" plate, used in the Kolster decremeter could not give this result unless the government separated all stations by the same percentage of increasing frequency, and the receiver damping were always kept the same. This would mean that each station would have a frequency of wavelength, say, of 101% of the preceding adjacent station. Even then the logarithmic plate would fail to do what the S.L.F. plate does, unless the receiving inductance changed proportionally to the capacitance, i. e., there would have to be an increase of 1% in both capacitance and inductance in order to get a wavelength 101% longer for the next station, and keep constant damping—assuming constant resistance. If this were done each station could be spaced, say, one D.S.D. apart and would detune the same amount at any reading. But how much simpler is the S.L.F. scale with its uniform detuning and its actual uniform frequency "spacing" of stations!

This means that the Government has been wise in arranging stations on equal frequency intervals in the broadcast band and below this band, down to 60 megacycles, by suitable frequency steps.

To tune out these stations better inductances than most of those now sold would be necessary, but once installed the detuning could be confined to one D.S.D. or even less.

The best possible reason for using either S.L.W. or S.L.C. scales is to avoid or to reduce the effects on detuning of high frequency resistance. This acts in present coils so that the S.L.W. station detuning is broadened but not "crowded" at long waves; as the resistance is proportionally lower here. We should, therefore, use as much S.L.W. calibration as possible in our condensers for safely detuning evenly on longer than broadcast waves, with the stations spaced out.

Detuning by S. L. W. Versus S. L. F.

We thus have this interesting relation in regard to the behavior of the D. D. I.—dial detuning interval—with varying resistance, when using S.L.F. or S.L.W. condensers: with a small percentage change in circuit resistance at high frequencies, the S.L.F. tuner has a practically constant D.D.I. and also has equal separation of stations. If we use an S.L.W. plate the D.D.I. is proportional to the D.S.D. squared, with practically constant resistance, as above. If we use the range where the resistance is proportional to the frequency we have a constant decrement measured by $\frac{\text{D.D.I.}}{\text{W.}}$ or $\frac{\text{D.D.I.}}{\text{F.}}$. Finally, when the stray capacitance of the receiver comes into play at the next highest range of frequencies, we find resistances proportional to the square of the frequency and it is the S.L.W. plate which now has a constant D.D.I. This is of merely academic interest as the changes in D.S.D. for one kc. separation are very small and now are getting smaller.

The use of 40 meters per D.S.D. in separating long-wave stations would be a very convenient unit on an S.L.W. dial. However, the detuning becomes "coarser" as the wavelength increases. For example, if we can tune out an adjacent station at 300 meters with a change of dial reading of one D.S.D. we must use 4 D.S.D. to tune it out at 600 meters, even if our coil resistance is kept sensibly constant.

In other words, we cannot afford to use a considerable S.L.W. range unless with such large inductances that at 350 meters—about midway in the broadcast range—we can get fairly sharp detuning between stations. This is one basis on which the Government could discuss any change in the present system of allocating stations of lower than broadcast frequencies.

We have two frequency calibration curves in Fig. 11. An S.L.W. type starts at 1200 kc. and an S.L.F. type at 150 kc. The points 3 and 4 are taken at three times the scale readings of 1 and 2.

For convenience, we assume an equal dial detuning interval "D" for points 1 and 2. This is quite allowable. Now comes the interesting illustration that, while point 3 has "D/9" for a dial detuning interval, point 4 on the S.L.F. graph has the same value "D" as point 1.

In other words, the dial detuning interval, with sensibly constant resistance, is equal all over the S.L.F. scale. Circuits can easily be designed to practically realize this performance.

Methods of Combining S. L. F., S. L. W. and S. L. C. Plates

The S.L.C. calibration can be designed to have good average sharpness of detuning—except when broadened by resistance—at the shorter waves. The S.L.F. calibration is especially unfavorable to sharpness of detuning at low frequencies, as its dial detuning interval is the same all over the scale, if the resistance stays sensibly constant. If this resistance goes down proportionally at low frequencies, the sharpness of detuning becomes almost constant. In all designs the wavelength change per D.S.D. must be designed to have an average value which is smaller in the S.L.C. segment than

(*Continued on page 67*)

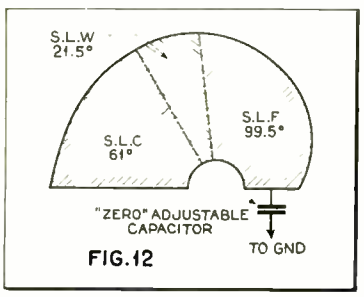


FIG.12

Triple-curve condenser plate—549 to 200 meters, or similar range.

Tantalum, Tungsten and Molybdenum in Vacuum Tubes

The Characteristics and Applications of These Rare Metals

*By Edgar W. Engle**

ELECTRON discharge devices consist of an outer envelope, usually of glass; electrodes, usually of metals; and structural parts of metals or insulated materials. The outer envelope provides for a controllable atmosphere around the electrodes. This enclosed space may be as highly evacuated as possible, or it may contain a definitely predetermined amount of gas. The metals used in the structural electrode parts are chosen both on account of their general characteristics and the specific problems en-

Welding molybdenum wire into vacuum tube grids in an experimental tube factory.

countered in the tube. The cathode element should be capable of emitting electrons readily and uniformly, over a long period of time under the conditions in which the tube is designed to function. The other metal parts should emit as little as possible. The metals used should be of such nature that it is relatively easy in processing to attain with them the desired degree of vacuum or gas content, and further they should not detrimentally affect these during the period of use of the tube. They must have such physical properties as will enable them to form to the desired shape of the elements and to hold proper shape and spacing during the processing and use of the tube. The metals must be obtainable in sufficient quantities to insure their availability and at a cost which will not render the selling price of the tube too high.

This article deals particularly with the metals tungsten, molybdenum and tantalum, all of which find very definite use in tubes. These metals are commonly classed among the rare metals, but are regularly produced commercially in ample quantities to meet all requirements of the tube industry.

* *Chief Engineer, Fansteel Products Co., Inc.*

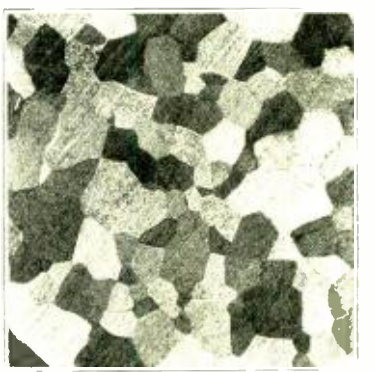
Tungsten

The metal tungsten is an element having the number 74 in the Moseley series. In a physical sense tungsten is distinctly metallic in its properties. In its chemical characteristics it is much less so. It cannot replace hydrogen to form the positive ion in salts of the oxygen acids as in the common metals, sodium, zinc, iron, nickel, etc. Tungsten crystals have a body centered cubic lattice.

The more important and more extensive commercial uses of the pure metal include filaments in incandescent lamps, electrical contacts in automobile ignition systems, X-ray targets, and structural and electrode parts in vacuum tubes, more particularly those of the transmitting types. In alloys and metal mixtures tungsten has valuable uses as a hardening material for use in cutting tools, wire dies, welding electrodes, etc. Tungsten among the metallic elements has the very valuable properties of highest melting point, greatest rigidity at elevated temperatures, and lowest vapor pressure. The broad utilization of these properties is quite limited by its oxidation in air at temperatures well above red heat. Tungsten is machineable only with great difficulty and it is not generally practical to adapt it mechanically to other than the more simple forms, such as wire, rod and sheet. It may be sealed through glass of proper expansion and give vacuum type seals. It is quite readily degassed in electron tubes and may be cleaned and freed from most harmful gases by heating in hydrogen. Its property with respect to secondary emission is good. Pure tungsten wire is generally used as cathode filament in power or transmitting type of tubes. Electron emission from pure metals is generally regarded as easiest to duplicate and control. High melting point, excellent rigidity, and low vapor pressure permit tungsten to be heated to sufficiently high temperature to give satisfactory and dependable emission with long life. The limiting factor is that it becomes very brittle after use and is quite subject to breakage from shock. The addition of thorium oxide to tungsten gives very greatly increased emissivity and such material is used in receiving tubes though much less than formerly. In receiving tubes tungsten has use as cathode heater element and as filament support spring.

Molybdenum

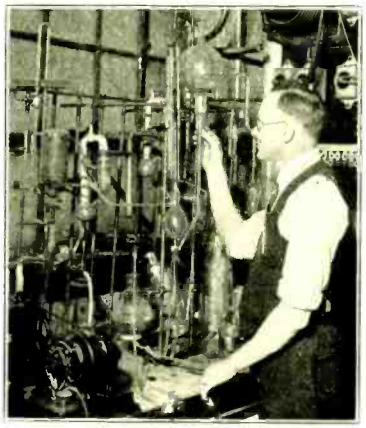
The metal molybdenum is element number 42 in the Moseley series. In the periodic chart of the atoms it occurs in Group 6 along with tungsten and has many properties broadly paralleling tungsten. It is often used where otherwise tungsten might be on account of its much greater ease of shaping and mechanical handling. It can be made quite soft and workable and is not nearly so susceptible to becoming brittle by heat as is tungsten. It is a standard accepted grid material in receiving and power tubes and is generally used for plates and structural elements in power tubes. The melting point is about 2500°C and is quite readily degassed in hydrogen and in vacuno. For grids it is used in the annealed state in the form of wire. Such wire is capable of being readily wound to give the desired accuracy of spacing and shaping. It is resistant to deformation by heat so that it maintains the spacing at the high temperature necessary to process the tube after the elements are sealed in. Molybdenum wire .005" in diameter is the standard grid material for receiving tubes. Many million meters of this are produced each year. Specifications for grid wire include tolerances for diameter, roundness, breaking strength, and elongation. It is used in the largest amounts to the following specifications: diameter, .005" plus or minus 5%; elongation, based on 10" length, 15% to 20%; breaking strength, 1 kilogram minimum. While the above may be regarded as the



Micro-photograph showing normal grain structure of tungsten.

standard specification, the processes of some tube manufacturers require a different wire, which is produced to their specifications.

In making grids the wire is attached to nickel uprights, either by electrical welding or by hammering into notches. On the welded grids it is desirable that sufficient heat be applied to soften the nickel and push the molybdenum into it without deforming the molybdenum or causing excessive recrystallization. The very wide difference of melting point between nickel and molybdenum render this operation practical. No more heat should be put on the wire during the welding operation than is necessary to secure good adherence to the nickel. Too much heat may render the molybdenum weak or brittle at the point of weld. After grids are wound it is usual to give them a cleaning and annealing operation by heating in hydrogen before final shaping. Temperatures ranging from 950°-1050°C for a period of ten minutes are usual. These temperatures are sufficient to clean and properly anneal the wire. Anything in excess may weaken or embrittle it, especially if the wire has been overheated at welding. After removal from the annealing furnace the flat type grids are usually formed to exact shape by slight stretching over a mandrel. In order to prevent undue scrap here only sufficient stretching should be given to cause the wire to take a permanent set. Winding jigs should be of such dimension and stretching machines so set that no appreciable elongation of the wire is necessary. An undue stretching of the wire will either cause breakage or reduce the diameter to such an extent that the characteristics of the tube will be unbalanced.



A special section of the Fansteel laboratory under F. L. Hunter, helps solve the problems of vacuum tube manufacturers.

Molybdenum wire in the hard, drawn, unannealed state has some use as a filament support spring. In general, however, it is somewhat too soft for this. Alloy wires of tungsten and molybdenum have proven superior through added stiffness and less softening at the temperatures necessary to heat the elements of the tube during processing.

Alloy wires of tungsten and molybdenum also show definite value for use as heater wires in the uni-potential cathode types of tubes. Such alloy wires stand quite well the necessary processing and operating temperatures in the tube, but will not stand sufficient temperature to be satisfactory for lamp filaments. The alloy wires have less tendency to become brittle by recrystallization than does tungsten. Their susceptibility to attack at high processing temperatures by the siliceous insulator is of the same degree as for tungsten.

Tantalum

The metal tantalum is number 73 in the Moseley series. It occurs in the periodic chart of the atoms adjacent to tungsten in Group 5. Tantalum has, next to tungsten, the highest melting point and lowest vapor pressure of the metallic elements. Tantalum has a very high degree of workability and when properly annealed may be pressed, stamped, spun or drawn cold into shape much the same as may be done with copper, nickel and iron. It welds readily to itself, making a strong, ductile joint, whereas under

Technical Characteristics of Certain Metals

Characteristics	Tantalum	Tungsten	Molybdenum	Platinum	Copper	Nickel
Atomic number	73	74	42	78	29	28
Atomic weight	181.5	184	96	195.2	63.57	58.7
Density, at 20° C	16.6	19.3	10.2	21.46	8.89	8.9
Atomic volume	10.9	9.4	8.8	9.25	7.15	6.6-6.8
Tensile strength lbs. per sq. in	130,000	490,000	260,000	53,000 35,000	62,000 35,000	155,000 hard 76,000 annealed
Compressibility per unit volume per Kg/Cm²	.52 x 10^{-6}	.26 x 10^{-6}	.46 x 10^{-6}	.37 x 10^{-6}	.74 x 10^{-6}	.42 x 10^{-6}
Brinnel hardness at 500 Kg	45.9	290	147	90 hard 35 annealed	94 hard 40 annealed	83
Scleroscope hardness	10	40	12	24 hard 13 annealed	18 hard 6 annealed	45 hard 10 annealed
Young's modulus of elasticity, kg. per sq. mm	19,000	42,200			12,200	22,000
Melting point ° C	2850	3370	2620	1755	1083	1452
Boiling point ° C	>4100	5900	3700	4300	2300	2900
Vapor pressure		6.45 x 10^{-12} mm 1727° C. .00114 mm at 2727° C.	6430 x 10^{-12} mm at 1517° C.	107 x 10^{-6} at 1727° C.	.001 mm at 1080°	
Heat of vaporization, total, cal. per gm.		129,000	113,000	88,000	76,600	84,000
Special heat cal. per gm. per ° C, at 0° C.	.0365	.0336	.0647	.0323	.0910	.1084
Linear coefficient of expansion per ° C.	6.5 x 10^{-6}	4.44 x 10^{-6}	5.45 x 10^{-6}	9.0 x 10^{-6}	17 x 10^{-6}	12.8 x 10^{-6}
Thermal cond. in cal. per cm. per cm², per sec. per ° at 18° C	.130	.476	.346	.1664	.918	.142
Heat of combustion cal. per gm	827	1040	1812	87.1	547	983
Heat of combustion cal. gm. atom	300,120	191,400	173,950	17,000	34,890	57,826
Temp. coefficient of resistance at 20° C.	.0031	.0045	.0033	.0031	.00393	.0066
Electrical resistance microhm per cm. cube at 20° annealed	15.5	5.51	5.7	10.0	1.72	6.4
Magnetic susceptibility	+.93 x 10^{-6}	+.33 x 10^{-6}	+.04 x 10^{-6}	+1.1 x 10^{-6}	—.085 x 10^{-6}	variable
Electrochem. equiv. mg. per coulomb	.3762	.31788	.1658	.5057	.3294	.3040
Refractive index	2.05	2.76		1.17	1.39	1.41
Thermoelectric E. M. F. against copper micro-volts per degree	4.1	4.5 (Above 200° C.)		13.3	0.0	25

similar conditions tungsten and molybdenum form a brittle weld of low strength. This property of easy fabrication, together with its many other desirable properties, renders tantalum of extreme value in vacuum tube construction. It is an efficient getter for most gases and absorbs them without itself volatilizing. When tantalum is used for electrode or structural elements, these parts aid in the gas clean-up. The power of tantalum to absorb gases is best at temperatures at or above red heat. It retains these gases when cold and gives them up at temperatures approaching its melting point, about 2800°C. This gas-absorbing property is selective. Practically all the ordinary gases are absorbed at red heat, but the noble gases such as helium, argon, neon, etc., are not taken up. This property of selective absorption has led to the use of tantalum as an agent to insure continued purity of the noble gas in so-called "gas tubes." Its high melting point and low vapor pressure render much less liable the clean-up of noble gases by sputtering than is the case with electrodes of many other metals.

Sheet tantalum may be rolled as thin as .001 inch.

In power tubes molybdenum and tungsten parts often become brittle after withstanding high service temperatures and it is impossible to reshape them when the tube is repaired. Under similar conditions tantalum remains soft and pliable and is capable of being used over again several times.

The desirable physical properties of tantalum, together with is relative freedom from back emission, has let to the fairly extensive use of tantalum wire for grids. Such use appears much more general in Europe than in this country. Considerable quantities of tantalum are exported from here each year to Europe for use in tubes. A low voltage gas filled rectifier tube for which long periods of satisfactory operation are claimed utilizes thoriated molybdenum filament and tantalum plates. It is believed that the main advantage of this tube results from the property of tantalum in continuously purifying the gaseous atmosphere. Tantalum is a somewhat newer metal to our tube industry than tungsten and molybdenum, but many manufacturers have realized its possibilities and are experimenting with respect to its utilization in further improving their products.

Molybdenum wire is drawn through diamond dies to exact diameters.

In order that easy comparison may be had between the properties of tungsten, molybdenum and tantalum and those of some of the better known metals a table of these properties is given. This table has been compiled from what is believed to be the most reliable sources to date.

Electromagnetic Phonograph Pickups

The Determination of Relative Frequency Characteristics and Sensitivity — and the Measurement of Record Wear

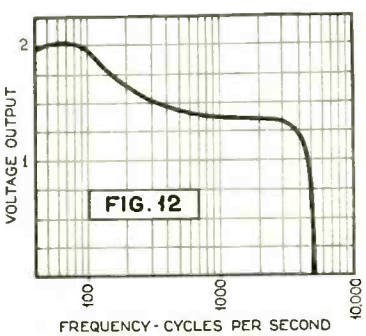
*By George B. Crouse**

PART III

THE purpose of this final article is to outline a suggested method for determining the relative merit of pickup devices of different designs and to describe the apparatus which has been used by the writer for making the various determinations of the essential characteristics involved.

As a preliminary to this outline, the desirable characteristics of a good pickup, as discussed in the previous articles of this series, will be summarized.

The purpose for which a pickup is designed is to faithfully convert the motion transmitted to the point of its stylus by the record into electrical oscillations. The relative successive amplitudes and frequencies of the electrical oscillation should be an exact reproduction of the record groove, except in so far as the pickup may be called upon to correct compromises in the record cutting, or to suppress surface noises or scratch. The degree to which the device meets these conditions is determined by the "response curve," showing voltage generated for constant velocity of the stylus point at all frequencies within the range of the instrument. This curve, in the writer's opinion, should have the approximate form shown in Fig. 12. The enhanced response at frequencies below 300 cycles is for the purpose of correcting the diminished amplitude of cut at the low frequencies, and the diminished response at frequencies above 3,000 cycles is desirable to partially suppress the surface noises. In no case should the curve show sharp changes in curvature, deep valleys or sharp peaks, as these always result in unpleasant "jingling" noises in the output.

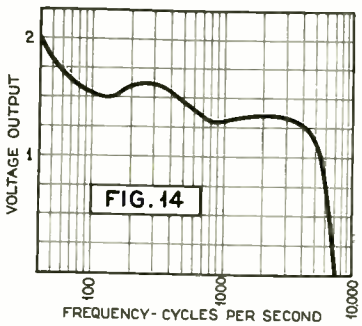


Ideal pickup response curve.

Granting that the device under consideration has a satisfactory response curve, probably the characteristic next in importance from the commercial viewpoint, is its ability to maintain a uniform level of performance throughout its life, which should be indefinitely long. This characteristic depends on the construction, quality of materials, and similar factors.

The importance of sensitivity de-

* *Consulting Engineer, Hardwick-Hindle, Inc., and Radiart Laboratories, Inc.*



Curve of pickup working into resistive impedance load.

pends very largely on the degree of amplification which is available, but when the device is intended for use with the audio amplifiers ordinarily used in connection with radio receivers, a high sensitivity is usually desirable and often necessary.

A factor in pickup performance which has only recently been given serious attention is the wear on the sides of the record groove occasioned by the use of the device. The wear at the low frequencies is due to the stiffness of the armature and that at the high frequencies is due to the mass of the moving system. For low record wear, both the stiffness and the mass should be as low as possible.

Use of Constant Frequency Records

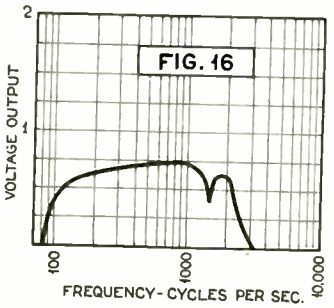
Probably the most satisfactory method of determining the response curve is by the use of "constant frequency records." These are disc records of ordinary construction, on which are cut bands of grooves, each band being cut to impart a constant frequency and velocity to the needle point. These records are available with frequencies from 40 cycles to 8,000 cycles in small steps.

The pickup is mounted and played on these records in the normal manner, the voltage output being determined by means of a vacuum tube voltmeter. A very convenient and satisfactory form of voltmeter for this purpose is shown in Fig. 13.

In this voltmeter, an —/01-A tube and a —71 tube are used. The switching arrangement provided gives the instrument a range of .2 volt to 150 volts. In most pickup measurements, the low voltage range is the only one which need be employed. A d-c. microammeter is connected to the terminals marked "output." The instrument is calibrated on 60 cycle a-c. against a standard a-c. meter of commercial design. If care is taken to adjust the filament voltage to the same value every time the instrument is used, the calibration remains constant over a long period.

Certain precautions must be observed in making these measurements. In the first place, if curves taken at widely separated intervals of time are to be compared, it is obvious that the calibration of the voltmeter must be checked and corrected at frequent intervals, and that the turntable speed should be clocked and adjusted before every series of tests.

The actual velocity imparted to the needle point by the constant frequency records is not exactly the same, the differences being marked on the record in dbs. The voltmeter reading must

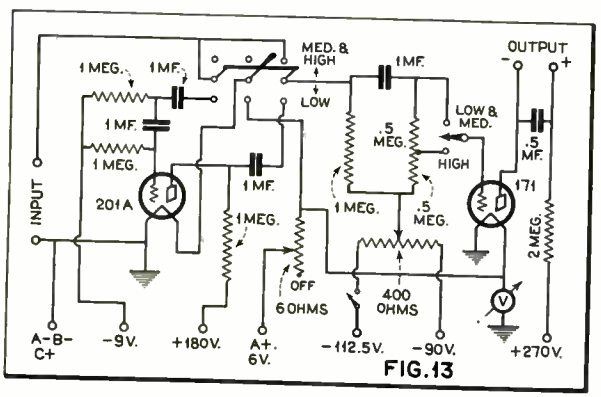


Effect of transformer with abnormally high or low impedance.

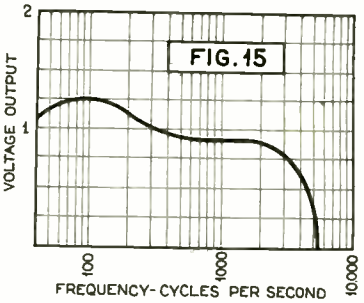
be properly corrected at each frequency by the factor given. In addition to these stated corrections, it was generally found that the cutting is not quite uniform throughout an entire length of groove on any one frequency, and if high accuracy is desired, it is a good plan to take the average voltage reading at several points on the record.

