Tenth Year of Service

RADIO ENGINEERING

Vol. X MARCH, 1930 No. 3

IN THIS ISSUE

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The Journal of the Radio Industry

One Industry Gathers Stimulating Facts from Hundreds of Others

Offers them free to men in thousands of Other Industries - - to Workers in all ranks, and to Executives - - First step in the "Democratizing" of Knowledge hitherto restricted to a Few

FACT-SHEETS OF INDUSTRY No. 1

will be mailed to ANY Worker or Executive. No charge or obligation. Just state work you do; company's name and products; and whether request is for self. Address: Librarian: (T-3); Fact-Sheets of Industry; National Vulcanized Fibre Company, Wilmington, Del. (Card will do).

Send for this

THE kind of facts that spur thought. The kind of thought that results in those small and large savings and advantages originated by workers and executives; which, in the total, have already done so much for the advancement and prosperity of each industry.

And that can be still more helpful to the prosperity of each industry, right NOW.

(Because, right now, if you realize what is going on, industry's thinking is getting ready for a new turning point, a new prosperity, a new and greater advancement than ever before.)

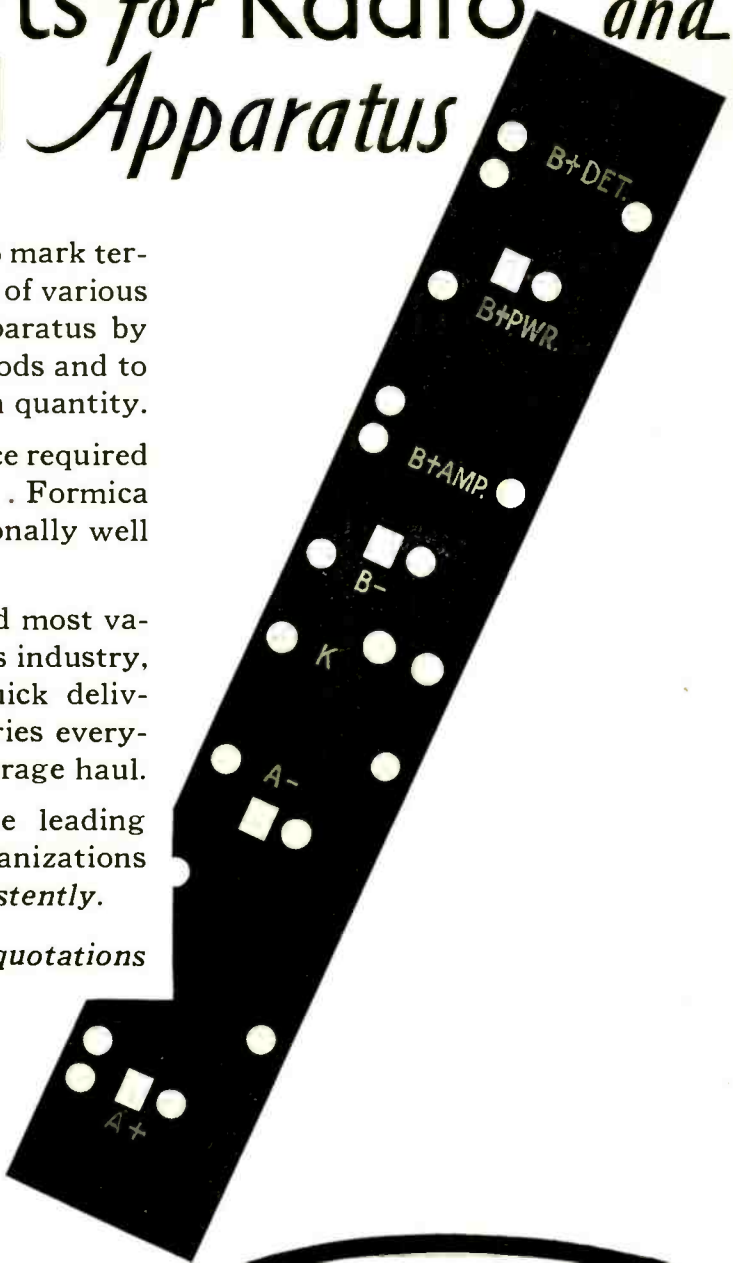
Write for these Fact-Sheets today.

The publication of this, the first of the Fact-Sheets of Industry, is the start of a plan which, when at its full growth, will supply freely to thinking workers in ALL levels of industry, practical knowledge which hitherto has not been readily accessible; facts from many other industries which may stimulate their own productive thinking; and which (though they affect practically every business, every department and every worker), are usually known only in part and only by a limited group of specialists in each industry. . . .

As a movement in line with national measures for further improvement of business conditions and of the circuit of producing, earning, consuming, equipping, etc.—and as the initial step in this democratizing of inter-industry knowledge, (which, under present conditions, is more needed by thinking workers, and can yield more important results than ever before)—all expenses of issuing the first of the Fact-Sheets of Industry are being borne by The National Vulcanized Fibre Company and its various divisions and associated industries.

NATIONAL VULCANIZED FIBRE COMPANY

Marked Insulating Parts for Radio and Electrical Apparatus



FORMICA is equipped to mark terminal strips and panels of various sorts used in electrical apparatus by two or three different methods and to turn the work out rapidly in quantity.

For almost any sort of service required by the electrical industry . . . Formica will be found to be exceptionally well prepared.

Formica has the largest and most varied service equipment in its industry, centrally located where quick deliveries can be given to factories everywhere over the shortest average haul.

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Western Editor EVANS E. PLUMMER | *Editor* DONALD MCNICOL | *Associate Editor* AUSTIN C. LESCARBOURA

Vol. X | March 1930 | Number 3

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Departments

Tobin Comes To Radio Engineering

L. C. TOBIN, veteran radio advertising salesman, on March 1st, joined the advertising sales staff of RADIO ENGINEERING. Mr. Tobin needs no introduction in the radio industry. For many years past he has been closely identified with radio advertising and publicity—the past eight years on the advertising sales staff of Doubleday, Doran and Company; the last four years as advertising manager of *Radio Broadcast*.

Mr. Tobin's many friends in the radio industry will be glad to know that his wide experience and knowledge of markets is to continue to be at their command.

▲ ▲

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ANACONDA

from mine to consumer

REG. U.S. PAT. OFF.

USE ANACONDA WIRE in your product

YOUR product may be designed for the luxury trade, the average purchaser, or the low-price market. Whether it be custom-made or produced in quantity, *the electrical wires* that carry the current and make it useful *must be safe and dependable!*

The coordinated control by a single organization, responsible for every step in production *from ore to finished products,* assures the uniformly high quality of Anaconda flexible-cords, magnet wire and all rubber insulated wires and cables.

Use Anaconda wire in your product. Make use of the engineering facilities of this nationwide organization . . . Let us discuss your problems and requirements with you now.

Anaconda safeguards quality from mine to consumer—provides a nationwide service, prompt, dependable, complete.

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General Offices: 25 Broadway, New York
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Magnet Wire Mills at
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Sales Offices in Principal Cities

EDITORIAL

March, 1930

THE PENTODE TUBE

THE members of the committees on receiver design and on tubes, of the engineering division of the Radio Manufacturers Association, held an important conference at the Astor Hotel, New York, on the afternoon of March 6. The purpose of this conference was to bring to the surface what the tube and set manufacturers have found out about the immediate availability of the widely heralded pentode tube, and what the receiver manufacturers propose to do about it.

In the discussion there was expressed a sincere desire to play fair with the consumer—the public. While some of the tube manufacturers appear to have faith in the advantages of the pentode over present standard tubes, the receiver manufacturers generally demur at its introduction until such time as its service characteristics may be determined and agreed upon by cooperative engineering between tube and receiver manufacturers.

Some of the larger receiver manufacturers frankly state their views that the pentode has no outstanding advantages. Others state their belief that the new tube may have an immediate application for special sets, rural receivers and for 110-volt d-c. operation.

At the conference several of the receiver manufacturers announced that their Fall lines already are laid out and that the use of the pentode in these receivers is not contemplated.

At the conference there were expressions to the effect that in no quarter is there a wish to stem progress. However, the pentode had its turn at the bat and at least got as far as first base. The undercurrent of feeling appears to be that the pentode is here and that with a few months more study of its performance and with further refinements it will find a useful place in the industry and become a stock element of at least some forms of radio receivers of the near future.

As time passes we shall no doubt hear much more of the pentode and its possibilities.

▲

SALUTATORY

RADIO ENGINEERING during the past four years has had a very gratifying growth in circulation and in usefulness to advertisers, manufacturers and engineers. Today it is read by more than twice as many radio technicians and executives as have so far identified themselves with the professional radio engineering society.

Our ambition is to make the journal of still greater use to those who make their livings out of radio. To this task we bring whatever of value there is in radio experience dating back to the beginning of the business in this country.

Our desire is to keep abreast of the engineering of all branches of radio; to report in the columns of this journal monthly the progress made by the laboratories, the manufacturers and the engineers.

We propose to do what we can to make the published information easy to read, and the "meat" of each story easy to find.

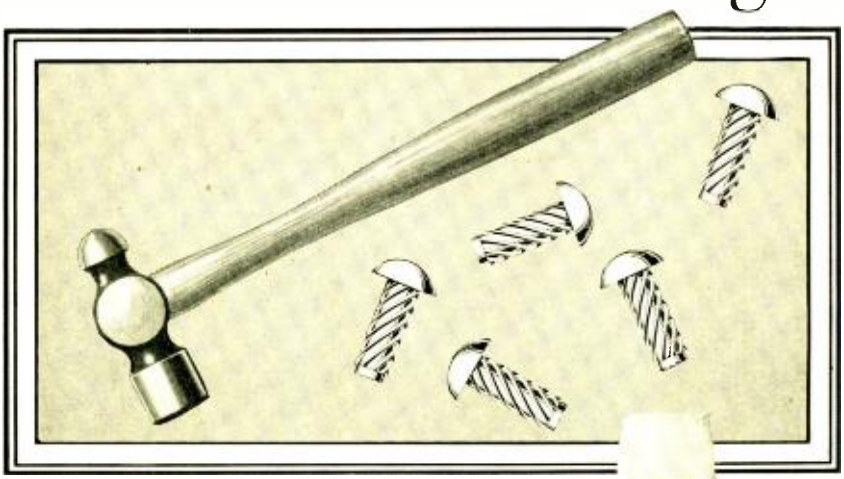
If we succeed in an outstanding way in making RADIO ENGINEERING of greater value to those who look to this journal for timely information, this will be due largely to valued personal contacts of long standing in the industry.

It is necessary only to look backward ten years upon radio development to form a reasonable conception of what the next ten years have in store.

In the work yet to be done in furthering the onward march of radio, RADIO ENGINEERING proposes to contribute substantially and constructively.

DONALD McNICOL, *Editor.*

All You Need to make Permanent Fastenings



No tapping . . . just hammer in Hardened Drive Screws

A HAMMER and some Hardened Metallic Drive Screws are all you need to make permanent fastenings to iron, brass and aluminum castings, steel, Bakelite, etc. No taps or tapping machinery necessary. A Hardened Metallic Drive Screw is its own tap—cuts a thread as you hammer it into a drilled hole.

Compare the ease, speed and economy of making fastenings this simple way with other methods of assembly. Then remember that these unique Screws have proven their ability to hold under vibration and severe service conditions.

Leading manufacturers of radio sets and accessories have made substantial reductions in time and cost of assemblies by using Hardened Metallic Drive Screws in place of machine screws, escutcheon pins, rivets, etc. Applications range from the fastening of name plates to assemblies where great holding power is a prime requisite.

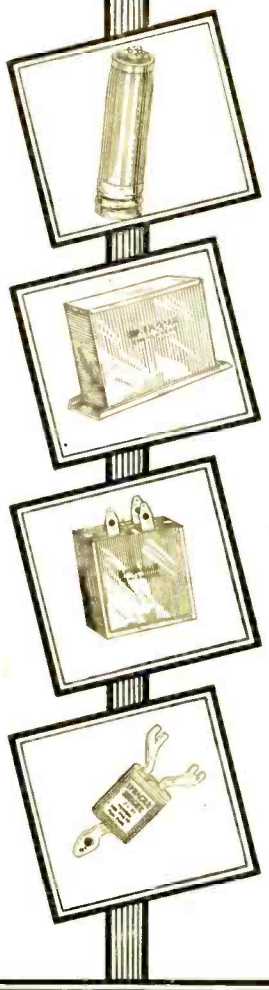
A test will show what these Screws will accomplish on your assemblies. It will certainly pay you to find out. We will provide proper samples for a trial—merely send a brief description of your assembly.

PARKER-KALON CORPORATION
Dept. L. 190-198 Varick St., New York, N. Y.

PARKER-KALON
TRADE MARK
HARDENED METALLIC
REG U S PAT OFF
DRIVE SCREWS
PAT. JAN. 29, 1924-NO 1482151-OTHERS PENDING

QUALITY

Sprague Precision Condensers are the Standard of Condenser Quality



WHEN critical engineers get together, they all agree that Sprague Condensers are superior . . . They know that Sprague Condensers have stood the severest tests of service — that they can be depended upon to perform their duties with unfailing faithfulness. Sprague Condensers are designed by the nation's foremost condenser engineers and assembled by skilled craftsmen . . . And here are a few reasons why Sprague Condensers are better:

THE SPRAGUE ELECTROLYTIC CONDENSER

A single unit allowing maximum flexibility for mounting in circuit. No welded or riveted joints in its one piece anode, made of purest aluminum. A lower leakage and better power factor than any other electrolytic unit, wet or dry. Rigid construction prevents possibility of internal shorts. Screw type socket makes for ease in mounting. Edge effect 10% of spiral type.

THE SPRAGUE BLOCK CONDENSER

Dielectrically superior due to patented paraffin layer process: Ruggedly protected by extra heavy sheet metal can. Impervious to moisture due to dipping of individual condensers, wrapping of assembled block in moisture-proof material, and triple sealing. Highest leakage resistance guaranteed above 5000 megohms per microfarad.

THE SPRAGUE ONE MICROFARAD UNIT

Flexible mounting — either unique stud or flange as desired. Correctly protected against moisture by double seal and only one small open end. Also furnished in midget assemblies using up to five sections of low capacity.

THE SPRAGUE MIDGET

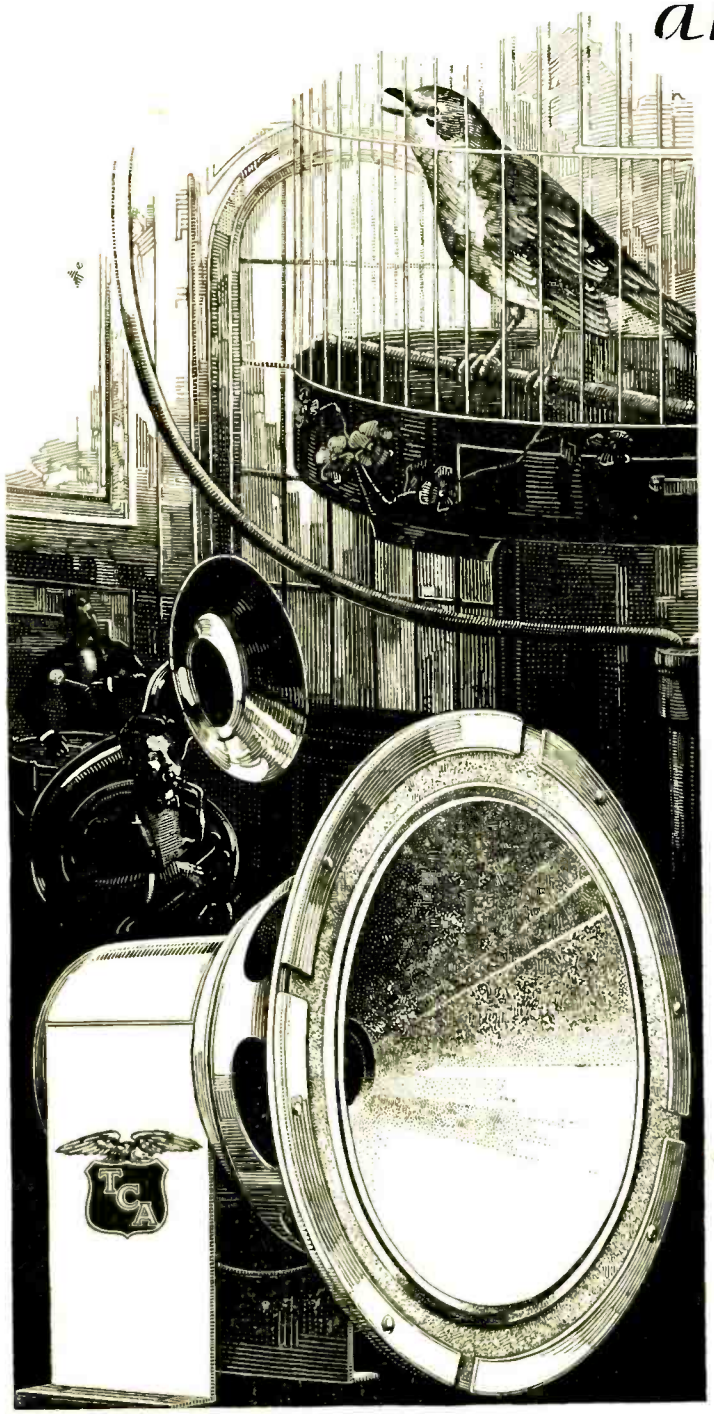
A compact and unusually strong unit. Tested to high voltage breakdown — waterproofed with asphalt covering and special process of triple impregnation. Easily and quickly mounted . . . Dual type of winding if desired.

SPRAGUE SPECIALTIES COMPANY
QUINCY, MASSACHUSETTS

SPRAGUE ELECTROLYTIC AND PAPER CONDENSERS
WILL SOLVE YOUR CONDENSER PROBLEMS

SPRAGUE

Range FULL-TONED and rich



If studio programs were planned to fit the limitations of the average loud speaker, the problem of full range tone reproduction would be simplified.

But with a listening public eager for variety . . . with pipe organs, symphony orchestras, and lyric sopranos, all crowding around the microphone, the reproducer has, indeed, an almost impossible job.

The new T·C·A Dynamics show astonishing fidelity on both high and low extremes of studio broadcasting, together with the same extraordinary freedom from noise and hum that made the 1929 model so outstanding.

Comparative tests have been unanimous in their unqualified endorsement.

No receiving set can have an output which is more full-toned and rich than the sets equipped with these new T·C·A Dynamics.

Write or wire for information

The assistance of our Engineering Department is at the service of Radio Manufacturers.

TRANSFORMER CORPORATION OF AMERICA

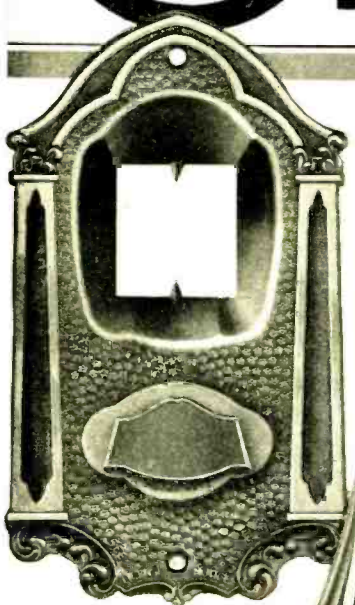
2301-2319 S. Keeler Ave., Chicago, Ill.

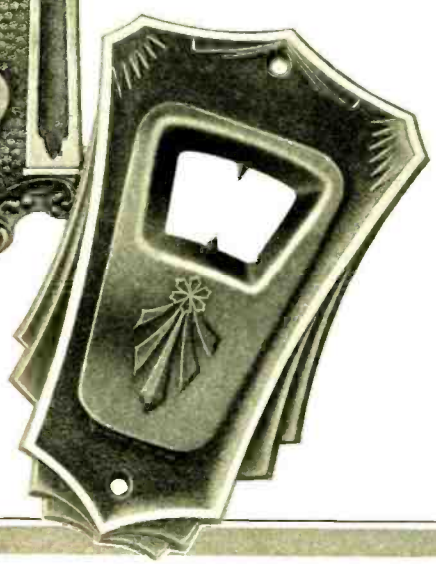
ESCUTCHEONS

COIN EMBOSSED :: ETCHED

DIALS AND CONTROL PLATES

CROWE





Radio engineers are invited to write for suggestions, and a copy of our descriptive Bulletin No. 30.

Your logical source of supply for designs that are original and distinctive . . . for practical assistance on engineering details . . . for die work of superior excellence . . . for assurance of mechanical accuracy and convenient assembly . . . for prompt service and dependable deliveries.

. . . . . Just now we have some new developments in rotary disc dials which it will pay you to investigate.

. . . . . Our engineers are conversant with changing trends and prepared to make valuable suggestions.

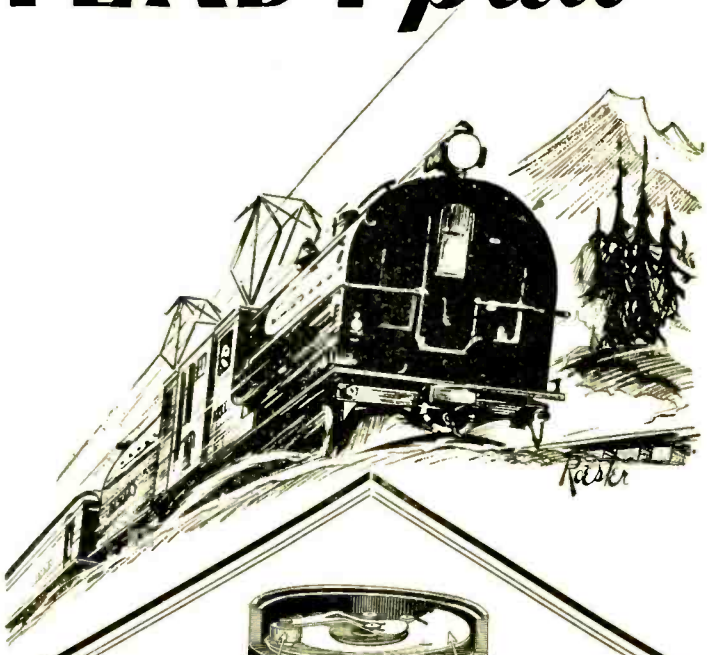
CROWE NAME PLATE & MANUFACTURING CO., 1749 Grace Street, CHICAGO

a SMOOTH start and a STEADY pull

THE giant electric locomotive starts with velvet smoothness and pulls the heaviest loads over steep mountain grades with steady, unfailing power.

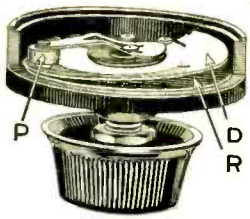
It's all a matter of control.

The increased sensitivity of your radio demands the s-m-o-o-t-h control that only Centralab can give. Noiseless, free of inherent sputtering - self inflicted static. For smooth, quiet, velvety radio reception your radio must be CENTRALAB equipped.



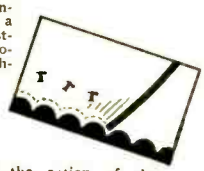
"Volume Control, Voltage Controls & Their Uses"

Write Dept. 212-B for Free Booklet



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 can not ruin the resistance because the rocking disc is in between the pressure arm and the resistance.

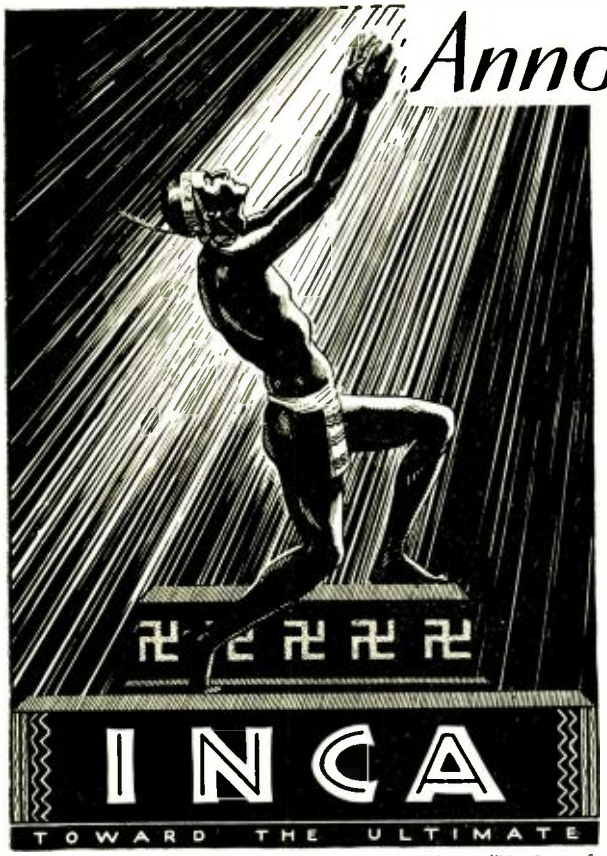


This is the action of the usual wire wound control after it has been in use for some time . . . like dragging a stick over a cobblestone pavement.

Centralab

CENTRAL RADIO LABORATORIES

Dept. 212 B., 28 Keefe Ave. Wilwaukee, Wis.

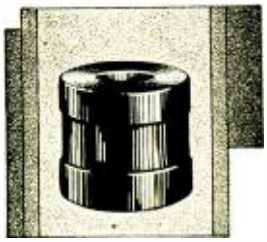


Picturization of Inca Indian, derived from Sir Clement Markham's "The Incas of Peru"—the original copper workers of early American history, noted for the perfection and skill with which they fashioned products from metal.

Announcing the

NEW

INCA COIL



Patent applied for.

An improved dynamic field coil many strides in advance

Mechanically and electrically the best on the market today! That is the claim unhesitatingly made for INCA'S latest development—the new field coil for dynamic speakers—a product of the engineering skill and facilities of INCA'S new and most efficiently designed plant. This coil supplies a basic need of the radio manufacturer—namely, enameled wire in coil form, *without the spool.* There are many superior features. The circumferential bands, for instance, add strength and provide instantly available terminals. Therefore the customer may order with or without leads. This and other coils are built to the precise specifications of the manufacturer.

INCA

engineers will be pleased to confer with you on any of your magnet wire or coil problems

INCA MANUFACTURING CORPORATION

Copper Wire Products *Fort Wayne, Indiana*

WESTERN REPRESENTATIVE: A. S. Lindstrom, 274 Brannan Street, San Francisco, California
EASTERN OFFICE: Newark, New Jersey—Industrial Office Building

What does *your* set say to "the man who knows"?

"Who really buys your set?"

"What points actually sell it?"

THE success of today's manufacturer and builder depends upon how well he knows the answers to these two questions.

The man who knows enough about radio to understand causes as well as results is becoming an increasingly important sales factor in the receiver market. Those who are not radio-wise hesitate to purchase sets without relying upon the advice of an acquaintance who has some knowledge of radio. To this man, Sangamo Transformers stamp your set as O.K. Sangamo in the "audio end" means true TONE.

TONE QUALITY is the magic key that finally opens the purse and closes the sale.

Transformer building is a science in itself—best left to an organization like Sangamo, whose research, experience and precision manufacturing facilities guarantee results. Sangamo "A" Line Transformers are built for the custom set maker or manufacturer who wants a "tone" advantage over competition. They cost a little more, but the set is easier to sell.

SANGAMO ELECTRIC CO.

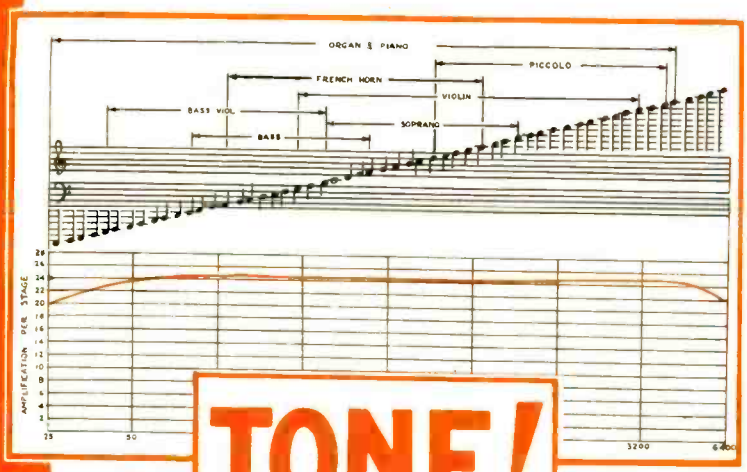
SPRINGFIELD, ILLINOIS, U. S. A.

Manufacturers of Precision Electrical Apparatus for 30 years

SANGAMO

See Reverse Side

"A" Line Transformers



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

Type "A" straight audio amplification. List price..... $10

Type "B" Push-pull Input Transformer for all tubes. List price..... $12

Type C-171 Push-pull Output, for 171 or 250 type power tubes with cone speaker. List price..... $12

Type D-210, same as C, except for 210 and 112 power tubes. List price..... $12

Type H-171, Push-pull Output for 171 or 250 power tubes for Dynamic Speaker. List price..... $12

Type G-210, same as type H, except for 210 and 112 power tubes. List price..... $12

Type F Plate Impedance for use as a choke to prevent oscillation and for impedance coupled amplifiers. List price.... $5

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

SANGAMO Type "A" 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.

SANGAMO "Illini" Condensers

"Illini" Condensers are standard with those manufacturers who insist on ratings being actually what the specifications call for. Manufactured by exclusively designed equipment, held to the tolerances your engineering department demands, Sangamo Condensers will reduce to a negligible quantity inspection department rejects and "re-assembly" losses in profit.

Prices on request

PIN THIS TO YOUR LETTERHEAD AND MAIL

SANGAMO ELECTRIC CO.
Springfield, Illinois, U. S. A., Dept. S

☐ (*For manufacturers*) I am interested in engineering data regarding your transformers and condensers.

☐ (*For set builders*) Please send circulars describing your apparatus and latest audio hook-ups. I enclose 10c to cover cost of mailing.

*Name*_____

*Address*_____

YOU CAN "HEAR THE DIFFERENCE AND SEE THE REASON IN EVEREADY RAYTHEON 4-PILLAR TUBES «

HERE is an entirely new type of tube . . . Eveready Raytheon! It combines the highest degree of sensitivity with lasting, rugged strength. The patented Eveready Raytheon 4-*Pillar construction*—a revolutionary improvement—safeguards fragile elements against the dangers of shipment and handling. Eveready Raytheon elements are assembled on jigs, to put them in most sensitive relation to each other. The 4-*Pillar construction* anchors these elements where they belong—assuring you of a new standard of reception.

You can see this exclusive construction inside an Eveready Raytheon. Look at the diagram on this page. See the solid, four-cornered glass stem. Notice, imbedded in it, the four sturdy pillars supporting the elements. That shows why Eveready Raytheons are stronger than ordinary tubes—and why they give you the best reception you can possibly get from your present receiver. No other tube can be made like this, because the 4-*Pillar construction* is patented.

4-PILLAR TUBES

Showing the exclusive, patented EVEREADY RAYTHEON 4-Pillar construction, *with its solid, four-cornered glass stem, its four rigid pillars, and anchorage to a stiff mica plate at the top.*

4-PILLAR SCREEN GRID

EVEREADY RAYTHEON SCREEN GRID TUBE, ER 224. *The weight of the four large elements in this type of tube makes the exclusive Eveready Raytheon* 4-Pillar construction *vitally important.*

Eveready Raytheons come in all types. They fit the sockets in every standard A. C. and battery-operated receiver in use today. They are built by the makers of the famous Eveready Layerbilt "B" Batteries—another radical improvement in radio. Get a set of new Eveready Raytheons from your dealer, and enjoy their reception today.

NATIONAL CARBON CO., Inc.
General Offices: New York, N. Y.
Branches: Chicago Kansas City
New York San Francisco

Unit of Union Carbide and Carbon Corporation

EVEREADY RAYTHEON

Trade-marks

IMPRESSIONS and EXPRESSIONS

By

AUSTIN C. LESCARBOURA

A New Deal for Tube Production

WHILE the industry at large has been satisfied to employ more or less standardized tube production equipment, at least one manufacturer has decided to develop entirely new equipment geared to a higher production capacity and a lower production cost. The recent announcement by one company of new list prices on eight standard types of tubes, ranging from 20 to 30 per cent, is of utmost significance to the radio tube industry at this time. This is no price-slashing move, as might be suspected. It is obviously no attempt to liquidate inventories. Ample proof is available that this organization has developed entirely new and special automatic production equipment which must force the rest of the tube industry to a higher degree of efficiency than has existed heretofore.

Briefly, the new production equipment averages about 2,000 tubes per hour. This applies to the sealing, exhausting, basing and other major units, not to overlook such detail production as automatic grid winders, automatic punch and forming presses with ribbon stock, automatic wire bending machines, improved weld machines, and so on. Heretofore, the usual units have been set for 300 tubes per hour. Thus the latest equipment is geared to more than six times the speed of standard units, while if anything the product is improved.

Strenuous competition faces the radio tube industry. Lower prices are now in order. Equipment must be scrapped and new and better equipment substituted. Many have been lulled into a false sense of security on list prices. The battle has, apparently, only begun.

A Sounder Industry

THE fact that a number of prominent radio set manufacturers have dropped out of the radio race is to be considered as a blessing in disguise. While it may seem painful to their managements and stockholders and to those who have been supplying them with materials and parts, in the long run the present elimination contest is working for the betterment of the industry as a whole.

It has been conservatively estimated that the radio industry, as set up during 1929, could produce 25,000,000 radio sets if operating at full blast. Fortunately, the production has been held down to one-fifth that amount. And even so, the market has been considerably less than even that curtailed production. It has been obvious for a long while back that there were too many manufacturers in the radio industry, while the market showed no signs of expanding to a point where it could absorb the vastly increased production facilities.

With bankruptcies, voluntary withdrawals, and greatly curtailed programs, the radio industry enters the 1930 season with a fair assurance of curtailed gross production. If the remaining manufacturers will only give up the practice of talking in telephone numbers, and get down to good, sound, sensible figures, the industry may yet enjoy one of the most profitable years in its career, even in the face of what would seem a depression. After all, a small production sold entirely at a profit is certainly to be preferred to a stupendous production sold at bargain prices.

The Self-Contained Idea Turns Boomerang

WHEN our radio engineers attained the self-contained radio set, housed in an attractive console cabinet, we were all agreed that the millenium in radio merchandising had arrived. Here at last was genuine home entertainment in compact, attractive form. Technicalities were dispensed with once and for all, so far as the lay public was concerned. But is it so?

That something ails the radio industry, most of us know only too well. Radio sets are not selling as rapidly as they should. Dealers are not doing the necessary volume of business to be happy.

Ask any small-town radio dealer. He will tell you that every set he sells means just that much more of his market used up. Many homes that can afford radio, are now provided with satisfactory sets. It may be several years before the sets sold during the past year or two are sufficiently obsolescent to warrant a new sale. The situation, gentlemen, is serious.

If only our radio sets called for accessories! Take the home movie proposition, for example. The average buyer starts with a projector. He then wants a camera. Soon he needs a real screen. After that he buys a carrying case. Special lenses follow. For colored movies, he buys a special attachment. Then comes a title board. For enlargements, he buys a suitable attachment. And so on and so on. It is estimated that the average home movie rapidly increases his investment up to $1,000.

Are we correct about self-contained radio sets?

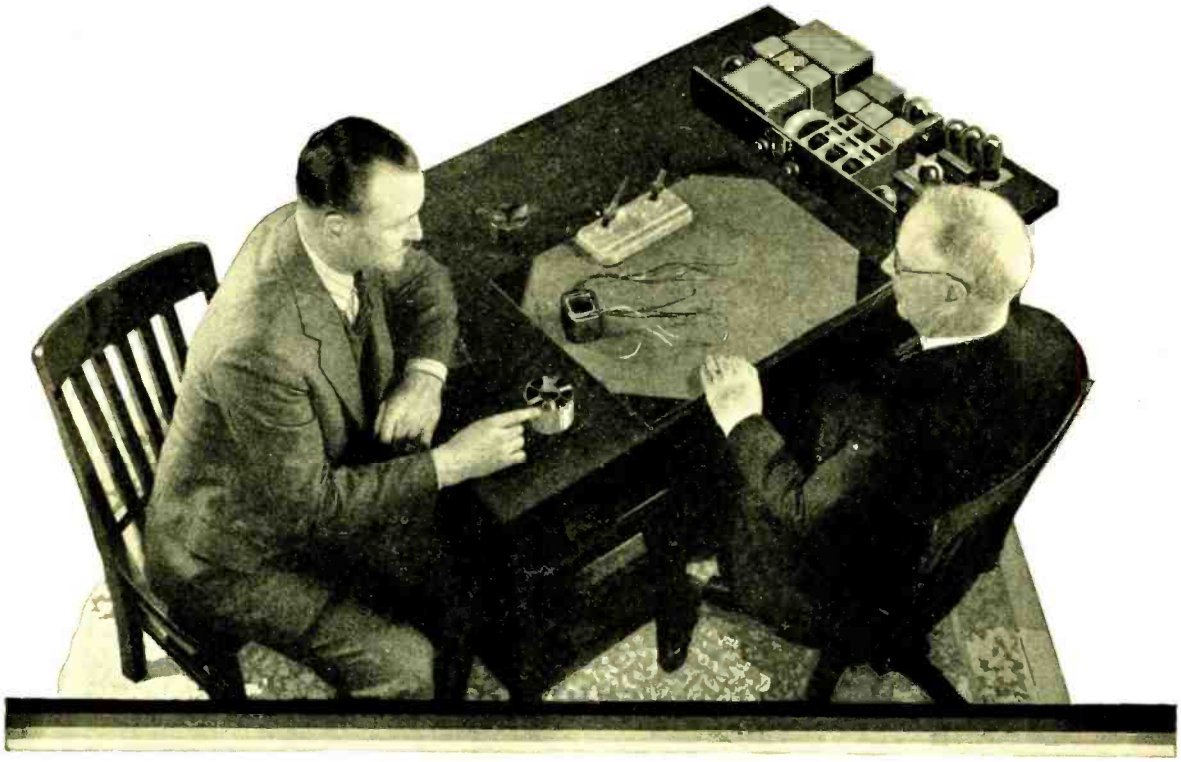
Patent, Patent—Who has Got the Patent?

THERE are many loose patents kicking about the radio industry. In the past, patents were not taken so seriously. They were usually of questionable value. However, when the RCA license agreement went into effect, radio patents became valuable property, capable of paying a big return in the form of royalties. Today, everyone with a radio patent is fully aware of the nuisance value thereof. And immediately proceeds to become a nuisance.

Many of us were of the opinion that the RCA license agreement would solve the patent problems of the industry. It seemed logical to concentrate all necessary patents in a pool, and for radio manufacturers to pay royalties for the use of those patents. It was also believed that this license agreement would do away with radio patent litigation. But unfortunately, all radio patents are not represented in the RCA patent pool. A few patents are at large. And therein lies a serious threat to the industry.

Thinking out loud, we wonder whether all the necessary amplifier patents are included in the RCA patent pool. There are many important vacuum tube patents at large. We wonder whether the rights to the recording and reproducing of music are really covered in those patents. We wonder whether the power pack is really covered. In fact, there are many features of the present-day radio set which, in our opinion, are in their patent aspects open to attack by those outside the RCA fold.

It would seem that the time has arrived when the radio industry must make a survey of the entire patent situation. Patents must be cataloged. They must be arranged in groups. Suitable license arrangements must be worked out. Otherwise, we are faced with chaos once more.



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The Pentode Tube†

Comparative Characteristics of the Triode and Pentode and the Applications of the Latter

By Keith Henney[1] and Howard E. Rhodes[2]

THE pentode is a tube with five elements; a filament, and a plate as in ordinary tubes and three grids. One of these grids is the control or signal grid upon which alternating voltages are put. The second grid is a space charge grid designed to rid the tube of the deleterious space charge, and the third or cathode grid is to get rid of secondary emission from the plate.

This new three-grid tube is a natural development of the screen-grid tube which in turn is a rather radical development of the triode. To have a clear picture of what engineers are trying to do in their work on the pentode, we must devote a little time to the simpler tubes, namely, the three- and four-elements tubes.

The mechanism by which an electron escapes from the filament and carries current to the plate has been described many times. The simplest explanation states that when a filament is heated to a sufficient degree, the electrons within it move rapidly enough and therefore acquire sufficient kinetic energy to escape from the filament and go shooting off into the surrounding space. The energy required by the electron to escape has been pretty well calculated and confirmed by experiment. For example, if a tungsten filament is the source of the electrons, the electrons must travel at a speed of one million meters per second before they can get up sufficient energy to escape through the surface tension of the filament. This speed is about one hundredth of the speed of light, which according to Einstein's theory is the greatest attainable speed in our universe.

Now what does an electron do when it gets away from its parent filament? It can do any one of several things depending upon its heredity, the start in life its parents gave it, and its environment. If its parent gave it a good start it may go very far. For example if it leaves the filament with sufficient energy to carry it to a plate a half centimeter away, it will have traveled 2.5 million million times its radius. This is equivalent to someone throwing a baseball from the Yankee Stadium to the sun, 90 million miles away.

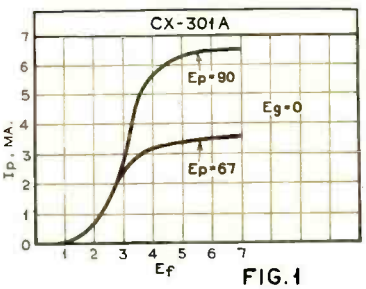

FIG. 1

On the other hand, if the filament gave the electron only a poor start the electron may merely fall dead as soon as it leaves the parent and fall back to the filament to be heated up and started off again.

After the electron, which is negatively charged, leaves the filament it is attracted to the plate which is kept at a positive potential. If 6.28×10^{15} electrons per second arrive at the plate, a current of one milliampere will be registered by a meter. In other words, a plate current merer is a device for counting electrons.

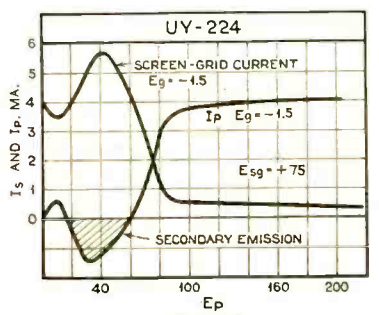

FIG. 2

Now it must be remembered that these electrons are negatively charged, and therefore have an abhorrence for each other. The first electron to leave the filament may repel the second if they come near each other. As soon as a number of electrons are situated out in the space between filament and grid, they constitute a cloud of negative electricity, and will tend to repel any other electrons which come near it. The sum total of these negative loafer electrons is called the space charge and its effect is to limit the plate current. If it were not for the space charge the plate current would be limited only by the supply of electrons, i.e., the temperature and chemical makeup of the filament. It would depend much less upon the plate voltage.

The space charge is a detriment to the tube, and many efforts have been made to do away with it. One method is to boost the plate voltage so that its positive attraction for the electrons is much greater than the combined repulsion of the space charge electrons. This is expensive, dangerous and uneconomical. Let us suppose the plate has a rather low voltage so that it does not have sufficient attraction to pull every electron through the space charge. Then raising the filament temperature will only increase the supply of electrons and cannot increase the attraction of the plate. It only results in maintaining or increasing the space charge. No more electrons get through to the filament. This flattening off of the plate current curve is called saturation.

Use of Space Charge Grid

Another method of getting away from the bad effect of the space charge is by means of another grid maintained at a positive voltage and situated where the loafer electrons congregate to form the space charge. These electrons are now attracted by the space charge grid and gotten out of the way. Some current will therefore flow to this electrode and some

† *Delivered before the Radio Club of America, January 15, 1930.*

[1] *Associate Editor, "Electronics."*

[2] *Technical Editor, Radio Broadcast Magazine.*

power will be wasted. In general this is small, because of this interesting fact. This grid is a coarse mesh, and only a few electrons stick on it. The rest are speeded up so much by the positive accelerating force of the space charge grid, that, instead of staying with this element they go rushing through it to land on the plate some distance away.

Now this seems a simple way to get rid of the space charge, but it is a method somewhat alloyed with trouble. The electrons which go through the space charge grid bang the plate so hard, because of their speed, that other electrons are knocked out of the plate. These negative carriers may be given sufficient kinetic energy that they get away from the field of the plate and into the positive field of the accelerating grid. In other words these new electrons, called secondary electrons, may constitute a current of electricity flowing away from the plate and toward the positive grid. This direction is opposite to that of the desired current and may not only decrease the plate current but may actually make it reverse and go backwards.

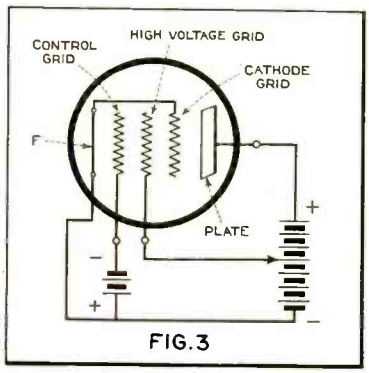

FIG.3

It is possible for a single electron to knock as many as twenty of its companions loose from the plate. If the total number which leaves the plate by this manner is equal to the number that stay there from the filament, the actual plate current is zero. If the number leaving is greater than the number arriving the plate current goes backwards. See Fig. 2.

We have the following dilemma. To get rid of the space charge and thereby increase the plate current from a given filament, we use an additional grid maintained at a positive potential somewhat lower than that of the plate. This extra grid gets away with the loafer electrons either by attracting them and neutralizing their effect or by so speeding them up that they go on through the grid and crash into the plate with sufficient energy to release other electrons at the impact. These secondary electrons constitute a secondary emission which makes a large part of the characteristic curve of the tube worthless for the purpose for which the tube was designed.

In the screen-grid tube the positive grid located between the control grid and the plate may not only reduce the space charge somewhat (Fig. 2) and make possible a tube with an amplification factor of 400 with a resistance of only 400,000 ohms but at the same time the extra grid at a high d-c. potential but low r-f. potential relative to the filament, effectively shields the control grid from the plate. In other words, it reduces the grid-plate capacity in the manner described many times in popular and technical literature.

Plate current curves. Note the "dips."

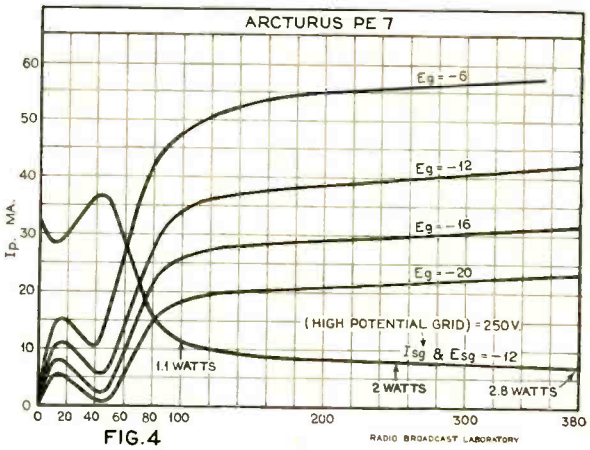

FIG.4

But due to secondary emission in the screen-grid tube there is a remarkable dip or valley in the plate current curve for values of plate voltage of the same order as the screen-grid voltage. This part of the curve represents a part of the tube that is worthless for the purpose for which the tube was made.

In other words, the presence of secondary emission in the screen-grid tube restricts the range over which the tube can be worked; at the lower value of plate voltage which may be due to large instantaneous values of input a-c. grid voltage, the curve takes a sudden slump and rectification may result. Some cross-talk in many modern receivers can be laid to the door of secondary emission.

The Pentode

So much for four-element tubes. Let us go one step farther to a five-element tube. There has been some demand for more efficient power tubes, that is, tubes which would deliver more power with a given supply of d-c. power or a tube which would deliver the amount of power we now require, say 1 or 2 watts with low values of plate voltage and current and with low values of grid excitation.

Power tubes we use now consume about seven times as much d-c. power as they deliver in a-c. power. A good pentode of the type engineers are striving for will consume only about 2.5 times as much d-c. power as they deliver in a-c. power. At the same time the pentode will be a high-mu tube so that it will require less grid excitation.

If a new positive grid is introduced into a three-element power tube, there will be excessive secondary emission because of the high voltages employed, and because of the necessity of using high positive grid voltages in order to get a low plate resistance. This secondary emission ruins the characteristic curve of the tube. It is absolutely necessary to get rid of it.