Effect of Load

An electromagnetic pickup is an electric generator with a relatively



Circuit diagram of vacuum tube voltmeter for use in making frequency runs.



Curve of pickup working into transformer primary.

high internal impedance, and, therefore, its voltage output will be a function of the impedance of the load. Further, its internal impedance is largely inductive in character and, therefore, varies with the frequency which it is generating. For this reason, it is important that the response curves be run with the pickup connected to a load circuit, which is very close in characteristics to that with which it will be used. In Figs. 14 and 15 are shown curves of the same pickup. In Fig. 14, the load comprised only the very high resistive impedance of the vacuum tube voltmeter shown in Fig. 13. In Fig. 15, the pickup was working into the primary of a high quality audio transformer having a 3:1 ratio secondary to primary, the secondary being connected in the grid circuit of a lighted audion. It will be observed that the effect of the transformer load is not only to reduce the voltage at all frequencies, but that marked changes in the shape of the curve are also introduced by the load.

It often happens that defects in the transformer are shown up in the course of such tests. Wherever a sharp peak or valley occurs in a response curve which cannot be easily accounted for from the design of the pickup, the transformer may be suspected. This can generally be checked by using the same transformer with a pickup of entirely different constants. If the peak or valley again occurs at the same frequency it is fairly positive evidence that the transformer has abnormally high or abnormally low impedance at this frequency, and that the trouble is not in the pickup. The effect of a transformer having an abnormally low impedance at a certain frequency is illustrated in the curves of Figs. 16 and 17, which were taken with two pickups of radically different designs, and yet both curves show a deep depression at exactly 1,500 cycles.

Effect of Tone Arm

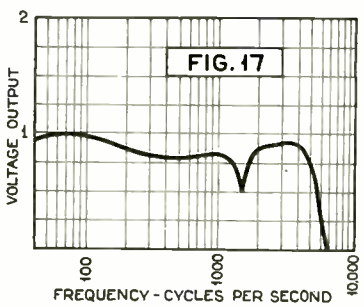
The tone arm also plays a very important part in the performance of the pickup, and response curves should always be run with the pickup mounted on the tone arm, for which it was designed. The character of the mounting affects principally the low frequencies. The effect of mounting is

illustrated in the curves of Figs. 18 and 19, which were made by the same pickup. In the curve of Fig. 18, the pickup was mounted on the tone arm supplied by the manufacturer and, as will be noted, very good characteristics were obtained. In the curve of Fig. 19, the pickup was mounted on an arm which allowed the entire weight of the pickup to rest on the needle point. The result was an enormously enhanced response in the low frequency region, but with violent changes of curvature, as will be seen from the curve. In this connection, it should be pointed out that a correctly designed tone arm will impose a weight on the needle point of not much over four and one-half ounces. If a greater pressure than this is required to obtain satisfactory response at low frequencies, the device will cause undue wear on the bottom of the record groove.

Frequency Characteristics

As an illustration of what may be expected from pickups of present commercial design, the curves of Figs. 20, 21 and 22 should be examined. Curve 20 is regarded by the writer as being as close an approximation to the ideal curve as is commercially possible. It will be noted that this curve has a broad peak in the lower frequency range, and falls off rapidly in the range above 3,000 cycles, thereby effectively suppressing the undesirable scratch noises. The curve has nowhere any sharp change of curvature nor any high peaks or deep valleys. The curve of Fig. 21 is at first glance much more uniform in response, but it will be noted that it has a large rise in the scratch frequency range and practically no increase of response below 100 cycles, where the records are deficient. Such a curve, in the writer's opinion, is not as desirable as that of Fig. 20. In Fig. 22 is shown a curve whose only defect is the sharp peak at 800 cycles. The effect of this peak will be to introduce a persistent ringing note into the reproduction which will be particularly annoying on the passages of low volume. The effect will be that of someone continuously sounding a string of particularly discordant sleigh bells.

While considerable space has been devoted in this article to the discussion of the technique of making response curves, the results of even the best made curves must be accepted with a degree of caution, and should always be checked by comparative ear tests on a variety of selections. In selecting records for ear tests, diversity in the character of music and voice should be the deciding factor, and not the tester's personal taste in music. In testing by ear for relative reproduction of scratch noise, records should be used which have been played from ten to twenty times. The frequency of the scratch noise is generally higher on the outside of the record and the first few grooves before the actual recording starts are admirably suited for scratch determination.



Same as Fig. 16 but with different make pickup.

Determination of Relative Sensitivity

The relative sensitivity of two pickups is a somewhat difficult thing to determine, but may be approximately evaluated in several different ways.

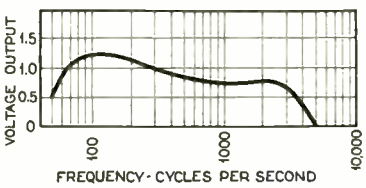


FIG. 18

Effect of tone arm on response curve.

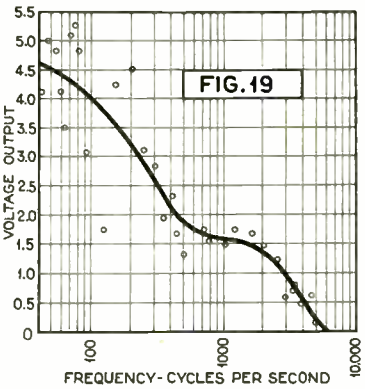
If the response curve shows a relatively flat horizontal response in the middle range, say, from 500 to 2,000 cycles, it is probably fair to take the voltage at these frequencies as a measure of the sensitivity. It is for this reason that the writer prefers to express the response curves in terms of voltage rather than of dbs, as it is then equally serviceable for both purposes.

Another method of determining sensitivity from the curves is to determine the average voltage throughout the usual range of frequencies, but this method generally results in a value which bears no identifiable relation to the apparent volume as heard by the ear.

Probably the most reliable method, if care and time are taken in carrying it out, is that of comparative listening tests on a variety of selections and with two or more observers. This method has the advantage of giving directly useful comparative results, but is, of course, tedious.

Permanent uniformity of performance in an electromagnetic pickup depends primarily on three factors. First, the excellence of workmanship and simplicity of design; second, on the character of the material used for damping the motion of the moving system, and third, on the design and material of the permanent magnet.

The first point can really only be determined by an inspection of the device in the light of a broad mechanical experience. It is generally true that the fewer the parts, and particularly moving parts, of any mechanical device, the greater the reliability. Fortunately, also, good workmanship is generally apparent on the surface in a device of this character.

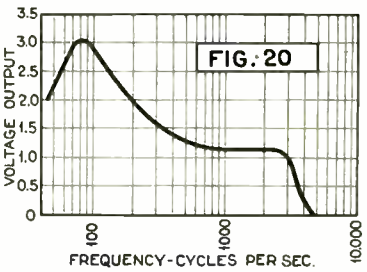


Effect of weighted tone arm on response curve.

Where rubber is employed for damping it is usually necessary to use it in such a manner that it is also relied upon, in whole or in part, for the centering adjustment of the moving system. Such, for instance, is the case in the structure illustrated in Figs. 1 and 2, of the article appearing in the August issue of RADIO ENGINEERING. Under these circumstances, the permanence of the device and of its adjustment are, at best, doubtful quantities, depending upon the quality of the rubber employed, and the seasoning to which it has been subjected. There is, unfortunately, no adequate method of determining the life of the adjustment, other than observation over an extended period. If life tests are undertaken to determine this point, the usual care should be exercised to subject the device to all of the conditions of temperature, moisture and vibration, which it is likely to meet with in service.

In case no rubber or similar impermanent material is used in a relation of the mechanical system which can affect the adjustment, this source of doubt entirely disappears.

The third factor affecting the life of the instrument, the permanent magnet, can best be checked indirectly by



Curve of commercial pickup which suppresses scratch noises.

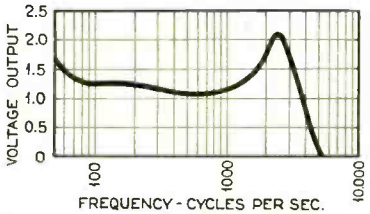


FIG. 21

Another curve of a commercial pickup. Low frequency response is poor and scratch noises are increased.

means of the expression given in the previous article for stability of permanent magnets, which is here repeated for convenience:

$$\frac{A_g}{L_g} \times \frac{L_1}{A_1} > 70$$

In this expression, A_g represents the area of the air gaps; L_g, the length of the air gaps; A_1, the area of the cross section of the magnet, and L_1, the length of the magnet. The value of the numeric on the right hand side of the above expression is for tungsten magnet steel, and this quantity should be reduced to 35 for steels containing 15% cobalt. The four quantities above should be carefully measured in the actual instrument, and should satisfy the relationship for the particular steel which is used. In making the measurements of the gap length and areas, it should be kept in mind that there are four air gaps involved in the usual magnetic bridge type of construction, and the upper and lower pairs of gaps will usually be different in both length and area, and it must be remembered, in computing the effective gap reluctance that the reluctances of the upper and lower pairs are in parallel.

Determination of Record Wear

Probably the most satisfactory way to determine the relative record wear occasioned by two pickups of different designs would be to make microscopic examinations of records played by each of them, and some work of this kind has been undertaken, using wax records in order to speed up the effect, but the whole process is too tedious and expensive to be undertaken in the usual case.

A reasonably close estimation of the effect can be secured by measurement and computation. As explained in detail in a previous article, the wear on the side of the record groove at low frequencies, that is, at frequencies below the first natural period of the moving system, is occasioned by the effective mass of the armature transferred to the point of the stylus. This quantity may be easily calculated from a drawing of the armature by means of the usual formulae to be found in mechanical handbooks. It should be noted in making these calculations that the effect is one of mass and not of weight, and, therefore, the weight of the armature used in the calculations must be divided by the gravity constant. The most convenient practice is to calculate the moment of inertia around an axis through the pivot of the armature and then to transfer the result to the point of the needle.

For determining the wear factor at high frequencies, it is most convenient to measure the actual deflection of the armature under a known force. A device which the writer has found very convenient for this purpose is illustrated in Fig. 23. In this figure, a pickup of usual design is shown in two views and indicated by the numerals 1 and 2, clamped in a U-shaped yoke 3 by means of the clamp screws 4. Inserted into the needle holder in the end of the armature is the rod 5, of stiff tempered steel wire, such as a bicycle spoke. In order that no stray magnetic field may leak down the rod, it is split, and the magnetic insulator 6, of bakelite, is inserted. 7 is a permanent magnet rigidly mounted on the same platform as the yoke 3, and provided with a small V-shaped groove on one of its pole faces. Resting in this groove is a small iron piece 8, provided with a knife edge to engage the groove, and carrying a tiny mirror 10, as shown. The iron piece 8 is bent up at an angle along the edge away from the magnet face, which rests aginst the end of the rod 5, and is held firmly against it by the stray field provided by the magnet 7. A suitable source of light is arranged at 11, and the image of this source is reflected by the mirror on the scale 12.

By means of this apparatus, very small deflections of the armature of the pickup device may be easily measured, when the dimensions of the parts are known.

A known force is applied to the rod 5 at a point from the end of the armature

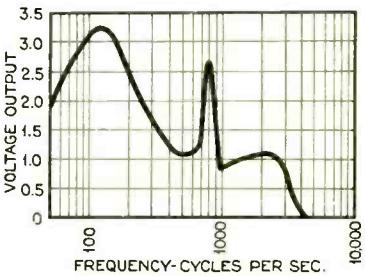


FIG. 22

Response curve of pickup with prominent peak at 800 cycles, this introducing a ringing noise.

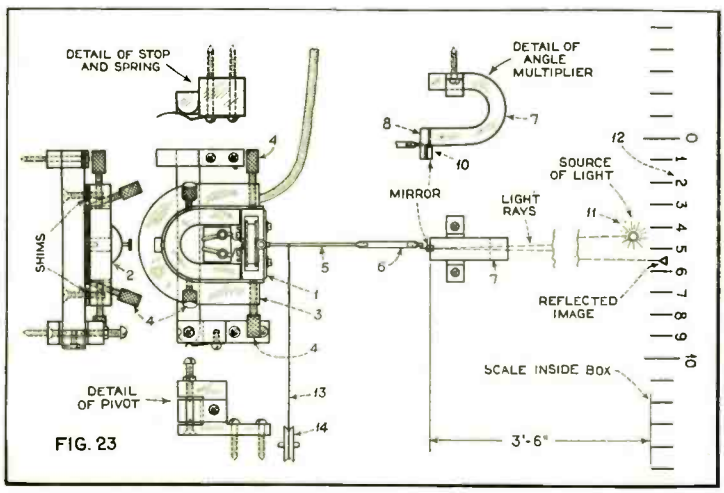
equal to the distance which the needle projects from the armature, by means of the thread 13 running over the pulley 14, to the lower end of which is attached a known weight (not shown). In making these measurements, the pulley bearings should always be gently tapped to prevent friction reducing the amount of the force applied to the rod.

In this manner, the ratio of the deflection to the force required to produce it, may be directly measured, and the relative record wear which will be occasioned at low frequencies by two pickups of different designs may be determined.

It should be pointed out that the stiffness of a pickup armature cannot be estimated even approximately by attempting to estimate the force required to move it by hand. The armature in normal use, moves through only a very small angle, and may be very free throughout this range, and yet very stiff outside of the normal range of motion.

The test methods outlined herein have been used by the writer and his staff in the investigation of pickup devices over a considerable period of time with entire success, and it is believed that with proper attention to technique they will serve to accurately gauge the relative merits of the various designs of pickup devices.

(The End)



Arrangement for the determination of the wear factor of a pickup.

Making The Price Grade

Impressions Gathered Here and There on How the Radio Industry Is Reconciling Maximum Quality With Minimum Cost

By Austin C. Lescarboura, Associate Editor

Mem. I. R. E. Mem. A. I. E. E.

THE theme song of the radio industry today is just about the same as that sung by the automobile industry, namely: standardized fundamentals justifying mass production, followed by sales volume based on maximum value at lowest prices, and concluded with a reasonable rate of obsolescene to prevent market saturation. On every side, or from vacuum tube to radio component and even to cabinet, every effort is being exerted to bring the selling price well within reach of everyone. And since industrial success has ever been associated with an appeal to the masses, radio today is prosperous.

Standardization—The Firm Foundation

At the bottom of today's radio prosperity is the firm foundation of standardization. Were it not for the fact that radio authorities have come to agree on certain broad fundamentals, we would still be laboring under the uncertainty and chaos of unrestrained experimentation and lack of public confidence. Fortunately, the day is now well passed when so-called radio experts can upset the apple cart and keep it definitely upset by introducing so-called new circuits at the rate of one every fifteen minutes. Periodicals catering to the new circuit fans have for the most part disappeared, indicating the passing of the radio experimentation era. We deal now with sound fundamentals.

Yet despite the fact that we have standardized radio technique as the basis for safe and sane production on a large scale, it is interesting to note that there is ample leeway for individual innovations. As one glances up and down the offerings of the present season, there is presented a delightful variety of design, so that each set or component manufacturer has the necessary talking points to distinguish his sales campaign from that of competitors.

It is the leeway, in fact, that has encouraged many radio manufacturers to build up research and engineering departments worthy of the name. During the past two years, or since standardization became firmly established, there has been a noteworthy increase in engineering talent employed for the purpose of working out refinements and innovations, as well as reducing definite circuits to commercial practice.

As It Was in the Beginning

In order to appreciate the meaning of standardized fundamentals, it is well to recall the chaotic days of only a half dozen years ago. The writer recalls one firm that made bold to engage in volume production, with the thought of reducing its selling prices to the point where volume sales would result. Said firm engaged in a production of half a million regenerative receivers. Just as the receivers began flowing freely from the two factories turning them out, the regenerative circuit suddenly became disgraced through the agitation of the neutrodyne folks regarding radiation and attendant squeals and groans. The market for those regenerative receivers dropped off over night, and the unfortunate firm was caught holding the bag on several hundred thousands which were ultimately disposed of through the bargain stores at a twentieth their original price.

Today, there is comparatively little danger of having a mass production program go bad in the manner just mentioned, for the fundamentals of broadcast reception are pretty firmly established and there is little danger of having the apple cart upset over night. That is why the industry makes bold to engage in production schedules of hundreds of thousands of radio sets of one brand and another, knowing that public confidence and therefore sales is pretty certain.

The One Danger—Over-Production

However, if we are safe on fundamentals and free from the danger of overnight obsolescence, we are nevertheless faced with a threat as great if not greater, and that is over-production. On all sides this season there is evidence of vast production schedules which, taken collectively, would seem to indicate that the industry will over produce on radio sets and perhaps on certain components, but hardly on quality vacuum tubes.

Here is where our industry might well take a leaf from the automobile industry, which, while seemingly running riot on mass production, always succeeds in clearing its production at list prices or very close to list prices. Even when car prices are knocked down a bit to move an existing model preparatory to introducing the usual "bigger, better, finer, more powerful, more beautiful, etc." models, the automobile manufacturer still comes out of the deal with a whole skin. The radio manufacturer, on the other hand, certainly comes out with little more than his trousers when his radio sets are sold for a fifth or less of the original list prices.

There should be some means of working out an intelligent production schedule for the entire industry. Other industries have had the same problem and have overcome it through their trade associations. It is the place of a trade association to analyze the market in general terms, and to determine in advance just what that market can absorb, followed by an intelligent discussion of that market and an agreeable apportioning of production and sales among various members of the association. Also, the trade association should endeavor in every possible way to increase the total market so as to provide ample opportunities for all its members.

We are not speaking at this time with reference to any particular radio trade association or organization. Rather, we are making suggestions in general and quite impersonally. However, it seems to us that the radio industry lacks the sort of trade association which is found in other leading industries, where markets are thoroughly analyzed in advance and manufacturers have some assurance as to what constitutes a safe and sane production schedule. We doubt if the radio market has ever been analyzed in that manner, and whether any move has been taken to make radio manufacturers agree in a general way as to safe and sane quotas.

The writer recalls some years ago the threatened over-production in the filter condenser field. Each condenser manufacturer seemed more or less bent on supplying the entire market himself, without much regard for his competitors whom he left to take care of themselves. Finally, one of the saner manufacturers decided that it was about time to curtail production so that the manufacturers might have some chance to ask for reasonable prices for their goods, instead of being entirely at the mercy of the buyers through the old rule of supply and demand. A group of condenser manufacturers were assembled. Some sort of market estimate was arrived at. Standards of condenser construction and rating were attempted. Unfortunately, however, the meeting broke up as usual, with each manufacturer still bent on supplying all the necessary condensers himself without regard for the other fellows.

No, that is hardly the right practice. Sooner or later, we shall have to agree on apportioning the probable market among a group of manufacturers, so as to avoid over-production.

What About Allied Fields?

A study of the sales of any radio set or component manufacturer usually indicates a sag in the curve during several months of the year. Indeed, the experience of most manufacturers is that there are more sales from September till December, or a period of four months, than during the remainder of the year. Some claim that they sell twice as much in these four months than during the remaining eight months.

Whether it be admitted or not the radio industry remains rather seasonable even though many manufacturers by now have succeeded in adapting themselves to the seasonable feature. Nevertheless, the industry as a whole and many manufacturers in particular would be far better off if they could smooth out that sales curve.

Of late, we note the tendency on the part of certain radio manufacturers to engage in allied fields which fit in well with their radio production facilities and schedules. There is much midnight oil being burned these days, with a view to engaging in other lines as a means of straightening up the sales and production curves during the entire year. Here again, we believe the radio trade associations have failed to dig down for vital information. Radio manufacturers would welcome information on various allied fields in which they might engage.

"I am a radio manufacturer. What do I care about other fields?" That is probably what our reader is telling himself as he reads these lines. Well, in answer we point out hurriedly that present radio prices can only be maintained and improved upon if the radio set and component manufacturer works his plant to the limit, and keeps up his sales throughout the year quite irrespective of what he may have to make and sell. In fact, we consider this feature so essential that in an early issue we shall present a survey of what radio manufacturers are doing and what they can do in other fields, as a means of utilizing their production and sales potentialities to the utmost.

"Purchasing Agent Engineering"

The present-day low prices obtaining in the radio industry depend to a large extent on correct buying. Indeed, never before has the purchasing agent assumed such important proportions as in the radio industry, where not only pennies but fractions of pennies are discussed and argued and fought over in making the grade on the low selling prices.

However, the writer has noticed the danger in this situation, when the purchasing agent oversteps the bounds of his job. This has already been referred to in other writings as "purchasing agent engineering." Here is an example:

Two loudspeaker diaphragms are under consideration by the purchasing agent. One is in the form of a cone alone, which must subsequently be mounted with a soft leather band and an outer supporting ring, representing a considerable amount of handling and production cost. The other is in the form of a one-piece cone, resilient mounting, and supporting ring, complete, ready to be installed in the loudspeaker chassis, with an absolute minimum of handling and production cost.

The purchasing agent, with instructions to buy cones of a certain size, may be quite unaware of production processes and costs. When he comes to consider the cones purely on the basis of price, which is his literal job, he may gladly accept the first diaphragm at a cost of say 10c, and immediately reject the second at a cost of 32c. Of course, he is showing good judgment, on the basis of purchasing alone. But when the cones are compared by the accounting department on the basis of production costs, we discover that the first cone ultimately shows up as 45c completely mounted, while the second shows up as the original 32c. Obviously, there is something wrong with this particular set-up, yet it exists in many radio companies today.

Or again, the purchasing agent may decide between two different products totally on the basis of dollars and cents. Yet one may be far ahead of the other, even if it does cost slightly more. The products may never be presented to the engineering staff, and the purchasing agent functions as an engineer without quite realizing the fact. Often the plea of the component or material purveyor to reach the engineering staff may be blocked by the purchasing agent, who feels that his head is being walked over by such a request.

We claim from our study of the situation that there is entirely too much "purchasing agent engineering" going on today. The wise radio manufacturer will see to it that his engineering staff examines everything that is presented by way of materials and components, and that, once having passed upon the matter from a strictly engineering standpoint, that the purchasing agent do the job of securing the most value for the least money. And also, please note, be sure the production staff has a say in the matter, so that the penny-wise-pound-foolish angle may not creep into the work of the over-ambitious purchasing agent.

The Best Equipment Is Cheapest in Long Run

Given the proper components and materials as the raw stock, the next step in production is to provide the necessary facilities to convert that raw stock into finished products. It seems hardly necessary to dwell at length on the best equipment, since this varies from one plant to the next. Suffice it to say that hand labor is being eliminated at every possible turn. It is interesting to note the remarkable automatic machinery steadily being introduced in the radio industry. The manufacturer who continues with hand labor, without giving thought to automatic equipment, is simply signing his death warrant, for competitors meanwhile are striving to reduce their production costs at every turn.

Perhaps the best case in point is the radio tube industry. Originally, vacuum tubes were largely hand-made products, for it was felt that tubes were far too intricate and too delicate to be made on the automatic machinery developed for the electric lamp industry. Consequently, production was small and prices were high. Then, as the demand for tubes went up by leaps and bounds, automatic machinery had to be introduced. Continuous production machinery took the place of stationary machinery.