The introduction of another grid, forming the pentode or five-element tube, is a method of eliminating the effects of secondary emission.

This new grid is placed between the plate and the screen grid and is usually permanently connected to the filament. It forms a grounded shield between the plate and the screen grid and so far as the secondary electrons are concerned increases the potential gradient toward the positive field of the plate. In other words the electrons released from the plate prefer to go down hill to the plate rather than up hill through the grounded zero potential grid.

The electron leaving the filament then proceeds as follows: It comes first within the zone of action of the control grid which may have positive or negative values about some fixed voltage determined by the C bias. The electron is drawn through this grid by the positive voltage on the plate and on the screen grid. It comes next into the field of the positive screen grid and is either attracted to it and neutralized or is speeded up sufficiently

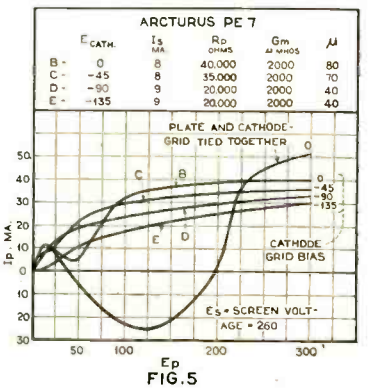

FIG.5

that it arrives at the plate instead of loafing about to form a space charge. Finally the electron, which is traveling at good speed by this time, comes to the cathode or zero potential grid. It may be retarded by this grid because it is at zero potential. But at any rate it hurries through and lands on the plate. If it knocks another electron out, or if it rebounds, it finds itself in a cage in the center of which is the positive field produced by the plate and the walls of which are made up by a zero potential screen. In other words the secondary electrons which leave the plate, and which in the screen-grid tube cause the loss of plate current, must return to the plate where they are useful. See Fig. 3.

In a two- or three-element tube, there is undoubtedly secondary emission. But since there is no positive element in the tube aside from the plate, these new electrons find themselves in the well-known situation of being "all dressed up and no where to go." Therefore they return to the plate and their derelictions from duty are never discovered.

Characteristics of the Pentode Tube

Up to the present time there are no pentode tubes being built in this country except as experimental models. Several of the better known tube manufacturers in this country are working on the pentode and it is our privilege to use some data from an Arcturus experimental tube of this new type.

In general the pentode tubes we have measured are high-resistance, high-mu tubes. For example, the data in Table 1 shows the constants of some well-known foreign tubes. At first the plate current (Fig. 4) rises fairly rapidly, sometimes with a dip in it showing the presence of some secondary emission not cleaned up by the cathode or zero potential grid, and then the plate current flattens out indicating a high plate resistance.

Owing to the fact that the space charge is partially done away with, a high mutual conductance can be secured with only moderate expenditure of filament and plate power. (Table 1).

A good tube of this type may deliver about 2.5 watts of undistorted power output, that is, not over 5% of second harmonic, the tube will require about 8 to 10 watts for the plate, and a grid excitation of not over 15 volts. This may be compared to the -45 tube which uses up 8.0 watts on the plate, delivers 1.6 watts and requires 50 volts (peak) to swing the grid.

It is not a simple matter to design such a tube. The number of possible variables is very great; and it seems that everything has some effect upon the characteristics of the tube.

For example, Fig. 5 shows, progressively, the effectiveness of the cathode grid in eliminating secondary emission. The cathode grid was first connected to the plate so that both of

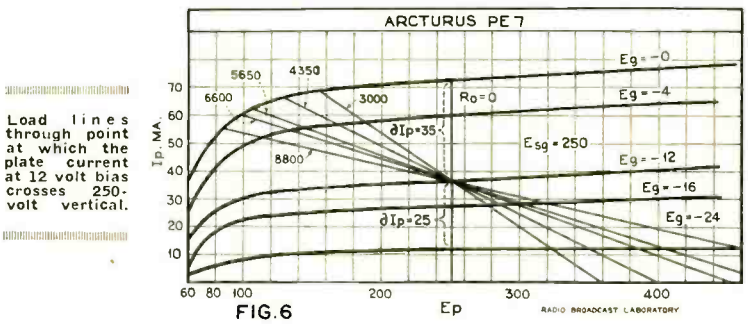

FIG.6

these elements had a positive potential of 260 volts. When so connected the tube consisted of a negatively charged control grid, a positively charged screen grid and a positively charged plate and cathode grid tied together. When so connected curve A was obtained. It indicates large values of secondary emission, the plate current going negative as much as 26 ma. The cathode grid was then disconnected from the plate and tied to the cathode of the tube. This connection gave curve B which is a normal pentode charactertistic. At low plate voltages it indicates some secondary emission but the plate current never goes negative as in curve A. Negatively charging the cathode grid should result in the more complete elimination of secondary emission. This was next tried, the cathode grid

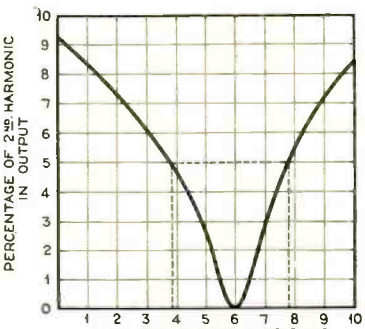

FIG.7

being biased negatively first at 45 volts and then at 90 volts. The two curves C and D were obtained. With a minus 45 volt bias (curve C) there are slight indications of secondary emission around a plate voltage of 25 volts. With a bias of 90 volts there is no sign of secondary emission, the I_p E_p curve for this condition being perfectly smooth. These curves show how effective the cathode grid is in decreasing secondary emission. It should also be noted that the cathode grid caused the secondary emission to occur at comparatively low values of plate potential where it has no serious effect on the operating characteristic of the tube.

It is interesting to compare the three curves, B, C, and D. It will be noted that the slope of the curve gradually increases as the bias on the cathode grid is increased. Increased slope means a lower R_p. Actually the R_p for curve B is about 40,000 ohms and the R_p for curve D is 20,000 ohms. Curve D also has a somewhat longer working range. It would seem therefore that the tube is improved somewhat by negatively biasing the grid. The practical disadvantages of doing this are obvious—it means that arrangements must be made in the set to get the necessary bias and also it means that the cathode grid must be brought out to a separate terminal. Inasmuch as these data were taken on an early experimental model, it is probable that further juggling the mesh and position of the various grids will eliminate all secondary emission, give a tube with a large output, at low power consumption.

To Determine Load Resistance

The pentode, then, is a high-resistance high-mu tube of mutual conductance of about 2000 micromhos. Since present-day power tubes are low-resistance low-mu tubes, worked into loads higher in resistance than the tube, it is interesting to speculate on what load the pentode grid tube should work into.

It is probable that the usual method of using the plate voltage-plate current family of curves to determine the proper load resistance can not be applied to the pentode. But until some other method is available, it may be useful. If it is desired to operate it with 250 volts on the plate and at 12 volts on the grid it is only necessary to draw a series of load lines through the point at which the I_p curve corresponding to 12-volt bias crosses the 250-volt vertical line. Thus in Fig. 6 are several such lines. It will be noted that the majority of them have long straight parts below the pivotal point, but shorter lengths above it. In other words, sufficient voltage applied to the grid to swing over the entire load line will produce an unsymmetrical plate current and distortion will occur.

If a line is drawn so that its lengths above and below the pivotal point are equal, which is the condition for distortionless amplification in the triode, it will be found that the load resistance required is considerably less than the resistance of the tube.

Here is a marked difference between the three-element power tube and the pentode. In the tubes of the type we now use the load resistance for greatest undistorted power output is about twice the tube plate resistance. In the pentode it may be ten times smaller than the plate resistance. Thus a 30,000-ohm tube will deliver the greatest undistorted power when worked into a load of from 2000 to 5000 ohms.

Because of the high resistance of the tube, the plate current is practically independent of plate voltage, and quite independent of the load that is usually put in its plate circuit. Whatever variations in plate current occur flow through the load and these variations across the resistance of the load produce the output.

In Fig. 6 are such curves on an experimental tube made by Arcturus. These load lines represent the working line over which the plate current varies under grid excitation. If the plate current on a positive half cycle of grid voltage increases exactly as much as it decreases on the negative half cycle there is no second harmonic distortion. In Fig. 6 the grid bias is —12. Hence the maximum grid peak voltage is 12 volts which will swing the grid from zero to —24.

With zero load resistance the plate current values are respectively 35 and 25 milliamperes. This will result in considerable second harmonic distortion. As the load is increased, the differentials of current become equal and for this particular tube minimum distortion is reached in the neighborhood of 6000 ohms. If 5 per cent second harmonic distortion is the criterion for distortionless power output, a range of 4000 to 8000 ohms in the load will produce it.

The differentials of current on the negative and positive grid voltage swings can be substituted in the following formula to calculate second harmonic distortion. The result is plotted in Fig. 7

$$\frac{\frac{I_{max} + I_{min} - I_o}{2}}{I_{max} - I_{min}} = \text{per cent second harmonics.}$$

It is interesting to note that second harmonic distortion in the output goes through a distinct minimum as the load resistance is varied. In a three-element tube the second harmonic becomes less and less as the load resistance is increased.

With zero load resistance the second harmonic distortion is high; with high values of load resistance both second and third harmonics become objectionable. At some value of load resistance, there is a minimum of second and third. Whether or not the minimum of third appears at the same load resistance which produces minimum second can be determined by measurement. Fortunately, it seems to be true that the ear objects less strenuously to thirds than to seconds.

Fig. 8 shows the result of measuring the power output from this experimental tube as the load resistance is increased. It will be seen that the power increases to a maximum and then becomes fixed in value. Probably at some higher value of load resistance the power will fall off when the proper impedance match is again destroyed.

Not only does the second harmonic content of the output increase as the load resistance is increased beyond a certain value but the voltages developed in the tube become much greater at high values of resistance. For example, Fig. 6 shows that with a load resistance of 8800 ohms a grid excitation sufficient to reduce the plate current to 13 milliamperes will develop a voltage of 460 volts. If still greater input voltages are applied, sufficient to reduce the plate current to zero, a voltage of 575 will be developed. Of course, such operation will result in severe distortion. Pentode tubes have been known to spark over from plate to cathode grid when a high load resistance is used with sufficient grid excitation.

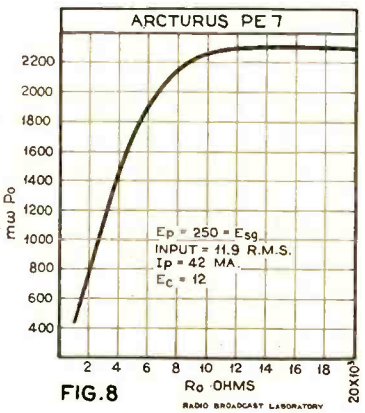

FIG.8

There was little benefit secured by increasing the load beyond 6000 ohms in the tube whose characteristics are given here. The minimum second harmonic distortion is present at about 6000 ohms, the power output does not increase beyond this point, and the maximum voltage developed in a full grid swing is only 400 volts.

Summary

The pentode tube, then, is a five-element tube designed for the power output stage. It will deliver more power with a given grid excitation and given consumption of plate power. It is a high-resistance tube but it gives best results when worked into a fairly low resistance so that existing loudspeakers can be utilized with it. The tube is more efficient from the standpoint of power output per volt input squared than any three-element tube. For example, three-element tubes have a power output in milliwatts per volt input squared of the order of 2.0 while the pentode made in the Arcturus laboratory, which served as the basis of this paper, has a factor of about 15.

The final tube will probably take from 30 to 50 milliamperes, will deliver from 2.0 to 4.0 watts, and therefore will require less from the rectifier than push-pull —45 tubes and may deliver more power output. Because it is roughly ten times as sensitive as a push-pull amplifier using low-mu tubes, the hum on its input originating from any source must be proportionately reduced.

The tube requires several leads through the stem; it has been estimated that the hazard in manufacture increases as the square of the number of the elements and trouble from gas directly as the weight of metal within the tube. Thus, it can be seen that the tube will be complicated to build in production and subject to high shrinkage; probably 30 per cent is a minimum figure.

The tube has been used as a detector in England, and curves on the present experimental tube show a remarkably sharp grid current-grid voltage curve. It is quite possible that the major application of the tube as developed in the future will be a true high power detector working directly into a loudspeaker. Thus, it can be most useful to automobile radios and other services where space is at a premium.

It is probable that the pentode tube will stand on its own feet sooner or later. Whether it will be economically possible or wise to bring out such tubes and to engineer receivers around them cannot be predicted now. The fact

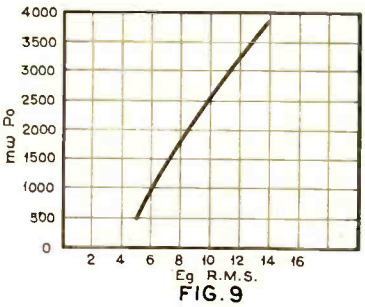

FIG.9

that it is difficult and expensive to make and that its production may change appreciably present-day receiver and power supply design may work against its appearance. The fact that a single tube will deliver as much as two —45's in push-pull and take less power from the power supply system is a point in its favor.

It is to be hoped that tube engineers will not forget that there are many thousand listeners, present and potential, who must operate their sets from batteries, and that a pentode tube which will be economical to maintain, efficient in operation, and deliver considerable power output at fair fidelity will perform a much greater service to

the listening public than a tube that merely delivers more power than the average listener wants on the same power consumption as present tubes.

DISCUSSION OF PAPER ON THE PENTODE TUBE

THE authors have described in an interesting fashion the underlying characteristics of the pentode or five-electrode power output tube. It should be understood that this configuration of grids adapts the tube for its function as a power amplifier and that there are other possible arrangements of three-grid tubes for other special purposes.

The power pentode has been in use in Europe for several years past and the reasons underlying the intensive developmental work in Europe on multi-electrode vacuum tubes might be mentioned briefly. The European conditions governing the design of radio receivers are vastly different from those encountered in the United States and the stimulus for the development of special purpose tubes has been greater there. The complexity of the power distribution systems of the European cities and the lack of any standardization of power line frequency or voltage has made it necessary for the manufacturer of radio receivers to confine his development to battery-operated receivers of as few tubes as possible in order to minimize the filament and plate battery drains. Another reason for the concerted effort on the part of the European manufacturer to reduce the number of tubes lies in the fact that royalties are assessed on the basis of the total number of tubes in the receiver. This will explain the apparent advance in Europe in the development of special purpose multi-electrode tubes, the retarded development in this country being an economic situation rather than a lack of engineering ability on the part of American tube laboratories.

The company with which the writer is connected has marketed for over a year a receiver (the Bosch model 52), utilizing the pentode in its output stage. This receiver is sold in foreign countries and incorporates two wavelength ranges. The pentode used is the British Mullard type P. M. 24 or its Dutch equivalent manufactured by the Phillips Company.

The problem of determining the optimum output load for the pentode has been briefly touched upon by the authors of this paper and it may be of interest to those familiar with conventional three-electrode circuits to explain briefly the reason for the apparent contradiction which the pentode seems to offer to the usual theory of output circuit design. It has been shown theoretically by W. J. Brown[1] and experimentally verified by Hanna, Sutherlin and Upp[2] that the optimum output resistance load for the triode power tube occurs when the output load is equal to twice the a-c. plate resistance of the tube measured at the operating point. If this theory were applied without qualification to the design of output circuits for the pentode, it would result in a set of operating conditions which would yield low power output, poor fidelity of reproduction and dangerously high peak voltages over the negative half cycle of the alternating-current grid swing. However, the general statement indicated above must be modified when dealing with tubes whose plate current versus plate voltage curves for various grid biases are not parallel throughout the operating range. A perfectly general statement which holds for any type of output tube including the pentode is that proposed and discussed by B. C. Brain[3] as follows: "To obtain the maximum power output from a thermionic amplifier the load resistance should be twice the value of the a-c. resistance of the amplifier *when the anode current is at its peak value.*" When the plate current versus plate voltage characteristics are examined with this statement in mind it will be found that although the a-c. resistance of the P. M. 24 pentode for example, is about fifty thousand ohms at its operating point, however, the a-c. resistance at the zero potential end of the grid swing is approximately five thousand ohms so that the optimum output resistance is found to be ten thousand ohms.

An interesting article on this general problem of designing the output circuit of the pentode can be found in the *Wireless World* (an English weekly periodical) for December 4, 1929, entitled, "The Pentode Under Working Conditions," contributed by the research department of the General Electric Company, Ltd., of England.

The problem of obtaining satisfactory fidelity and freedom from harmonic distortion in the output circuit is somewhat involved due to the fact that the satisfactory performance of the tube as regards these considerations demands that the output load resistance should be held within rather narrow limits and should not vary with frequency. In this connection, the impedance rise of the average American dynamic speaker would cause rather serious loss of fidelity unless corrective measures can be taken to prevent the change of impedance with frequency. Those who heard the demon-

TABLE I

Name	Ef	If	Rp	Gm μ mho	μ	High voltage grid Ep	High voltage grid Es	Ec	Ipma	PO milli-watts	High voltage grid current Is
Cossor 230	2	.3	20×10^3	2000	40	180	120	9	14	....	1.6
415	4	.15	20×10^3	2000	40	180	120	9	14	....	1.6
Marconi PT 240	2	.40	55×10^3	1650	90	150	150	9	16	500	6.0
PT 625	6	.25	.....	1850	..	250	200	15	26.5	2000	7.0
Mullard PM 24	4	.15	28.6×10^3	2300	65	150	150	12	12	500	3.0
PM 24A	4	.275	.....	1550	300	200	21	18	2000	5.0
PM 22	2	.3	62.5×10^3	1300	80	150	150	10	13	350	3.5
Six Sixty SS 230 pp	2	.3	64×10^3	1250	80	150	150	10	13	350	3.5
415	4	.15	27×10^3	2200	60	150	150	12	12	500	3.0
4 pen	4	.275	.....	1550	..	300	200	21	18	2000	5.0
Mazda 425	4	.25	.....	2000	..	150	150	12	18	750	5.0
Philips C443	4	.25	40×10^3	1500	60	300	200	15	28	....	....

TABLE II

Comparison of Present Power Tubes and the Pentode from Standpoint of Sensitivity, D-C. Power Input, and Efficiency.

Tube	Ec	Ep	Ip	Output Mw	Mw / E^2	DC power watts	Eff Pac / Pdc	Ir power
112A	9	135	7	120	2.9	0.945	12. %	1.25
171A	40	180	20	700	.47	3.6	19.5%	1.25
210	31	400	18	1325	2.73	7.2	18.4%	9.4
250	84	450	55	4050	1.12	24.7	16.3%	9.4
245	50	250	32	1600	1.27	8.0	20 %	3.75
PE 7	12	250	42	2200	30.5	10.5	21 %	3.75
150 Volt Pentodes.	10	150	12	500	10.0	1.8	28 %	0.6 to .8

$\frac{Mw}{E^2}$ = milliwatts output per volt input squared Eff = efficiency = power (a. c.) ÷ power (d. c.).

stration of the pentode tube which followed the presentation of the paper ("Demonstration of a Three Watt Pentode" by A. D. MacLeod and R. S. Briggs of the Champion Radio Works, Inc.) will recall that the higher frequencies were unduly emphasized. This was due to the fact that the moving coil impedance of the speaker was matched to the tube for the middle range of frequencies and the rise of impedance at the higher frequencies caused the development of high-voltage peaks and harmonics in that region of the musical scale.

The writers of the present paper have discussed the output distortion on the basis of second harmonic distortion. The pentode unlike the triode power tube when overloaded gives rise to the production of third harmonic distortion and the limiting condition of distortion in this case is the third harmonic which has to be reduced to 5 per cent to become unobjectionable.[4]

The introduction of auxiliary grids in radio tubes raises the important question of nomenclature. The present writers have called the grid which lies between the control grid and the zero potential grid, a space charge grid. This term has been reserved in the past for an electrode usually interposed between the cathode and the control grid functioning to dispel the electron cloud near the surface of the cathode.

It is suggested that the vacuum tube committees of the various national bodies interested in standardization might devote some thought to the problem of properly naming these auxiliary grids so that confusion will not arise in the future.

References

(1) W. J. Brown—"Symposium on Loudspeaker"—*Proceedings London Physical Society*, April, 1924.

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(3) B. C. Brain—"Output Characteristics of Thermionic Amplifiers"—*Experimental Wireless and The Wireless Engineer*, March, 1929.

(4) "Valve Data"—*Wireless World*, December 4, 1929.

BENEDICT V. K. FRENCH,
American Bosch Magneto Corp., Springfield, Mass.

DISCUSSION OF PAPER ON THE PENTODE TUBE

ALTHOUGH the normally overworked full-wave type of rectifier tube used at present in a-c. operated receivers would gain a much needed respite by the adoption of a tube, such as the pentode discussed by the above authors, which draws only fifty to sixty mils plate current, there are a number of other considerations which would cause the engineer contemplating a new set design to moderate his enthusiasm concerning it.

The tube contemplated by our larger American manufacturers, it appears, is to have a mu of about 100, a plate impedance of 30 to 40 thousand ohms, around four watts undistorted output, and will draw 50 to 60 mils at about 300 volts on the plate. The first question that arises is whether such an output is needed. In the normal case the answer is definitely, no, as hinted by the above authors. In most medium-sized rooms such an output level would be decidedly uncomfortable.

Whereas it is comparatively easy to filter out any a-c. hum introduced into the plate or grid supply voltages when a push-pull output stage is employed, the problem is greatly complicated when only a single tube is used. Since the effective mu of the pentode, loaded so as to secure maximum undistorted output, is only about 20, the filtering of the grid biasing voltage is no more difficult than in the normal a-f. amplifier, as the gain is about the same.

The design of an output transformer to operate from 6000 ohms into any of the popular types of speaker, which will give good frequency characteristics while a 50 mil current is passing, unbalanced, through the primary, is not such a simple matter. It will necessarily be more bulky and expensive than an output transformer performing a similar function in a push-pull output circuit.

A pentode having the above-mentioned characteristics will have nearly the same plate dissipation as two —45's. It should therefore be a larger tube. Production economy would probably demand that it be put in a —50 type bulb. The elements are large, the structure complicated, degassing important and tedious. The tube will probably cost more than two —45's, and possibly as much as two —45's and a —27 which combination would do the same job. Since the performance and tube cost of these two combinations are comparable and the added expense of the filter and output transformer for the pentode would more than make up for the interstage transformer required by the combination of the three usual tubes, it seems that the chief remaining advantage of the pentode is its sales appeal as a novelty.

Some advantages could doubtless be obtained by the use of pentodes in push-pull in the output circuit, but the undistorted output would be too great for use in any place but halls and auditoriums. It would seem to the writer that a much more practical way of utilizing this undenied improvement over the two-grid tube would be in the direction of lower powers. An enlargement on the suggestion contained in the last paragraph of "The Pentode Tube" might not be out of order.

Push-pull operation offers the same advantages in the case of pentodes as in that of triodes. A balanced circuit may be used to largely eliminate even harmonics. If then the output load is so chosen and the tube so operated as to produce a minimum of the uneven harmonics, and the evens are balanced out by the use of push-pull, a highly economical use of the tubes would result. A considerably smaller tube could be used, so that the combined output would be about that of a single —45, which is really sufficient for the normal uses. This tube could operate on 200 volts or less, would take no more filament or plate current than a —71-A and would work directly from the detector. Such an arrangement would make for very high quality audio amplification, great filter and output transformer economy, and more reasonable tube and power cost.

A glance at foreign practice along this line may be worth while. The attached data show a tube, operating with the three grids as space charge, control and screen, respectively, whose characteristics, if used in such a circuit as that just mentioned, would make it the ideal output tube for low power, battery-operated sets. Due to the low plate voltages applied secondary emission is very small and the cathode grid is not required. This tube would immensely simplify the problem of supplying the farmer and his auto with a really good radio set. This tube's characteristics include a filament consumption lower than that of the —99, an output of the order of that of a —12-A, and a gain as great as that of the conventional resistance coupled amplifier, all on a single 45-volt B battery! Perhaps it might pay American manufacturers not to be too hasty about deciding on the type of pentode which is really needed.

J. KELLY JOHNSON.

DISCUSSION OF PAPER ON THE PENTODE TUBE

THE following features of the "Pentode" described in Mr. Henney's paper attract attention:

First: the tube draws forty milliamperes (at 250 volts) and gives enough power to eliminate the necessity of push-pull arrangements.

Second: the pentode needs a load which is more uniform throughout the audio range than the present dynamic speaker. Fig. 1 shows the impedance curve of a popular dynamic speaker vs. frequency. Mr. Henney's statement that present dynamic speakers will work well with the pentode seems to be a little optimistic. The low-frequency peak may cause considerable trouble if left as it is, introducing undesirable harmonics and also raising instantaneous voltages above desirable values. This peak can be easily taken down by reducing the primary inductance of the output transformer. However, this will result in lowering the low-frequency response of the speaker. Then, in order to satisfy tube requirements and also low-frequency response requirements, we must have loudspeakers with exaggerated low-frequencies and

(*Concluded on page* 44)

Immortalizing Air Waves

The Rejuvenation of Radio Programs in Recorded Form to the End That Business Be Served and Art Preserved

By Austin C. Lescarboura
Mem. I.R.E. Mem. A.I.E.E.

RADIO engineers work in huge research laboratories. Millions of dollars are invested in machinery, in radio stations. The radio industry is the sixth largest in the United States. Its long arms of radio stations are located here and there throughout the country, and its many fingers of receivers are in every home.

To what end? That radio programs may be broadcast to the multitude.

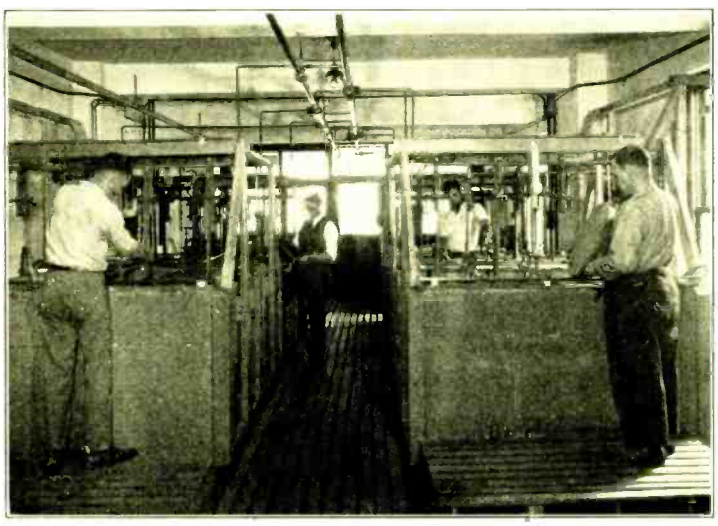

Fig. 1. Section of Galvano Department

And then what? Vanish into thin air. Where are the thousands of programs broadcast yesterday to about 50,000,000 people at a cost of hundreds of thousands of dollars? Only on the lifeless program charts, timetables and the newspaper program sections. Radio broadcasting is built upon the shifting sands of transient programs that bow themselves into eternity almost before the last chords die away and the call letters are announced. Why, even the first half of the program is dead before the second half is born. The radio program is "as a moth that comes upon a flood of light, and eddies in the sunshine, and is gone."

It is to make less etherial this condition of radio broadcasting that the recorded program has come into vogue. Recorded programs may be said to have originated in 1928. Of course, the earliest broadcasting made use of phonograph records, but only because nothing better existed. With the rise of direct broadcasts the recorded form died a natural death. In the meantime, however, radio technique was being infused into the phonograph industry. Whereas in pre-radio days the artist performed before a horn, the actual vibrations of his voice, or of an instrument cutting the wax, the new method used the microphone, the electrical pickup and the vacuum tube amplifier. Mechanical recording was limited as to range, both the high and low frequencies being lost. But the application of radio technique placed the phonograph industry on a par with radio.

Enter Big Business

But how, one may ask, was this improved phonograph industry to become linked to radio? Through the efficiency of American Big Business. As the sponsored program grew in favor, competition for a place in the broadcast sun grew more strenuous. Sponsors vied with each other, each trying to procure the finest program, hiring the best directors, composers, continuity writers, actors, singers and instrumentalists. In addition to forcing dials to be turned to stations from which they broadcast, sponsors sought a monopoly of the air by increasing their networks so that the listener could hardly keep from hearing a particular sponsor's program. They resorted to tricks and special programs, such as the Dodge Victory Six program which cost a reputed $25,000 for talent alone. The fight was on to get the radio audience's ear, not only get it but hold it, for an entire performance, for an entire series of performances.

And that costs money. It would be foolish to develop a fine and costly program to be sent out by only one local station. A network was necessary to extract the last ounce of good-will from such a fine performance. On the other hand, it was equally senseless to rent an entire network for the presentation of an inferior program. So fine and costly programs combined with fine and costly networks that the sponsor might gain for his product or service the good-will of the nation.

Fortunately for the radio industry the trend of American business was away from the small independent to the large corporate bodies. And likewise, the possibilities of radio advertising aided in the consolidation of such concerns. In this manner the sponsored program grew.

Came the day in 1928 when some executive, more efficient-minded than his brothers, on looking over the month's costs of radio advertising, sought the programs for which so much had been paid. They were not to be found. The continuities were there. The musical selections were there. The names of the performers were there. But it was all so cold and wasteful. The Texas sales manager had just written in to the effect that he saw no reason why he should not have the benefit of radio programs in his territory. The executive was about to answer that the network over which the company broadcast did not include Texas. The Boston sales manager wrote that sales were not pulling so well in New England, especially in Vermont and New Hampshire. A request had come in from Florida to have week-before-last's program repeated. The executive felt very helpless. The program could not be recalled. The executive wondered. Why the week-before-last's? Why not last week's program? Then he remembered. Last week the announcer made the mistake of announcing the program as sponsored by the American Concrete Company instead of Cement Company. That was a bad break. Must be avoided in the future. But how? And so the thought of the recorded program.

Return of the Disc

If the radio programs had been recorded, discs might be sent to Texas for spot broadcasting at local stations.

Other discs of the same program might be sent to New England, and the desired program repeated in Florida. Selected stations might be used, just where they would do the most good. The fine programs sponsored by the firm over the network could not be repeated over individual stations. And programs originating in Texas stations could not compare in quality to the fine network programs. Moreover, the recorded programs could be edited. Announcement mistakes could be caught before being heard by 10,000,000 listeners. The performance could be repeated several times, and the best one made into the final discs. Seldom were all the selections perfectly played. They could take the first rendition of the second selection, and the second performance of the first. The finest of each. The executive investigated.

Let us too investigate. We find that station WTMJ of the Milwaukee Journal has installed new Western Electric turntables for both the 78 and 33⅓ r.p.m. discs. Many others have done likewise. WTMJ and others have investigated the rumor that listeners dislike recorded programs. The rumors have been found baseless.

How about the methods of recording? We went recently to a representative firm, Sound Studios of New York, Inc. There was found that at the hands of Gustave Haenschen and Frank Black, the programs were prepared, scores specially written, musicians rehearsed, and the performance put in shape. Then it was taken to the recording room. This room resembled a broadcasting studio in appearance. The walls and ceiling were made of sound-proof material. The floor was laid with linoleum. Draperies covered the walls to absorb any sound that might cause the least echo. Through a glass panel in the wall beside the piano one might see the mixing room, where the volumes of the various microphones used in the recording could be adjusted to receive the proper volumes. The microphones themselves were of the latest condenser type. The room was kept at a constant temperature. An increase in temperature caused an expansion of the air, and a consequent distortion of sound. It also caused expansion of the microphone and a change of its characteristics, as well as those of the musical instruments. Any cooling of the air would also have a deleterious effect.

Electrical Pickup

In an adjoining room was the Western Electric turntable, a duplicate of those used in the broadcasting stations from which the discs would be played. The electrical pickup was also the same as those in the stations. This particular recording was to be made on one of the huge 16-inch discs, revolving at 33⅓ r.p.m. and playing for 14½ minutes. The turntable is motivated by a synchronous motor adjusted to the frequency of the generator in the power house which supplies the current. Line voltage fluctuations do not affect its speed. There are no springs to lose their elasticity. The speed of the turntable is kept absolutely constant. The wax is placed on the turntable. It is 16 inches in diameter and about an inch and a half thick.

We return to the studio. The director of the program; he happens to be Mr. Frank Black, informs us that although recorded broadcast programs use technique similar to that of phonograph recordings, the machinery must be much finer, more sensitive. And in comparison to direct broadcast performances, there is all the difference in the world. In direct broadcasts, the sound waves are transformed into electrical counterparts, then back into sound at the loudspeaker end. But in recorded work, the sound, after being turned into electrical current, is indented on the wax, a mechanical element lacking in the direct programs. And although the microphone picks up the sound values the same for recording as for broadcasting, the wax does not. One example of the changes necessary for recording is in the seating arrangement of the performers. In recorded work the violins are placed nearer the microphone than in broadcasting.

But our conversation with Maestro Black was cut short as the recording commenced. When the soloist sang into the microphone placed there for his use, the mixer in the control room lowered the volume of the "mike" before the orchestra, that the singer's voice might stand out above the orchestra even though in the studio the singer could not be heard above the instrumentalists. Altogether, four microphones were used. Meanwhile the needle, electrically actuated, cut the wax.

The Galvano Bath

The performance over, the wax was immediately taken to the galvano baths on the floor below. The sooner the wax is placed in the bath, the better, so eliminating any chance of changing the minute lines carved thereon. Suspended on a long rod the wax swishes back and forth through the bath for 24 hours, the effect of which is to coat the recorded side of the wax with copper. The man to the left in Fig. 1 is holding one of the levers at the lower end of which is the wax. The man to the right is inspecting one of the copper-plated waxes. In the background, the head of the galvano department is inspecting a "master" recently taken from a wax. The copper plate or "master" is then taken from the wax, and the wax shaved for future use. Whereas the lines were indented in the wax, they are raised on the copper "master" which was made from the wax. The final discs might be pressed from the "master" but such is not the usual procedure, especially if a large number of discs are to be made. For if in the pressing the "master" should be spoiled, no impression would remain, the wax having been shaved, and the entire performance would have to be repeated, at great cost. For the sake of safety, a "mother" is made from the "master." But being made from the "master," whose lines are raised above the surface of the disc, the "mother" grooves are indented in the surface, as were those of the wax, and as will be those of the final discs. Therefore, it is impossible to press the final discs from the "mother" and a stamper is made, its lines being raised. The "master" is filed for emergency use and for future orders for the same selections, while the discs are pressed from the stamper.

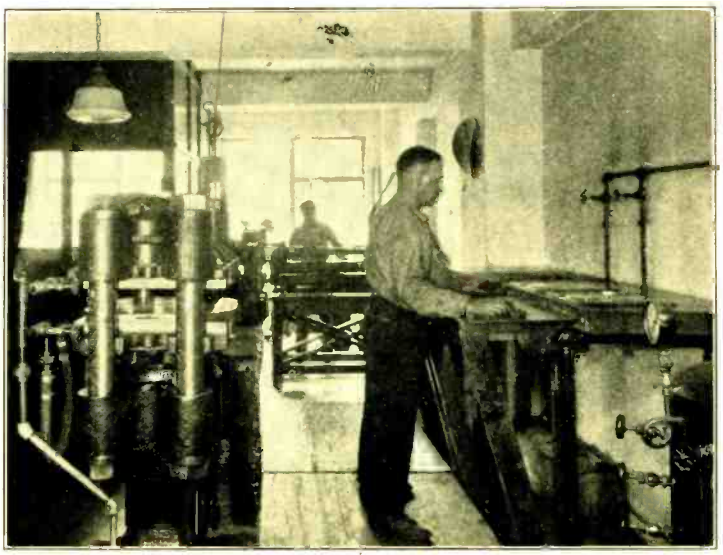

Fig. 2. Test-Record Pressing

The photograph shows the earth and shellac material from which the final discs are made, being heated under the supervision of a presser, while to the left is the pressing machine. When the material is in a pliable state, a consistency similar to that of dough, it is placed in the press together with the die, and under enormous pressure and heat, is pressed.

The test record is played before the director, the technicians of Sound Studios of New York, the sponsor's representatives, and other interested parties. When it is okayed, other discs are pressed to be sent to the radio stations for broadcasting.

So far we have spoken of recording as it is done in one of the finest establishments. It would appear that with such discs, recorded broadcast programs would be more widely used than they are. Why is not the direct broadcast put into the discard?

Too Many Broadcasters

When broadcasting first took hold

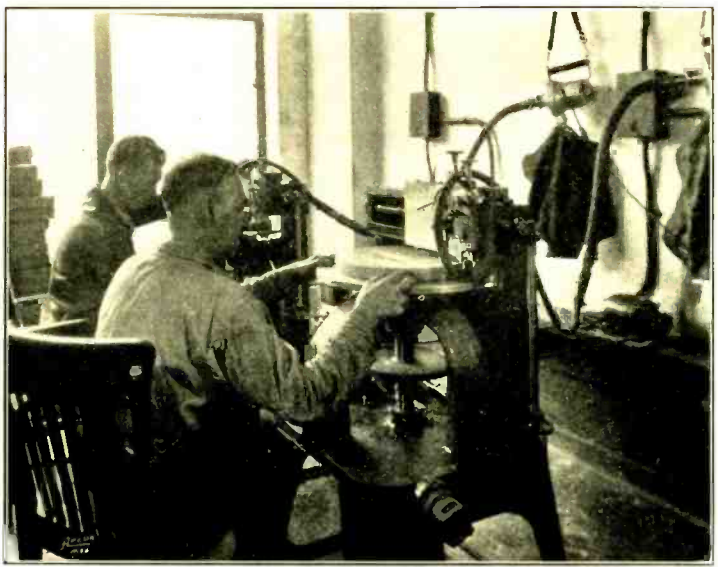

Fig. 3. Shaving Wax Master Records

about ten years ago, many individuals and firms rushed into radio, knowing nothing about the problems to be met, over-enthusiastically believing that fortunes were to be made by anyone who desired to broadcast. By 1924, 1400 stations were on the air, interfering with each other, carrying the fine stations to ruin and almost disrupting the institution of broadcasting before it got under way. The public, little realizing that the fault lay not with broadcasting, but with individual broadcasters, came to look upon the entire broadcasting situation with disfavor. Only stringent measures of the government brought order out of chaos.

The same situation now prevails with regard to recorded broadcast programs. Hundreds of firms have set up shop with inferior equipment, and personnel untrained in the methods of recording. Unfortunately, no legislation drives them to cover. Working with unlicensed machinery, they can quote lower prices than the better organized concerns. And sponsors, ignorant of the pitfalls of poor recording, are lured by low prices and rash promises to entrust their material to firms inadequately prepared to handle it. Many sponsors are unaware of the fact that the finest developments of recording have been accomplished in the past year. Machinery dating back three and four years cannot produce the finest results possible. Many of these fly-by-night recording companies do nothing more than record cheap orchestras playing ordinary dance selections. No thought is given to the fact that because the recorded program is to be sponsored by a commercial concern, the music should be specially scored to suit the quality of the sponsored product and the audience the sponsor wished to reach. Both the material and the recording is bad, very bad. Stations consent to play the material, and lose their prestige for broadcasting fine programs. They become enemies to the recorded broadcasts. The sponsor loses good-will and also becomes an enemy.

Unfortunately, the public's opinion of recorded programs has been gained for the most part from hearing the inferior kind. When people have heard enough of the finest recordings made possible by the developments of the past year on the part of the large electrical companies working in conjunction with talking motion pictures, the radio world will come to look with favor upon recorded broadcast programs.

Sound Studios of New York is waging a campaign against the upstart, unlicensed, poorly equipped and manned recording companies, whose only virtues are low prices, predicated on equally low quality of work, and rash promises which are incapable of fulfillment. Sponsors must be made to realize that the many advantages of recorded broadcasts, the ability to choose stations individually, to repeat programs, to have a number of broadcasts in various sections of the country at only one talent cost, to address the entire nation at the same hour despite the three-hour time difference between the east and the west coasts, to broadcast the finest programs from stations far removed from entertainment centers without the use of networks—all these and many other advantages count for naught unless the program is of the finest quality, and the recording, absolutely faithful. A sponsor contemplating the use of recorded programs should beware of rash promises and false statements, such as that all station time must be contracted through the recording company or that the recording company has a monopoly on the use of 33⅓ turntables in various stations. The sponsor and his agency should demand equipment and operators, expert technicians, electricians, sound and acoustic experts, galvano men, pressers, etc.

Supplements Work of Networks

Now that Western Electric equipment is being installed in many stations throughout the country and the finest recording companies are being licensed by this organization, sponsors will be able more easily to recognize the legitimate from the illegitimate recording company.

It has been thought that the recorded program will threaten the existence of the networks. But such is not the case. Quoting Mr. A. J. Kendrick, president of Sound Studios of New York, and well-known authority on the subject, "Recorded programs are not a substitute for network broadcasting. It supplements the network. We do not seek to dissuade sponsors from the use of networks. On the other hand, we ourselves prepare such programs. But we do believe that the beautiful network programs may have a fuller life and be used to their utmost in good-will value if they are recorded for spot broadcasting from independent stations after their original network presentation.

"Recorded programs do not have to usurp the place of the networks," continued Mr. Kendrick. "They can stand on their own value to the sponsor, in making the great facilities of the nation's broadcasting stations doubly valuable to him."

The recorded broadcast program is here to stay. With the realization of the quality possible by the finest methods of recording the illegitimate concerns will be driven from the field. The independent radio stations, which have been losing popularity in the face of the network, will be able to give their listeners the finest programs of

(*Concluded on page* 44)

Now—A Dry-Cell Screen-Grid Tube

Application of Screen-Grid Tubes to Rural and Small Portable Receivers

*By Allen B. DuMont**

THE unwired rural home has been grievously neglected in Radio's steady march towards perfection. With a view to providing a truly modern set of dry-cell tubes for rural and portable receivers of advanced design, an improved —99 type tube has been perfected. To complete this set there has been developed a dry-cell —22 type tube—the 422-A deForest Audion. This tube incorporates the same filament developed for use in the —99 and —20 type audions, namely, an oxide-coated filament employing a special composition base metal. By the use of this filament, as previously mentioned, the tube draws only 60 milliamperes of current. Still, the filament diameter is three times as great as the usual —99 type tube.

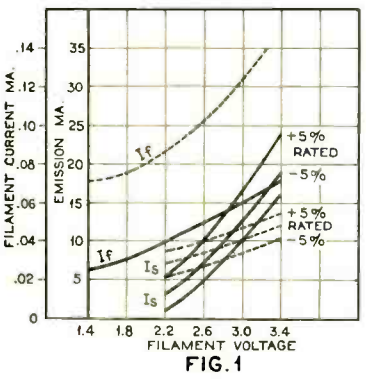

FIG. 1

Emission and filament current.

Employing the new filament, the —99, —20, and now the —22-A type tubes enjoy an exceedingly long life, are non-microphonic, do not become brittle while operating, and have approximately 25 per cent greater output than previous types.

The coating of active material in the thoriated-tungsten filament, as universally employed, is formed while the tube is operating, and not in the process of manufacture. As a result of this, any over-voltage will destroy the active coating, with the consequent loss of the tube's emission, the tube behaving erratically during its very short life.

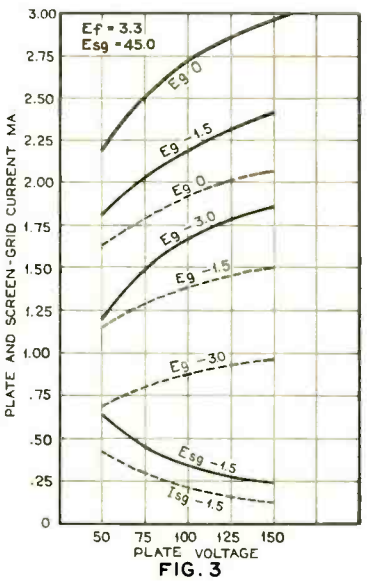

FIG. 3

Plate and screen-grid current at 45 volts.

The new deForest dry-cell tubes are prototypes of the conventional brands as regards characteristics. Consequently, they may be substituted in existing sets. In this connection their output will equal, and possibly exceed, that of the standard types. However, in special circuits designed to take advantage of advanced features, the new tubes will give approximately 25 to 30 per cent greater output at the same voltages.

In a series of comparative tests the accompanying set of curves was obtained. In such case the dotted-line curves represent the present conventional —22 type tube, while the straight-line curves represent the 422-A deForest Audion.

In Fig. 1 the curves show the emission and filament current at various filament voltages as compared to the present thoriated-tungsten type —22 which requires 132 milliamperes filament current.

Fig. 2 shows the plate and screen-grid current at various plate voltages with 22½ volts applied to the screen-grid.

Fig. 3 represents the same test with 45 volts applied to the screen grid.

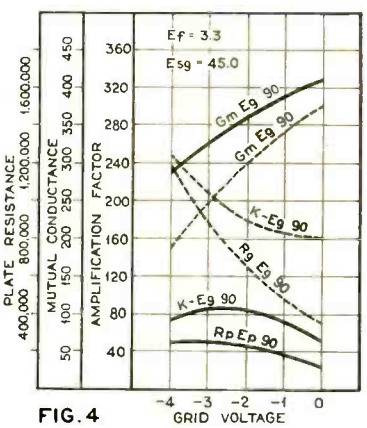

FIG. 4

Amplification constant, plate resistance and mutual conductance.

Fig. 4 gives the amplification constant, plate resistance and mutual conductance with 45 volts applied to the screen-grid and 90 volts on the plate.

In Fig. 5 the same characteristics are shown but at various plate voltages. Note the lowered plate impedance of the new 422-A in contrast to that of the thoriated-tungsten type —22. With the rated voltage, i. e. 3.3 volts on the filament, 45 volts on the screen-grid, minus 1½ volts on the control grid, and plus 135 volts on the plate, the plate impedance is about 200,000 ohms. With a circuit designed to take advantage of this feature, much greater gain may be obtained than is possible

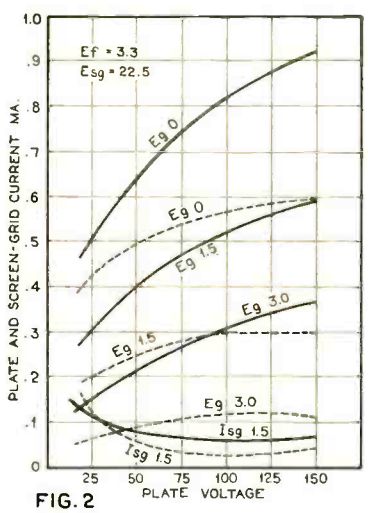

FIG. 2

Plate and screen-grid current, at 22½ volts.

* *Chief Engineer, DeForest Radio Company.*

with a plate impedance of 750,000 ohms, as in the thoriated-tungsten type —22. The graph also demonstrates that the mutual conductance of the new tube is approximately 30 per cent higher than the old.

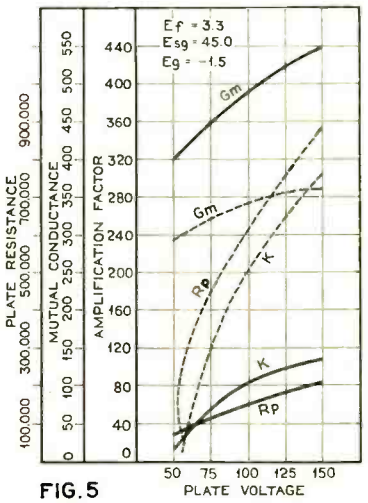

FIG. 5

Amplification constant, plate resistance and mutual conductance at various plate voltages.