Today, the vacuum tube industry is spending virtually millions on new automatic machinery. Every stage in making a tube is being critically examined with a view to introducing the most efficient machinery possible. Even such tasks as assembling stem mounts, scrapping the ends of coated filaments, winding and trimming grids, and so on, are being placed on an automatic basis, reducing hand labor to an absolute minimum. The manufacturer who does not keep up with the parade is certain to be dropped out altogether, since the automatic machinery can drop price levels if necessary, thus eliminating the manufacturer depending on hand labor.

In our trips about the field we have recently come upon plant after plant with a special engineering department devoted to production methods. Here are mechanical engineers and draftsmen working on new and special automatic machinery to eliminate hand labor still further, and machinery specialists studying radio plants and designing equipment for lowering production costs.

It is impossible, indeed, to let well enough alone in the radio industry. The satisfied manufacturer is on his way out. There can be no stopping or resting. We must continue to move ahead.

Interchangeable Products

Special equipment costs a great deal and must be kept working at full blast if a fair return and the promised economies are to be realized. For this reason, we note in the radio industry a definite trend towards interchangeable products and components made in huge quantities. Among the component manufacturers particularly, there is every indication of ingenious mechanical design whereby a given part can be made to serve in the largest possible array of assemblers, so that said part can be produced in enormous quantities. In set manufacturing, we note that the number of types is being

kept at a minimum. While the manufacturer may offer several grades of radio sets so as to cover the entire price range in the market, nevertheless, the chassis may be more or less the same. As in the automobile industry, the chassis is standard, while the trimmings, or cabinet, may be changed around to meet different tastes and purses.

Trained—and Contented—Help

Equipment is one thing, but personnel or help is quite another. The human factor in the radio industry is of prime importance, although in the past it has been sadly neglected. The writer knows of one manufacturer after another who has paid little attention to personnel, hiring and firing with great abandon, only to discover that there was something radically wrong with the business which could not be accounted for. And that something was personnel.

In the past, we have had radio manufacturers hiring a brand new force each season, training that force, then swinging into full production, only to disband the force at the end of the rush. While that may be safe enough with the usual run of help that can be readily trained in simple assembly or routine production jobs, it hardly goes for highly trained and specialized help. We recall one instance where a radio manufacturer of a highly specialized product made a practice of discharging all the help, including most of the research and engineering staff, at the end of a season, with the childish idea that all said help could be recalled several months later when business was resumed. Instead, the help simply evaporated from the spot, only to turn up later in the ranks of competitors. The highly specialized knowledge and training of that manufacturer became available to his competitors, who rapidly gained the upper hand in the market and left the erstwhile leader sadly in the lurch.

No, help cannot be handled that way—at least the key men who form the skeleton or frame work of the organization. It is for management to find ways and means of holding the necessary skeleton organization together, even if it means engaging in allied fields to level up the production and sales curve.

We also note the tendency of radio manufacturers to move to better, larger and more encouraging quarters. Of late, many have moved out of the crowded city to the open country or suburbs, where light, air and surroundings are more conducive to a happy personnel.

Ducking the Replacements and Returns

No item in making the price grade is more important than that of eliminating replacements and returns to the utmost extent. Here the vast majority of radio manufacturers are showing good judgment, even when it means a higher production cost. Nothing tends to soar production costs out of sight as the return of goods for repair or the call for replacements out in the field.

In the case of socket-power radio equipment, replacements and returns have been reduced to a minimum. It is not so long ago that manufacturers of sets and power units were frantic with returns and replacements, at first in connection with broken-down filter condensers, and later with faulty resistors. Fortunately, both these items have been brought up to the mark, so that replacements and returns are now rare. The writer recalls one time when pioneer power amplifier manufacturers were experiencing returns as high as 30 per cent, coming back through dealers and jobbers, and serving to wipe out whatever profit might have been in sight.

There are just two points to bear in mind with regard to the servicing of products out in the field, so as to avoid turning a potential profit into a very definite loss: first, the product must be right in the first place, with nothing left undone. Better that each component have an ample safety factor to make due allowance for all possible normal and abnormal conditions of service, than to economize to the extent of a few cents or even dollars. Secondly, the product must be serviced or replaced out in the field, by the dealer if at all possible and certainly by the jobber, without coming all the way home to roost on the hands of the manufacturer. It is the handling that runs up the cost of servicing. Hence the importance of the foregoing suggestion.

Perfecting Products Out in the Field

The radio manufacturer should be prompt to recognize any complaints and to endeavor to correct them out in the field. We note, for example, one of the most popular sets this season, which in some instances has been subject to excessive hum background. Dealers have complained. The buyers have complained. Immediately, the manufacturer has made up a supplementary filter condenser with terminals to slip in place in the assembly. Dealers have been supplied with these filter condensers and have inserted them in such sets as have been found with excessive hum. That's service!

Too often, radio manufacturers are quite disinterested in their products the moment they are shipped. That is a wrong attitude. We see the same situation in the automobile industry: some manufacturers lose all interest the moment a car is shipped to the dealer, with the result that the shortcomings are left to the dealer to straighten out, with the inevitable result that the latter loses such good will as he may have to begin with, and eventually fades out, dead broke. On the other hand, there are just a very few automobile manufacturers who maintain an interest in their cars, and who follow them in the hands of buyers so as to be sure that the engineering and production are correct to the last detail. One manufacturer in particular has sent out new parts, accessories and other things to dealers to be placed on cars sold up to six months before, in correcting certain little defects which did not turn up in the manufacturer's own tests. That's service—and good-will building.

The radio manufacturer must maintain an interest in his products, even when they are in the hands of consumers. Remember, the only thorough test of a radio set is when it gets out in the field and is employed under typical conditions. Therefore, if there is any slight adjustment or change or replacement that can be made, by all means make it!

Building Up a Capable Service Force

Lastly, the radio manufacturer today must pay close attention to the servicing of his products out in the field, for his very future depends on consumer satisfaction. We note the excellent service data prepared and issued by some of the leading radio manufacturers, so that the serviceman can become intimately familiar with every detail. We note special factory courses for servicemen and dealers, so that sets can be serviced out in the field quite as well as by those who actually build them. We note classes held out in the field for servicemen and dealers. We note traveling service experts for radio manufacturers, who not only instruct dealers and servicemen but also help solve local problems.

And all this effort is by no means sheer philanthropy. It is good business sense, for radio sets must be serviced out in the field, and not in the factory.

In Conclusion

The radio industry, following in the footsteps of the automobile industry, is based on maximum value at minimum price—an appeal to the masses—a universal product. The reconciliation of trimming down costs and building up quality is being effected every day. The dangers of the industry are being more and more appreciated. And all those willing to steer the proper course are assured of a bigger and better future, while those not so minded are certain to drop out as time goes on.

It is a case of survival, as the industry now goes. It is not a case of "may the best man win." He is winning right now.

Vacuum Tube Design—and Production

The Production Testing of Vacuum Tubes

By Dr. Paul G. Weiller

Part II

AN article in last month's issue treated in detail the reasons for selecting plate current gas and emission as production tests for vacuum tubes to be used in broadcast receivers. This article will cover actual methods and equipment used in testing.

Fig. 1 gives the basic tube testing circuit. Nearly all production testers are built on this pattern with variations made necessary for protection of the instruments from overload and shorts.

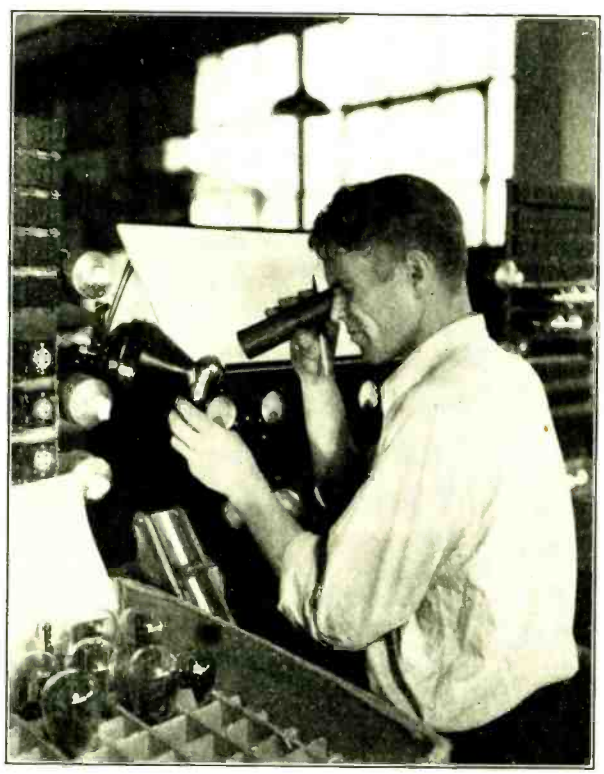
On the face of it, the problem appears to be simple. One would even be tempted to build a universal tester by using multi-range instruments, or at least one taking care of several types of tubes. After thorough consideration of the problem, one cannot but come to the conclusion that it is preferable to use a different tester for each type of tube.

It is apparent to anyone familiar with tube making that little or no reliance can be placed on the operator to use intelligence and care, particularly when pushed for production. If the operator was to be relied on to switch each individual instrument of a universal tester, the wrong ranges would often be used. This would result in ruined meters and wrong readings.

It is, of course, possible to construct a tester, where all switching is done by pushing a button, or it is possible to switch by hand and protect each range separately.

Such a tester would be very complicated and too expensive to be desirable. As the capacity of any tester where meters have to be read ranges only from about 1500 tubes per day for —26 tubes to much less than 1000 for —50's, approximately, one test set for each thousand tubes per day must be provided. It is better to provide a special test set for each type of tube.

The production figures for test, given above, are apt to be challenged by some as too low. It is possible that in well-supervised small plants a somewhat greater speed may be expected during a single day. However, if we take average conditions and average type of help, and if we take, not a single day's record, but the average over a long period, these figures will be found fairly accurate.



The human element, as well as the mechanical, is an important agency in the accurate testing of tubes, as is shown in this scene in the laboratories of E. T. Cunningham, Inc. Here, the trained eye of the testing expert is examining the condition of the inner elements of a tube, aided by a magnifying lens and a special lamp.

The Power Supply

One of the most important items of the test plant is the power supply.

For filament power, a storage battery for every test set is quite adequate. Keeping the batteries in condition is not a troublesome task for a well-organized maintenance force. A 10-volt generator connected to all test sets is, however, more convenient and requires less attention.

It is hardly practical to provide a supply of exactly the proper voltage for each type of tube. A rheostat must be employed in each test set for filament voltage regulation.

The bias voltage is best provided by individual dry-cell B batteries for each set. As such batteries are tapped mostly only at half and full voltage, a potentiometer must be provided to obtain the desired voltage. Large B batteries are designed for a drain of not more than 20 ma. Any steady drain of even that much will ruin them very quickly.

At 50 volts, the normal bias of —45 tubes, a 2500-ohm potentiometer across the C battery will draw 20 ma. An ordinary voltmeter may draw 10 ma. If, in addition to that, the battery is subjected to the strain of occasional shorts, its life is apt to be greatly impaired. It is, therefore, necessary to keep the battery normally disconnected and to connect it only while each tube is read. This is accomplished by the use of relays.

Where only a small number of testers are used and low first cost is a consideration, the B batteries may be replaced by a battery of No. 6 dry-cells which will easily stand up under the strain, even when permanently connected. A battery supplying 50 volts can be made up of 34 cells. It is very satisfactory from the operating viewpoint, but cumbersome.

For plate voltage supply, dry B batteries are entirely inadequate. A drain of from 30-70 ma. as required by the —45 and —50 tubes will cause rapid deterioration of the battery and may even cause a voltage drop during a single observation when the battery begins to run down. For small plants a battery of No. 6 dry cells is again the cheapest and most easily available solution. Storage B batteries of customary size are entirely unsatisfactory. Besides being messy in their upkeep, they are unreliable. They

unfailingly cause trouble after a short time.

It is feasible to use a bank of generous size storage batteries, well insulated in glass cases, as power supply for all testers. The battery is kept floating on a 500-volt generator, or it is charged every night. Even a well-designed installation of this type must be handled intelligently. The required voltages are tapped off at proper places between cells. The voltage at the tester is then never more than one volt removed from the specified voltage, which is sufficient accuracy.

Individual constant-voltage generators for each voltage required are more satisfactory, in the writer's experience. If the generators are properly designed, there will be no appreciable variation in voltage from no load to maximum.

A simpler, but less desirable, installation consists of an ordinary 500-volt generator connected to a voltage divider. To avoid voltage variations, it is, however, necessary to choose a generator of very generous dimensions and to dissipate most of the energy in the divider. The maximum load must be kept at a small fraction of the energy dissipated by the divider, otherwise voltage fluctuations will occur.

Meter Protection

One of the problems of tester design is the proper protection of meters. Gassy tubes, shorts within the tube, and last but not least, shorts in a worn-out socket in the tester itself are apt to destroy meters. A dead short between grid and plate of a —50 tube, for instance, will subject the grid microammeter and the plate milliammeter to the combined plate and grid voltage, that is, 500 volts total—enough to do serious damage. It might be contended that a short test prior to the final test for characteristics would prevent damage to testers. This would, however, be placing too much reliance on the average operator. Such procedure would also introduce an additional operation. One must also remember that tubes are apt to develop shorts while being tested. A lamp of proper size, in series with the plate supply will effectively protect the milliammeters from shorts or

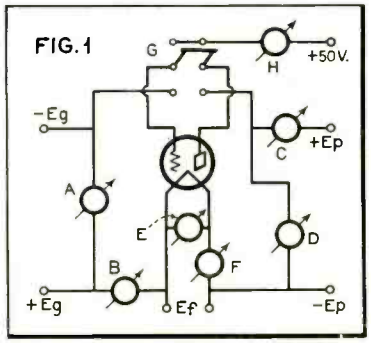
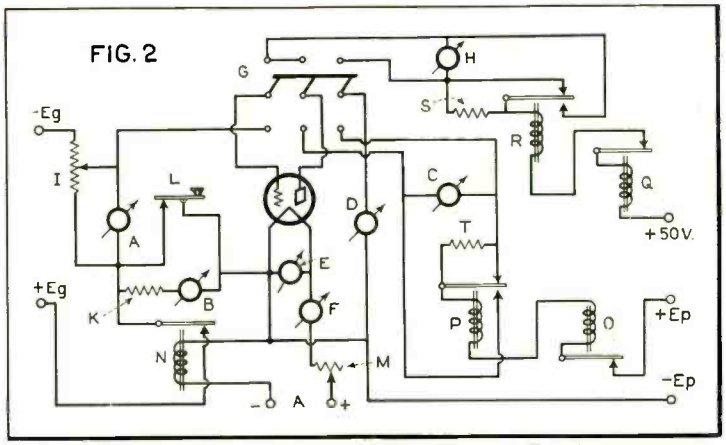


Diagram of basic tube testing circuit. Identifications are the same as in Fig. 2.



Complete tester circuit. A is the grid voltmeter; B, microammeter; C, plate milliammeter; D, plate emission voltmeter; E, filament voltmeter; F, filament ammeter; G, T. P. D. T. switch; H, emission milliammeter; I, grid potentiometer; K, 1-meg. resistor; L, shorting key; M, fil. rheostat; N, C bat. relay; O, plate current breakers; P, plate relay; Q, emission current breaker; S, resistance to prevent chattering.

overload. Such a lamp will, however, cause a considerable voltage drop which will vary with the plate current. To avoid errors, it is then necessary to provide a plate potentiometer which must be carefully adjusted for each tube, considerably slowing down operation.

Circuit breakers in place of lamps furnish rather complete protection without introducing errors. The former, however, are still subject to carelessness of the operator to some extent. If the circuit breaker is closed again before the defective tube is removed the tester will be damaged. Fuses are free from this objection as the operator must call the foreman before another fuse is obtainable. Fuses with a rating of from 25-250 ma. are, however, somewhat expensive.

In up-to-date installations, the milliammeters are protected by relays in series with the meters which break the circuit and close an indicating lamp circuit. Provision is also made for locking the relay in the open position as long as the short persists.

The microammeter cannot be protected in this way, as no relays are available which trip at a few microamperes. It is, however, possible to do so by storing sufficient energy in a condenser to operate a relay.

A resistance of 1 meg. inserted in series with the instrument will not affect the gas reading appreciably up to about 3 ma. which is the permissable gas limit for small tubes in combination with a normally closed switch which shorts the instrument and resistance.

Plate current is read with the switch closed: gas with the switch open. It will be noticed that a shorting switch is necessary for a correct plate current reading as even the resistance of the microammeter alone in the grid circuit sometimes affects the plate current. This method of protection for the grid circuit is quite effective. The operator is not inclined to transgress in this particular case.

To guard against failures of relays, the tester is further protected by two circuit breakers or fuses in the emission and plate voltage leads. This additional protection is necessary to prevent expensive general conflagrations which would occur from time to time.

In case of dead shorts, sensitive relays have to break up to 500 volts. Sticking of contacts and arcing is infrequent, but does occur. The circuit breakers are intended for protection against such contingencies.

A fully protected tester is quite complicated and expensive, but it repays the outlay very quickly in increased production, greater accuracy and comparatively low maintenance costs. It also has a good effect on the morale of the operators. The fact that they are given elaborate equipment instead of make-shifts, helps to impress them with the importance of their tasks.

In the manufacture of tubes where, in spite of closest supervision, so much depends on the care of the individual, considerations affecting the morale are of first importance.

The designers must be very careful in choice and placement of relays in the different parts of the circuit. Resistance in series with the current meters must always be negligible compared with the resistance of the tube. Relays must stand the strain when exposed to short circuits. The contacts must be of generous proportions; the gaps must be sufficient to extinguish the arc at the prevailing voltage.

Fig. 1 shows the basic circuit. Fig. 2 shows a method of protection.

In Fig. 2, relay N cuts out the C battery when the tester is idle; R and P are the plate and emission current relays: Q and O are the circuit breakers.

The normally closed contacts of the relays are by-passed by a suitable resistance to prevent chattering. Short

(*Continued on page 67*)

Public-Address and Centralized Radio Systems

1. The Power Amplifier and Power-Supply Unit

By E. W. D'Arcy

THIS particular subject has gained an unusually great amount of interest in the last eighteen months, due to the development of several forms of talking motion pictures. At the same time, there has been very little information relative to public-address systems, power supply, and associated equipment, available to the engineer not in the employ of one of the several leading manufacturers. It is quite a problem, and it would be impossible to attempt to cover all the angles in anything short of a text book. We will, therefore, content ourselves with concentrating salient points into a group of articles to appear in subsequent issues of RADIO ENGINEERING. The following article deals with this subject generally; mainly with the power supply and actual amplifier unit, the best way to obtain maximum efficiency out of this equipment, and the minimizing of hum.

Several different electrical units, such as phonograph pickups, microphones, attenuation pads, etc., are used in public-address equipment, and for ease of discussion we will subdivide them and discuss each one individually.

Combined Amplifier and Power-Supply Type

A great many of the more popular amplifier units have their power supply built in as an integral part of the complete unit. This system has its advantages where no great degree of amplification is occurring in the unit, or in the enclosure of the stage of amplification under discussion. However, where a complete public-address amplifier is used with a high grade type of microphone the gain throughout the whole amplifier system is quite considerable, which means that the first stage of the amplifier becomes extremely sensitive so a great deal of difficulty is encountered from hum, due to pickup in filament leads, wires, and stray electromagnetic coupling. This can be overcome to a large extent by placing the audio transformers at a proper angle with respect to the power transformer. The angle is extremely critical and the transformer should be placed in its angle under actual conditions, the best way of doing this being to short circuit the grid of the tube preceding the transformer under hum adjustment to its cathode, then turning the amplifier on and adjusting the transformer for minimum hum output as shown on a hum meter. All the transformer cases should be grounded and, if possible, all wiring incased in iron pipe for shielding.

THIS is the first of a series of articles on Public-Address and Centralized Radio Systems by Mr. D'Arcy. Subsequent articles will deal with fader control systems, line balancing, level-indicating devices, impedance-matching; then centralized distributing systems, channel-selecting devices, relay control, and so on, completing the series with data on laboratory test equipment.—EDITOR.

In some of the better grade of public-address and theatrical amplifying systems, separate power supply is incorporated for each particular stage of amplification. This precaution is necessary due to the voltage drop through the choke coils and rectifier tubes. If a slightly gassy tube is used in one of the stages the increased current causes a drop in voltage on the preceding stages with a resultant amount of distortion. It is not necessary where voltage amplifiers are used and the impedances of the tubes are so high that no considerable amount of current is likely to be drawn in the plate circuit, but where a large amount of power is required in the amplifier, it is necessary to minimize the possibility of a voltage drop such as has just been mentioned. Consequently, this system has received the approval of the largest manufacturer of motion picture sound equipment. There is still, however, a considerable amount of difficulty arising from transient electromagnetic fields. It would seem from the results obtained that the difficulties of this particular system are very much over-balanced by the superior quality obtained and the reliablity of the equipment.

Separate Power Supply

Where portability is not a necessity and the equipment is being built for a permanent installation, to be operated off the commercial lighting supply available, a very much better type of equipment can be constructed by separating the power supply from the amplifier. This is a very exeellent practice and can be accomplished quite easily. By this method it is possible to remove the power supply transformers far enough away so no great trouble is encountered due to stray electromagnetic fields and hum; therefore, this source of trouble can be considered as eliminated with this type of apparatus. This particular design merely necessitates the building of a separate rack on which is placed all the power supply equipment, such as power supply transformers, filter chokes, rectifiers, voltage dividers, and the power control equipment. A small expenditure of money is required for this design but the additional expenditure is more than warranted in the improvement of results. The same warning holds true, however, that where a low impedance tube is used and there is a possibility of one of the tubes becoming slightly gassy and drawing an enormous plate current from surges of its applied grid voltage, a necessity still exists for separate power supply, especially, where push-pull stages are used.

The author so far has not witnessed

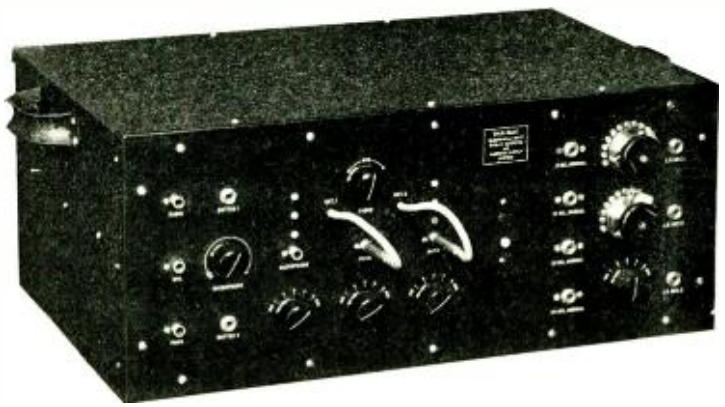


Fig. 3. Front view of a portable public-address amplifier. Provisions are made for its use with microphone, pickup or rad o. Fading also can be accomplished.