The following chart of typical battery-operated receivers shows what can be done with an absolute minimum of current consumption:

Typical Short-Wave Receiver

De Forest Audions Stage	Type	Fil. Current	*Tubes Previously Obtainable* Type	Fil. Current
1st. R-F.	422-A	.06	—22	.132
Det. (Regen)	499	.06	—99	.060
1st. Audio	499	.06	—99	.060
Output	420-A	.06	—20	.132
		.240		.384
	Watts..	.792	Watts..	1.27

Typical Broadcast Receiver

De Forest Audions Stage	Type	Fil. Current	*Tubes Previously Obtainable* Type	Fil. Current
1st. R-F.	422-A	—06	-22	.132
2nd. R-F.	422-A	—06	-22	.132
Det.	499	—06	-99	.060
1st. Audio	499	—06	-99	.060
Output	420-A	—06	-20	.132
		.300		.516
	Watts..	.9	Watts..	1.69

Typical Broadcast Receiver (Power)

De Forest Audions Stage	Type	Fil. Current	*Tubes Previously Available* Type	Fil. Current
1st. R-F.	422-A	.06	—22	.132
2nd. R-F.	422-A	.06	—22	.132
Det.	422-A	.06	—22	.132
1st. Audio	499	.06	—99	.060
Output (push-pull)	2-420-A	.120	2—20	.264
		.360		.720
	Watts..	1.19	Watts..	2.38

UNTUNED R-F. AMPLIFICATION RETURNS

There are two methods of radio-frequency amplification, namely, *tuned* r-f., as featured in most of the present-day broadcast sets, and *untuned* r-f., as featured in the sets of some half-dozen years ago. Because of the modest gain with untuned r-f. stages, together with the uneven amplification throughout the broadcast frequency band, the untuned r-f. method has lost its appeal, even though it makes for the simplest form of receiver. Indeed, only one tuning circuit is required, for the first tube, since the other tubes are in untuned circuits. No elaborate gang condensers and group controls are needed.

The introduction of screen-grid or four-element tubes, together with recent research on r-f. transformers, states J. E. Smith, President of the National Radio Institute, may bring back the untuned r-f. method stronger than ever before. There are transformers now available, with special iron lamination as thin as a sheet of paper, which amplify uniformly over the entire broadcast frequency band. With screen-grid tubes, a gain of better than half that obtained with tuned screen-grid stages, is claimed. This is sufficient, in view of the simplicity of the receiver. We may, according to Mr. Smith, see a marked change in radio receiving sets, due to practical untuned r-f. amplification.

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U. S. SUPREME COURT ASKED TO PASS UPON VALIDITY OF FEDERAL RADIO ACT

The United States Supreme Court, in Washington, D. C., was asked on January 16 by the Seventh Circuit Court of Appeals, in a case from Chicago, to pass on the constitutionality of the Federal radio act. Using a case brought by Clinton R. White, operating Station WCRW at Chicago, as the basis for its inquiry, the Circuit Court asked the Supreme Court to decide whether a person who operated a radio station prior to the enactment of the radio act of 1927 had the right to continue to operate with the power that was being used. It also asked determination of whether the provisions of the Federal radio act, in requiring applicants for licenses to waive rights as to wavelength, and to the use of the air for broadcasting purposes, were constitutional. The Circuit Court said, it was asserted by White, that the Federal Radio Commission in insisting upon these waivers as required by the law, was taking private property for public use without just compensation and was depriving persons of property without due process of law. White also contended the radio act was invalid because it did not require the Commission to state its reasons for refusing to renew licenses.

▲

RADIO MUSEUM FOR THE SMITHSONIAN

Historic radio apparatus will be preserved in a radio museum to be established at the Smithsonian Institute in Washington, D. C. A world-wide search has been begun for transmitters, receivers and other equipment under the direction of C. W. Mitman, Curator of Mechanical Technology of Smithsonian. Immediate action is necessary, Dr. Mitman says, if material of value but unsuited for modern use is to be obtained. A search will have to be made in foreign countries, particularly England, as radio had its inception in that country, and much of the original material is still there.

Adaptation of Screen-Grid Sets to Use of the Pentode

*By F. S. Huddy**

THE changes necessary to make possible the use of the CeCo a-c. pentode in sets designed to operate with type 224 tubes are neither difficult nor expensive.

Tests have shown that although the optimum plate voltage for the pentode is 250 and the optimum screen voltage is 135, it will work satisfactorily with 180 volts on the plate and 75 on the screen. The last named voltages are those most commonly found in present-day sets, and, in general, it is not advisable to attempt to change them. Where 245's are used in the last audio stage it is a simple matter to connect the plate returns from the pentodes to the 250 volt tap on the voltage divider. All the pentodes in a set will operate at the same plate and screen voltages.

The outstanding difference in construction between the pentode and the 224 is the presence of a space charge grid in the former. Hence the first consideration in changing a set is the provision of a potential of 13.5 volts positive for application to the space charge grid. This may be done in two ways. The simpler is to provide a battery of nine small dry cells connected from the space charge grid terminal on the side of the base to the cathode terminal on the socket. The other way is to connect the space charge terminal through a resistance of 8200 ohms to the 75-volt screen-grid tap on the voltage divider or 16,500 ohms to the 135-volt tap. Where it is possible to secure an extra tap on the voltage divider the space charge terminal may be connected to a tap giving a voltage equal to 13.5 plus the grid bias which is usually one and one-half volts. In any one of these connections, the space charge grid should be held at ground potential with respect to any radio-frequency voltages by the connection of a one-half mircrofarad condenser from its terminal on the base to the ground. When these connections have been properly made, a high resistance d-c. voltmeter will read 13.5 volts between the space charge connection and the cathode terminal. Voltages in excess of 13.5 will give somewhat improved results and very greatly foreshortened life, while voltages less than 13.5 will cause somewhat inferior reception.

The correct voltage to be applied to the control grid is one and one-half volts negative with respect to the cathode. This is most commonly done by inserting a resistor in series with the negative B return to the cathode. The plate current of the tube causes a voltage drop in the resistor and makes the grid which is connected to the terminal of the resistor nearest to the B supply negative with respect to the cathode.

The plate current of the pentode is somewhat higher than that of the 224, and for that reason the grid will be made too much negative because of a greater drop in the bias resistor. The current will be different if a separate battery is used to furnish space charge grid potential, and a different value of bias resistor is needed as shown below.

With Separate Battery

I_p 3.5
I_s .5

4.0 milliamperes

$$R = \frac{1.5 \text{ volts}}{.004 \text{ amps.}} = 375 \text{ ohms}$$

When Taken from Power Pack

I_p 3.5
I_s .5
$I_{s.c.}$ 7.5

11.5 milliamperes

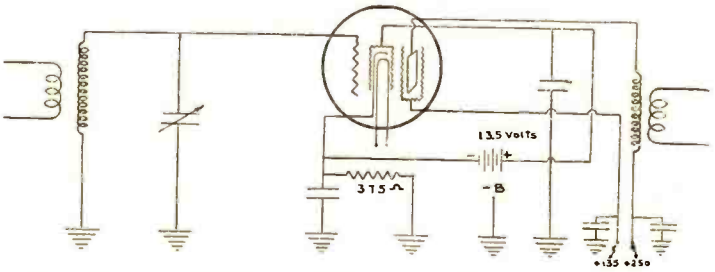
$$R = \frac{1.5 \text{ volts}}{.0115 \text{ amps.}} = 130 \text{ ohms}$$

Aside from the changes outlined above, no others are required to make possible the use of the pentode.

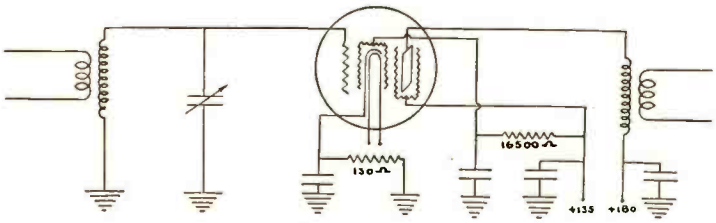
Owing to the fact that the inter-electrode capacities of the pentode are slightly higher than those of the 224, some small difference in tuning may be noticed, but if pentodes are used throughout the alignment of the set will not be disturbed.

In some sets using the 224 tubes, some means of neutralizing are employed. When the pentodes are substituted, it may be necessary to re-adjust the neutralizing condensers in order to prevent oscillation.

It may be found that when pentodes are used in a set previously adapted to 224's some oscillation will occur at advanced settings of the volume control. This is entirely natural since the tremendous amplification obtainable from the pentode requires that the set shielding be very complete, more so than usually found in sets using 224's. It will be found, however, that it will be unnecessary to advance the volume control to the point of oscillation since the greater sensitivity of the pentode will permit excellent reception at lower settings.



Connections of a-c. pentode used with separate battery for space charge grid



Connections of a-c. pentode providing space charge potential from power pack

* *Assistant to Chief Engineer, CeCo Mfg. Co.*

A New Radio Yardstick

Description of the New Government Frequency Standard Having an Accuracy Better Than One Part in a Million

By S. R. Winters

THE precision micrometer of radio—a yardstick of exacting measurements—has been installed in the Radio Laboratory of the Bureau of Standards. Designed and constructed by the Bell Telephone Laboratories this new reference index or ultimate frequency standard is virtually errorless in its functioning. Dr. J. H. Dellinger, the Nation's technical radio chief, who for many years has visualized a radio yardstick having an accuracy better than one part in a million, sees his ambition realized in the instrument about to be described.

Most of the design work on this standard was done by W. A. Marrison of the Bell Telephone Laboratories. The equipment is being adapted to the purposes of the Bureau of Standards by Dr. Charles G. McIlwraith of the Bureau's staff.

Three Crystal-Controlled Oscillators

More than one instrument, this reference radio-frequency standard is a series of instruments but each of the units operates with such perfect unison with the others as to defy division. For example, the three oscillating units, each governed by quartz crystals, are interchangeable and this shifting of units does not interefere with the harmonious working of the complete outfit. In fact, it is this interchangeable and intercomparison of the several crystal-controlled oscillators that give novelty to this frequency standard and insure a constancy and precision of accuracy not attainable in previously designed means of checking the frequencies of transmitters. For instance, any one of the 600 broadcasting stations or 16,000 amateur stations could consult this apparatus, in determining their operating frequencies, with the assured precision of better than one part in 1,000,000.

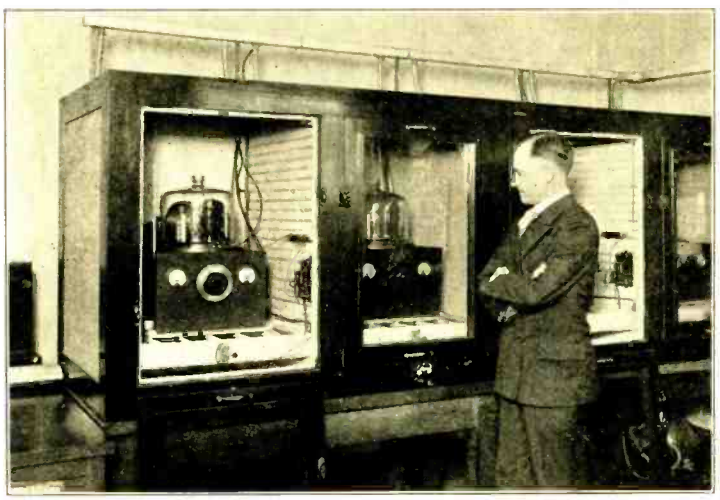
The room in the Radio Laboratory containing this precision micrometer of radio, figuratively, presents a bewildering spectacle of instruments—all contributing to this radio reference index. The four oscillating units are housed in cabiners and the temperatures in each are maintained at an unfailing constancy, because temperature variations would influence the plates of quartz crystal and thus errors would be introduced in the standard-frequency system. A clock is the visual means of momentarily checking the accuracy of the crystal-controlled oscillators. This clock is driven by a synchronous motor. Too, there are the usual array of electron tubes, transformers, current-indicating meters, generators, batteries, and thermometers for indicating the temperatures within the cabinets housing the crystal-governed oscillators.

The Visual Indicator

More about the clock as the visual indicator to the operating accuracy of this novel high precision standard of frequency: The accuracy of this timepiece is dependent upon the correct functioning of its governing radio frequency—that is, the 1,000-cycle synchronous motor is so geared to the clock that if the controlling frequency is at its precise desired value the timepiece will keep accurate time. For example, an error of 0.864 of a second in 24 hours in the clock is equivalent to an error in the radio frequency governing it of one part in 100,000. Distrustful of the eye as a visual means of checking the rate of the clock—to an accuracy of only one part in 400,000 during one day—the Bureau of Standards employs a mechanical and electrical observer. This procedure involves a comparison of the clock with radio time signals in which a pointer, operated by a cam driven by the 1,000-cycle synchronous motor, makes contact once each second—or, more precisely speaking, once for each 100,000 cycles of the primary oscillator. This contact actuates one component of a two-element recorder and time signals actuate the other element. Thus, comparisons may be made by measurements on a tape; this method guaranteeing greater accuracy than could be assured by the human eye.

Reference Oscillator

When the operating wavelengths of 600 broadcasting stations and 16,000 amateur stations are to be checked frequently and with an unerring precision—otherwise mutual interference is set up—the single standard of frequency is regarded as inadequate to the exacting requirements of our national and international radio yardstick. Therefore, the Bureau of Standards—the yardstick and thermometer of American industries—where the standard volt and other reference units are kept, has adopted the multiple-radio reference standard. Not only are three primary oscillators to act as the standard of the future but a fourth oscillator is used for automatic checking of the constancy of precision of the three primary oscillators. This fourth or ready reference oscillator operates at a frequency slightly different from that of the other three units—a variation of one cycle in ten seconds. The number of beats between the fourth oscillator and each of the other three similar units is recorded automatically during each 1,000-second interval. This



Dr. J. H. Dellinger, Bureau of Standards, observing crystal-controlled oscillators, to serve as national standard.

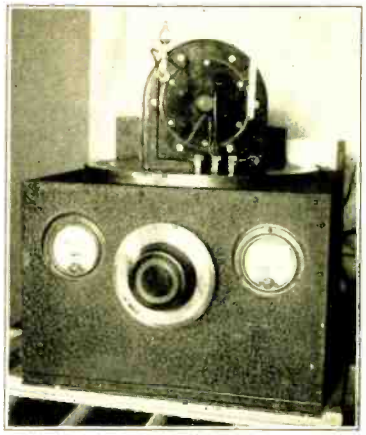
registration is about 100 beats during each interval. During the comparatively brief period of 1,000 seconds, each oscillator generates 100,000,000 radio waves—and the number recorded represents the number of parts in 100,000,000 by which the fourth oscillating unit differs in beat frequency from the three primary oscillators during the interval.

The heart of this three-in-one radio-frequency standard is the quartz crystal itself. This essential element has been selected and mounted with unusual regard for the constancy of its operation. That is to say, the quartz crystal is subject to such variable factors as temperature and pressure. To compensate for these variations, the Bureau of Standards' slabs of quartz crystal are kept in constant-temperature cabinets and the rings of mineral are mounted in special holders and in such a way as to permit the quartz crystal to vibrate freely.

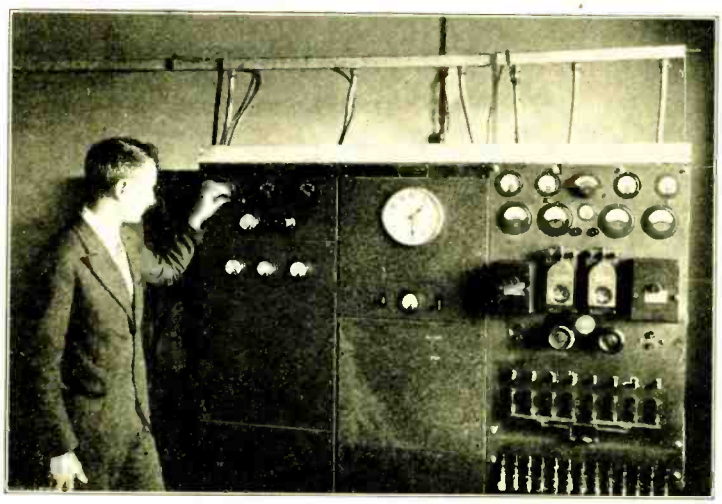
Other than being housed in cabinets, these rings of quartz crystal are further safeguarded from moisture and pressure variations by enclosing them within a bell jar, at a pressure slightly below atmospheric. Tests have indicated that for the slabs of mineral employed in this frequency-standard system the frequency varies one part in a million for 10 centimeters of mercury change in pressure. Therefore, it is desirable to maintain the pressure to a constancy of minus or plus one millimeter. A gauge within the bell jar indicates the pressure and this may be adjusted by a vacuum pump through a valve in the surface plate. The pressure in this bell jar is influenced slightly by the temperature and this factor, too, must be governed. To control this, a thermometer has been installed in the bell jar—thus making known the influence of temperature upon pressure and making corrections in the radio frequencies due to these variable factors. Frequency, we are told, varies with the pressure surrounding the crystal and corrections in frequency may be made by proper adjustment of the pressure.

Ring-Shaped Crystals Employed

Exhaustive tests by the Bell Telephone Laboratories with all manner of shapes of crystals indicated that the ring-shaped unit is least subject to temperature variations. Therefore, we find the new radio yardstick of the Bureau of Standards incorporating ring-like shapes of mineral as its governors. The variation of frequency with temperature for one of these ring-shaped crystals, it was found, is over such a restricted scale as to correspond to the ordinary room-temperature range. Speaking more scientifically and specifically, the three ring-like crystals when in reasonance with 100,000 cycles, have temperature coefficients of less than one part in a million for each degree of Centigrade temperature. This small range of temperature variations has been observable in all ring-like crystals tested. On the other hand, disk-like crystals, with the same outside dimensions as the 100,000-cycle rings, have temperature coefficients of 30 parts in a million for each degree of Centigrade temperature—or more than 30 times that of the ring-shaped crystal. Thus, it has been proved conclusively that the shape of a slab of quartz crystal has a direct relationship with the extent of its temperature variations—rings, in this respect, corresponding to low-loss condensers and other radio parts in which efficiency is conserved to the utmost.



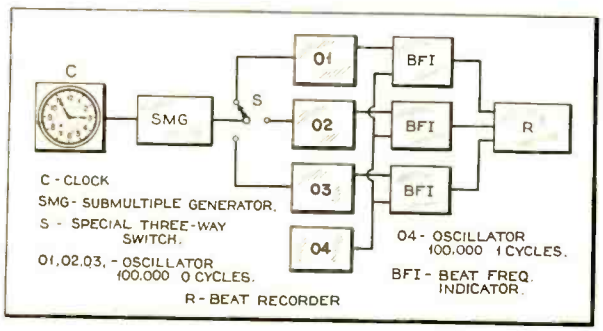
View of one oscillator unit—of the new radio "yardstick."



Dr. Charles G. McIlwraith, Bureau of Standards at indicator panels.

Crystal Holders

Not without obstacles, however, are ring-shaped crystals mounted. As a result, we find a specially designed holder for the rings of mineral that are to be consulted as our ultimate radio standard. For instance, the holder is built so that the spacing between the electrodes may be varied slightly. And, with the frequency changing with the electrode spacing, this variable factor in the crystal holder may be utilized in effecting slight adjustments of frequency. A thread on the adjustable plate is kept taut by a spring, thus avoiding the undesirable effect of spasmodic and irregular spacing between the electrodes. In mounting a ring of crystal, the hole is of such a shape that when the mineral is suspended on a hori-



Schematic layout of elements of standard oscillator.

zontal cylinder the point of contact is at the so-called nodal point for mechanical vibration. Slight vibration has been observed when the central plane of the crystal intersects the double conical hole, but the Bell Telephone Laboratories found that this vibratory effect is inconsequential compared with that noticed at the outer surface, where a crystal is ordinarily supported. The ring of crystal is maintained at a centrally-located position between the electrodes by paper spacers, placed on each side of the crystal. It, however, has freedom of movement laterally over a narrowly-defined area and this does not exercise an influence on the constancy of the radio frequency that it is to insure. As further assurance that the electrodes are accurately spaced a ring of pyrex glass is employed, thus counteracting any variation in frequency due to the electrode spacing.

Temperature Control

Just as all ships using crystal-controlled oscillators find it necessary to employ heating cabinets for the crystals, it is even more important that the nation's yardstick of radio be immune from variations that temperature changes would exert in the absence of a temperature-control chamber. The latter, in this instance, takes the form of a shell of aluminum, cylindrical in shape, with a wall one inch thick. This wall contains a heater and there is a temperature-responsive element in this wall to govern the rate of heating. This aluminum shell, with a snugness comparable to the terrapin's back is provided with a plug which screws into the open end, forming a chamber for the crystal, and when closure is effected there are no apertures except the tiny hole for electrical connections. Aluminum is an equitable conductor of heat and as such this shell is heated with such a uniformity of temperature as to render unnecessary the use of a fluid bath. While the temperature of this aluminum shell may rise or fall 0.02 of a degree Centigrade, this temperature fluctuation is not imparted to the crystal, since a piece of felt, half a centimeter thick, surrounds the crystal holder.

Automatic Counting Units

With human-like ingenuity, there is an automatic mechanical and electrical device for keeping tab on the number of frequency beats between the fourth oscillator and the other three oscillating units during 1,000-second intervals. This mechanism not only counts these relay operations for the specified time intervals of 1,000 seconds but it prints the total results and then returns to its zero position for a repetition of its ingenious procedure. Five of these counting units are available, and they print on a wide strip of paper similar to that used in adding machines. Three of these Robot-like counters are employed to keep tab on the beat frequencies, while the fourth unit records the average of these three numbers, computed automatically by an auxiliary instrument. The fifth counter records the time, either directly or by numbering the 1,000-second intervals consecutively. These human-like counting machines obtain their operating electric energy from a motor, which runs without ceasing. The elements comprising the automatic beat counters, somewhat like the operation of a telegraph printer, are operated at suitable times by clutches governed by electromagnets. The latter, in turn, are selected by relays in the modulator electric circuits. The counting, printing, and resetting functions are interlocked by cams and relays, thus insuring a faithful count, with no missing or duplicating of records.

Oscillator Circuit

The general circuit of the crystal-controlled oscillators in the new frequency standard offers no radical departure. There is the usual hook-up in which the electrodes of the quartz crystal are associated with the grid and ground elements. A tuned-plate circuit is employed. The Bell Telephone Laboratories selected this particular circuit because of the advantage of grounding one electrode. Moreover, we are told that in the choice of plate-tuning elements there are only minor variations in the factors of inductance and capacity and that these changes have no appreciable effect on the radio frequency desired. Thus, with the variations of temperature and pressure well within the bounds of control and with the tuning elements negligible in their influence upon the frequency there is little wonder that we have a radio yardstick that is well-nigh errorless in its measurements.

LIMITS TO SENSITIVITY AND SELECTIVENESS OF RADIO RECEIVERS

NO matter how many good qualities a radio receiver possesses, it cannot give satisfaction unless it is sufficiently sensitive and selective to meet the crowded condition of the ether which it must face. It may be capable of most perfect quality of reproduction; it may be easy to tune, and it may give plenty of volume, but, if it jumbles the programs of two stations together, its good qualities are useless. For this reason, selectivity, especially in congested areas, is of the utmost importance, says J. A. Dowie, Chief Instructor of the National Radio Institute, Washington, D. C.

There is a very definite limit, however, to the selectivity allowable in a receiving set used for the reception of voice or music, for in order to receive these, it is necessary to receive equally well, not merely a single wavelength or frequency, while listening to a given station, but a channel of frequencies about 10,000 cycles (10 kc.) wide. For example, suppose we wish to listen to a broadcasting station whose frequency is 950 kc. A receiving set that is so selective as to receive only this frequency would not be able to pick up voice or music from that station. The receiving set should, therefore, be made so as to receive equally well, and all at once, all frequencies from about 945 to 955 kc. while listening to the 950 kc. station. Furthermore, if the selectivity of the receiving set is to be the best possible, all frequencies below 945 kc. and all above 955 kc. should, at the same time, be completely rejected.

In other words, the ideal receiving set should be like a slit or a door that opens only wide enough to let in the desired music and speech. (In order to carry out this simile, we may say that good quality music is about 10 kc. wide, while 4 kc. is as wide a range as speech needs to be to be satisfactorily natural and understandable.) If the door is not opened wide enough, the sidebands will be pinched and the quality of the received voice or music will suffer. On the other hand, if the door is opened wider than necessary, there is just so much more room for static and other interfering outside noises to get in the receiving set.

No End of Purchasers

Anyone who is in doubt as to whether or not the demand for radio receivers and parts has lessened should make a trip to radio row in the vicinity of Cortlandt Street, New York, any time of the day, any day of the week. Believe it or not, the streets thereabouts are blocked with potential purchasers inquiring for the latest and the best.

Radio Noise Detection and Elimination

Combating Inductive Interference Caused by Electric-Oil Burners, Motors, etc.