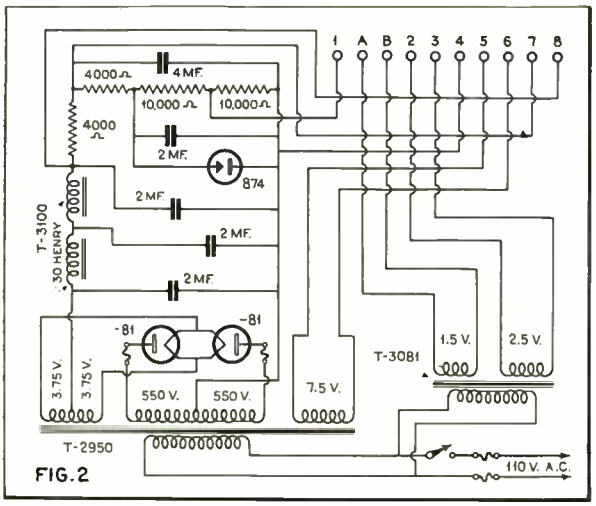


FIG. 2

Schematic diagram of the the portable p.-power unit for a. amplifier. The terminal numbers indicate the connections to be made between this unit and the amplifier.

a commercial type of push-pull, low impedance, high output, stage of amplification working without an unexplainable high plate current. The plate current variation in this stage, using type-50 tubes, increases to as high as 185 milliamperes from the normal level of 110 milliamperes when delivering an output of 7 watts. This terrific increase in current makes it an impossibility to operate the tubes off the same power supply as used for the preliminary stages. Fair results can be obtained, however, where push-pull stages are eliminated and the iron in the output transformer is operated far enough beyond its saturation point to become an effective impedance, thus aiding in choking out any transient gassy current which might occur. As an actual demonstration of this point, with the two type-50 tubes previously mentioned, the same identical tubes delivered an output of 15 watts with an increase in the plate current of only 10 milliamperes. This statement can be checked very easily in practice, the only necessity being that of an output transformer with enough iron and copper in it to insure good reproduction at high values of plate current.

Portable Public-Address Amplifier

An illustration is shown here (Fig. 3) of a portable public-address amplifier with every facility included for operation from microphone, phonograph pickup, and radio. Fading also can be accomplished between any of the three mentioned sources of supply. The mixer circuits, as shown in the schematic diagram of Fig. 1, are matched and built for a 600-ohm line impedance. Special designed transformers of an unusually high quality are used. However, even in this amplifier, the hum is still quite a considerable element, and a compact amplifier of this type would not be practical for theatrical purposes. This particular schematic diagram has been subdivided into several separate sections—the power-supply unit being shown in Fig. 2—so that we may take up the discussion of each component section in subsequent issues.

Input and Fader Controls

The line input volume controls and fading controls are somewhat novel, as can be easily discerned. It is quite obvious that for good reproduction without attenuation of the higher frequencies, it is extremely necessary to have all the impedances of the system worked out correctly. For that reason, instead of merely short-circuiting the primary of one of the transformers for a volume control, a three legged T arrangement is used, by that means resulting in an unusually flat frequency response curve for any given degree of attenuation. The power output transformer in this amplifier unit is so arranged as to match the impedance of the following loudspeakers—4, 8, 12 and 16, or by using the tips of the speaker plugs for the output circuit, as shown, and plugging into the output jacks on the panel, further impedance reductions can be obtained down to where impedance matches are possible with the voice coil of a dynamic speaker, which is approximately 6 ohms.

This transformer has been especially designed to withstand the quite high degree of current flowing through its primary and still give an excellent frequency response. Insulation is an important factor in an output transformer used in this manner, and transformers insulated for 1,000 volts have a disgusting tendency to break down unceremoniously, therefore, a primary requirement for a good output transformer is that of high insulation value.

A further discussion on output transformers will be taken up in a subsequent issue.

(To be continued)

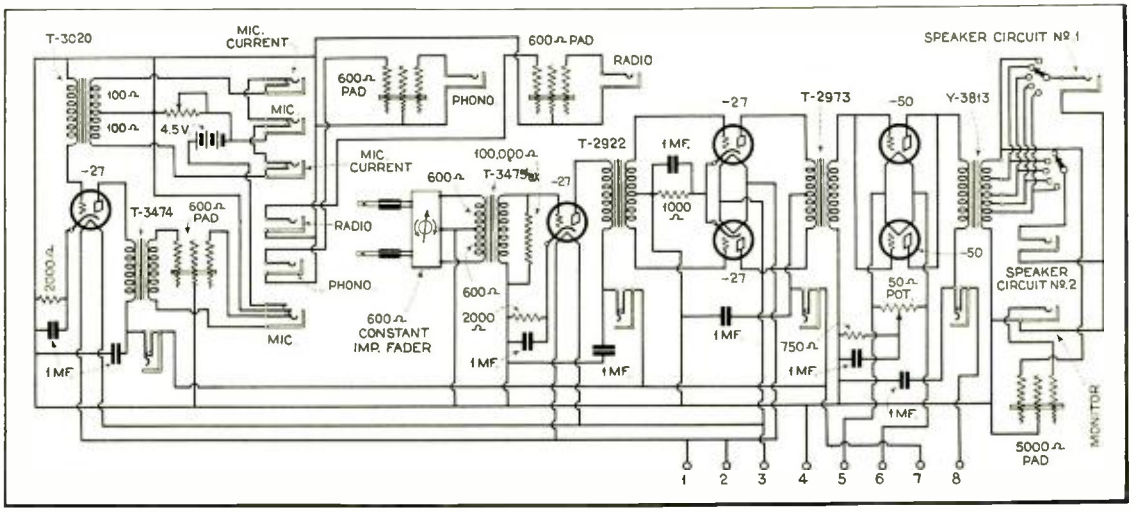


Fig. 1. Schematic diagram of the public-address amplifier, along with the switching arrangement, faders and pads.

The Engineering Rise in Radio

By Donald McNicol

Fellow A.I.E.E., Fellow I.R.E., Past-President, Institute of Radio Engineers

Part XVII

The Super-Regenerative Receiver

SHORTLY after his return from army service, Armstrong began the development of another type of radio receiver by the extension of the regenerative principle into a field beyond that previously explored by him. Out of this research, which was in part carried on simultaneously with the improvement of the superheterodyne, came the receiver known as the super-regenerative set.

In the simple regenerative circuit the energy in the plate circuit feeds back into the grid circuit by way of coupling, and at an increasing rate as the coupling is increased, until a point is reached at which the apparent resistance of both circuits is overcome, setting up the generation of oscillatory currents. If at the approach to the oscillatory state a resistance could be inserted in the grid circuit which would absorb the extra energy, and removed when that is accomplished, the process being repeated with the requisite rapidity, the advantage of regeneration would be considerably increased. Armstrong's investigation disclosed three methods for accomplishing this. Resistance could be applied to the circuit by means of an additional tube circuit coupled to the grid, periodically tuned and detuned to the frequency of that circuit. Or, the additional circuit could be coupled to the plate, or a combination of these two arrangements could be employed to accomplish the desired end.

In England, L. B. Turner[11] by means of tubes prevented the regenerative circuit from generating oscillations when no signals were being received, by impressing a negative potential on the grid of just sufficient value to maintain the state at which self-oscillation could not occur. Return to the sensitive state was accomplished by relay action caused by increase in the plate current of the tube, shunting the feedback coil as a result of which the source of added energy was shut off. Thus the potential of the grid dropped to a value below that which would produce oscillations.

In England, also, J. B. Bolitho[12] improved on the mechanical relay idea by connecting a second tube to the oscillating circuit of Turner's arrangement with a reversed feedback connection, supplying the plate circuit of the second tube with alternating-current. The novelty here was that at the "spill-over" point of the first tube the reversed feedback of the second tube, acting at a time when the voltage supplied to the plate was positive, served to damp out the free oscillation started by the first tube thus causing the grid of the first tube to return to the non-oscillating state.

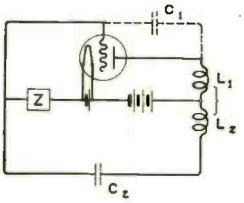


Fig. 44. Fundamental Neutrodyne circuit.

About the time that Armstrong was at work on the super-regenerative receiver (1920–1921), C. V. Logwood apparently was close on the track of the same problem. In March, 1921, he filed a patent application covering means whereby regeneration was fully availed of without undesired oscillation effects. His proposal was to use a mechanical exciter, such as an alternator, shunted by a resistance and capacity in series, and connected to filament and plate of the tube of the regenerative set. (Presumably a tube also could be used as the exciter.)

Referring to the second paragraph under the caption "The Super-Regenerative Receiver," Armstrong devised various more or less related methods of accomplishing the desired purpose, one of which is illustrated in Fig. 43.

When an above-audibility frequency of variation is used, it may be of advantage to have the detection function cared for by the oscillator tube, as here illustrated. Operation of the receiver is as follows: Incoming signals are amplified by means of the regenerative action of the amplifier tube R, and the variations of potential across the tuned frequency circuit LC impressed on the grid of the oscillator tube O. The oscillations are then rectified, two frequencies being produced in the circuits of the amplifier tube. One of these corresponds to the frequency of modulation of the incoming waves: the other, to the frequency of the variation and contains a modulation corresponding in amplitude to that of the signal wave. This second frequency is then impressed upon the circuits of the oscillating tube with which it is in tune; amplified by the regenerative action of the system $L_1C_1L_2O$, and then rectified.

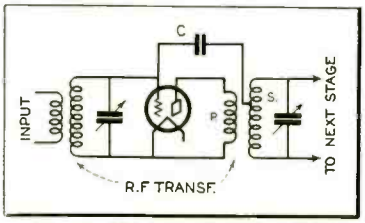


Fig. 45. The radio-frequency stage of a Neutrodyne receiver. C is the neutralizing condenser.

The super-regenerative circuit illustrated in Fig. 43, using three tubes (one stage of audio-frequency amplification added), and with loop antenna proved to be a receiver particularly efficient in broadcast reception.

In the simple regenerative receiver various ingenious methods were worked out by means of which it was possible to control the amplifying energy fed back to the grid circuit. Methods were proposed by R. A. Weagant, R. V. L. Hartley, A. H. Grebe and John L. Reinartz, and a number of excellent receivers were designed which performed satisfactorily over reasonable distances. Among the various modifications might be mentioned the developments of E. T. Flewelling, the Grebe split-variometer circuit, and the improved ultra-audion circuit due to L. C. Cockaday.

Shortly after the introduction of popular radiophone broadcasting, many amateur experimenters in designing and constructing receiving sets for their own use were confused by what the inventors and engineers were about, as disclosed in technical radio literature. With the first regenerative receivers the cry was sounded that the tube must not be permitted to oscillate. Then appeared more elaborate receivers in which advantage was

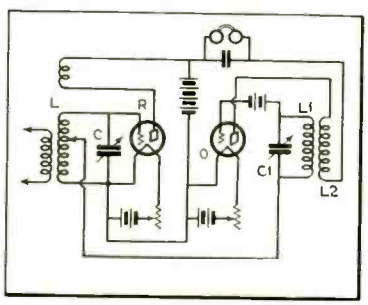


Fig. 43. Diagram of early super-regenerative circuit.

[11] *Br. pat.* 130, 408; *U. S.* 276, 856 (1919).

[12] *Br. pat.* 156, 330 (1921); *U. S. pat.* 1,407,245 (1922).

taken of the oscillating properties of the tube, in which it was important that the tube should oscillate.

The engineering reasons for this situation are outlined in the foregoing paragraphs.

In the original regenerative feedback and ultra-audion receivers the incoming antenna currents were rectified, amplified and passed on to audio amplification stages. It was natural that engineers engaged in developing improved radio receivers should sense that the radio-frequency currents oscillating in the antenna circuit in response to transmission from a distant station, might be amplified, transformed or "boosted" so that in the case of very weak incoming waves the energy passed to the detector tube would be considerably increased in strength.

The German engineers were early in the field with radio-frequency amplification ideas. Von Bronk, in 1911,[13] invented a circuit in which the plate circuit of a tube was by means of an air-core coupler associated with a secondary circuit containing a crystal detector and telephone receiver. In 1913 Schloemilch and Von Bronk procured a patent [14] covering a receiving system in which a radio-frequency tube was followed by a crystal detector and by an audio-frequency tube circuit. A modification of the latter showed a single tube serving as radio-frequency amplifier and as audio-frequency amplifier, a crystal being used as detector. In the course of time this arrangement was the basis of various ingenious developments called Reflex circuits.

Alexanderson[15] in America, in 1913 procured a patent for a multi-stage radio-frequency amplifier, comprising two stages of radio-frequency amplification followed by a tube detector, the radio-frequency stages being transformer-coupled, the grid or secondary circuits being tuned. At the same time Langmuir,[16] in America, applied for a patent covering a receiver system consisting of two stages of radio-frequency amplification, a tube detector, with grid-leak rectification and one stage of audio-frequency amplification.

The "grid-leak" function here referred to is distinct from the high-resistance gridleak in series with the grid of a tube, first shown in circuits by deForest, and concerned a potentiometer-shunted battery from the grid of the detector tube (the third tube), connected across a grid condenser, thence to the secondary of the radio-frequency coupling, the primary of which connected with the plate of the second radio-frequency tube.

[13] *Br. pat. No.* 8,821 (1913).
[14] *U. S. pat. No.* 1,087,892 (1913).
[15] *Br. pat. No.* 147,147 (1913).
[16] *Br. pat. No.* 147,148 (1913).

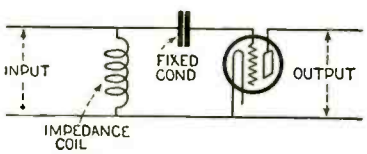


Fig. 47. An impedance-coupled radio-frequency circuit.

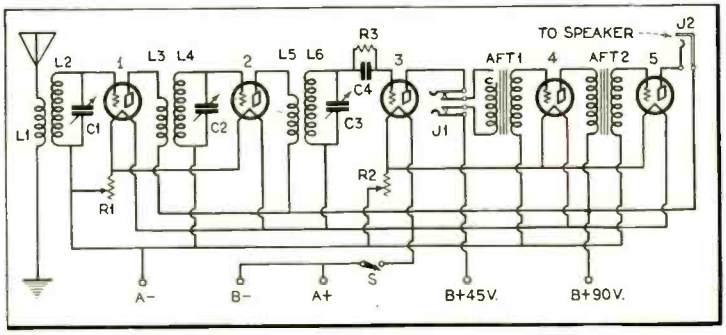


Fig. 46. Schematic diagram of early tuned radio-frequency receiver.

Actually, the conception of radio-frequency amplification preceded by a year or more the invention of the regenerative circuits, and it was out of the combined inventions that the superheterodyne inventions of Levy, in France, and Armstrong, in America, were evolved, as well as various other efficient receivers, and modifications.

It was recognized that only by the employment of radio-frequency amplification could the long-distance possibilities of the radio receiver be developed. The addition of radio-frequency stages, however, introduced elements which, unless properly designed, and expertly handled in operation of the set, rendered the receiver somewhat unstable in performance as compared with the simpler circuit arrangements not employing radio-frequency amplification.

In the present broadcast frequencies particularly, the maximum amplification of a tube circuit is reached just before the stage is reached at which the tube oscillates. In tuned radio-frequency circuits oscillations occur unless means are provided to prevent oscillation. Further, radio-frequency stages must be tuned if they are expected to provide close selectivity—sharp tuning. In radio receiver circuits using radio-frequency stages, the efficiency of the method used to suppress local oscillations determines largely the efficiency of the receiver as to sensitivity, selectivity and quality.

Following the radio improvements which occurred during the war years (1914–1918), the principle of radio-frequency amplification was applied in the design of various receivers, some of which have been described herein. Immediately it was apparent that there was a need for a satisfactory method of stabilizing the operation of such receivers by suppressing the tendency of the tubes to oscillate.

When the requirement was clear there followed within a few years various proposals with the desired object in view. Among the methods proposed were: inductive neutralization, capacity neutralization, the potentiometer method, and various "losser" methods.

The Neutrodyne Receiver

A simple and highly satisfactory method based on "capacity neutralization" was invented in 1919, by Professor Louis A. Hazeltine,[17] of Stevens Institute of Technology. His U. S. Patent No. 1,489,228, covered a method for neutralizing capacity coupling in three-electrode tubes, comprising a coil connected between the grid and filament, and an auxiliary coil and neutralizing capacity in series and connected between the plate and filament. The auxiliary coil was coupled with the first coil, the coefficient of coupling being substantially unity and having a ratio of turns equal to the ratio of the coupling capacity to the neutralizing capacity—the ratio differing from unity.

Prior to Hazeltine's invention of the neutrodyne system, the coupling which made cascade amplification unsatisfactory was that inherent in the tube itself; that introduced by the capacity between grid and plate. Applied to the radio-frequency amplifier, capacity-neutralization removes the undesirable effects of the capacity relation within the tube.

The fundamental neutrodyne circuit, as illustrated in Fig. 44, shows a neutralizing condenser C_1 connected across the plate and grid of the tube. If the inductances L_1 and L_2 are very loosely coupled, voltage occurring in the plate circuit cannot produce an effect in the preceding grid circuit, represented by Z, provided the condenser C_2 is properly adjusted, and the neutralization thus accomplished is independent of frequency. Professor Hazeltine developed mathematically the theorem that magnetic coupling between any number of symmetrical coils may be eliminated by placing them with their axes parallel and at a certain angle to a common line of centers, permitting the use of single layer cylindrical coils which are an efficient type of high-frequency inductance, and may

[17] *U. S. pat. No.* 1,489,228, *applied for December* 28, 1920, *issued April* 1, 1924. *Also see U. S. pat. Nos.* 1,450,080 *and* 1,533,858.

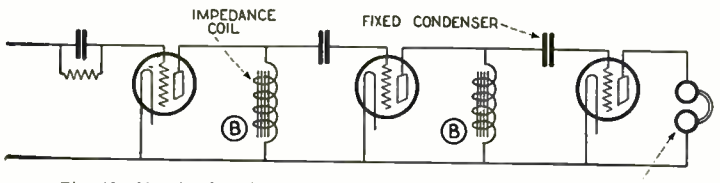


Fig. 49. Circuit of an impedance-coupled audio-frequency amplifier.

be mounted in relatively small space. (See Fig. 45.)

To clarify the function of the neutralizing condensers it may in another way be stated that "feedback" through the tube (with its internal capacity) is one of the chief causes of self-oscillation. Obviously this capacity within a given tube cannot be altered, it follows that one thing to do is to employ a form of capacity neutralization which will oppose the grid-to-plate capacity within. An effect of the transfer of energy from plate to grid is to set up strong radio-frequency currents in the radio-frequency circuits of the amplifier which interfere with the oscillations induced therein by the received waves in the antenna circuit.

The neutrodyne is a non-radiating receiver and a typical set is made up with two stages of tuned and neutralized radio-frequency amplification, detector and two stages of audio amplification, employing five tubes in all.

Other Neutralizing Inventions

Naturally the race for the solution of the oscillating difficulties in radio-frequency amplifiers was participated in by several engineers well aware of the needs. Among these were C. W. Rice[18] and R. V. L. Hartley,[19] in America and John Scott Taggart,[20] in England.

The electrostatic capacity inherent in the audion in the early regenerative sets, cascade amplifiers, and other tube receiving circuits, was not at first suspected as being a disturbing element; something to be neutralized or balanced out. Rice proposed neutralization of the grid-plate capacity by setting up an auxiliary circuit including inductance and capacity. In a bridge assembly the tube capacity constituted the quantity in one leg.

Hartley aimed to avoid the effects of the tube capacity by providing means for neutralizing the effect of the coupling so that greater amplification might be obtained and still maintain stability of performance. He utilized the radio-frequency energy in the plate circuit through a reversed feedback connection, thus opposing the energy due to regeneration through the tube.

Another ingenious method of accomplishing the same purpose was brought out in America in 1926 by Edward H. Loftin and S. Y. White, wherein by means of constant coupling non-reactive radio-frequency amplification is practicable.

As to who "neutralized" first, it is likely that for some years to come courts in several countries will be engaged in the task of determining the relative values of the claims in patents granted to Hazeltine, Rice, Hartley and Taggart.

Fig. 46 shows a diagram of a five-tube tuned radio-frequency radio receiver without oscillation control, comprising two stages of radio-frequency amplification, detector and two stages of audio-frequency (transformer coupled) amplification.

In this chapter on radio receivers the purpose has been to trace in chronological fashion the evolution of the receiver from the days of the filings coherer down to the present time, noting discoveries and forward steps which contained elements of fundamental importance. It would be a difficult task, and one of little useful purpose to undertake to describe and illustrate all of the variations of the fundamental circuits which have been devised, many of which work quite efficiently, but it may be in place here to describe briefly means of transferring energy from one stage to another in a radio receiving system other than those previously described wherein air-core transformers or couplers are used to connect succeeding sections.

Instead of a transformer with two separate coils it is practicable to use what is termed impedance coupling as illustrated in Fig. 47. The energy to be applied to the input of the tube is that set up across the terminals of the impedance coil, which is a coil having inductance, and may or may not have an iron core, depending upon whether it is to be used for passing or amplifying radio-frequency or audio-frequency currents. In Fig. 48 plain "resistance" coupling is shown, the input voltage being that due to the difference in potential between the terminals of the resistance inserted.

Viewing extensions of this principle, in Fig. 49 is illustrated the wiring of an impedance-coupled amplifier to the right of the detector tube. Here, one winding serves as primary and secondary. The condensers in series with the grids of the two tubes to the right are there for the purpose of interrupting the conductive path from the high-voltage "B" battery (not shown) which would be by way of the impedance coil to the grid.

Where impedance coils are shown in Fig. 49, plain resistance coils may be connected instead. Based on this simple form of coupling many excellent receiver circuits have been devised, especially those known as "resistance-capacity" amplifiers.

Reflex Circuits

It has been recorded that Von Bronk and Schloemilch, in Germany, in 1913, introduced a receiver circuit employing both crystal detector and tubes. This arrangement was the forerunner of several highly ingenious and efficient radio receiver systems introduced in service following the launching of popular broadcasting, and called "Reflex" circuits.

One of these is illustrated in Fig. 50, wherein a variometer is used for tuning purposes. The primary and secondary windings of two audio-frequency transformers are denoted by "P" and "S." "A" may be the stationary element of a split variometer, and "R" the rotary element. "D" is a crystal detector.

By means of reflex receivers "dual amplification" is accomplished; that is, both radio-frequency and audio-frequency amplification are accomplished simultaneously in a single tube. The received radio-frequency oscillations are first amplified by a tube, then rectified by a crystal detector (or a two-electrode tube) which in turn are passed back to the input circuit of the tube and thus further amplified.

Reference has been made herein to the needs of war (1914–1918) stimulating the development of radio receivers which would be more sensitive and selective than receivers previously in use. Much of the development which took place in the few months during which the American, British and French radio engineers were to some extent cooperating in a common objective, was the result of invention. In times of peace invention usually is followed promptly by applications for patent protection, but in war emergencies when the nation's resources are consolidated with the individual and collective efforts of combatant and non-combatant citizens contributing to a main objective, patent protection for particular inventions occurs only to the far-sighted who realize, practically, that even wars come to an end. When wars end there is at once termination of community interest. Individual interest at once resumes the even tenor or the troublous dissonance of its way.

These thoughts are prompted by a consideration of the situation in regard to priority of invention in radio as it has developed gradually through-

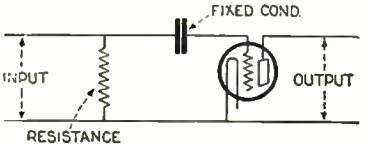


Fig. 48. A resistance-coupled radio-frequency circuit.

[18] *U. S. pat. No.* 1,334,118.
[19] *U. S. pat. No.* 1,183,875.
[20] *Br. pat. No.* 217,971.

out the ten years following the close of the great war. In the development of the superheterodyne receiver, the super-regenerative receiver and the reflex circuits, undoubtedly work proceeded simultaneously in France and America which formed the bases of patent applications. In America, W. H. Priess in 1916-1917 in the service of the U. S. Navy, invented various circuit combinations employing reflexing. La Tour, in France, in December, 1917, applied for an American patent [21] on a reflex receiving system, and presumably the patent records of each country, viewed as records of priority of invention, would in several major cases vary as to the names of the inventors of particular radio receiving systems.

(To be continued)

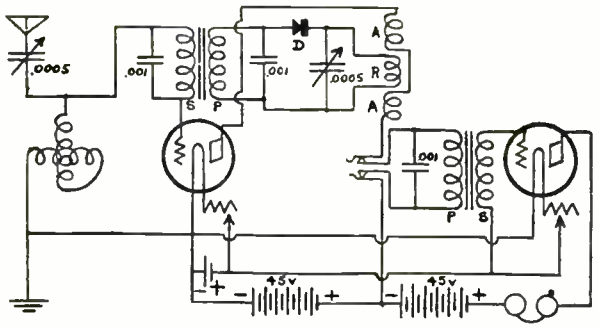


Fig. 50. A Circuit diagram of the once popular reflex receiver.

[21] *U. S. pat. No. 1,405,523, issued February 7, 1922.*

SIMPLIFYING "STRAIGHT LINE" CONDENSER DESIGN

(Continued from page 50)

in the S.L.W. segment. The S.L.F. segment can be rated at 10 kc. per D.S.D., starting at around 1500 kc.

Let us test a tentative design for 180° plate of "triplecurve" calibration, with 180 D.S.D., each corresponding to one angular degree. Starting with 60 D.S.D. of S.L.F. covering 2000 to 1000 kc., we can add to it another 60-degree segment of S.L.W. covering 300 meters to 420 meters, or 2 meters per D.S.D. To complete the plate we can add an S.L.C. segment of 60 degrees starting from 120 D.S.D. at 420 meters and going as far as 180 D.S.D.

How long a wave can we reach in this last case, starting at 120 D.S.D. and finishing with a capacitance 50% greater? The answer is—we reach 420 meters multiplied by the square root of 1.5, which is 1.224. This gives us 514 meters,—a change of 514 minus 420 or 94 meters in 60 D.S.D., or about 1.5 meters per D.S.D. on the average. We have, however, failed to reach 549 meters and will now redesign so as to be sure of reaching it, by working backwards.

Let us assume 549 meters at the 180 D.S.D. of the S.L.C. segment. We also will assume an average of 3 meters per D.S.D. Hence, we have 183 meters difference along 61 divisions, bringing us at 119 D.S.D. to the beginning of the S.L.C. segment, where we tune to 386 meters, corresponding to ⅔ of the wavelength, or, to 4/9 of the area of 180 D.S.D. We now have the S.L.W. segment to lay out.

Assume 4 meters per D.S.D., which will bring us to 300 meters, with 24.5 D.S.D. of S.L.W. calibration. This leaves us 99.5 D.S.D. for our S.L.F. segment.

Adopting 5 kc. per D.S.D., we start at 300 meters or 1000 kc. to go up to 1370 kc. or higher. As we have 99.5 D.S.D. we can reach 1497.5 kc., bringing us down to 200 meters.

The above set of design segments is quite satisfactory, as the average change in frequency per D.S.D. in the S.L.C. section becomes considerably smaller than that in the S.L.W. section. This is the sole object of the S.L.C. segment. Such a plate is shown in Fig. 12.

The designer of radio broadcast receivers will immediately say that we should use only S.L.F. plates for condensers working over this range, and, he will be right but—the above condenser has a wavelength range of 550 to 200 or approximately 11/4 and by using different coils or larger plates of the same geometrical shape the lowest wavelength of 200 meters may be raised to 300, 386, 549, meters or higher. Under the latter conditions the "triple-curve" condenser plate shows up well.

VACUUM TUBE DESIGN—AND PRODUCTION

(Continued from page 61)

indicating lamps are omitted in this diagram.

The meters may be replaced by meter relays which actuate indicating lamps by a further series of auxiliary relays. It is then possible to test by simply observing the lamps instead of reading meters. In this way, a considerable speeding up and increased reliability is obtained.

The Preheaters

Most of the coated filament or heater tubes take appreciable time to heat up to normal operating temperature. To avoid delays, it is necessary to preheat the tubes. For all tubes except —50's, five sockets provided with filament voltage will serve.

Whenever a tube is taken from the preheater to be tested, a new one is inserted in the preheater. In this way, a heated tube is always available. Type —50 tubes must be preheated with plate voltage on.

It is to be remembered that only limited accuracy can be obtained from production testers. An accuracy of about 5% is all that can be expected, particularly if only three-inch meters are used. Metering relays permit a higher degree of accuracy. Emission readings are affected considerably by slight variations in filament temperature. It is, therefore, essential to regulate filament voltages accurately.

The gas reading is also subject to considerable errors. Often a tube starts with a relatively high gas reading which decreases more or less rapidly. If emission is read before gas, the heating of the plate by the heavy emission current may cause an increased gas reading if the emission switch is held too long.

There is nothing fool-proof about tube testing. It is necessary to use judgment and great care if consistent results are expected.

SCREEN-GRID EFFICIENCY DEPENDS ON MUTUAL CONDUCTANCE

THE preponderance of screen-grid radio sets in evidence at the New York Radio Show has given rise to considerable speculation as to the efficiency of this new idea in broadcast reception, particularly since many set manufacturers are still presenting the usual three-element tube circuits as alternative offerings. Commenting on this point, Allen B. DuMont, chief engineer of the DeForest Radio Company, points out that the output of a screen-grid circuit is directly proportional to the mutual conductance of the screen-grid tubes employed, provided other characteristics are as they should be.

"Last year's sets," states Mr. DuMont, "employing the three-element tubes, had an overall gain of somewhere between one-quarter and one-half million. This season's sets, utilizing screen-grid tubes, have an overall gain of somewhere between one and three-quarter and two and one-half million, so far as the radio set designers are concerned. However, the deciding factor in the efficiency of present-day screen-grid sets is the mutual conductance of the screen-grid tubes themselves. Unfortunately, the matter of mutual conductance is not receiving as much attention as it deserves.

"Properly designed and employing screen-grid tubes with a satisfactory mutual conductance, the usual screen-grid circuit should have a gain of 25 to 50. The three-element tube circuit should have a gain of 5 to 10. It is just a question of tubes and circuits."

The Trend of Invention

By RICHARDS & GEIER

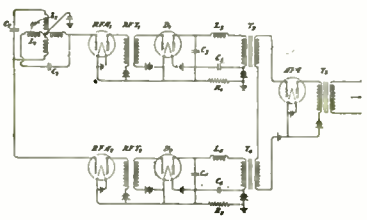
PATENT AND TRADE MARK ATTORNEYS 274 MADISON AVE NEW YORK CITY

Reduction of Fading of Radiosignals

De Loss K. Martin, of West Orange, New Jersey, Assignor to American Telephone and Telegraph Company, a Corporation of New York. U. S. Patent No. 1,719,896. (*Issued July* 9, 1929.)

THIS invention relates to improvements in methods of and means for reducing the fading of radio signals.

The term "fading," as applied to radio signals, is used with the commonly accepted meaning, referring to the relatively slow changes in the amplitude of the signal with time. The phenomena of fading is usually manifested at night, but is not limited to this general period of time, as signal fading has also been observed during the sunlit period of the day. The fading of the radio signal is caused by the interference of two or more signals which are varying in amplitude and phase; the received signal is, of course, the resultant of the interfering signals. Fading is also variable with respect to space; this includes the physical position of the receiving antenna and the space absorption characteristic of the antenna. The receiving signals may be conceived as being the resultant of several interfering wave fronts which are traversing a medium which is changeable in its characteristics. One component wave may be assumed to be intimately associated with the conductivity of the earth's surface over which



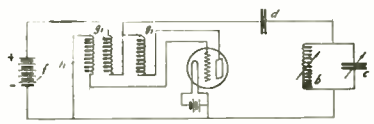
it is passing. The transmission of this wave component, termed the direct wave, would not be modified by the presence or absence of sunlight as there is no reason to believe that light affects the conductivity of the ground. However, the other component waves traversing the upper atmosphere are materially modified by the absence of sunlight. Hence, in theory it would be desirable to select with suitable means, the component or direct wave, from the resultant which will give uniform amplitude.

In practice, however, it is very difficult to make this selection, as it is necessary to balance out the variable components by combining out of phase these variable signals from two or more receiving points, and, due to the very nature of these variable components, it probably would be impossible to get a perfect balance. Or, the direct wave signals may be balanced out, leaving the combination of variable components whose resultant also would be expected to be variable to a degree. Hence, a compromise of these two methods would seem to afford a desirable method of obtaining a solution. Accordingly, it is the general purpose of the arrangement of this invention to combine the signals from two or more receiving points and to provide means to maintain the resultant of this combination substantially uniform in amplitude.

Oscillation Circuits

Wilhelm Kummerer, of Berlin, Germany, Assignor to Radio Corporation of America, a Corporation of Delaware. U. S. Patent No. 1,726,076. (*Issued August* 27, 1929.)

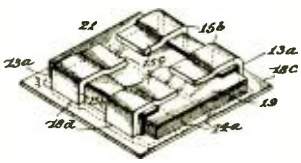
It is well known that the anode a-c. as well as the grid a-c. potential of oscillation tubes must have very definite values at a given anode d-c. potential, if the oscillation tube is to operate under optimum conditions. However, these values are unvaried within rather wide limits as the wavelength is changed. The consequence is that the ratio between anode a-c. potential and grid a-c. potential should remain invariably the same as the wavelength undergoes changes.



Electrical Condenser

William M. Bailey, of Lynn, Massachusetts, Assignor to Wireless Specialty Apparatus Company, of Boston, Massachusetts, a Corporation of New York, U. S. Patent No. 1,725,123. (*Issued August* 20, 1929.)

This invention relates to capacitors, and

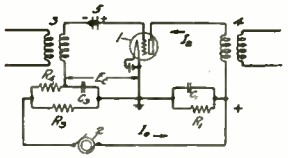


more particularly to the small fixed type for use in radio and other electrical purposes.

Amplifying Circuits

Francis X. Retteumeyer, of Montclair, New Jersey, assignor to Western Electric Co., Incorporated, of New York, N. Y., a Corporation of New York. U. S. Patent No. 1,724,965. (*Issued August* 20, 1929.)

An object of this invention is the suppression in the output circuits of space discharge devices, such as amplifiers; of

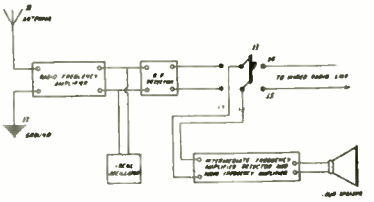


noise currents due to voltage ripples that may be unavoidably present in the continuous voltage of the energizing source.

Broadcast Receiving System

Julius Weinberger, of New York, N. Y., Assignor to Radio Corporation of America, a Corporation of Delaware. U. S. Patent No. 1,725,946. (*Issued August* 27, 1929.)

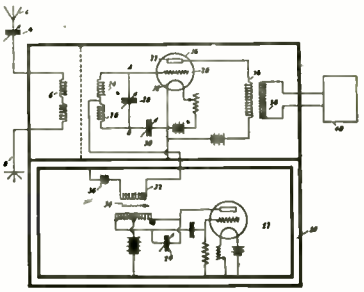
This invention relates to the art of broadcast receiving system and deals more specifically with a receiver designed for use in connection with the usual broadcasting frequencies, or alternatively for use in connection with the reception of wired radio programs.



Method and Means for Combining Frequencies

Harold O. Peterson, of Riverhead, New York, Assignor to Radio Corporation of America, a Corporation of Delaware. U. S. Patent No. 1,725,721. (*Issued August* 20, 1929.)

This invention relates to a method and means for combining frequencies, and more

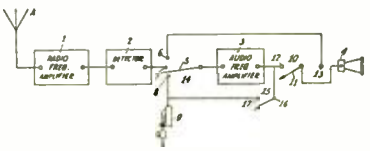


particularly for combining signal energy with energy from a local oscillator for heterodyning.

Combined Radioreceiver and Phonograph Reproducer and Recorder

Alfred N. Goldsmith, of New York, N. Y., Assignor to Radio Corporation of America, a Corporation of Delaware. U. S. Patent No. 1,724,191. (*Issued August* 13, 1929.)

The invention concerns an arrangement for receiving radio broadcast programs, re-

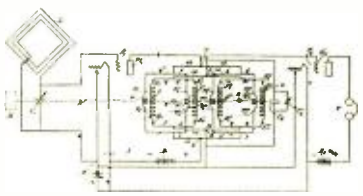


producing phonograph selections or recording phonograph selections either from broadcast programs or from a local source.

Radio Receiving System

Sewall Cabot, of Brookline, Massachusetts. U. S. Patent No. 734,205. (*Issued August* 20, 1929.)

This invention relates to radio receiving systems of the radio-frequency amplifier type in which a three-electrode vacuum



tube is interposed between an oscillatory receiving circuit and a second oscillatory circuit, the said circuits not being exteriorly coupled or interlinked, but coupled or interlinked only by the capacity between the elements of said tube.

Research

A complete production laboratory is devoted to the development of transformers and other items for general production as well as sample transformers for set manufacturers' requirements and special transformers for various purposes. Factory testing, service and drafting are controlled by the production laboratory.

An elaborately equipped research laboratory is maintained as an individual department totally independent of the production laboratory. In the field of independent research Thordarson is far famed. Not only is the research laboratory abreast of the trends in radio engineering, but is recognized in transformer circles as outstanding in its leadership.

THORDARSON

Transformer Specialists Since 1895

THORDARSON ELECTRIC MANUFACTURING CO.

Huron, Kingsbury and Larabee Streets, Chicago, Ill.

NEW GENERAL CONTRACT PURCHASE CORP. CATALOG

Filling a highly important statistical gap in the radio production and distribution system, the General Contract Purchase Corporation announced that the new 1929–30 Winter Edition of the General Radio Catalog, the only reference handbook of its kind, was off the press and available to the industry.

A ready reference of accurate and detailed information concerning practically every receiving set and speaker on the market, the new handbook is the outgrowth of an early reference guide which was issued a year ago.

Practically all radio set and speaker manufacturers cooperated in the production of this new 125 page manual which provides a complete reservoir of data of indispensable value to the entire radio industry.

Information compiled in the book includes the names and addresses of radio set and speaker manufacturers and their branch offices; names of company officials and branch managers; all recent consolidations and mergers; trade association memberships; company representatives in trade associations; patents and patent licenses held; broadcasting carried on by manufacturers; types of sets and speakers manufactured; cabinet styles; types of all tubes or rectifiers used in each set or speaker and list prices of sets and speakers.

The new Winter Edition has been prepared in regular bound pocket-size, catalog form as a result of the enormous demand which met the distribution of the 1928 edition. The present volume is regarded as a distinct improvement both in appearance and in contents.

The book is being marketed at the Central Offices of the General Contract Purchase Corporation in the Graybar Building, New York City.

N. B. M. A. MEETING AT CLEVELAND, OHIO

Manufacturers of storage batteries will be afforded another opportunity to meet together and discuss with each other the various problems now facing the industry at the annual meeting of the National Battery Manufacturers' Association. Mr. W. J. Parker, Commissioner of the Association, has just completed arrangements at the Hollenden Hotel, Cleveland, Ohio, for the official headquarters during the convention which will be held on Thursday and Friday, October 24th and 25th. The election of officers is planned for Friday afternoon.

The Program Committee is now at work on an exceptionally interesting business program for the two-day session. Several members of the United States Chamber of Commerce, as well as other prominent speakers, are to be present and various technical subjects will be discussed as well as the problem of standardization.

N. B. M. A. committees, all of which are doing constructive work for the betterment of the battery industry, will be ready to give their reports on their activities during the past year. The Data Book Committee which have done a very valuable piece of work in the publication of standard battery specification sheets will consider publication of additional data. These sheets have been used very effectively by most of the members who are looking forward to the regular annual publication. The Guarantee Committee have been working on a standard guarantee for some time and will be ready to make their recommendations.

CHAS. FRESHMAN RETURNS TO RADIO

Chas. Freshman is back in the radio business. Nearly 100 men prominent in the radio business gathered about the banquet table at the Hotel Astor recently for the purpose of welcoming him back in the most auspicious manner.

Chas. Freshman, pioneer radio manufacturer, returns as president of Chas. Freshman Radio Stores, Inc., operating a chain of eleven radio stores throughout the Metropolitan district, with executive offices at 3 East 43d Street. In forming this company, Chas. Freshman acquired the Colonial Radio Sales Co., Inc.

Associated with Mr. Freshman are B. Abrams, President of Emerson Radio & Phonograph Co., and Sidney A. Joffee, formerly Merchandise Manager of the Colonial Radio Sales Co., Inc.

NEW STEINITE SUBSIDIARY

The formation of the Aircraft Radio Corporation as a subsidiary of the Steinite Radio Company of Fort Wayne, Ind., was made known by Oscar Getz, Vice-President of the latter organization.

The Aircraft Radio Corporation has taken over the Atchison, Kan., plant of the Steinite Company, and will build a specially designed receiving set for airplanes as well as a d-c. set for automobiles. It will also manufacture d-c. sets for the extensive farm market which has over 9,000,000 prospective owners.

This new Steinite subsidiary will be under the direction of Fred W. Stein, inventor of the original all-electric Steinite receiving set, and a pioneer in the radio business. Mr. Stein has also designed the automobile and aircraft set which is extremely compact and light in weight.

NEW CONCERN MANUFACTURING WIRE

The Radio Wire Corporation of Chicago has been formed to manufacture all kinds of low resistance, radio-frequency coil wire, owing to the increased demand for use of this type of wire, in connection with screen-grid tubes, the Radio Wire Corporation has developed a new type of machine which turns out any of the standard requirements in stranded, insulated wires, commonly known as Litz.

Mr. Wm. P. Lear, a Chicago radio engineer, has been elected President of the new Corporation which has established a factory at 6629 So. Central Park Avenue.

POLYMET AGAIN INCREASES SPACE

Orders on the books of the Polymet Manufacturing Corporation have increased to such an extent that an entire additional floor has been added to the Polymet New York Plant at 829 East 134th Street.

The additional floor space provided by this acquisition will run over 25,000 square feet and is being whipped on to a production basis as rapidly as possible. This should serve to increase capacity production to a considerable extent and relieve the strain of day and night shifts now running.

Polymet officials also state that announcements will soon be forthcoming relative to additions to other Polymet Plants in Winsted, Conn., and Easton, Pa.

News of the RMA.

Trade Show to Atlantic City

CHOICE of Atlantic City for the 1930 RMA convention and trade show, protection of the radio industry and public against harmful radio legislation, stimulation of broadcasting features, and other trade promotion, pressure of the RMA patent interchange plan, and the semi-annual convention of the Engineering Division, were the highlights of a crowded calendar of the Radio Manufacturers Association, its Board of Directors and Committees, at the Hotel Astor, during the week of the annual Radio World's Fair at Madison Square Garden, September 23-28.

The RMA got into full swing on its many and wide activities and enterprises, serving its members of the radio industry and public, during the New York show week. Radio leaders from all parts of the country were in attendance, and meetings of twenty-three RMA committees within five days attested the comprehensive program on many important industry projects which are being pressed by the RMA.

President H. B. Richmond of Cambridge, Mass., presided at the meeting of the Board of Directors of the RMA on Wednesday, September 25th, and received reports from many committees. During the week the twenty-three committees developed new services of wide variety for all radio interests.

A plan to transfer the annual RMA convention and trade show from the west, where it has been held in Chicago for the last three years so successfully, to the east was approved unanimously by the RMA Show Committee, headed by Jess B. Hawley of St. Charles, Illinois, Chairman, subject to final approval by the Board of Directors. The date of the trade show, probably around June 1, will be fixed later.

The RMA program of national radio exhibitions also was considered by the Board of Directors. Announcement was made that the National Radio World's Fair would be held again in New York next year and again under the management of U. J. Herrmann of Chicago and G. Clayton Irwin, Jr. of New York, who will again also manage the RMA trade show.

Improved Broadcasting Features

Stimulation of new and improved broadcasting features for the radio public, including measures to insure public reception of national events, such as sports which some private promotors are reluctant to have broadcast, was planned. Plans were made to cooperate with broadcasting interests and commercial sponsors' programs, which include many members of the Radio Manufacturers Association, to place every possible feature on the air.

In the development of radio programs, the Association's Broadcasting Committee, headed by B. G. Erskine of Emporium, Pa., in conjunction with the Merchandising Committee, will enlist the further interest of manufacturers and also work with the chain broadcasting interests in securing broadcasts of all the national events possible.

Radio Legislation

New radio legislation in Congress and in the various states and municipalities also was considered by the RMA Board of Directors who authorized action to protect the radio public and the industry against harmful radio legislation anywhere.

Except for the probable continuation of the Federal Radio Commission for another year, comparatively little important radio legislation is expected during the present session of Congress, according to reports to the RMA Board by Mr. C. C. Colby of Boston, Chairman of the Legislative Committee, and Mr. Frank D. Scott of Washington, Legislative Counsel. Changes in the law improving procedure of business before the Federal Radio Commission are probable which will give relief to the broadcasting interests appearing before the Commission.

The RMA Board approved the plan presented by the Legislative Committee to establish an information service in connection with all radio legislation in the states and important cities. The new information service, already organized over half of the States, includes the appointment of state chairmen from among the ranks of radio

manufacturers, jobbers or dealers, and organization in each state of committees to advise the RMA central office of the new radio legislation which is proposed. This will be followed by effective steps to protect the interests of the radio public and the industry, manufacturing and distributing, against harmful legislation. The new information service is being organized by Mr. A. T. Haugh of Rochester, New York, former president of the RMA, acting as Field Secretary to organize the information service.

Engineering Division Reports

The Engineering Division, headed by its Director, Mr. Walter E. Holland of Philadelphia, had two days of busy sessions with about 150 prominent radio engineers in attendance and together at luncheon on Thursday, September 26. Separate meetings of the Standards Committee, headed by Mr. R. H. Manson of Rochester, and of its special Committees on Receivers and Power Supply, Mr. R. H. Langley, of Cincinnati, Chairman; Vacuum Tubes, Mr. George Lewis of Newark, N. J., Chairman; Acoustic Devices, Mr. F. W. Kranz of St. Charles, Ill., Chairman; Television, Mr. D. E. Replogle of New York, Chairman; Cabinets, Mr. R. H. Ewing of Louisville, Ky., Chairman and the Service Section, Mr. H. E. Fenner, of Springfield, Mass., Chairman, were held and were well attended. Important engineering work was undertaken under the new organization of the Engineering Division and Sections, including standardization, improved servicing for the public, and safety in conjunction with the National Underwriters and the Institute of Radio Engineers. Progress of television experiments were reported and discussed by the Television Committee.