By Harry W. Houck *

WITH the remarkable increase in the sensitivity of the latest radio sets, particularly certain screen-grid types of approximately 10 microvolts per meter rating and, in one extreme case, 2 microvolts per meter, the problem of a quiet local atmosphere becomes more and more pressing. Indeed, the pursuit of radio happiness today, in most localities, is largely dependent on the amount of man-made static or inductive interference, since powerful broadcast transmitters provide sufficient signal strength to cope with the normal static disturbances.

There are two ways of combating inductive interference caused by electric motors, oil-burner ignition apparatus, electric flashers and so on, namely: first, installing an interference prevention device in the 110-volt supply line to the radio receiver; secondly, going to the source of the disturbance and installing an interference prevention device at that point in the electric power line. While the first procedure may usually be followed by choice, as it is generally the simplest, especially when the listener-in has no control over the cause of the disturbance, nevertheless, the second procedure is more desirable and effective. Often the installation of the interference prevention device at the receiving set will prove an insufficient remedy. Hence it is always better practice to face the trouble at its source, even if it means enlisting the aid of others. That is the *ounce of prevention*, which is preferable to the *ton of cure* at the receiver itself. If the usual inductive interference could be cured at the receiving end, radio sets would have self-contained devices for just that purpose

All noises are not line noises. Some come in over the antenna. Others originate within the receiving set. It is for the elimination of line noises—those noises that arise from impulses in the line that supplies power to the receiver set, that the interference devices have been designed. It is interesting to note that where a component of the disturbing impulses comes in partly through the antenna, the device, when located at the origin of these impulses, will eliminate that component as well as the componetnt on the line.

Line Noises

Usually, a line noise is already known as such to the buyer of an interference device. The detection of a line noise usually is a matter of discovering just what apparatus is in operation during the disturbance in the loudspeaker.

Power companies have become particularly interested in radio interference, for radio listeners, who are good customers, invariably make complaints directly to them. According to James G. Allen in the May, 1929 *Proceedings of the Institute of Radio Engineers*, the power companies find the causes of radio noises about as follows:

Industrial apparatus	30%
Lighting Company equipment....	17%
Household appliances	26%
Defective radio equipment.....	15%
Miscellaneous	13%

Flash!

Vacuum Tubes! Vacuum Tubes! The April issue of RADIO ENGINEERING will be a comprehensive "Tube" issue. Among the wealth of informative stories will be a complete summary of the tube situation, and an article on tube research by Dr. Paul G. Weiller, entitled, "The Chemistry of Vacuum Tubes."

The foregoing tabulation represents a typical year's survey of radio noises by a power company, and shows that only 17% can possibly be due to the power company's equipment, the remainder being definitely outside its province.

To determine whether a disturbance comes through the antenna, disconnect same from the receiving set. Try it both with and without the ground connected. If this stops the noise, it is evident that it is a noise coming in over the antenna. Such a noise is not one which the interference device is designed to eliminate.

If, with the antenna disconnected, the noise continues, it is apparent that it is not coming through the antenna alone, and, unless an apparatus has been identified as developing the noise, it is possible that the noise arises in the receiving set, and it may be caused by such conditions as: Poor tube contact; dirt in tube sockets; tube faults; loudspeaker rattles; dirt between variable condenser plates; variable condenser plates in contact; defective audio-transformers; faulty solder connections; and such in power pack as poor filter condenser, improper wiring, defective voltage-dividing resistor, poor rectifier, and so on.

Must Be Suppressed at Source

Noise coming in over the antenna must be suppressed at its source, since any suppression at the receiving set will suppress the program also. So far, we cannot get at the source of static. But there are plenty of other sources of disturbance — miniature "broadcasting" stations radiating electric waves through space, such as spark-gap equipment, electric sign flashers, oil-burner ignition systems, elevator starting apparatus, direct-current motors, universal motors, household equipment, etc. These waves, radiated to the antenna, are of course components of disturbances known as line noises, and, because of the radiated components, persist at the loudspeaker when the interference device is positioned on the line at the receiving set. It may be thought that the device is not eliminating the noise on the power line, whereas it may be doing so quite thoroughly. The radiated component gets into the antenna in the same way as "cross-talk" got into the lines of early telephone systems, carrying conversations into lines not connected.

If the lines from any disturbing apparatus up to the power line supplying the radio receiving set run fairly parallel to the antenna lines or to any lines that serve as auxiliary antennas, a "capacitive" condition may be set up between these lines, in which the disturbing impulses on the power line transfer to the antenna.

With the object of confining these impulses as closely as possible to the source, so as to prevent the disturbance from reaching radio sets through their antennas, the interference prevention device is placed as closely as possible to the source.

And so, in conclusion, it will be noted that there are just three factors to bear in mind: one, place the interference prevention device as close to the cause of interference as possible; two, place it at the receiving end, if it is impossible to do so at the source of the trouble; three, be sure to employ a reliable make of interference prevention device, designed by specialists in this field.

* *Chief Engineer, Dubilier Condenser Corporation.*

Public-Address and Centralized Radio Systems

V. Testing Equipment for Disc Reproducers

By E. W. D'Arcy

POSSIBLY a description of a type of test equipment designed to obtain accurate comparisons of reproducers would be of some interest to the reader. We will therefore devote a small amount of space to the discussion of reproducer testing equipment.

The use of frequency records for making tests of reproducer efficiencies has the great advantage of economy. However, there are many types of reproducer actuating mechanisms of undeniable superiority over the recorded frequency method.

It is extremely difficult to reproduce a given amplitude repeatedly by means of a recorded disc, as there is no way to compensate in calculations for the wear of a record, or if the pressing is not quite up to standard a marked discrepancy exists between different records of the same frequency bands. These disadvantages can be overcome by other types of reproducer actuating mechanisms.

The driving mechanism displayed in Fig. 25 (see February issue) possesses a considerable number of points of superiority over the recorded disc method of actuating reproducers for test. It allows measurements of needle displacement to be made accurately, at the same time allowing linearity response curves, as well as frequency response curves, to be made of the reproducer under test. In addition to this, no element of wear exists, and a frequency can be reproduced repeatedly with assurance of the same actuation of the reproducer armature.

Mechanical Construction

The construction of this driving mechanism is of extreme simplicity, being based on two dynamic driving units in order to enable successful operation of the mass of the cross member and damping device. In practice it is impractical to operate the complete device from one source of applied power, due to the inertial impedance of the moving members. Damping is applied to the system through the immersion of the spiders and driving coils in low viscosity oil.

The cross member joining the two units is made of hard rubber, and its mass weight is kept as low as practicable. A slot is filed in the center of this cross member, of the approximate dimension of the record groove, approximately .004 inch deep and .01 inch wide. Attached at right angles to the face of the slot side of the cross member is a small concave mirror, which deflects the light beam, thus allowing magnification of the cross member movement on a calibrated scale located at a previously determined distance from the concave mirror.

The light source and condensing lens are normal and can be obtained quite easily. No special mention need be made of them other than sufficient light is required to project the reflected light beam a considerable distance, and the more powerful the light source the more clearly defined the reflected light beam will be.

Uses of This Device Efficiency of Reproducers

This system allows the measurement of actuation of the reproducer head to be made in an accurate manner. Its use, therefore, is practical to measure the relation of output energy in microwatts as compared to the input energy of the same character required to produce a measured movement of the needle point.

The following operations are used in making these measurements. The dynamic driving units are first operated without the additional load of the reproducer, and the amount of power required to move the cross member a previously determined distance measured.

The reproducer with its electrical load is then placed in position on the cross member and the required amount of increased excitation to actuate the crossarm and reproducer the previously determined distance is measured.

The difference between the no-load power absorbed in the driving mechanism and the power consumed when operated with the reproducer load added, is then assumed as the power required to actuate the reproducer head a known amplitude of needle and armature movement.

This power input is then divided into the power output of the reproducer, furnishing an exact measure of the reproducer efficiency under the previously stated conditions of frequency and needle amplitude excitation.

Linearity Response Curves

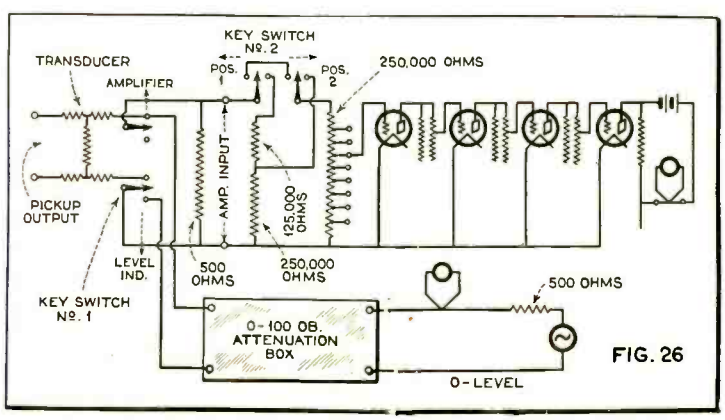
The question of linearity of the response of a reproducer is of considerable consequence in the study of disc reproducers, and the use of a driving mechanism of the type herein described greatly facilitates the study of this effect.

As stated in the previous article on reproducers, the formulae for this effect is given as follows:

$$\frac{V^1}{V^2} = \frac{E^1}{E^2}$$

V^1 = reference level actuation.
V^2 = comparative level actuation.
E^1 = reference level output of reproducer.
E^2 = comparative level output of reproducer.

A simple mathematical treatment of the system used in making these measurements would expedite and facilitate their explanation; so formulae are here given—



Illustrating function of key switch in relation to resistance network.

V^A = Unloaded dynamic driving power for reference level.
V^B = Loaded dynamic driving power for reference level.
E^1 = Reproducer output at reference level.
V^C = Unloaded dynamic driving power for comparative level.
V^D = Load dynamic driving power for comparative level.
E^2 = Reproducer output at comparative level.
V^1 = Reference level actuation.
V^2 = Comparative level actuation.

$$\frac{V^1}{V^2} = \frac{E^1}{E^2}$$

$$\frac{V^B - V^A}{V^D - V^C} = \frac{E^1}{E^2}$$

Any discrepancy on the part of the driving mechanism can easily be shown and allowance made in the observed data for any such discrepancy by the means of calibration of the mechanism without the load furnished by the reproducer under test. This is very easily done, due to the facility with which measurements of the cross member and consequent driving mechanism output power can be made.

Frequency Response Measurements

The system just described is very accurate and allows exact determination of the frequency response of a reproducer to be made, due to the ability of the mechanism permitting exact knowledge of reproducer actuating movement at all frequencies.

Test Set-up for Frequency Response Measurements

In Fig. 26 a circuit is shown, consisting of the following component parts, each of which will be taken up in its order.

Transducers

One of the primary requirements of measurement of reproducer response is that it be tested under loaded conditions. The author well realizes the difference between an inductive load and a resistive one. But since a standard method of procedure is required in making comparative tests of reproducers and a resistive load is much more flexible in respect to impedance adjusting than an inductive load, the resistive method was decided upon.

A resistance of 500 ohms is used for the terminating impedance of both the transducer and standard level. This value is merely an arbitrary one, as there is no accepted standard at this time.

Key switch No. 2 (Fig. 26) is used for two purposes. The resistive network it controls allows an increased attenuation of 6 dbs. by means of dividing the input voltage, while the input impedance, so far as the resistive network is concerned, is kept constant. Additional variation in input voltage is obtained by the 250,000 ohm potentiometer which is adjustable in 20, 2-db. steps.

Use is also made of this network for obtaining the impedance of a reproducer. The diagram is displayed in Fig. 27. The theory on which this system of measurement is based is only accurate where the generator may be assumed as being a constant source of e.m.f. acting through its a-c. resistance. These measurements of the impedance of a reproducer, therefore, are not to be construed as replacing the more accurate method of measuring the inductance and resistance, then calculating the impedance. However, the system does allow a reasonable accuracy of measurement, and the author has found that it is a quite satisfactory one, due to the speed with which measurements can be made.

The operations of making these measurements are simple and are given as follows: The generator whose impedance is to be measured is connected to the amplifier input. The key is thrown so as to divide the voltage appearing across its output. The potentiometer is then adjusted so as to obtain a convenient setting on the amplifier thermo-galvanometer. This setting is then noted. The key switch is then thrown so the full output voltage is impressed across the 250,000 ohm potentiometer, and enough resistance shorted across the generator by means of the decade resistance box to reduce the output voltage to the level previously noted. The resistance of the decade box, in use as a short circuit, is then assumed as the impedance of the generator under test.

The amplifier used as a level indicator is a direct coupled type and possesses an unusually flat frequency response curve, of the nature of +—1, db. from 30 cycles to 15,000 cycles. A more detailed discussion of this particular amplifier will be taken up in a subsequent issue.

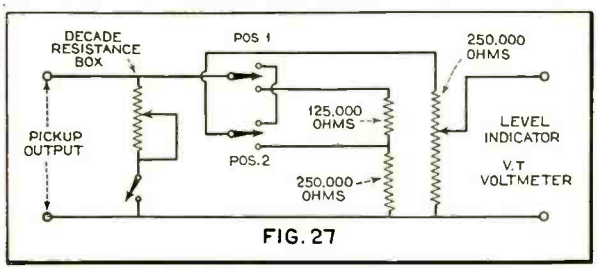


FIG. 27

Circuit setting for obtaining impedance of reproducer.

The thermocouple galvanometer is of an ordinary type. Little need be said about the circuit used for balancing out the direct current flowing through it, as the circuit diagram makes this system quite obvious.

The attenuation box and source of the reference level is of some consequence in this discussion: so we shall deal with it in some detail.

Due to the flat frequency response of the level indicator, commercial current is satisfactory to supply the reference level. The only requirement is that the impedance of the source of supply must be 500 ohms at all frequencies. Means for regulating the current flowing in this circuit without affecting the impedance also should be incorporated. "0" level for these measurements is assumed to be a current of 4.475 milliamperes flowing through a load of 500 ohms.

The attenuation box is designed to operate between a source and load, both of which must possess an impedance of 500 ohms.

The operation of this equipment is very simple. The voltage appearing across the 500 ohm load resistor is first measured with the reproducer operating through the transducer connected by means of key switch No. 2. The key switch is then thrown so as to connect the level standard to the 500 ohm load, and enough attenuation is introduced by the attenuation box to duplicate the voltage appearing across the 500 ohm load resistor, generated by the reproducer. The gain of the reproducer can quite easily be calculated then, as the loss through the transducer can be considered a positive one and the loss through the level standard a negative one. Adding these two values algebraically gives the gain of the reproducer in decibels.

(*To be continued*)

RADIO BUSINESS REPORTED IMPROVED

THE radio industry is receiving many reports of improved business conditions. At a meeting of the Radio Manufacturers Association's Board of Directors at Cleveland, February 10th, coincident with the annual convention of the National Federation of Radio Associations, of jobbers and dealers, there were numerous reports of better business during January, and also in future prospects.

Effects of last year's over-production of radio receiving sets, according to industry reports, are almost past. The era of cut prices, due largely to distress merchandise, is about over, it is said, and with reduced production, normal manufacturing schedules and distribution soon will be reached.

Improved Engineering and Standardization of Reproducers and of Television Equipment

R. M. A. Engineers Announce Program

NO major engineering developments or changes in radio receiving sets are in prospect, according to a statement issued by Mr. Walter E. Holland of Philadelphia, director of the engineering division of the Radio Manufacturers Association. Purchasers of standard radio receiving sets, Mr. Holland declared, have every assurance that they will not be obsolete by new developments and that such purchasers will for some time to come get their money's worth of real performance.

"In radio, as in automobiles," said Mr. Holland, "standardization has contributed greatly to giving the public excellent radio receivers and vacuum tubes at very low prices."

Mr. Holland reviewed the work of the engineers of the radio industry in connection with the big program of standardization and other technical work inaugurated last fall by the engineering division of the Radio Manufacturers Association.

"This standardization work is under the general direction of Ray H. Manson of Rochester, New York, a pioneer in and leading proponent of radio standardization.

"The committee on receivers and power supply is a large and very important group of which Ralph H. Langley of Cincinnati, Ohio, is chairman, and Virgil M. Graham, vice-chairman. Several sub-committees of specialists have attacked specific problems assigned to them and made recommendations to the main committee. Of interest to the public are the following definitions proposed by Mr. Langley's committee:

'Screen-grid receiver—A receiver in which all of the radio-frequency amplifier tubes are screen-grid tubes employed as such.

'Uniform selectivity—The characteristic of a receiver by which it is equally capable of discriminating between signals of the same intensity at any point in the broadcast frequency range.

'Uniform sensitivity—The characteristic of a receiver by which it is equally capable of responding to broadcast signals of the same strength throughout the broadcast frequency range.

'Automatic volume control—Means whereby a receiver accommodates itself to the strength of the received signals within limits, depending on the characteristics of the signal, but without affecting the quality, so that the sound volume may be manually pre-adjusted.

'Linear detection—Any form of rectification in which the audio-frequency output voltage is substantially proportional to the radio-frequency input voltage throughout the useful range of the device.'

"The committee on vacuum tubes under the chairmanship of George H. Lewis of Newark, N. J., is making good progress on the following rather complicated subjects:

'Standard characteristics and ratings for vacuum tubes of all types.

'Standard methods of determining tube characteristics.

'Recommended form of life test for tubes.

'Standard system for identifying tubes.

'Standard dealer method of determining the merit of tubes.'

"The committee on acoustic devices under the chairmanship of Frederick W. Kranz of Springfield, Ohio, has several important projects well under way in connection with loudspeakers and electromagnetic pickups. This committee has recommended the following much-needed standard for adoption:

'The size of a loudspeaker having a cone type radiator shall be expressed as the diameter in inches of the inner edge of the supporting ring or the maximum diameter of the unsupported portion of the system.'

"This proposed standard has not yet been reviewed by the General Standards Committee and there is room for argument as to the exact wording. As a practical matter, it would seem advisable to state that the cone diameter shall be expressed to the nearest half-inch.

"The committee on television under the chairmanship of D. E. Replogle of Jersey City, N. J., working as they are in a new field, consider it unwise to formulate definite standards until research and engineering development shall have reached the stage where fairly definite trends meet with general acceptance. They have, however, made a number of important recommendations as to practice which should be of great assistance to those working on the development of equipment for television broadcasting and reception. Among these recommendations are the following:

'The scanning at the receiver shall be from left to right and from top to bottom in uninterrupted sequence, looking directly at the frame.

'It is recommended that in horizontal scanning, the centre of curvature be placed below the scanned area and, in vertical scanning, the centre of curvature be placed to the left of the scanned area, as viewed from the front of the receiver.

'It is recommended that the following standards of lines per frame be used—48 and 60, and the following frame proportions be adopted—6 horizontal to 5 vertical.

'It is recommended that one of the following frame speeds be used—15, 20, 24 frames per second.'

"The television committee is in complete agreement that special separate receiving apparatus will be required for television, as evidenced by the following resolution passed by them:

'It is our belief that television will add to but not replace aural entertainment and that complete synchronism with sound may be had at all times. Present broadcast receivers will not be made obsolete, but their usefulness will be enhanced by the advent of television which will come with definite separate receiving and reviewing mechanisms.'

"The committee on cabinets of which R. H. Ewing of Louisville, Ky., is chairman have recommended a number of terms and definitions applying to radio cabinets. They have also prepared considerable useful information on woods and veneers, on cabinet construction, on finish and on packing cases.

"The service section under the direction of H. E. Fenner of Springfield, Mass., has held a number of well-attended meetings. The discussions of common service problems have proven of great benefit to servicemen and managers.

"The safety section under the direction of A. F. Van Dyck of New York City, N. Y., has kept in touch with the development of safety ordinances throughout the United States and Canada and has kept R.M.A. member companies advised as to the requirements and interpretation of such ordinances. This section is also working with the Underwriters Laboratories and with the Ontario Hydro-Electric Power Commission on the development and revision of safety standards.

"The engineering division work of the current season will culminate, probably in June, in the publication of a handbook of standards, practices and general information which it is thought will be exceedingly useful and valuable to all members of the radio industry."

THE PENTODE TUBE

(*Concluded from page 30*)

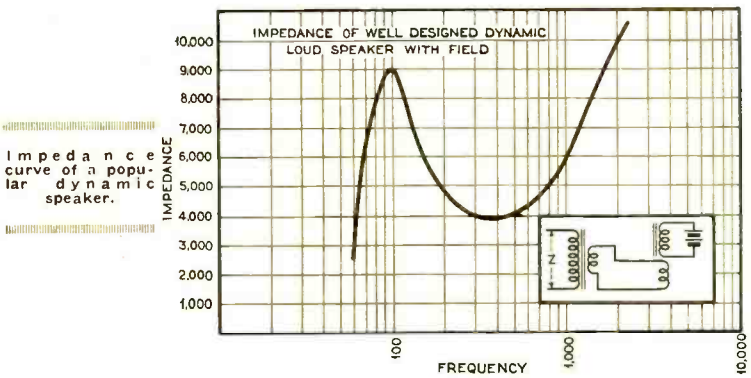
output transformers, cutting down the impedance of the system at the impedance peak.

The same reasoning applies to the high-frequency part of the impedance curve with the exception that loudspeakers will not respond to harmonics of that range. It seems to be an easy matter to cut down the impedance to any desired value by means of a by-pass condenser. A conespeaker inherently has exaggerated responses to frequencies between 3000 and 4500 cycles, and usually it is hard to bring this down.

The exaggeration of low-frequency response may present a more serious problem but one probably not impossible of solution.

With the above modifications power pentodes will probably give performance comparable with that of power triodes and at lower costs, this latter being the only "raison d'etre" for the pentode.

I. G. MALOFF.



Impedance curve of a popular dynamic speaker.

Fig. 1, I. G. Maloff's Discussion

IMMORTALIZING AIR WAVES

(*Concluded from page 33*)

the large metropolitan centers. The sponsors will add another good-will medium and the public will hear the best programs and only the best, whether they listen to the large metropolitan stations or the smaller local ones. The radio industry has perfected recording methods and equipment. It is now taking the recorded program to its bosom, that it may become an integral part of radio broadcasting.

▲

NATION-WIDE SURVEY BEING MADE OF VOLTAGE CONDITIONS AS AFFECTING RADIO RECEPTION

Here is a chance for radio listeners to co-operate in a nation-wide survey being made by the Allied Engineering Institute, at the instance of a group of leading radio manufacturers. The purpose of this survey is to secure up-to-the-minute, authentic data on voltage conditions in every town and city of the United States, so that radio set manufacturers will be able to furnish receivers adaptable to the voltage conditions of each particular locality.

Those who have experienced imperfect radio reception such as undervolume, fading, sudden blasts of volume, tube burn-outs and distortion, will realize the need of a survey of this kind, as all of these troubles are likely to result from incorrect voltage and from line voltage fluctuations. As a matter of fact, improper line voltage control is the cause of most of the present-day troubles in electric radio sets.

Radio listeners, servicemen and dealers can help in this survey by writing to the Allied Engineering Institute, Suite 429, 30 Church Street, New York City, telling of the conditions of radio reception in their vicinity. Those who have a-c. meters can be of enormous assistance if they will send in a record of the line voltage readings at several different times of the day. For example, it is an established fact that in most cities, the voltage is considerably higher during the day than it is in the evening, when most of the lights are turned on. These are the facts which are to be recorded for each city in the present survey.

▲

RADIO CODE ESSENTIAL TO RADIO CAREER

There is a mistaken idea abroad that the radio code is essential only to those desirous of becoming radio operators, and quite unessential to those planning to work in the non-communicational branches of radio, according to Rudolph L. Duncan, President of R.C.A. Institutes.

"It is generally not realized," states Mr. Duncan, "that the Government requires anyone in charge of radio transmission of any kind to be licensed as a radio operator. The situation is virtually the same as that in most states regarding the driving of a car, calling for a license irrespective of whether the driving be for profit or pleasure. There are severe penalties imposed on those who operate radio transmitters, and this applies to radio telephones quite as well as radio telegraph transmitters.

"Time and again the radio man is confronted with the need for the radio code. In broadcasting, a man may often be called upon to handle the transmitting end, or again the network or remote control wires, in which the code is required. In experimental work, the possession of a license may make all the difference between qualifying for important research and engineering work on transmitters, or being relegated to work of less importance. Engineers and attendants at transoceanic and marine radio stations are expected to know the code, even though they may have nothing to do with the traffic itself.

"It is a serious mistake to neglect the code when training for a radio career. By so doing, one limits the opportunities."

▲

PHOTOCELL PHOTOMETRY

By L. R. Koller*

A STANDARD text book on photometry published in 1910 makes no mention of the photoelectric cell. Since then, photocell photometry has made such rapid progress that within another year there will probably be no visual photometers in use in the incandescent lamp industry in this country, except for the preparation of standards.

The disadvantages of visual methods of measuring light are that they are subject to the personal equation of the observer, which, of course, may and does vary from day to day. In addition, they are slow and time must be allowed for eye adaptation. Measurements must be made in a dark room. All observations must be made in terms of a comparison standard.

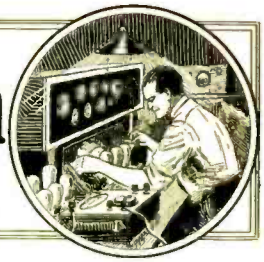
The photoelectric cell is an electrical substitute for the human eye. When stimulated by light it allows a current to flow which is directly proportional to the intensity of the light. Its response is instantaneous. It does not require any time for adaptation. It will respond at once to a very low intensity after having been exposed to a high intensity. The cell is a small object and can be easily screened from all light except the lamp which is being photometered so that it is no longer necessary to work in a dark room. It can be calibrated by means of a single or very few working standards.

It makes possible rapid photometry, independent of the operator, with an accuracy of the order of 0.5 per cent over a wide range of intensities.

* *Manager Engineering Dept., Edison Lamp Works of General Electric Co.*

The Trend of Invention

By RICHARDS & GEIER
PATENT AND TRADE MARK ATTORNEYS 274 MADISON AVE NEW YORK CITY

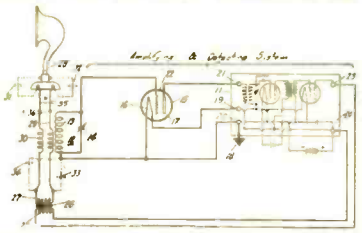


RADIO RECEIVING SYSTEM

Harold F. Elliott, of Palo Alto, California, Assignor, by Direct and Mesne Assignments, to Victor Talking Machine Company, of Camden, New Jersey, a Corporation of New Jersey. U. S. Patent No. 1,737,078. (Issued November 26, 1929.)

It is one of the objects of this invention to eliminate the necessity for a special absorbing circuit, so that no separate antenna loop or wire is required to intercept energy; and to make it possible nevertheless to absorb a considerable amount of energy from the surrounding medium.

In combination, a radio receiver, a loudspeaker having metallic parts, means connecting said radio



receiver and loudspeaker for energizing the latter and an antenna circuit for said receiver including at least some of said metallic parts as a capacity area and said means, said antenna circuit being operatively connected with said receiver to transfer energy thereto.

SOUND GENERATOR

Ernst Hueter, of Darmstadt, Germany. U. S. Patent No. 1,740,651. (Issued December 24, 1929.)

The object of the present invention is the creation of a diaphragm showing a non-pronounced resonance curve, i. e., one as flat as possible, in order to warrant a better reproduction, as free from distortion

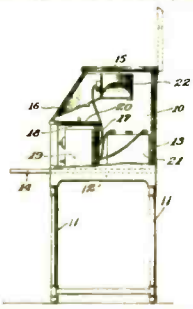
as possible, thereby causing a quicker succession of the natural vibrations.

A sound reproducer having a diaphragm comprising a sheet of elastic material and a plurality of reinforcing members of porous material and a second sheet of elastic material secured to said reinforcing members in spaced relation to said first mentioned sheet and a rim member connecting the peripheries of each of said sheets and predetermining the special relation thereof.

SOUND AMPLIFIER FOR RADIO-CABINETS

James W. Small, of Chicago, Illinois. U. S. Patent No. 1,745,511. (Issued Feb. 4, 1930)

This invention relates to sound amplifiers for radio cabinets containing a radio receiving set or other reproducing instrument and has for its object the provision of an amplifier of the class mentioned which



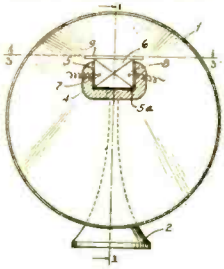
shall be of improved construction and operation which shall be conveniently arranged in the radio receiving set and which will develop improved acoustic properties.

Free books on patent and trade-mark law can be obtained by our readers upon request to Radio Engineering or direct to Richards & Geier. Copies of the patents described on this page may be obtained through the above mentioned firm of patent attorneys.

ECCENTRIC CONE LOUDSPEAKER

Alexander McLean Nicolson, of New York, N. Y., assignor to Wired Radio, Inc., of New York, N. Y., a Corporation of Delaware. U. S. Patent No. 1,742,002. (Issued December 31, 1929.)

It is an object of this invention to provide a loudspeaker or sound radiating device which shall be as nearly as possible, a faithful reproducer of the vibrations impressed thereon, and, to this end, shall



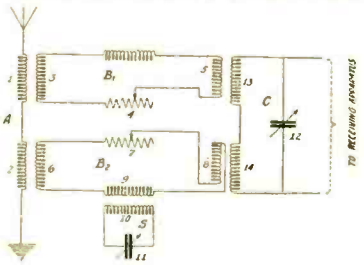
be free from parasitic resonance at various frequencies which would tend to diminish the accuracy of reproduction desired.

ARRANGEMENTS FOR ELIMINATING ATMOSPHERIC DISTURBANCES

Abraham Esau and Friedrich Lange, of Berlin, Germany, assignors to Gesellschaft Fur Drahtlose Telegraphie M. B. H. Hallesches, Ufer, of Berlin, Germany, a Corporation of Germany. U. S. Patent No. 1,743,124. (Issued January 14, 1930.)

This invention relates to the radio art and more particularly to a method and means for eliminating certain disturbances caused by natural electric phenomena in the ether, commonly called static.

An object of the invention is to provide a method

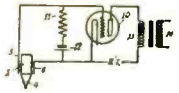


and means for effectively eliminating these disturbances without eliminating the desired signal in a simple and efficient manner.

MEANS FOR RECORDING AND REPRODUCING SOUND

Alfred Aubyn Linsell, of Brentwood, England, Assignor to Radio Corporation of America, a Corporation of Delaware. U. S. Patent No. 1,737,253. (Issued November 26, 1929.)

This invention relates to means for recording and/or reproducing sound, and more particularly to means



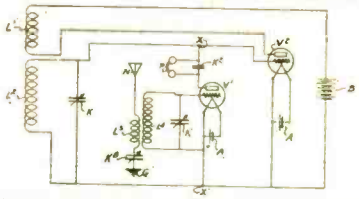
for recording sound upon gramophone and the like records and/or reproducing sound therefrom.

A reversible electrical reproducer comprising a piezo-electric crystal section, said section having a body portion and a projecting portion, said last mentioned portion being shaped to fit the grooves of a record, and electrodes connected to two opposite faces of said body portion.

RADIO RECEIVING SYSTEM

Robert E. Lacault, of New York, N. Y., Assignor, by Mesne Assignments, to Radio Corporation of America, a Corporation of Delaware. U. S. Patent No. 1,740,946. (Issued December 24, 1929.)

In this method of radio reception the important

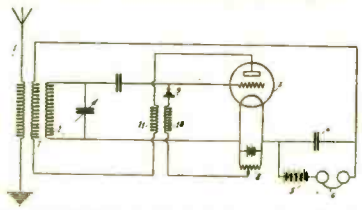


feature resides in the employment of the internal resistance or impedance of a vacuum tube as a variable resistance in the circuit, and the making use of the plate-filament resistance in the reception of the signals.

RECEIVER ARRANGEMENT

Siegmund Loewe, of Berlin, Friedenau, Germany, Assignor to Radio Corporation of America, a Corporation of Delaware. U. S. Patent No. 1,740,864. (Issued December 24, 1929.)

A radio receiving circuit comprising a thermionic tube, a feedback arrangement for strengthening radio-

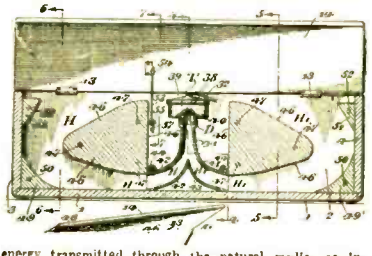


frequency impulses, a detector between the grid and filament of the tube, and means in series with the detector and coupled to said feedback arrangement for biasing the tube in a manner such that sustained radio-frequency oscillations of high amplitude cannot exist.

RADIO LOUD-SPEAKING APPARATUS

Arthur Atwater Kent, of Ardmore, Pennsylvania. U. S. Patent No. 1,743,145. (Issued January 14, 1930.)

This invention relates to loud speaking or amplifying telephonic receiving apparatus for receiving electrical energy, and more particularly high-frequency electrical



energy transmitted through the natural media, as in radio systems, or transmitted over an artificial conductor or conductors extending between transmitting and receiving stations.

GRIGSBY SALES UP DURING JANUARY

That the country is inherently prosperous and willing to buy that which it considers necessary for entertainment and education is indicated in a statement made by Mr. B. J. Grigsby, president of Grigsby-Grunow Company, makers of Majestic Radio, relative to last month's sales.

"The company's sales for the month of January, 1930 were $5,368,788.16," he reports, "which compares with $5,255,975.29 for the corresponding month last year. Reports from our dealers indicate that their sales for the month were substantially in excess of the company's production."

GILBERT JOINS PILOT

Charles Gilbert, one of the best known executives in the radio industry, has become affiliated with the Pilot Radio & Tube Corporation, of Brooklyn, N. Y., in the capacity of vice-president in charge of merchandising.

Mr. Gilbert is one of the real radio pioneers, his connection with the art dating back to the early days of the DeForest Radio Telephone and Telegraph Company. He was treasurer of that company from 1915 to 1921, and president and general manager from 1921 to 1924. With the sale of the controlling interest of the DeForest Company in 1924 to a Detroit syndicate, he became secretary of the Brandes Division of the Kolster Radio Corporation, in charge of the Purchasing and Material Control Division, and held that position until a short time ago.

Mr. Gilbert has figured in many patent deals that greatly affected the radio industry. As a close business associate of Dr. Lee DeForest he was particularly active in the important litigation involving the vacuum tube, the device that is the foundation of present-day radio.

NEW PILOT BRANCHES

The establishment of branch offices and warehouses in Chicago, Detroit and San Francisco, for the purpose of accommodating the increasing dealer demand for Pilot products, is announced by Charles Gilbert, vice-president in charge of merchandising of the Pilot Radio & Tube Corporation. The main offices of the company are at 323 Berry Street, Brooklyn, N. Y. Shipments to dealers in these various territories will be made directly from the branch warehouses.

The Chicago office is located at 234 South Wells Street, and is in charge of Nathan Cherof. The actual sales work in this territory, comprising the states of Indiana, Illinois and Wisconsin, will be handled by the American Manufacturers' Agency, 208 North Wells Street, of which Joseph J. Day is president. This organization has eleven men in the field.

Warren E. Brennan, with offices in the Convention Hall Building, Detroit, has been appointed sales representative for the state of Michigan. Pending the establishment of a separate branch warehouse, Pilot merchandise will be shipped from the warehouse of the Detroit Radio Products Company, Inc., which is affiliated with the Pilot Radio & Tube Corporation.

The West Coast business will be handled by Arnold Sinai, with the Pilot salesrooms and warehouse at 1278 Mission Street, San Francisco.

CHANGES IN R.M.A. BOARD OF DIRECTORS

Personnel changes among prominent executives of several radio manufacturers have resulted in several changes on the Board of Directors of the R.M.A. At the Cleveland meeting of the board resignations were received from Vern W. Collamore, formerly of Philadelphia; George C. Furness, of New York; A. J. Carter, of Chicago; Major H. H. Frost, of New York, and Jess B. Hawley, of St. Charles, Illinois. Mr. Furness will continue service for the R.M.A. as chairman of the Statistics Committee. Major Frost also will continue as chairman of the Merchandising Committee, and Mr. Hawley as chairman of the Show Committee.

To fill the five vacancies caused by the above resignations, the R.M.A. Board of Directors elected unanimously to its directorate the following: A. T. Haugh, of Rochester, former president of the R.M.A.; Fred D. Williams, of New York; E. N. Ranland, of Chicago; James M. Skinner, of Philadelphia, and Arthur C. Kleckner, of Racine, Wisconsin.

WORLD VALUE OF RADIO EQUIPMENT

The total value of radio set installations in the world is estimated at $1,843,750,000 by the Electrical Equipment Division of the Department of Commerce. The value of broadcasting stations in operation is placed at $22,682,222. The report states there are 21,629,107 receiving sets in the world; the United States having 10,250,000, Europe, aside from Russia and Turkey, has 9,139,824 sets.

The figures indicate there is one receiving set for every twelve and one-half persons in the United States, one for every fifty-three in Europe and one for every eighty-eight in the world.

GENERAL MOTORS AUTOMOTIVE RADIO

The entire sales and service of the new Delco Automotive Radio, manufactured by General Motors, is to be handled by the national organization of United Motors Service, according to announcement at Detroit by Ralph S. Lane, president and general manager of United Motors. This is the first authentic information regarding the marketing plans for this radio, which has been developed by General Motors.

TRIAD EXPANDS

The Triad Manufacturing Company, Inc. of Pawtucket, R. I., have announced their advertising plans for 1930. As in 1929, the appropriation will be handled by the Harry M. Frost Co., of Boston, Mass. In actual figures, the money to be spent by the Triad Company amounts to double that spent last year.

The 1929 business far exceeded the most optimistic hopes of Triad officials, and last year's sales records would alone justify the added expenditure. Added to that, however, there has been a tremendous increase in the company's sales records, since the news has been made public that Triad Tubes are now licensed under all R.C.A. General Electric and Westinghouse Electric patents. This fact, coupled with the recently announced improvements in Triad T-24 and T-27 tubes which are now protected against burn-outs and rendered non-microphonic, has resulted in an even greater increase in the monthly sales.

CONVENTION REVEALS EXPANSION IN RADIO TRAINING

The first convention in history of graduates of a home-study training school in Washington on November 22, 23, focused national attention upon the rapid strides being made in the field of adult education and particularly the training of technical radio men by correspondence. Since the World War colleges have greatly increased their enrollments, but an even larger gain has been made in the home-study field. For every college student there are probably eight who in their spare time at home are preparing themselves for a specialized field of work. The home-study student has no gridiron team to follow, his doings are not chronicled by the newspapers, he is not interrupted by the "Sophomore Hop" or the "Junior Prom," but in the quiet of his own home he masters his lessons and conducts his experiments in preparation for radio positions in need of skilled technical men. He is typical of that vast army of eight to ten million who form the backbone of the present movement for further specialized training.

The National Radio Institute of Washington, D. C., which is celebrating the Fifteenth Anniversary of its founding, is an example of the growth of the home-study training field. Starting in 1914 with four students, it today has graduates in every branch of the radio field and with its executive staff of 125 is training over 18,000 men to supply the needs of radio. Its President, J. E. Smith, had charge of training 800 Radio operators for the U. S. Navy during the World War.

TEMPLE GOES TO SYNDICATE

Leonard C. Welling, president of the K. W. Radio Company, Inc., New York, representing a syndicate of business men, has just purchased all the assets of the Temple Corporation, Chicago, Ill. The syndicate will continue operations in the plant immediately. The trade name "Temple" will be continued in the future. The purchase includes all patents, good-will, trade name, machinery, equipment and merchandise inventory, which is well above one million dollars.

R.C.A. VICTOR EXPANSION PROJECT

An expansion program involving the expenditure of more than $7,500,000 during 1930 is to be undertaken at once by the R.C.A. Victor Company, according to a statement by Edward E. Shumaker, president of the company, in an interview recently. More than $5,500,000 of this sum will be spent for the construction of a new building, and mechanical equipment including machine tools, small tools, conveyors and other important items. The new building is to be used for the manufacture of radio parts for radio assembly and shipping. In addition to this, over $2,000,000 worth of equipment is being brought to Camden from the General Electric and Westinghouse plants for use in radio production in the R.C.A. Victor plant. Combined with the appropriation of $3,820,000 which was authorized last year and which is still being expended, the R.C.A. Victor Company by the end of 1930 will have made an outlay of $11,420,000 for plant expansion and development.

Preparations for the construction of the new building are already under way. The structure will occupy the entire square bounded by Delaware Avenue, Cooper, Front and Penn Streets, with the exception of the plot now covered by the R.C.A. Victor executive offices. Several rows of houses, two parking places, the Victor individual garages, the present factory employment office, an old factory building and the engine house of the Victor private fire department will have to be removed to make room for the new factory building.

Mr. Shumaker pointed out that since the unification of Victor with R.C.A. and with the radio manufacturing organizations of General Electric and Westinghouse, the need for expansion of the RC.A. Victor plant has been acute. It has been decided that not only Victor radio, electrolas and records, but also R.C.A. Radiolas—which formerly were manufactured in Westinghouse and General Electric plants—will now be produced in the Camden plant of the R.C.A. Victor Company. This plan demands immediate addition of space and equipment and will make Camden the radio manufacturing center of the United States.

"The great expenditures authorized by the R.C.A. Victor Company," said Mr. Shumaker, "are significant of the confidence in radio's future entertained by the financial and industrial leaders who are directing the destinies of the R.C.A. Victor Company. They are a part of the purpose of the company to bring to the American public the finest and most advanced radio and phonograph products at prices made possible by an enormous demand and production. These expenditures also reflect our belief in the fundamental soundness and prosperity of the country upon which our industry, like all others, depends. We face the immediate as well as the distant future with absolute confidence."

FABRIC DIAPHRAGMS ESSENTIAL FOR OUTDOOR SPEAKERS

With the increasing popularity of centralized radio and sound systems, especially for outdoor purposes, many new problems arise with regard to the nature of the equipment to be employed. Ordinary radio equipment that may have proved satisfactory indoors, is found quite unsuited to the requirements of outdoor sound installations.

According to Clifford E. Stevens, Chief Engineer of the Stevens Manufacturing Corporation of Newark, N. J., the loudspeaker requires more care in its selection than any other piece of equipment for outdoor use, due to the delicate nature of its diaphragm. "All too many store owners, amusement park owners, and so on, have mounted ordinary dynamic speakers outdoors only to have them 'go bad' after several weeks of operation," states Mr. Stevens. "It should be remembered that the average paper diaphragm, while it may function properly in the home, is not designed to withstand atmospheric changes and an occasional wetting.

"Speakers equipped with impregnated cloth diaphragms, or burtex diaphragms, must be employed for outdoor purposes. An impregnated cloth or burtex cone will actually hold water for weeks without leaking, indicating positive moisture-proof qualities. The outdoor speaker, thus equipped, may be rained upon indefinitely without changing form or characteristics, a thing that paper obviously cannot do," concludes Mr. Stevens.

STILL THOUSANDS OF HOMES TO BE EQUIPPED WITH RADIOS

W. D. Terrell, chief of the radio division, Department of Commerce, Washington, in hearings on the department's annual supply bill, stated that there are at least 10,000,000 homes now equipped with radio receivers, in the United States. This is an increase from 60,000 in 1922. Mr. Terrell stated that the present radio audience totals approximately 40,000,000 persons. On this basis there are 70,000,000 persons not regularly served with radio programs. Continuing his report Mr. Terrell said:

"The total radio sales covering mostly receiving sets and accessories for the fiscal year 1922 amounted to $60,000,000, while in 1928 the figures were given as $650,550,000. The exports amounted to $2 800,000 and in 1928 to $10,907,000.

"The Radio Manufacturers Association states that although $2,500,000,000 in radio products have been manufactured since 1922 there was no saturation point."

N. B. C. EARNS $15,000,000 IN YEAR

In his annual report for the year 1929, M. H. Aylesworth, president of the National Broadcasting Company states that the gross revenue for 1929 was approximately $15,000,000, all of which was turned back into plant and service.

The growth of broadcasting activitity is shown in the fact that the personnel of the company, exclusive of artists, increased during the year from 558 to 917. One hundred and ninety-nine clients paid for use of WEAF-WJZ and network radio facilities, compared with ninety-six in 1928.

"The permanent wire network used in the transmission of programs now totals 32,500 miles," continued Mr. Aylesworth. "Our networks have been expanded by the addition of fourteen stations, necessitating an increase of approximately 4,500 miles of specially constructed telephone wires for permanent service and 900 miles for special recurring service. This makes a total of seventy-three network stations and 32,500 miles of telephone wires. Effectivve on Jan. 1, 1930, we found it possible to reduce the sustaining rates 50 per cent, which permits a greater number of stations to send out the NBC programs. The mail division handled more than 1,000,000 letters in 1929."

G. A. YANOCHOWSKI NEW KELLOGG PRESIDENT

The Kellogg Switchboard & Supply Company announces the election of Mr. G. A. Yanochowski as president, succeeding Mr. W. L. Jacoby, who died recently. Mr. Yanochowski has been associated with the Kellogg Company for the past fifteen years, entering the service of the firm in 1915 as an assistant to the head of the Legal Department. In 1925 he took complete charge of the Kellogg Legal Department and served in that connection until his appointment as president.

Mr. Yanochowski studied electrical engineering at the University of Illinois. Upon leaving the University, he became connected with a telephone manufacturer. Starting at the bottom, he first worked in the factory and later took a student's course in the manufacturing plant to become familiar with the business, after which he worked as a telephone switchboard installer and maintenance engineer.

After several years of experience as a maintenance and installation engineer, Mr. Yanochowski was offered an opportunity in the Patent Department of the firm with which he started. There he familiarized himself with the legal division of the telephone business.

In 1915 Mr. Yanochowski became identified with the Legal Department of the Kellogg Switchboard & Supply Company. He took up the study of law and was admitted to the Illinois State bar in 1919.

For the past five years Mr. Yanochowski has been in direct charge of the Kellogg Legal and Patent Department. This work has brought him in close touch with the various departments of the business both administrative, production and engineering, and for the past three years he had practically daily association with the president, assisting him in matters of major importance. His election to the presidency of the Kellogg Company was the logical and unanimous choice of the Board of Directors.

AUTOMATIC CONTROL IN RECEIVERS

In a recent I. R. E. paper Dr. L. M. Hull says: "As broadcast reception becomes more a matter of service and less a question of chance the noise levels and fading characteristics of the incoming waves become more important in determining the merit of the service than the absolute magnitude of the average field intensity. The introduction and development of automatic volume controls for broadcast receivers is a more significant development than any changes in the sensitivity of receivers that are likely to occur in the future. Devices for holding the output level to within a maximum variation during a variation of over 500 to 1 in field intensity are now available in practical form. A general public acceptance of such controls may not be immediate, but receiver designers will undoubtedly find it commercially profitable to refine the technique of the automatic control until a stage is reached where the practical elimination of the effects of fading will bring about a general increase in the accepted service areas of most broadcasting stations."

A MARKET FOR A HUNDRED THOUSAND RADIOS

Utilization of the advantages of radio for educational purposes, and the employment of radio receivers in schools has been a subject conjured with from the early days of popular broadcasting. There is present evidence, however, that real accomplishment will come out of various projects now to the fore.

Of immediate interest to manufacturers of radio receivers are the inquiries being made by State boards of education into the availability, adaptability and cost of receivers now on the market. In one Southern state recently a comoittee of the State Board examined a number of standard makes of radio receivers for the purpose of endorsing one make as the most suitable for rural school use. In this instance the examination and the tests were simple. The various receivers were set up for operation; the examiners switching the antenna from one to another of the receivers while transmission continued from broadcast stations whose services were desired regularly.

Reports from all parts of the country indicate that, in addition to the installations proposed for schools in cities and towns, in which equipment for two or three programs simultaneously, with control panel and classroom loudspeakers, is required, there is a rapidly growing demand for radio receivers in the small country schools, where in hundreds of instances there are but a score or so of pupils.

From the inquiries at hand it is clear that one standard form of assembly will not meet the general needs. There are many small schools where a dry-cell operated receiver would be the most satisfactory. An odd, but do doubt important, requirement stated by state and county school authorities is that radio receivers intended for use in small schools (locked at night and without janitor or watchman service) must have some sort of provision made for "nailing them down." Various methods of meeting this requirement will at once occur to designers and manufacturers.

There are in the present interest in the application of radio to educational purposes on a large scale, opportunities for manufacturers of radio receivers which if developed intelligently and systematically should yield highly satisfactory money return.