Patent Pooling

An intensive campaign in support of the RMA patent cross-licensing plan also was ordered by the Board of Directors upon recommendation of LeRoi J. Williams of Cambridge, Mass., Patent Committee Chairman. Recent patent litigation and decisions are regarded as having given stimulus to the wide demand within the radio industry for a pooling of radio patents, strictly within the limits of the law and similar to the patent pools in the automotive and aeronautical industries which have been so successful. Better radio products at cheaper costs to the public are possible under a pooling of patents, according to the supporters of the plan. The RMA membership will be divided territorially for an aggressive campaign to secure adoption of the cross-licensing agreement by the necessary fifty-one per cent. of RMA members, under the authorization for submission of the plan to the manufacturer members.

Statistics, Credit and Collection

Plans for the RMA Statistics Committee, headed by Mr. G. C. Furness of New York, to secure reliable industry data in the aid of merchandising, were approved by the RMA Board of Directors. With the co-operation of the Association membership it is hoped to develop valuable statistical information regarding several branches of the industry and its practices.

Development of the RMA credit information and collection services under the direction of Leslie F. Muter of Chicago, Chairman of the Credit Committee, and through its eastern division at New York and western division at Chicago, also were approved by the RMA Board. Commercial contracts with commercial organizations, supplementing the credit information exchange by RMA members, will be continued.

Conferences were held by the Contact Committee, headed by Mr. Lester E. Noble of New York, with officers of the Federated Radio Trade Association and other radio organizations with a view to development of joint industry interests.

NORTHERN MERGES WITH NATIONAL UNION

Stockholders of the Northern Manufacturing Company, 371 Ogden Street, Newark, N. J., voted unanimously, at a recent meeting at the company's offices, to turn the assets over to the National Union Radio Corporation, 400 Madison Avenue, New York City, according to an announcement by Nathan Chirlestein, National Union's executive Vice-President.

Amalgamation of Northern Manufacturing, a pioneer tube company whose modern plant has a capacity of 25,000 tubes a day, now makes the National Union Radio Corporation one of the three largest makers of radio tubes in the United States.

The Northern stockholders, according to E. A. Tracey, head of the stockholders' committee, voted to exchange 70,000 shares on a basis of 7/20th of one National Union share for one Northern Manufacturing. The Northern's Newark plant was one of the six largest tube producers in the industry since it was organized in 1924 by Mr. Tracey, N. M. Mains, R. H. Amberg and Charles Eisler.

The Northern plant, which now becomes No. 4 unit in the National Union combine, has a sales record of 8,000,000 tubes and introduced the a-c. kit for conversion of battery sets to electricity.

Authorized capital stock of National Union Radio Corporation is 1,000,000 shares, of which 400,000 are outstanding. The Radio Corporation of America loaned the new combine $2,000,000 and has an option for the purchase of 50,000 shares of National Union stock at $40.

NEW VREELAND PATENT

An additional patent on the Vreeland band receiving system, which is said to solve many perplexing problems of faithful tone reproduction in radio receiving sets has been issued to Dr. Frederick K. Vreeland, according to an announcement made by the Vreeland Corporation, New York. The new patent, No. 1,725,433, covers the "band selector." It is one of a group of patents on the Vreeland inventions which includes also the spaced band amplifier.

STEVENS-SIBLEY PHONOGRAPH MOTOR TO BE MADE IN ENGLAND

The Stevens-Sibley electric phonograph motor now used in many standard and portable types of electric phonographs operating on socket power or dry cells, is to be made and sold in England and the British Isles, according to the statement of Clifford E. Stevens, Chief Engineer of the Stevens Manufacturing Corporation.

"We have just closed a contract with The Music Roll Company of England," states Mr. Stevens, "whereby the Stevens-Sibley phonograph motor will be made in England. At least, we shall ship the parts from this country to an assembly plant abroad. Our Mr. Sibley will shortly leave for England, where he will be in charge of the production of motors."

STEVENS GRANTED BASIC PATENT ON CLOTH DIAPHRAGM

A basic patent on the method of making loudspeaker diaphragms of fabric, has just been granted to the Stevens Manufacturing Corporation, according to the statement of Clifford E. Stevens, Treasurer and Chief Engineer of the organization.

"Patent No. 1,729,407, just issued to us," states Mr. Stevens, is exceptionally broad and therefore may be considered basic. We have been allowed seventeen claims on the method of making loudspeaker diaphragms of fabric. Our patent covers the method of making large, direct-acting, acoustic diaphragms of conical form, by stretching a continuous piece of flat-woven fabric impregnated with stiffening material in a moist condition over a form to shape the fabric, without lapping and to tension it in all directions until the stiffening material has become set; and thereafter applying to the diaphragm a material to fill the interstices in the fabric and to waterproof and further stiffen the fabric. That is essentially the process employed in making the well-known Burtex diaphragms.

NATIONAL UNION RADIO CORP. FORMED

Organization and production plans of the new National Union Radio Corporation, formed by the merger of the companies manufacturing Sonatron, Marathon, Televocal and Magnatron tubes, are moving forward rapidly, according to information following the initial announcement of this consolidation.

It is announced that Nathan Chirelstein, who was President of the Sonatron Company, will be executive Vice-President of the National Union. Another important executive from one of the constituent companies is E. A. Tracy. He was Vice-President of the Northern Manufacturing Company makers of the Marathon tube, and is Vice-President in charge of sales and advertising in the new corporation.

Joseph E. Davies, attorney of Washington and New York, who was Chairman of the Federal Trade Commission in the Wilson Administration, has been elected Chairman of the Board. Other directors thus far chosen are Paul M. Mazur, and Sylvester W. Muldowny of Lehman Brothers, bankers.

"The consolidated companies create what is already the largest company doing an exclusive tube business," said Mr. Tracy today. "They have five tube plants, located at Chicago and at Newark, Hoboken and Union City, N. J., with a total capacity of from 75,000 to 100,000 tubes daily—far greater than any existing factory. All these will now be co-ordinated and brought under one management."

In addition to its reciprocal contracts with R. C. A. by which each company is licensed to use the tube patents of the other, the National Union has entered into an agreement with R. C. A. by which the latter loans the new company $2,000,000, secured by notes, and receives in return an option to buy 50,000 shares of stock in the National Union within five years. It is stated that this transaction has been completed and that the new concern will go ahead promptly in its merchandising and advertising programs.

The R. C. A. contracts also give the National Union all advantages as to tube research in the laboratories of the Radio Corporation and of the General Electric and Westinghouse companies, with which it is affiliated. In addition, the new company will develop extensive laboratories of its own for research and invention in the tube field.

One million shares of common stock are authorized by the new company's charter, which was secured in Delaware, but only 400,000 will be issued at this time. As this issue will be given a value of about $40, the National Union will thus begin operations with a capitalization of $16,000,000.

GENERAL MANUFACTURING CO. MOVES

The General Manufacturing Company announce their removal to 8066 South Chicago Avenue, Chicago, Illinois.

The General Manufacturing Company are producers of GEN-RAL radio coils and with their increased floor space, are now in a position to supply radio manufacturers and professional set builders with plain and bank wound coils, screen-grid coils and radio-frequency transformers of all types.

The General Manufacturing Company make a specialty of coils wound with "Litz" wire.

OXFORD INCREASES MANUFACTURING FACILITIES

The Oxford Radio Corporation, formerly Joy Kelsey Corp., has been forced to again increase their manufacturing facilities. Having moved into their new plant on May 1st, they immediately found that they could not handle all the business being placed with them for electrodynamic speakers so leased more space in June. Now, with their customers increasing their set production at such a rapid pace, the Oxford Radio Corporation have leased their third factory.

Production is now proceeding at the rate of four thousand a day it is stated.

GULBRANSEN EXTENDS C. I. T. PLAN

The Gulbransen Company of Chicago has recently announced completion of arrangements with Commercial Investment Trust Incorporated (C. I. T.) whereby radio dealers may receive financial aid in their instalment selling. This represents an extension of the plan made with C. I. T. in the early days of instalment selling as an aid to Gulbransen piano dealers.

In general the finance plan worked out by the two companies embodies a 90% advance to the dealer, low rates, and return of the reserve upon liquidation. Furthermore, the dealer is allowed to make his own collections, which permits him to maintain his contact with the purchaser.

RADIO ENGINEERS ELECT LANGLEY

Ralph H. Langley, director of engineering, Crosley Radio Corporation, will serve as chairman of the Cincinnati Section of the Institute of Radio Engineers during the coming year. He was elected on Sept. 16 at the annual meeting of the organization in Cincinnati.

POLYMET STOCK SPLIT

Upon recommendation of the directors, stockholders of Polymet Manufacturing Corporation at their first annual meeting voted to increase the authorized capitalization of the company from 60,000 shares to 300,000 shares of no par value stock and to split up the stock at present outstanding 3 shares for 1. The shares will be issuable to stockholders of record September 18, 1929.

Directors of the corporation voted to place the new stock on a $1.00 annual

basis, payable 25 cents quarterly, the first dividend to be distributed October 1, 1929, to stockholders of record September 18. This rate is equivalent to $3.00 a share on the old stock on which $2.50 has been paid.

At the same time, the directors, in addition, voted to initiate stock dividends on a 4 per cent annual basis, payable 1 per cent quarterly, the first payment to be made January 1, 1930 to stockholders of record December 20, 1929.

The board of directors of the company, re-elected by the stockholders, is constituted as follows:

Carl L. Schmidt, Edmund J. Sampter, Otto Heineman, Foster G. Smith, Judge Hadley Howd, Otto Paschkes and Nathaniel Greene.

PREDICTS BRISK RURAL RADIO SALES THIS FALL

Promising an early announcement of entirely new and refined battery-operated radio sets, E. A. Nicholas, Vice-President of the Radio-Victor Corporation of America, now predicts a brisk trade this fall in the heretofore neglected rural or farm radio market, in addition to the excellent prospects in the metropolitan and suburban markets catered to by socket-power receivers.

"Although the radio industry has rightfully and wisely concentrated on the socket-power radio field during the past three years," states Mr. Nicholas, "it has long been evident that the farm or rural radio market was being sadly neglected. Engineering staffs have been busy evolving the necessary a-c. vacuum tubes, rectifiers and circuits for successful socket-power operation, in an effort to provide ideal radio reception for some 16,000,000 American homes equipped with electric light wiring. But now, with our a-c. and d-c. socket-power radio technique highly developed and stabilized, we have turned to the task of perfecting the battery radio set. As a result of concentrated engineering efforts during the past eight months, we are about to announce new and practical battery-operated radio sets which will bring to the unwired home many of the advantages heretofore confined solely to the wired home."

LOFTIN AND WHITE SELL GROUP OF PATENTS TO R. C. A.

Edward H. Loftin, representing the Loftin-White Laboratory of New York City, has announced that he has recently completed the details of a sale to the Radio Corporation of America of a large group of radio patents and applications of himself and S. Young White, his associate in the Loftin-White Laboratory.

RMA TO MAKE STUDY OF ADVERTISING COSTS

One of the first major problems to be attacked by the newly-established Merchandising Department of the Radio Manufacturers' Association, will be an analysis of the manufacturers' advertising costs. This was decided at the first meeting of the Merchandising Committee, held in New York City, Friday, August 23d, under the direction of Major Herbert H. Frost, Chairman of the Committee.

"The entire subject of the manufacturers' costs of doing business," Major Frost said after the meeting, "is one that vitally concerns every RMA member. Advertising plays a very major part in manufacturers' costs and the Committee has decided that we need thorough and comprehensive information as to the industry's advertising costs and advertising practices.

"For instance, do we know what is the proper amount of money we should spend on the various types of advertising? Do we know whether our advertising literature should be given away or charged for at cost? Do we know what are the proper relationships between the dealer and jobber on the one hand and the manufacturer on the other, in regard to the proper apportioning of the advertising expenses?

"These and other questions concerning advertising practices are ones on which it was the Committee's opinion that information needs to be obtained."

The meeting was well attended, and a number of excellent suggestions as to the work of the Merchandising Department were made and approved.

Mr. Oscar Getz, of Fort Wayne, Ind., was appointed Chairman of a sub-committee to work on plans, in cooperation with the Broadcasting Committee, toward presentation of a monthly feature broadcast under the auspices of the Association.

The Committee also favorably received plans by Mr. Arthur Moss, of New York, to interest the youths of the country in radio.

Hon. John W. Van Allen, of Buffalo, General Counsel for the Association, was present at the meeting and outlined some of the legal aspects of the merchandising work. William Alley, Merchandising Manager of the Association, was instructed to carry on the work of the Merchandising Division in strict accordance with State and National laws pertaining to distribution problems.

U. S. RADIO AND TELEVISION CORP. REPORT

As a result of the complete reorganization of U. S. Radio & Television Corporation by Don M. Compton, Vice-President and General Manager, the corporation is currently running at a profit and is making a rapid reduction of inventories and accounts payable. Inventories have been reduced more than $1,000,000. According to Mr. Compton, the company definitely has turned the corner and within 30 to 60 days will begin to reflect economies the new management has introduced.

The corporation has developed an entirely new line of radio sets which went into production the first of this month, according to Don M. Compton, Vice-President and General Manager.

NEW JENKINS & ADAIR PLANT

The office and factory of Jenkins & Adair, Inc., are moving to a new and strictly modern one-story plant, located at 3333 Belmont Ave., Chicago.

The new building will provide manufacturing facilities far superior to those which the Company has had since its inception six years ago. The new plant will also permit a substantial increase in production.

The new Jenkins and Adair plant, in Chicago.

The basis of the business of Jenkins & Adair is the production of special transformers and retard coils, condenser transmitters, broadcast and recording amplifiers, mixing controls and gain controls.

POOLE JOINS TRANSCONTINENTAL

Transcontinental Coil, Inc., announce the appointment of Mr. William C. Poole as Chief Electrical Engineer.

Mr. Poole has been associated in an engineering capacity with many of the foremost manufacturers in the radio business, dating back to the Federal-Brandes Corporation in 1923, and is consequently thoroughly in touch with the problems which have arisen in radio design and service.

Mr. Poole will be in complete charge of both the Laboratory and Inspection Department of Transcontinental Coil, Inc.

GREENE OF POLYMET ELECTED BANK DIRECTOR

At a meeting of the stockholders held September 11th, Nathaniel C. Greene, vice-president, secretary and treasurer of the Polymet Manufacturing Corporation, of 829 East 134th Street, New York City, was elected to the board of directors of the Fort Greene National Bank of Brooklyn.

Mr. Greene is also vice-president and treasurer of the Strand and Sweet Company of Winstead, Conn.

NEW VAN HORNE REPRESENTATIVES

Recent appointments made by D. M. Kasson, President of the Van Horne Tube Company, of Franklin, Ohio, are of interest to many in the industry. The following set-up insures national distribution for Van Horne Tubes this year, according to Kasson.

R. R. Bean serves the trade in the Pacific Northwest, and in British Columbia.

The New England States are handled by the Gerber Sales Company, 94 Portland Street, Boston, Massachusetts.

Gil Stadeker, long in the automotive game as a manufacturer, and who is known to every automotive jobber in the country, is located in Chicago, and covers northern Illinois, northern Indiana, and eastern Wisconsin.

The F. T. Reuter Company, of Kansas City, serves the trade in Missouri, Kansas, Iowa, Arkansas, Oklahoma, Texas, Louisiana, and western Tennessee.

The entire state of Michigan is traversed regularly by J. D. Palmerlee.

Jobbers in Colorado, Wyoming and Utah look forward to the visits of Paul Douden of Denver.

Jobbers in Kentucky are rapidly falling in line, under the guidance of A. W. Marshall, of Louisville, who has been serving electrical supply houses in that territory for many years.

NEW CECO DISTRIBUTORS

E. T. Maharin, vice-president in charge of sales of CeCo Manufacturing Co., Inc., Providence, R. I., announces the appointments of two Chicago firms as distributors of CeCo tubes. The Sheridan Auto Supply Company, of 3921 Sheridan Road and the Siegel Electrical Supply Company, of 130 North Clinton Street, are the new appointees.

FOREIGN EXPERT HANDLING EXPORTS FOR ARCTURUS

Walter A. Coogan, B. Sc. from Columbia, has taken over the management of export sales for the Arcturus Radio Tube Company of Newark, N. J. Coogan, who is the brother of A. G. Coogan of the export department of Atwater-Kent, was with the Baldwin Locomotive works for ten years, specializing in foreign sales advertising, and as the Philadelphia Manager for India, Burma and Ceylon.

RADIO-VICTOR "THEREMIN"

The Radio-Victor Corporation of America has begun preliminary production of the first commercial models of the Theremin "ether wave" musical instrument, which is played by simply moving the hands in the air above it, according to an announcement by E. A. Nicholas, vice-president in charge of the Radiola Division of Radio-Victor. Mr. Nicholas disclosed that the RCA has acquired an option on the exclusive patent rights from Professor Leon Theremin, the young Russian scientist who invented the instrument.

NEW DUOVAC DISTRIBUTORS

The Duovac Radio Tube Corporation announces that the Hudson-Ross Co. has been appointed as exclusive distributor for Duovac tubes in the Chicago territory.

This is the first independent tube to be handled by the Hudson-Ross organization. Duovac sales will be under the personal direction of Robert Himmel, President.

In the St. Louis territory, Duovac tubes will be distributed by the Tieman Stove & Hardware Co., Shapleigh Hardware Co., and the Electric Lamp and Supply Co.

The Indianapolis market, as well as the South Bend area will be handled by the Kruse Radio Corporation.

NEW KOLSTER CANADIAN DISTRIBUTOR

Word has been received from Canada that the Columbia Phonograph Company, Limited, of Montreal, one of the best known distributing houses in Canada and makers of Columbia records in the Dominion, has become the representative of Kolster Radio for the province of Quebec. This well established organization is expected to increase materially the sales of Kolster products in eastern Canada. The appointment was made by Canadian Brandes, Limited, the Canadian subsidiary of the Kolster Radio Corporation.

"PHILCO NEWS" MAKES APPEARANCE

The value of a house organ as a means of keeping in closer touch with its dealers has been realized by the Philadelphia Storage Battery Company with the appearance of Volume One, Number One of the "Philco News."

The new house organ is a sixteen-page publication copiously illustrated with sales photographs and copies of advertising layouts used in Philco's national advertising campaign.

NEW DEVELOPMENTS OF THE MONTH

NEW HAMMARLUND PRODUCTS

Complete units for the audio and radio channels, separate audio units as well as many special r.f. components for screen-grid receivers have just been brought out by the Hammarlund Manufacturing Company, Inc., 424 West 33rd Street, New York City.

R-F. Amplifiers

The new parts include a three stage radio frequency band filter designed to work into a screen-grid radio frequency amplifier; a three stage screen grid radio frequency amplifier unit; a shielded polarized radio frequency choke; a group of audio amplifying apparatus which includes straight and push pull transformers, and a power supply for the receiver as well as for a pair of –45 tubes, this containing a specially designed power transformer, voltage divider, condenser block and choke unit.

The three stage band filter unit, BS-3, is a completely wired and assembled three stage band filter pre-selector tuning unit, containing a matched .0005 mf. three-gang Battleship Midline condenser housed in an aluminum shield, and a set of three special radio-frequency filter coils, each enclosed in a copper can. This unit affords absolute flat top tuning, producing a pure radio frequency signal for entrance into the r-f. and a-f. amplifying channels, it is claimed.

The companion unit of the BS-3 is the three stage screen-grid r.f. amplifier, RF-3, also completely wired and assembled. This also contains a matched .0005 mf. three-gang Battleship Midline condenser, enclosed in an aluminum can with partitions shielding each condenser, and three matched r-f. coils in separate copper cans, each can also containing a shielded r.f. choke. The r.f. unit which feeds into the detector also contains a metallized grid leak and mica condenser.

Both the BS-3 and RF-3 units are tested and sealed before leaving the factory.

R-F. Choke

The shielded choke, SPC, is housed in an aluminum shell and is polarized. The polarization, together with the choke's high inductance and low distributed capacity permits a total absence of an external field, it is said, preventing feedback and consequent receiver instability.

To further prevent feedback and permit greater amplification, there is the aluminum screen grid tube shield, TS. The control grid outlet which protrudes through the top of the shield is protected with a soft rubber grommet. This prevents vibration as well as accidental shorts. It is designed for use with sub panel sockets.

Audio and Power Transformers

The first stage audio frequency transformer, AF-2, has a ratio of 1½ to 1, while the ratio of the push pull input transformer, AF-4, is 2 to 1, on each side.

The primaries of both transformers are very large. This coupled with the use of treated laminations grouped in a special way into unusually large cores permits uniform amplification from as low as 16 cycles to as high as 4,800 cycles.

One of the output transformers, AF-M, is an impedance matching unit designed to match –45 tubes to magnetic speakers, while the other AF-D, works directly into the moving coil of a dynamic speaker. This unit takes the place of the impedance matching transformer usually supplied with the speaker. The large cores of treated laminations which are also used here, prevent current saturation, thus affording true energy transfer.

All these transformers are enclosed in enamelled steel cases with pigtail terminal leads for sub base connection.

The power supply unit, PS-45, consists of a pair of 30-henry chokes and of a high voltage transformer, with a 110 volt primary, tapped at 80 volts for use with a voltage regulator. The high voltage secondary has an output of 750, is rated at 100 mils, and is center tapped. There is also a 5-volt, 2 ampere center tapped winding for supplying filament voltage to an –80 tube; a 2½-volt, 3 ampere center tapped winding for the filaments of a pair of –45 tubes, and a 2½-volt, 9 ampere winding for the heaters of five –24 or –27 tubes.

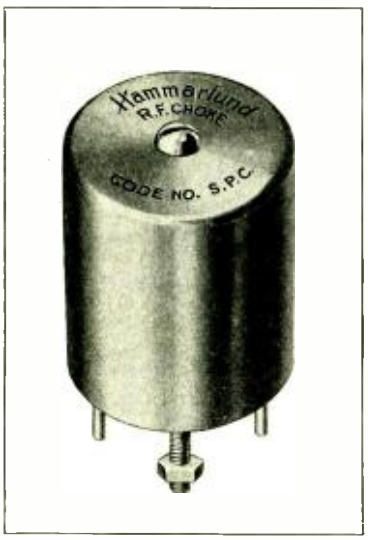
Continuous operation at the rated output without overheating is assured because of the use of exceptionally large cores of treated laminations, and heavy wire.

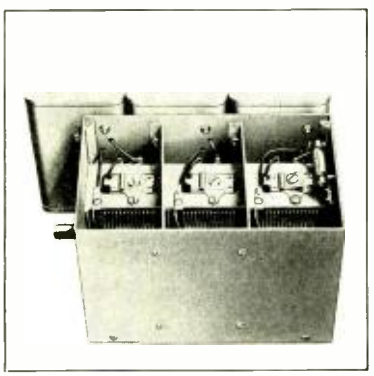
Voltage Divider and Condenser Block

The voltage divider, RHQ-30, consists of a 9525-ohm treated enamelled wire wound resistor conservatively rated at 30 watts. It is wound on a ¾ in. diameter vitreous tube, 5 in. long, and is accurately tapped at 850, 3000, 2160 and 2375 ohms.

The filter condenser block, CHQ-30, has seven condenser sections consisting of a 2 mf. condenser rated at 600 volts, a 4 mf. condenser rated at 500 volts, a 2 mf. condenser rated at 400 volts, a 1 mf. condenser rated at 300 volts, 1 mf. condenser rated at 400 volts and a pair of 1 mf. condensers, each rated at 200 volts. Pig tail leads are provided for sub-base connections.

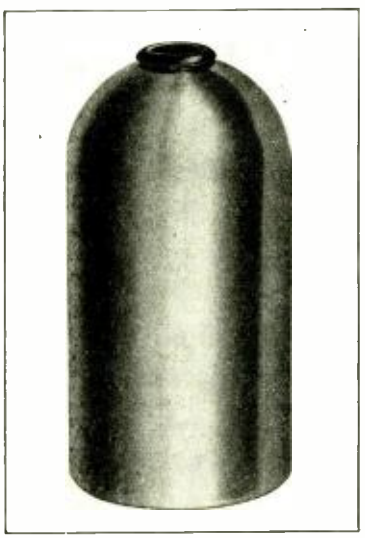
New Hammarlund products. Above: Audio transformer. Left: r-f. choke. Right: Screen-grid tube shield and below, radio-frequency amplifier unit.





SPARTON ANNOUNCES D-C. MODELS

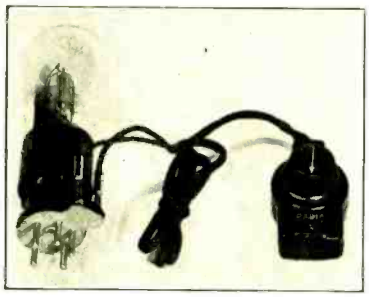
To meet a definite demand in many metropolitan cities, The Sparks Withington Company announces that Models 931 and 301 are available in either d.c. or a.c. circuits without extra cost. This announcement was received with much enthusiasm by Spartan Distributors and Dealers, in view of the fact that there is no price difference. In some cities the d.c. areas cover large and rich markets which heretofore have been closed to Spartan Dealers. The d.c. models are ready for immediate delivery.



NEW PACENT PICKUPS, MOTOR, AND PHONOTROL AUTOMATIC CHANGEOVER SWITCH AND ADAPTOR

The Pacent Electric Co. announce three new models of the Pacent Phonovox electric pickup, specially designed to give maximum efficiency with new model, all-electric, screen-grid receivers. The new series 106 Super Phonovox models embrace a number of improvements to secure the utmost quality and volume from electrically recorded records when played through the modern power amplifier or radio receiver.

The new type changeover switch gives an instant change from radio to record entertainment by merely turning a single knob. No electric connection changes are required when going from one to the other. Formerly, it was necessary to change cer-

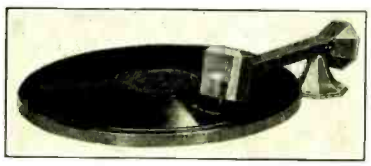


The Pacent Phonotrol Adapter.

tain connections. The Phonotrol adaptor, used with the new changeover switch, fits easily over the prongs of the 5-prong type detecror tube. It was designed to meet the demand for a device which would give better results and greater volume with new type receivers using 5-prong, a-c. detector, and screen-grid tubes.

The new 106 Phonovox are announced as having a greatly increased frequency coverage, from 50 to 8,000 cycles, which more than covers the range of commercial phonograph records. Special English 36 per cent cobalt magnets, accurately counterbalanced tone arm giving exact needle pressure and minimum wear of records, elimination of all rubber bearings and fold-back hinge for easy needle changing are among the features of the new Pacent pickups.

The new type electric phonograph motor is specially designed with the requirements of radio-phonograph combinations in mind, where elimination of sparking and all vibration, is of paramount importance. The Pacent motor is of the squirrel cage induction type, and is completely insulated against noise. There are no commutators or brushes, and consequently no radio interference. It has unusually high starting and running torque.



Pacent Super Phonovox Pickup.

The new motor operates equally well on either 50 or 60 cycles, 110 v., a-c.

Pacent has also introduced a complete new line of power amplifiers in assembled form. They are unusually compact units, housed in sturdy metal cases. Tube sockets are left in readily accessible position outside the housing, while all other parts are encased to keep out dust and prevent possibility of shock at high voltage points.

In addition to the new Phonovox pickups, the electric motor, and the amplifier line, Pacent has introduced a new line of small size transformers, including power, output and push-pull types. The Electrovox, a complete pickup and turntable unit for reproducing records through the radio set, gives the owner of a good radio receiver, results obtainable only with the high priced phonoradio combinations.

DUBILIER REPLACEMENT BLOCKS

The widespread popularity gained by the first Dubilier replacement condenser block for Majestic receivers has lead the Dubilier Condenser Corporation of New York to design a number of new models for replacement use in different types of sets and power supply outfits. These new models are as follows:

PL–1223, for use in Majestic B-eliminators, super-B and Master-B models.
PL–1737, for use in Majestic B-eliminators, and special Master-B models.
PL–1309, for use in 1928 Majestic set using the 171 tube.
PL–1765, for use in 1928-9 Majestic power units using the 250 tube.
PL–1766, for use in 1929 Majestic power units using the 245 tube.
PL–1761, for use in Stewart Warner and Mohawk units built by Majestic.

These replacement blocks incorporate the usual Dubilier features, namely, increased paper insulation, extra large safety factor, and exceptionally long life. The blocks come ready for installation, being equipped with soldering lug connections.

NEW BINKS SPRAYING UNIT

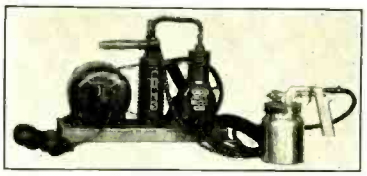
The Binks Manufacturing Company, 3114 Carroll Avenue, Chicago, announces the completion of an all purpose utility spray painting and finishing outfit, known as the Binks New Hurley Unit.

This outfit is being manufactured on a large production basis for general utility work such as touching up, refinishing, repainting, and lacquering practically any product within an organization.

It is a complete unit equipped with a full size quart all metal container and a New Binks Pressure Cup Spray Gun supplying an atomized flat spray four inches in width.

The air compressor unit is belt-driven and connected to a ¼ H.P. General Electric motor. This unit has a capacity of 2.16 cubic feet of air per minute.

The outfit is sturdily constructed. A rib cast iron air container is mounted between the motor and the compressor on a pressed



New Binks Spraying Unit.

metal base all of which is mounted on rubber feet. The cylinder and base are cast in block of seasoned grey iron and accurately machined.

Ten feet of rubber covered electric cord, attachment plug, and ten feet of durable braided rubber air hose are attached to the outfit.

The Binks New Hurley Unit is complete ready for use upon delivery.

NEW PHILCO SET

Philco radio has put into production a new model chassis known as No. 95, involving a new circuit and a number of highly important features which have been developed in their research work on screen-grid tubes.

Model 95 is a nine tube (including rectifier) a-c. screen-grid receiver with automatic volume control. There are five radio-frequency circuits. These include double tuning of the antenna input to the first screen-grid tube followed by two more screen-grid tuned stages and then an untuned detector input.

The following tubes are used:

3 Screen Grid UY 224 Tubes in the Radio Frequency Amplifier
1 UY 227 Detector Tube
1 UY 227 Detector Amplifier Tube
1 UY 227 First Audio Tube
2 UX 245 Power Tubes in Push-Pull
1 UX 280 Rectifier Tube.

One of the most important things in this receiver is the fact that a double-tuned antenna circuit is used ahead of the first screen-grid tube, thus eliminating one of the fundamental difficulties common in other screen-grid receivers, namely, "cross talk." The four balanced tuned circuits together with new design features in the radio-frequency transformers give the utmost selectivity and sensitivity with remarkably little change in either throughout the broadcast frequency band.

The tone quality is exceptionally fine even at very high volume. This is due to the use of a resistance-coupled first audio stage ahead of the push-pull power stage, combined with a radically new detecior circuit. This detector circuit utilizes two –27 tubes, the first as a true two-element rectifier, and the second to perform the amplifying function of the detector.

The automatic volume equalizer reduces fading and to a large extent equalizes the volume of strong and weak stations to the level for which the manual volume control is set. It also prevents overloading of the amplifier tubes and resultant distortion on strong local stations.

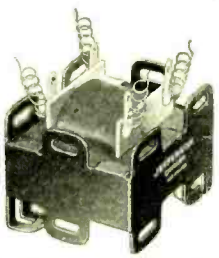
Model No. 95 has two –45 tubes in push-pull which deliver an enormous undistorted volume through the speaker.

There are four controls on the panel; volume control, tuning knob, local-distance switch and power switch.

Chassis No. 95 will be supplied in the Table Model and Lowboy, Highboy and Highboy Deluxe cabinet models. It will have the new matched Philco electro-dynamic speaker. The ten-inch cone of this new speaker is of moisture-proof seamless fabric. In the furniture models the Philco Acoustic Equalizer will be used, thereby preventing undesirable cabinet resonance.

JEFFERSON NO. 371 REPLACEMENT TRANSFORMER

A new low-priced universal replacement audio transformer No. 371 for a-c. or d-c. sets, has been announced by Jefferson Electric Company, 1500 South Laflin Street, Chicago.



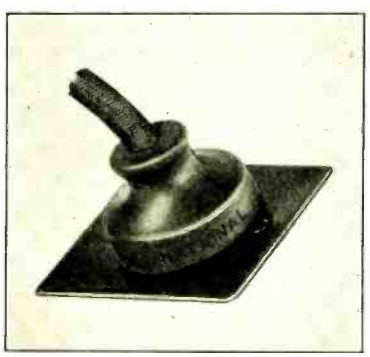
The new Jefferson No. 371 Replacement Transformer.

It is small and compact, measuring only 1¾" high, 2⅝" wide and 2" deep and will fit under or over the sub-base. It can be mounted vertically or horizontally, having brackets on sides, ends, top and bottom, and will replace the old transformer without the necessity of redrilling the holes.

Made of the best material throughout, it will replace the most expensive transformers, yet its price is so low that it may be used in the cheapest sets.

Two types of connection are supplied—lugs and flexible silver leads. The leads need not be tinned for soldering. Their convenient length eliminates splicing extra wire for longer connections. Whichever connection is not used may be snipped off. The lugs may be bent over to fit under sub-base, if necessary.

The No. 371 gives full amplification without distortion, which assures real reproduction of voice and instrument. List price $2.25 each.



The new semi-soft rubber connector plug, with 4 or 5 prongs, manufactured by The National Co., Malden, Mass. Can be used for connecting a chassis or dynamic speaker to power pack, etc.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912, OF RADIO ENGINEERING.

Published monthly at Albany, N. Y., for October 1, 1929.

State of New York } ss.
County of New York }

Before me, a Notary Public in and for the State and county aforesaid, personally appeared B. S. Davis, who, having been duly sworn according to law, deposes and says that he is the Business Manager of RADIO ENGINEERING, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24th, 1912, embodied in section 411, Postal Laws and Regulations, to wit: 1. That the names and addresses of the publisher, editor, managing editor, and business managers are: Publisher, Bryan Davis Publishing Co., Inc., 52 Vanderbilt Avenue, New York; Editor, M. L. Muhleman, Mount Vernon, N. Y.; managing editor, G. C. B. Rowe, Mount Vernon, N. Y.; Business Manager, B. S. Davis, Scarsdale, N. Y. 2. That the owners are: B. S. Davis, Scarsdale, N. Y.; Roy T. Atwood, Albany, N. Y. 3. That the known bondholders, mortgagees, and other security holders owning or holding 1% or more of the total amount of bonds, mortgages, or other securities are: None. 4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where a stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustees is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

(Signed) B. S. DAVIS, Business Manager.

Sworn to and subscribed before me this 1st day of October, 1929.
(Seal) J. A. WALKER, Notary Public.

Kings County.
Kings Co., Clerk's No. 363.
Kings Co., Registers No. 1062.
New York Co., Clerk's No. 167
New York Co., Registers No. 1W177.
Commission expires March 30, 1931.

Buyers Directory of Materials and Apparatus

Readers interested in products not listed in these columns are invited to tell us of their wants, and we will inform the proper manufacturers. Address Readers' Information Bureau.

Addresses of companies listed below, can be found in their advertisement—see index on page 100

ADAPTERS:
Lynch, Arthur H., Inc.

ALUMINUM:
Aluminum Co. of America
National-Harris Wire Co.

AMMETERS:
Ferranti, Inc.
General Electric Co.
General Radio Co.
Jewell Elec. Inst. Co.
Weston Elec. Instrument Corp.

AMPLIFIERS, POWER:
Ferranti, Inc.
G. M. Laboratories, Inc.
General Amplifier Co.
General Radio Co.
National Co., Inc.
Radio Receptor Co., Inc.
Samson Elec. Co.

ANTENNAE, LAMP SOCKET:
Dubilier Condenser Mfg. Co.
Electrad, Inc.

ARRESTERS, LIGHTNING:
Jewell Elec. Inst. Co.

BASES, VACUUM TUBE:
Formica Insulation Co.
General Electric Co.
General Plastics Co.
National Vulcanized Fibre Co.
Synthane Corp.

BAFFLES:
Wright-DeCoster, Inc.

BATTERY COMPOUNDS:
Mitchell Rand Mfg. Co.

BENCHES, STEEL WORK:
Standard Pressed Steel Co.

BINDING POSTS:
General Radio Co.

BRACKETS, ANGLE:
Electrad, Inc.
Scovill Mfg. Co.

BRASS:
Baltimore Brass Co.
National-Harris Wire Co.
Scovill Mfg. Co.

BROADCAST STATION EQUIP'T:
Cardwell, Allen D., Mfg. Co.
Ferranti, Inc.
General Radio Co.
Jenkins & Adair, Inc.
Nelson, I. R., Co.

BULBS, PANEL:
Palatine Industrial Co., Inc.

BUTTS:
Scovill Mfg. Co.

CABINETS, METAL:
Aluminum Co. of America

CELLS, PHOTOELECTRIC:
Burt, Robert C.
G. M. Laboratories, Inc.
National Carbon Co., Inc.

CEMENT, LOUD SPEAKER:
Maas & Waldstein Co.

CENTRALIZED RADIO SYSTEMS:
Ferranti, Inc.
Samson Elec. Co.

CHARGERS:
Elkon Co.

CHASSES
Aluminum Co. of America
United Scientific Laboratories, Inc.

CHOKES, AUDIO FREQUENCY:
American Transformer Co.
Ferranti, Inc.
General Radio Co.
Jefferson Electric Co.
Thordarson Elec. Mfg. Co.
Transformer Co. of Amer.

CHOKES, RADIO FREQUENCY:
Cardwell, Allen D., Mfg. Co.
General Radio Co.
Hammarlund Mfg. Co., Inc.
Samson Elec. Co.

CHOKES, B ELIMINATOR:
American Transformer Co.
Dongan Elec. Mfg. Co.
Ferranti, Inc.
General Radio Co.
Jefferson Electric Co.
Nelson, I. R., Co.
Polymet Mfg. Corp.
Transformer Co. of Amer.

CLAMPS, GROUND:
Fahnestock Elec. Co.
Scovill Mfg. Co.

CLIPS, SPRING:
Electrad, Inc.
Fahnestock Elec. Co.
Scovill Mfg. Co.

COIL FORMS:
General Radio Co.

COIL WINDING:
Acme Wire Co.
Dudlo Mfg. Co.
Polymet Mfg. Corp.
Rome Wire Co.

COILS, CHOKE:
Acme Wire Co.
Dudlo Mfg. Co.
Ferranti, Inc.
General Mfg. Co.
Jefferson Electric Co.
Nelson, I. R., Co.
Polymet Mfg. Corp.
Rome Wire Co.

COILS, IMPEDANCE:
Acme Wire Co.
Dudlo Mfg. Co.
Ferranti, Inc.
Nelson, I. R., Co.
Polymet Mfg. Corp.
Rome Wire Co.

COILS, INDUCTANCE:
Acme Wire Co.
Cardwell, Allen, D., Mfg. Co.
General Radio Co.
Hammarlund Mfg. Co.
National Co., Inc.
Nelson, I. R., Co.
Rome Wire Co.

COILS, MAGNET:
Acme Wire Co.
Dudlo Mfg. Co.
Nelson, I. R., Co.
Polymet Mfg. Corp.
Rome Wire Co.

COILS, RADIO FREQUENCY:
General Mfg. Co.

COILS, RETARD:
Hammarlund Mfg. Co.

COILS, SCREEN GRID:
General Mfg. Co.

COILS, SHORT WAVE:
General Radio Co.
Hammarlund Mfg. Co.

COILS, TRANSFORMER:
Acme Wire Co.
Dudlo Mfg. Co.
Nelson, I. R., Co.
Polymet Mfg. Corp.
Rome Wire Co.

CONDENSER PARTS:
Aluminum Co. of America
Ferranti, Inc.
Scovill Mfg. Co.

CONDENSERS, BY-PASS:
Acme Wire Co.
Aerovox Wireless Corpn.
Amrad Co.
Condenser Corp. of America
Dongan Electric Mfg. Co.
Dubilier Condenser Mfg. Co.
Electrad, Inc.
Fast, John E. & Co.
Ferranti, Inc.
Flechtheim Co.
Gerd Electric Co., Inc.
Leslie F. Muter Co.
Polymet Mfg. Corp.
Potter Co., The
Powrad, Inc.
Wireless Specialty Apparatus Co.

CONDENSERS, EQUALIZING:
Hammarlund Mfg. Co., Inc.

CONDENSERS, FILTER:
Acme Wire Co.
Aerovox Wireless Corpn.
Amrad Co.
Condenser Corp. of America
Dongan Electric Mfg. Co.
Dubilier Condenser Mfg. Co.
Fast, John E. & Co.
Flechtheim Co.
Gerd Electric Co., Inc.
Leslie F. Muter Co.
Polymet Mfg. Corp.
Potter Co., The
Powrad, Inc.
Wireless Specialty Apparatus Co.

CONDENSERS, FIXED:
Acme Wire Co.
Aerovox Wireless Corpn.
Amrad Co.
Condenser Corp. of America
Dongan Electric Mfg. Co.
Dubilier Condenser Mfg. Co.
Electrad, Inc.
Electro-Motive Eng. Co.
Fast, John E., & Co.
Flechtheim Co.
Gerd Electric Co., Inc.
Leslie F. Muter Co.
Polymet Mfg. Corp.
Potter Co., The
Powrad, Inc.
Wireless Specialty Apparatus Co.

CONDENSERS, MIDGET:
Cardwell, Allen D. Mfg. Co.
General Radio Co.
Hammarlund Mfg. Co.
National Co., Inc.
Scovill Mfg. Co.
United Scientific Laboratories

CONDENSERS, MULTIPLE:
Cardwell, Allen D. Mfg. Co.
Hammarlund Mfg. Co.
National Co., Inc.
Scovill Mfg. Co.
United Scientific Laboratories

CONDENSERS, NEUTRALIZING:
Hammarlund Mfg. Co., Inc.
Polymet Mfg. Corp.

CONDENSERS TRANSMITTING:
Dubilier Condenser Mfg. Co.

CONDENSERS, VARIABLE TRANSMITTING:
Cardwell, Allen D. Mfg. Co.
General Radio Co.
Hammarlund Mfg. Co.
National Co., Inc.

CONDENSERS, VARIABLE:
Cardwell, Allen D. Mfg. Co.
DeJur-Amsco Co.
Frost, Herbert H., Inc.
General Radio Co.
Hammarlund Mfg. Co.
National Co., Inc.
Scovill Mfg. Co.
United Scientific Laboratories

CONNECTORS:
Scovill Mfg. Co.

CONTROLS, CURRENT:
Allen Bradley Co.
Central Radio Laboratories
DeJur-Amsco Corp.
Polymet Mfg. Corp.
Shallcross Mfg. Co.

CONTROLS, ILLUMINATED:
Hammarlund Mfg. Co.

CONTROLS, VOLUME:
Allen Bradley Co.
Central Radio Laboratories
Clarostat Co.
Electrad, Inc.
Ferranti, Inc.
Polymet Mfg. Corp.
Radio Receptor Co., Inc.

CONVERTERS:
Cardwell, Allen D., Co.
Electric Specialty Co.

CONVERTERS, ROTARY:
Electric Specialty Co.
Janette Mfg. Co.

COPPER:
Baltimore Brass Co.
Scovill Mfg. Co.

CORDS, EXTENSION:
Acme Wire Co.

COUPLINGS, FLEXIBLE:
Hammarlund Mfg. Co., Inc.

CURRENT CONTROLS, AUTOMATIC:
Radiall Co.

CUSHIONS, SPEAKERS:
Western Felt Co.

DIALS:
Crowe Nameplate & Mfg. Co.
General Etching & Mfg. Co.
Hammarlund Mfg. Co.
National Co., Inc.
Scovill Mfg. Co.
United Scientific Laboratories

DIALS, DRUM:
Hammarlund Mfg. Co.
National Co., Inc.
United Scientific Laboratories

DIE-CASTINGS:
Allied Die-Casting Corp.

DIES:
Willor Mfg. Corp.

DYNAMOTORS:
Electric Specialty Co.

ENGINEERS, CONSULTING:
Allied Engineering Institute
W. P. Lear

ESCUTCHEONS:
Crowe Nameplate & Mfg. Co.
General Etching & Mfg. Co.
Scovill Mfg. Co.

EXPORT:
Ad. Auriema, Inc.

FELT, ACOUSTICAL:
Western Felt Co.

FELT, PACKING:
Western Felt Co.

FILAMENTS:
Callite Products Co., Inc.
Fansteel Products Co., Inc.
Gilby Wire Co.
Radio Prod. Corp.
Vacuum Tube Products Co.

FILAMENT CONTROLS, AUTOMATIC:
Lynch, Arthur H., Inc.
Polymet Mfg. Corp.
Radiall Co.

FOIL, ALUMINUM:
Aluminum Co. of America

FOIL, ZINC:
Lehmaier, Schwartz & Co.

FRICTION TAPES:
Mitchell Rand Mfg. Co.

GALVANOMETERS:
Ferranti, Inc.
General Electric Co.
General Radio Co.
Jewell Elec. Inst. Co.

GASES, RARE:
Palatine Industrial Co., Inc.

GENERATORS:
Electric Specialty Co.
Janette Mfg. Co.

GETTER MATERIAL:
Gilby Wire Co.
National-Harris Wire Co.
Radio Products Corp.

GRID LEAKS:
Aerovox Wireless Corpn.
Allen-Bradley Co.
DeJur-Amsco Co.
Electrad, Inc.
Electro Motive Eng. Co.
Hardwick, Hindle, Inc.
International Resistance Co.
Lynch, Arthur H., Inc.
C. E. Mountford
Polymet Mfg. Corp.
Shallcross Mfg. Co.
Ward Leonard Elec. Co.

HEADPHONES:
Amplion Co. of Amer.

HINGES:
Scovill Mfg. Co.

HORNS:
Amplion Co. of Amer.
Best Mfg. Co.
Magnavox Co.
Miles Mfg. Corp.
Oxford Radio Corp.

INDUCTANCES, TRANSMITTING:
General Radio Co.

INSTRUMENTS, ELECTRICAL:
Ferranti, Inc.
General Electric Co.
Jewell Elec. Inst. Co.

INSULATION LAMINATED
Formica Insulation Co.
General Electric Co.
National Vulcanized Fibre Co.
Synthane Corp.

INSULATION, MOULDED:
Bakelite Corp.
Formica Insulation Co.
General Electric Co.
General Plastics Co.
National Vulcanized Fibre Co
Synthane Corp.

INSULATION, VARNISHED:
Acme Wire Co
Mitchell Rand Mfg. Co.

JACKS:
Carter Radio Co.
Electrad, Inc.
General Radio Co.

JACKS, TIP:
Carter Radio Co

KITS, BROADCAST:
Hammarlund Mfg. Co., Inc.

KITS, SHORT WAVE:
Hammarlund Mfg. Co., Inc.
Lynch, Arthur H., Inc.

KITS, TELEVISION:
Lynch Arthur H., Inc.

KITS, TESTING:
(See Testing Kits)
General Radio Co.
Jewell Elec Inst. Co.

LABORATORIES, TESTING:
Electrical Testing Labs.

LABORATORIES, ENGINEERING:
Allied Engineering Institute

LACQUER, WOOD:
Maas & Waldstein Co.
Zapon Co., The

LACQUER, METAL:
Maas & Waldstein Co.
Zapon Co., The

LACQUER, ENAMEL:
Maas & Waldstein Co.
Zapon Co., The

LAMINATIONS:
Lamination Stamping Co.
Willor Mfg. Corp.

LAMPS, MINIATURE:
National Carbon Co., Inc.

LAMPS, PANEL:
National Carbon Co., Inc.

LAMPS, SOUND RECORDING:
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Electrad, Inc.

LOCK WASHERS:
Shakeproof Lock Washer Co

LUGS:
Scovill Mfg. Co.
Shakeproof Lock Washer Co

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American Safety Table Co.

MACHINERY, TUBE:
Arrow Mfg. & Machine Co., Inc.
Engineering Co., The
Central Scientific Labs.
Elsler Eng. Co.
Int'l Machinery Works, Inc.
Lepel High Frequency Labs.
Manhattan Electric Bargain House, Inc.
Radio Products Corp.

MACHINES, SPECIAL
Willor Mfg. Corp.

MAGNESIUM:
Aluminum Co. of America.

MAGNETS:
Thomas & Skinner Co.

METALS, RARE:
Fansteel Products Co., Inc.
American Electro Metal Corp.

MERCURY SWITCHES:
(See Switches)

METERS:
Ferranti, Inc.
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Weston Elec. Instr. Co.

MICROPHONES:
Amplion Co. of America
Electro-Acoustic Prod. Co.
Jenkins & Adair, Inc.
Radio Receptor Co., Inc.
Universal Microphone Co.

MOLDING MATERIALS
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Formica Insulation Co.
General Electric Co.
General Plastics Co.
National Vulcanized Fibre Co.
Synthane Corp.

MOTORS:
Electric Specialty Co.

MOTOR-GENERATORS:
Electric Specialty Co.

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Electrad, Inc.
Lynch, Arthur H., Inc.
Polymet Mfg. Corp.

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Scovill Mfg. Co.

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OSCILLOSCOPE:
Robert C. Burt Scientific Labs.

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Engineering Co., The
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Gilby Wire Co.
Lepel High Freq. Labs.
Nat'l.-Harris Wire Co.
Radio Products Corp.

PHONOGRAPH MOTORS:
(See Motors)

PHOSPHOR BRONZE:
Baltimore Brass Co.
Riverside Metal Co.

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(See Cells)

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Jensen Co.
Magnavox Co.
Wright DeCoster

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Carter Radio Co

PLUGS:
Carter Radio Co.
General Radio Co
Polymet Mfg. Corp.

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Central Radio Laboratories
DeJur-Amsco Co.
Electrad, Inc.
General Radio Co.
Polymet Mfg. Corp.
United Scientific Laboratories

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Elkon, Inc.
Jefferson Electric Co.
Kodel Radio Corp.
Radio Receptor Co., Inc.

POWER UNITS, B-:
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General Radio Co.
Jefferson Electric Co.
National Co., Inc.
Thordarson Electric Mfg Co
Webster Co.

POWER UNITS, A-B-C:
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General Radio Co.
Jefferson Electric Co.
Kodel Radio Corp.
National Co., Inc.
Thordarson Electric Mfg Co.

POWER UNITS, PARTS FOR:
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American Transformer Co.
Dongan Elec. Mfg. Co.
Ferranti, Inc.
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Jefferson Electric Co.
Kodel Radio Corp.
Lynch, Arthur H., Inc.
National Co., Inc.
Nelson, I. R., Co.
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Transformer Co. of Amer.

PRESSINGS:
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Arrow Mfg. & Machine Co., Inc.
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Int'l Machine Works, Inc.

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Scovill Mfg. Co.

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Carter Radio Co.

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Elkon, Inc.
Kodel Elec. & Mfg. Co.

REGULATORS, VOLTAGE:
Central Radio Laboratories
Clarostat Co.
DeJur-Amsco Co.
Polymet Mfg. Corp.
Radiall Co.
Ward Leonard Elec. Co.

RELAYS:
Cardwell, Allen D., Mfg. Co.
Leach Relay Co.

REPRODUCERS, TALKING MOTION PICTURES:
R. C. Burt Scientific Labs.

RESISTANCES, FIXED:
Aerovox Wireless Corp.
Allen-Bradley Co.
Central Radio Laboratories
Clarostat Mfg. Co.
DeJur-Amsco Co.
Electrad, Inc.
Electro-Motive Co
Ferranti, Inc.
Frost, Herbert H.
General Electric Co.
Hardwick, Hindle, Inc.
International Resistance Co.
Lynch, Arthur H., Inc.
C. E. Mountford
Polymet Mfg. Corp.
Ward Leonard Elec. Co.

RESISTANCES, VARIABLE:
Allen-Bradley Co.
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Clarostat Mfg. Co.
Electrad, Inc.
Electro-Motive Co.
Frost, Herbert H.
General Electric Co.
Hardwick, Hindle, Inc.
International Resistance Co.
Lynch, Arthur H., Inc.
C. E. Mountford
Polymet Mfg. Corp.
Shalleross Mfg. Co.
Ward Leonard Elec. Co.

RHEOSTATS:
Allen-Bradley Co.
Central Radio Laboratories
DeJur-Amsco Co.
Electrad, Inc.
Electro-Motive Co.
Frost, Herbert H.
General Radio Co.
Polymet Mfg. Corp.
United Scientific Laboratories

SCREW MACHINE PRODUCTS:
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National Vulcanized Fibre Co.
Scovill Mfg. Co.
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Synthane Corp.

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Candy & Co.
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Hammarlund Mfg. Co., Inc.

SHIELDS, TUBE:
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Radio Products Corp.

SHORT WAVE APPARATUS:
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General Radio Co.
Hammarlund Mfg. Co., Inc.
Lynch, Arthur H., Inc.

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Frost, Herbert H.
General Radio Co.
Lynch, Arthur H., Inc.
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Chicago Solder Co.

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Miles Mfg. Corp.
Oxford Radio Corp.
Rola Co., The

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(See Lamps)

SPAGHETTI:
(See Wire, Spaghetti).

SPEAKERS:
Amplion Corp. of Amer.
Electro-Acoustic Prod. Co.
Best Mfg. Co.
Jensen Radio Mfg. Co.
Magnavox Co.
Miles Mfg. Corp.
Leslie F. Muter Co.
Oxford Radio Corp.
Potter Co., The
Rola Co., The
Transformer Co. of Amer.
Wright-DeCoster, Inc.

STAMPINGS, METAL:
Aluminum Co. of America
Radio Products Corp.
Scovill Mfg. Co.

STEEL, MAGNETIC:
See *(Iron Magnetic.)*

SUBPANELS:
Formica Ins. Co.
General Radio Co.
National Vulcanized Fibre Co.

SWITCHES:
Electrad, Inc.
Ferranti, Inc.

SWITCHES, MERCURY:
G. M. Laboratories, Inc.

TABLES, STEEL WORK:
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TANTALUM:
Fansteel Products Co., Inc.

TAPES, FRICTION:
Mitchell Rand Mfg. Co.

TAPPERS
Eastern Tube and Tool Co.

TELEVISION PARTS:
Allen-Bradley Co.
Clarostat Co., Inc.
Lynch, Arthur H., Inc.
Shalleross Mfg. Co.

TESTERS, B-ELIMINATOR:
General Radio Co.
Jewell Electrical Inst. Co.

TESTERS, TUBE:
Ferranti, Inc.
General Radio Co.
Jewell Elec Inst Co
Weston Elec. Inst. Co.

TESTING INSTRUMENTS:
Ferranti, Inc.
General Electric Co.
General Radio Co.
Jewell Elec. Inst. Co.
Weston Elec. Instrument Corp

TESTING KITS:
General Radio Co.
Jewell Elec. Inst. Co.
Weston Elec. Inst. Co.

TESTING LABORATORIES:
Electrical Testing Labs

TIN COATED METAL:
Baltimore Brass Co.

TOOL STANDS:
Standard Pressed Steel Co.

TOOLS:
Eastern Tube and Tool Co
Willor Mfg. Corp.

TRANSFORMERS, AUDIO:
Dongan Elec. Mfg. Co
Ferranti, Ltd.
General Radio Co.
Jefferson Electric Co.
National Co., Inc.
Radio Receptor Co., Inc.
Samson Elec. Co.
Sangamo Elec. Co.
Thordarson Electric Mfg. Co
Transformer Corp. of America
Webster Co.

TRANSFORMERS, B-POWER UNIT:
Dongan Elec. Mfg. Co.
Ferranti, Ltd.
General Radio Co.
Jefferson Electric Co.
National Co., Inc.
Nelson, I. R., Co.
Radio Receptor Co., Inc.
Samson Elec. Co.
Thordarson Electric Mfg. Co
Transformer Corp. of America
Webster Co.

TRANSFORMERS, BROADCAST STATION:
Ferranti, Inc.
Radio Receptor Co., Inc.
Samson Electric Co.

TRANSFORMERS, FILAMENT HEATING:
Dongan Elec. Mfg. Co.
General Radio Co.
Jefferson Electric Co.
Nelson, I. R., Co.
Thordarson Electric Mfg. Co.
Transformer Corp. of America

TRANSFORMERS, OUTPUT:
Dongan Elec. Mfg. Co.
Ferranti, Ltd.
General Radio Co.
Jefferson Electric Co.
Nelson, I. R., Co.
Radio Receptor Co., Inc.
Samson Elec. Co.
Sangamo Elec. Co.
Thordarson Electric Mfg. Co.
Transformer Corp. of America

TRANSFORMERS, POWER:
Dongan Elec. Mfg. Co.
Ferranti, Ltd.
General Radio Co.
Jefferson Electric Co.
National Co., Inc.
Nelson, I. R., Co.
Polymet Mfg. Co.
Radio Receptor Co., Inc.
Samson Elec. Co.
Thordarson Electric Mfg. Co.
Transformer Corp. of America
Webster Co.

TRANSFORMERS, R. F., TUNED:
Cardwell, Allen D. Mfg. Co.
Hammarlund Mfg. Co., Inc.

TRANSFORMERS, STEP-DOWN:
Amplion Corp. of Amer.
Radio Receptor Co., Inc.

TUBE MACHINERY:
See (Machinery, Tube.)

TUBE TESTERS:
(See Testers, Tube)

TUBES, A.C.:
Allan Mfg. Co.
Arcturus Radio Co.
Armstrong Elec. Co.
Cable Radio Tube Co.
De Forest Radio Co.
Dilco Radio Corp.
Duovac Radio Tube Co.
Gibraltar Radio Supply Co.
Hyvac Radio Tube Co.
Marvin Radio Tube Corp.
National Carbon Co., Inc.
Nat'l Union Radio Corp.
Perryman Electric Co.
Sylvania Products Co.
Televocal Corp.
Triad Mfg. Co.

TUBES, RECTIFIER:
Allan Mfg. Co.
Arcturus Radio Co.
Armstrong Elec. Co.
Cable Radio Tube Co.
De Forest Radio Co.
Dilco Radio Corp.
Duovac Radio Tube Co.
Gibraltar Radio Supply Co.
Hyvac Radio Tube Co.
National Carbon Co., Inc.
Nat'l Union Radio Corp.
Perryman Electric Co.
Sylvania Products Co.
Televocal Corp.
Triad Mfg. Co.

TUBES, SCREEN GRID:
Allan Mfg. Co.
Arcturus Radio Co.
Armstrong Elec. Co.
Cable Radio Tube Co.
De Forest Radio Co.
Dilco Radio Corp.
Duovac Radio Tube Co.
Gibraltar Radio Supply Co.
Hyvac Radio Tube Co.
National Carbon Co., Inc.
Nat'l Union Radio Corp.
Perryman Electric Co.
Sylvania Products Co.
Televocal Corp.
Triad Mfg. Co.

TUBES, TELEVISION
See (Cells, Photoelectric.)

TUBING, REFRACTORY:
Stupakoff Labs. Inc.

TUBING, VARNISHED:
Mitchell Rand Mfg. Co.

UNITS, SPEAKER:
Amplion Corp.
Best Mfg. Co.
Jensen Radio Mfg. Co.
Rola Co.
Temple, Inc.
Transformer Corp. of America
Wright DeCoster, Inc.

VARNISH:
Maas & Waldstein Co.
Mitchell Rand Mfg. Co.
Zapon Co., The.

VOLTAGE REGULATORS:
(See Regulators)

VOLTMETERS, A. C.:
Ferranti, Inc.
General Electric Co.
General Radio Co.
Jewell Elec. Inst. Co.
Weston Elec. Instrument Corp.

VOLTMETERS, D. C.:
Ferranti, Inc.
General Electric Co.
General Radio Co.
Jewell Elec. Inst. Co.
Weston Elec. Instrument Corp.

WASHERS:
Aluminum Co. of America
Scovill Mfg. Co.
Shakeproof Lock Washer Co.
Synthane Corp.

WAXES, IMPREGNATING:
Candy and Co.
Mitchell Rand Mfg. Co.

WAXES, INSULATING:
Candy and Co.
Mitchell Rand Mfg. Co.

WAXES, SEALING:
Candy and Co.
Mitchell Rand Mfg. Co.

WIRE, ANTENNA:
Acme Wire Co.
Dudlo Mfg. Corp.
National Vulcanized Fibre Co.
Roebling, J. A., Sons Co.
Rome Wire Co.

WIRE BALLAST:
National-Harris Wire Co.
Radio Wire Corp.

WIRE, BARE COPPER:
Alpha Wire Corp.
Dudlo Mfg. Corp.
Roebling, J. A., Sons, Co.
Rome Wire Co.

WIRE, COTTON COVERED:
Acme Wire Co.
Alpha Wire Corp.
Dudlo Mfg. Corp.
Radio Wire Corp.
Roebling, J. A., Sons Co.
Rome Wire Co.

WIRE, ENAMELED COPPER:
Acme Wire Co.
Alpha Wire Corp.
Dudlo Mfg. Corp.
Polymet Mfg. Corp.
Radio Wire Corp.
Roebling, J. A., Sons Co.
Rome Wire Co.

WIRE, FILAMENT:
American Electro Metal Corp.
Callite Products Co., Inc.
Fansteel Products Co., Inc.
Gilby Wire Co.
National-Harris Wire Co.
Radio Products Corp.
Vacuum Tube Products Co.

WIRE, HOOK-UP:
Acme Wire Co.
Alpha Wire Corp.
Dudlo Mfg. Co.
Roebling, J. A., Sons, Co.
Rome Wire Co.

WIRE, LITZENDRAHT:
Dudlo Mfg. Corp.
Radio Wire Corp.
Roebling, J. A., Sons Co.
Rome Wire Co.

WIRE, MAGNET:
Acme Wire Co.
Dudlo Mfg. Corp.
Rome Wire Co.

WIRE, MOLYBDENUM:
American Electro Metal Corp.
Callite Products Co., Inc.
Fansteel Products Co., Inc.
Palatine Industrial Co., Inc.

WIRE, PIGTAIL:
Dudlo Mfg. Corp.
Roebling, J. A., Sons Co.
Rome Wire Co.

WIRE, RESISTANCE
Gilby Wire Co.
National-Harris Wire Co.

WIRE, SILK COVERED:
Acme Wire Co.
Dudlo Mfg. Corp.
Radio Wire Corp.
Roebling, J. A., Sons Co.
Rome Wire Co.

WIRE, SPAGHETTI:
Acme Wire Co.
Mitchell Rand Mfg. Co.
Rome Wire Co.

WIRE, TINNED COPPER:
Dudlo Mfg. Corp.
Roebling, J. A., Sons, Co.
Rome Wire Co.

INDEX OF ADVERTISERS

ADAPT SHAKEPROOF TO YOUR PRODUCT

THERE are many places on many products where engineers are adapting the SHAKEPROOF principle. On this page four of these special applications are shown. There is probably a place on your product where SHAKEPROOF can save you time and money. We will be glad to work with you. Write our engineering department.

SHAKEPROOF
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Please send me samples of

☐ *Shakeproof Lock Washers to fit bolt size* _____
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Firm Name _____
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By _____

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NO Radio set is any better than its weakest link, and the weakest link is very often a filter Condenser. No Condenser is any better than the thin strips of Insulating Tissue which separate the layers of metal foil. A pinhole or a speck of metal in the Condenser Tissue means a breakdown of the Condenser, with the entire set put out of commission.

DEXSTAR Condenser Paper is regarded by Radio experts as being the highest grade Insulating Tissue ever made—the freest from defects, the most uniform in quality, the most lasting under exacting and unusual requirements. DEXSTAR Condenser Tissue is the specialized product of a paper mill which has excelled in Tissue Paper production for three generations.

RADIO designers and builders should have the assurance that Condensers which they use are made with DEXSTAR Condenser Tissues. It is insurance against many radio troubles. The leading Condenser manufacturers are now using DEXSTAR Condenser Tissues exclusively.

C. H. DEXTER & SONS, INC.
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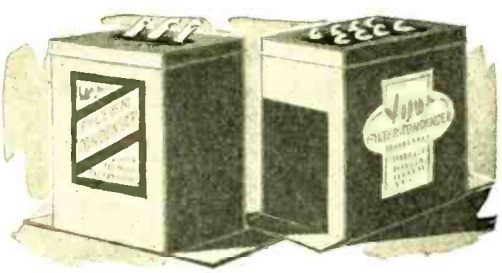

This year is scheduled by all seasoned manufacturers, both sales and manufacturing. It is on next year's production that Dongan best can serve you.

You then will require a source for the finest of transformers — a source that will always keep your production moving.

You are assured exactly that from Dongan — designing and manufacturing the finest of approved audio and power transformers. Our sales-engineering department is ready to discuss with you next year's vogue in Transformers.

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SERVICE ENGINEERS !
Available Now

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No. 5554—Double Choke (use in Filter Circuit)	$11.00
No. 2124—Transformer (for Push Pull Radio and Phonograph Amplification)	$6.00

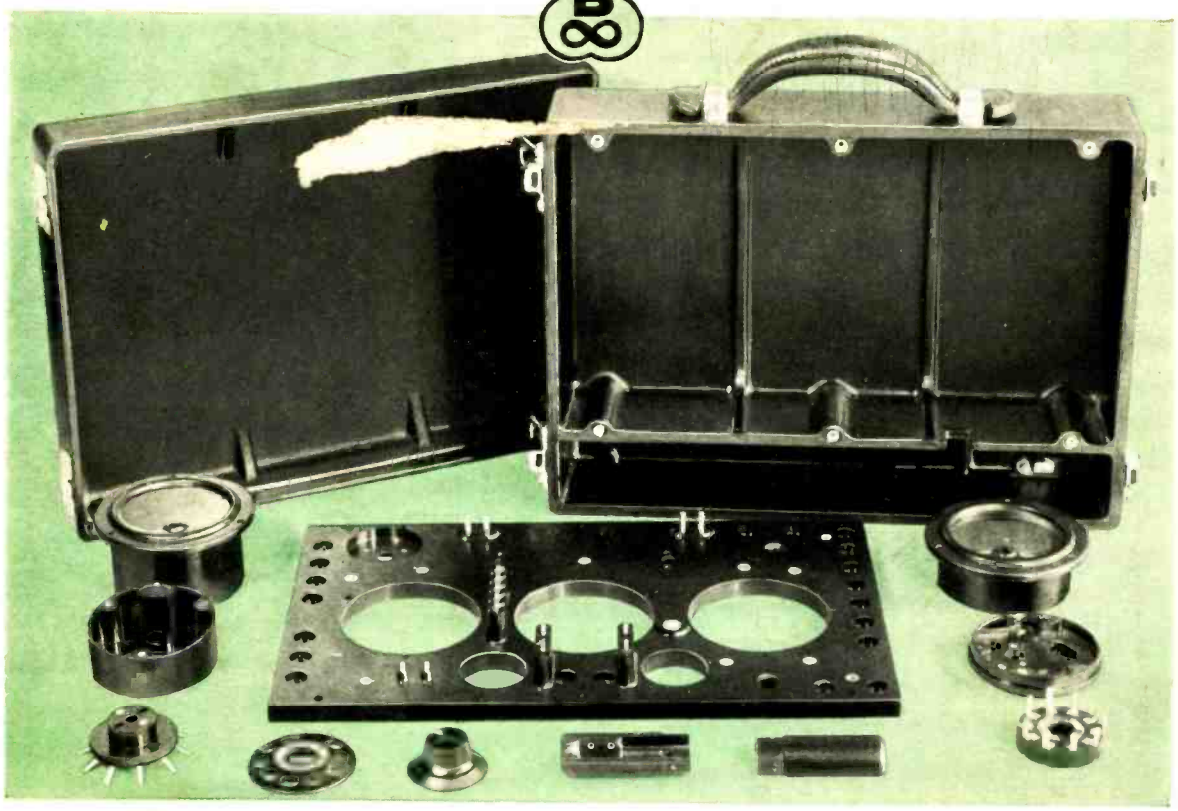
Send check or money order for prompt delivery.

Transformers, Chokes, Condenser Units

We are prepared to furnish complete parts for construction of amplifiers for theaters, dance halls or public address systems.

Dongan Electric Manufacturing Co.

2991-3001 Franklin St., Detroit, Mich.



Bakelite Molded case and parts of Weston 547 Radio Set Tester—made by Weston Elec. Instr. Corp., Newark, N. J.

A splendid example of the adaptability of Bakelite Molded to varied needs

Carrying case, panel, plugs, dials, knobs, bases, meter cases, and in fact all of the principal parts of the Weston radio set tester are of Bakelite Molded. The photograph of the component parts is worthy of the study of every radio engineer.

Both box and cover are interesting demonstrations of large, deep shell Bakelite Molded parts. The panel illustrates the accuracy with which a multiplicity of holes, recesses and bosses may be formed, and numerous metal inserts embedded—all in one press operation. Each of the other parts is a practical solution of a manufacturing problem through the use of Bakelite Molded.

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