SPEED GETS R.C.A. LICENSE

One of the most important announcements of recent months has just issued from the headquarters of the Cable Radio Tube Corporation and the Radio Corporation of America—henceforth, Speed radio tubes are licensed for manufacture under all present and future patents of the R.C.A., General Electric, and Westinghouse Electric and Manufacturing Co.

J. J. Steinharter, president of the company, considers this announcement the most vital Speed news for jobber, dealer, and consumer, to be issued in recent months.

Prospects for Speed in 1930 look particularly opportune. Five factories are now in operation, distribution facilities are better than ever, sales figures are mounting, pep pervades the company.

ZENITH RADIO

Zenith Radio Corporation reports for the quarter ended January 31, 1930, profit of $52,662 after charges, but before Federal taxes. For the nine months ended January 31, profit before Federal taxes amounted to $130,256. For January, 1930, profit before Federal taxes was $57,502, comparing with loss of $27,273 in January, 1929. Capital stock consists of 400,000 no par shares.

STEINITE RADIO

The Steinite Radio Company reports for the year ended September 30, 1929, net loss of $148,592 after charges. Previous report was for year ended August 31, 1928, and showed net profit of $383,017 after Federal taxes, equal to $2.25 a share on 170,000 shares of no par stock.

EDISON LAMP WORKS TO MOVE TO NELA PARK

In March, the Edison Lamp Works of General Electric Company will transfer its headquarters from Harrison, N. J., to Nela Park, Cleveland. The recently organized R.C.A. Radiotron Company, which was formed to handle the sale, distribution and manufacture of R.C.A. Radiotrons, has purchased the Harrison site and will be located there.

C. G. Osborn has resigned as sales manager of the Edison Lamp Works to accept the position of vice-president of the R.C.A. Radiotron Company. Mr. Osborn is succeeded by E. E. Potter, who will have his headquarters at Cleveland. P. D. Parker has been appointed assistant sales manager of the Edison Lamp Works while H. F. Barnes will be assistant sales manager in charge of advertising and sales promotion.

INTERFERENCE FROM HARMONICS

Complaints of harmonic interference often are received by broadcasting stations, which can be traced directly to faulty design of radio receivers. When a radio receiver with poorly designed selective circuits is subjected to relatively high local field intensities, a radio-frequency tube may become overloaded, functioning then as a modulator or harmonic generator; erroneously suggesting that the received wave is "broad" or that it contains disturbing harmonic components.—I. R. E. Committee on Broadcasting.

NEW APPOINTMENTS ANNOUNCED BY SPEED TUBE CORPORATION

Nineteen hundred and thirty got off to a flying start at No. 84-90 N. Ninth St., Brooklyn, the general offices of the Cable Radio Tube Corporation, with three appointments of unusual interest.

Mr. Nestor Roos, for seventeen years, associated with the Plaza Music Company, covering the United States, Latin America and the Hawaiian Islands, has been appointed national field representative for Cable. He will bring the Speed line of radio tubes to the attention of department store buyers throughout the country.

As general field representative, Cable has obtained the services of B. J. Hamilton, formerly serving Sonatron in the same capacity.

For New York State, Barney Williams, former salesman for Sonatron, has been added to the Speed staff.

A "KICKING AND BITING HERD"

While F. B. McKinnon, president of the Independent Telephone Association, was a witness before the Senate Committee, February 3, on the hearing on the Couzens Communications Bill, he stated that the members of his association had no desire "to be driven into the same corral with the kicking and biting herd that is known as the radio industry."

Mr. McKinnon, like a man up a tree, has for many years been in a position to view the evolution of the radio industry, from an interested but not involved rantage point.

Well it has occasionally been recalled that the automobile industry, and for that matter the telephone industry itself, passed through prolonged periods of strangling warfare over patents. In 1930, those engaged in producing radio equipment for commercial and private use still are not far from the scratch line at which radio started. The art is young. The industry is young.

There is one view in which there appears to be little or no disagreement. That is, that it is impossible now to visualize the ultimate complete usefulness and value of radio to the world. An art that has made such marvelous progress in a comparatively few years unquestionably has ahead of it a glorious future.

To meet the manufacturing needs of radio's future there must be a vast radio industry. The rewards will come to those who possess the keenest vision; who practice conservatism, and who persist in the desire to succeed.

WHERE SHOULD HIGH-POWER BROADCAST STATIONS BE LOCATED WITH RESPECT TO POPULOUS CENTERS?

Radio engineers generally are in agreement with the practice recommended by Dr. J. H. Dellinger, engineer of the Federal Radio Commission, in regard to the location of broadcast transmitters. Following thorough study and analysis of the present conditions in the broadcast field Dr. Dellinger recommends that every station of five kw. or more shall be located at such a place that the radio field intensity at the nearest boundary of a populous center shall be not more than 100 mv. per meter.

In round figures this means that a five kw. station should be at least two miles; a ten kw. station two and eight-tenths miles; a twenty-five kw. station four and one-half miles, and a fifty kw. station six and three-tenths miles away from the outskirts of populous centers.

The purpose of requiring broadcast transmitters to be shifted to locations outside of populous areas is to make it possible for persons owning radio receivers and who live in cities, to pick up satisfactorily broadcast transmission from stations at a considerable distance away, without the interfering or blanketing effect from high-power stations nearby.

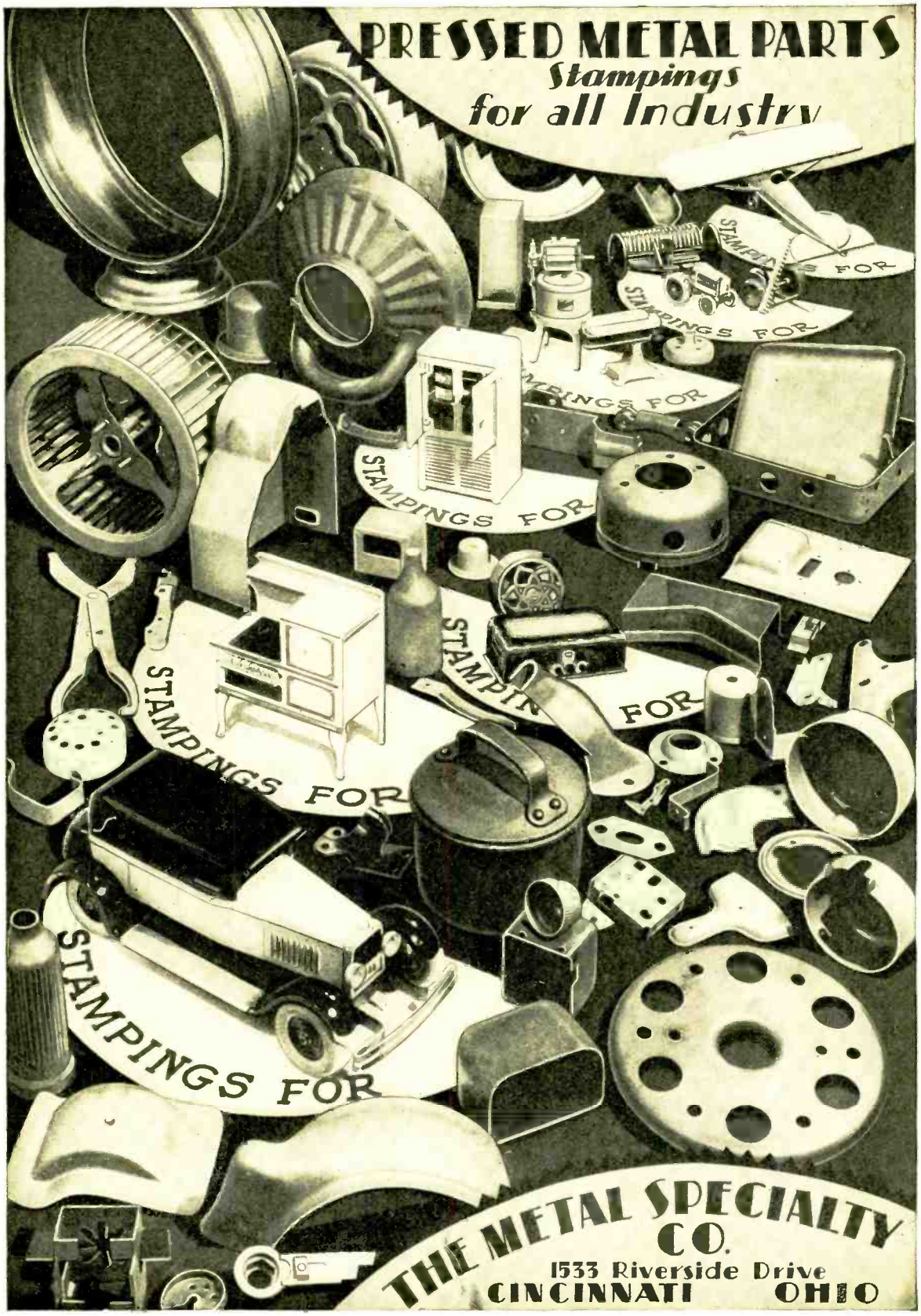
Obviously, of course, the owner of the radio receiving set has certain responsibilities in the circumstances. If he expects to "bring in" distant stations clearly—one at a time, without being subjected to interference from a broadcast transmitter located but a few miles away, he must look to his receiver.

At the present stage of radio development there appears to be general agreement that a separation of fifty kc. should afford reasonable protection against interference from other broadcast stations. In a given case, when the owner of a radio receiver experiences consistently good service from a particular broadcast transmitter, he should still receive satisfactorily from that transmitter when another transmitter separated fifty kc. or more is in operation.

The practice, begun some time ago, of pressing broadcasters to find locations for their transmitters some miles away from large centers of population is as much in the interest of the broadcaster as of the owner of a radio receiver.

GEORGE E. PALMER JOINS TOBE

Mr. George E. Palmer, for years General Sales Manager of the Dubilier Condenser Corporation has resigned his former connections to join the Tobe forces as Vice-President, in charge of the Condenser Division.



LIGHTNING HAZARDS TO RADIO ANTENNAS

With the advent, in 1920, of the public's use of radio antennas, the question was early presented: whether it was necessary, or of advantage, to connect an efficient lightning arrester between antenna and ground?

As time passed and the number of antennas throughout the country increased from a few hundred to hundreds of thousands, insurance companies and underwriters had opportunity to gather information about fires resulting from lightning-struck antennas, from which statistics were compiled.

The experience of the fire insurance companies in the years 1921 and 1922 made it clear that where outdoor antennas are employed, properly designed and properly made lightning arresters unquestionably very greatly reduce the risk of fire in radio receivers and in buildings to which outdoor antenna wires are connected.

When the first statistics were circulated, the National Board of Fire Underwriters, sponsors of the National Electric Code, set up requirements for lightning arresters used for antenna protection, and framed rules governing methods of installation. In setting up these requirements and rules the N. F. P. A. was given continuous assistance by the Institute of Radio Engineers.

As time passed and the number of radio antennas multiplied the demand for lightning arresters grew apace. Soon the market was invaded by a number of cheaply made, fragile and altogether useless makes of arresters. Few of these met the Underwriters' requirements, but many were sold by dealers before the Underwriter's laboratories had opportunity to get control of the situation.

Fortunately, the one or two manufacturers of lightning arresters who had been in the business for many years prior to 1920, were able by means of large production to keep arrester prices down to figures not burdensome to radio users.

The Underwriters' Laboratories examinations which result in granting or refusing to manufacturers the right to brand their products as "APPROVED" are carried on in a systematic manner, and with the interests of the consumer and manufacturer equally in view. Maintaining judicial status has not at all times been an easy matter. Pressure from manufacturers who believe, or hope to make others believe, that their fifty cent product is as dependable as someone else's dollar product, must be difficult to contend with.

No doubt there is continuous pressure from manufacturers who for their own profit only desire to be granted the right to carry the word "APPROVED" on arresters which are not strongly made, which are not reasonably permanent as to gap separation, which are not weather-proof, and which are not equipped with contact lugs of sufficient capacity to accommodate the ground wire of required guage.

Also, the Underwriters' Laboratories must keep abreast of the times so that their engineers are familiar with progress in manufacture. Tests applied to products submitted for examination should take cognizance of advances in science.

In general the radio industry is to be congratulated upon the condition that scientific progress and sound engineering contribute continuously to the upbuilding of the business.

CARRIER "WOBBLE"

There are in service throughout the country many broadcast transmitters which are made up of a simple vacuum-tube oscillator coupled to the antenna and modulated by superimposing the signaling voltage upon the direct emf. impressed on the plate element of the tubes. In view of the fact that the frequency of power oscillators is affected by variations in plate voltage; while the desired variation in carrier amplitude is accomplished, yet there are accompanying changes in frequency which may range to 1000 (plus or minus) cycles, or more.

This produces what is termed carrier "wobble." The condition not only prevents proper control of frequency but frequently causes interference in neighboring channels, and may produce serious distortion at distant receiving points.

As pointed out by the I.R.E. Committee on Broadcasting the disturbing effect may be avoided by employing a properly-designed master oscillator separated from the modulating amplifier by one or more isolating stages.

Thus, slowly but surely, beat note interference is traced, card-indexed and listed among the identified.

BROADCAST ZONES ESTABLISHED BY THE FEDERAL RADIO COMMISSION

Zone 1: Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Delaware, Maryland, District of Columbia, Porto Rico, Virgin Islands.

Zone 2: Pennsylvania, Virginia, West Virginia, Ohio, Michigan, Kentucky.

Zone 3: North Carolina, South Carolina, Georgia, Florida, Alabama, Tennessee, Mississippi, Arkansas, Louisiana, Texas, Oklahoma.

Zone 4: Indiana, Illinois, Wisconsin, Minnesota, North Dakota, South Dakota, Iowa, Nebraska, Kansas, Missouri.

Zone 5: Montana, Idaho, Wyoming, Colorado, New Mexico, Arizona, Utah, Nevada, Washington, Oregon, California, Hawaii, Alaska.

MANY CONTEMPLATE RADIO AS VOCATION

Although radio, as an industry, is well past the infant stage, it still holds the attraction of a pioneer business to many men and women. The National Union Radio Corporation advances this theory as a result of the wide response to its offer to send the National Union lecture course on radio tubes to those who were considering radio as their future vocation. This offer, made through the medium of the National Union radio program, attracted hundreds of replies. The writers were most eager to secure access to the information and data contained in the National Union lecture course, which embodies the principles, construction and operation of radio tubes.

While this course was primarily intended for those already engaged in radio and kindred industries, officials of the National Union Radio Corporation conceived the idea that it could also serve admirably as an introduction to radio for those who had in mind turning to radio as a business. The course is clearly and simply written so that it is easily understood by the laymen, and it gives a vivid picture of radio both from an historical and practical working angle.

RADIO INDUSTRY IMPROVING

Marked improvement in radio trade activities is evidenced by increasing orders and inquiries received by the Polymet Manufacturing Corporation, makers of radio set essential parts. As the radio parts business is generally a good radio trade barometer, this is information of considerable importance.

In accordance with the report of Mr. Nat. C. Greene, vice president of the Polymet Manufacturing Corporation, a survey among manufacturers shows that most of the distress merchandise has been absorbed and that the sales curve is commencing to swing upwards. Inventories are well reduced and manufacturers are finding it necessary to place parts orders for production programs now under way.

DUBILIER REPLACEMENT CONDENSER BLOCKS

Both for the purpose of replacing broken-down condensers and with a view to providing condensers of greater safety factor than the set manufacturer's original specifications the Dubilier Condenser Corporation, New York City, announces a comprehensive line of replacement condenser blocks. Dubilier stock replacement blocks are now available for Kodel "A" and Kuprox "A" eliminators, Greene-Brown "A" eliminator, Willard and Exide "B" eliminators, Freed-Eisemann "B" eliminator, RCA Loudspeaker 104, Garod, Freshman, Sentinel, Crosley, Zenith and Majestic radio sets.

CORWICO SUPER BRAIDITE

The Cornish Wire Company, 30 Church Street, New York City, announce a new hook-up wire known as Corwico Super Braidite.

In tests, Super Braidite was shown to have an average voltage breakdown of 1340 volts against 1000 volts for the ordinary hook-up wire.

Super Braidite can be readily stripped back with any automatic stripper, and the neat appearing, glossy, flame-proof insulation does not bunch up nor fray when pushed back. Corwico Super Braidite is made with a solid or stranded core in fifteen different color combinations.

To manufacturers using Super Braidite, the Cornish Wire Company supplies one of their Model A Stripping Machines.

INDISPENSIBLE TOOL FOR TESTING

A rugged, neat-appearing device, about the size of a fountain pen, has been introduced for testing power supply circuits up to 400 volts a-c. or d-c. For tracing whether or not power from mains or branch circuits—110 or 220 volts—is available at service outlets this little instrument is of real value as a time saver to the radio serviceman. The instrument is called a Testolite. It is manufactured by the L. S. Brack Mfg. Corpn., 127 Sussex Avenue, Newark, N. J.

ALL RADIO LISTENERS DO NOT HEAR TRANSMISSION EQUALLY WELL

Listening to the excellent reproduction from the loudspeaker of my—call it, "Radiomaker" receiver, which gives sufficient volume with good selectivity and faithful reproduction of the highest and lowest notes, my family seated comfortably in the library hears the best of the world's music as clearly as if they had journeyed by train, ferry and subway to the auditoriums where the artists appear in person before assembled patrons.

With such splendid reproduction it is easy to be enthusiastic about the art of the singers and the players; about transmission, modulation, adherence to exact frequency, and absence of distortion and other irregularities of broadcast operation. But the thought is present that with a million or more persons listening to the same transmission I hear, there must be many radio receivers in use which give poor results; results which throw undue discredit on the broadcast station and on the art of the performers.

It is the desire of the radio engineer to see the time when, through standardization of product, radio receivers will be available to all, which will give uniform results so that all may hear the matter sent out as it is originally produced in the studio, auditorium, dining room or hall.

"MIKE" MUST HAVE THE BEST

The listener's attitude toward the performers—the artists—is consciously associated with the atmosphere of the stage, as the listener from memory visualizes this, and with the habiliments of the performers; flowing locks, evening clothes and all. The radio broadcast art being new is served by artists trained in stage technique, in stage presentation. And, artists being of a temperamental mold, very likely would not do so well were they to appear before the microphone in raiment not suited to stage appearance before an audience which has provided itself with opera glasses.

Yet, what need is there before the microphone to wear the cloth? to beam forth ingratiating expressions or to curtsey? No need, unless the unseen habiliments and unseen motions from custom aid the performer in attaining excellence in the rendition of his piece.

In time a class of artists may come to the microphone who have no stage background—radio-trained artists who from experience as radio listeners-in have all needed assurance that their performances are being appreciatively heard by hundreds of thousands of persons. In that time the factors which create temperament in the artist shall have experienced change, and the broadcast studio may take on the appearance of a workshop, the broadcast performance being more in the nature of a mechanical task than of an auditorium recital.

There is a speculative—almost an amusing aspect to the spectacle of a man on a hot summer day wearing an overcoat (in order to render inconspicuous evening clothes) as he is sped by subway to play a xylophone before a radio microphone where none other is in attendance except an announcer.

BOOK REVIEWS

PHOTO ELECTRIC CELLS—202 *pages, 6x9½ inches. Hard cloth binding. Illustrated. Published by Isaac Pitman and Sons, New York. Price* $4.50.

This book will appeal to readers ranging from the professional physicist to the wireless amateur, and the difficulty of this wide range of readers has been overcome by adapting the treatment of each topic to the class whom it is likely to interest.

The contents cover mainly the problems and methods which have been studied and used by the authors, together with the larger problems and the sound methods of other experimenters and practicians. The division of the contents into three parts, dealing in turn with the Theory, the Use, and the Application of Photoelectric Cells, will enable the reader to obtain an immediate and clear view of the subject. Useful diagrams and illustrations supplement the text throughout the book.

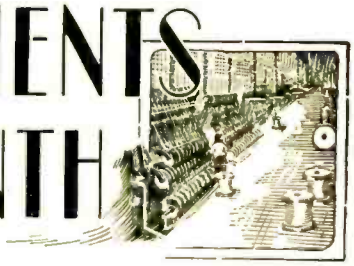
RADIO TRAFFIC MANUAL AND OPERATING REGULATIONS—187 *pages, 6x9 inches. Hard paper binding. Illustrated. Authors—Rudolph L. Duncan and Charles E. Drew. Published by John Wiley and Sons, Inc., New York.*

This book is of value to radio operators on shipboard and at shore stations. It is a complete guide for the handling of radiograms. It explains the forms and reports used by the radio employing companies and outlines the operating requirements at stations and offices. An excellent feature of the book is the inclusion of the articles of the International Telegraph Convention as applied to communication.

HOW TO PASS U. S. GOVERNMENT RADIO LICENSE EXAMINATIONS—167 *pages, 6½x9½ inches. Stiff paper binding. Illustrated. Published by John Wiley and Sons, New York. Price* $2.00.

This is a revised up-to-date edition of a standard book that has helped hundreds of radio operators to prepare for and pass Government examinations for radio service. The question and answer method is used throughout the work; the answers given in sufficient detail to be of real instructional value.

NEW DEVELOPMENTS OF THE MONTH



NEW A-C. TUBE CHECKER

The model "B" Day-Rad Tube Checker, recently developed by the Radio Products Co., Dayton, O., is applicable to tubes: 112, 199, 201A, 171, 226, 227, 210, 222,, 224, 240, 245, 250, 280, 281, Kellogg and Cardon. It can be plugged into any 110-v. 60 cycle. a-c. source and is supplied with extra leads for special types. Table of readings is engraved on the panel. There are no rheostats to regulate. Tests both types of type -80 rectifier tubes separately. It has a standard milliammeter, genuine D'Arsonval movement (either Jewell or Weston meter). It is housed in a moulded bakelite case wtih carrying strap.

NEW INDICATING FREQUENCY METER DEVELOPED BY WESTINGHOUSE

A new frequency meter of the indicating type has been developed by the Westinghouse Electric and Manufacturing Company in Newark, New Jersey. The design of this type SY frequency meter permits the production of instruments having a scale range of plus or minus 2 cycles for 60 cycle work, with operating torques at least equal to those used in corresponding voltmeters, and with a remarkable freedom from temperature or voltage error effects.

The earlier forms of frequency meters operating on the ratio principle used a divided electrical circuit, one branch being wound as non-inductively as possible, while the other side was made purposely as inductive as possible. As the frequency varied, the ratio between the currents in the divided circuit varied, and this allowed the instrument to be calibrated in terms of frequency.

The scale range of from 25 per cent below to 25 per cent above normal frequency was about the limit for such instruments making most of the scale range practically useless on modern systems, the frequency of which is maintained within close limits. The necessity for accurate indications within a narrow range of frequency only, led to the development of resonant circuits for the ratio type instruments, preferably using the dynamometer form of construction.

INDUSTRIAL TAPE HAS MANY USES

The industrial tapes manufactured by Johnson & Johnson, of New Brunswick, N. J. have many uses in radio manufacturing.

Some regular uses are:

Loudspeakers: Binding of paper edges or various joined pieces. Weighting—to change undesirable natural period of vibration. Binding of leads together. Padding under name plates or other loose metal parts to prevent rattling. Protective covering for armature and field windings.

Coils: Anchoring of leads at start and finish of coil. Covering of soldered joints due to breakage or flexible leads. Protection of taps. Binding of outer cover. Loops for securing first and last turns. Binding of core to replace metal clamps.

NEW ROLA ELECTRODYNAMIC SPEAKER

The Rola Company, of Cleveland, Ohio, announces a new line of electrodynamic speakers which are said to have extraordinary output efficiency, obtained by the use of high flux density in the air gap. An exclusive feature of this series is the removable center pole-piece which provides for easy elimination of any magnetic particles which may enter the gap.

These Rola power models meet the newer requirements for talking pictures, radio receivers and school systems.

AUTOMOBILE RADIO RECEIVER DATA INCLUDED IN NEW POLYMET LEAFLET

Among the interesting circuits discussed in Leaflet CL-1, the Polymet Manufacturing Corporation's new constructional booklet, is a practical and efficient automobile screen-grid superheterodyne receiver. Inasmuch as the automobile set is sweeping the country, this particular set should receive considerable attention from the radio amateurs and custom builders of the country.

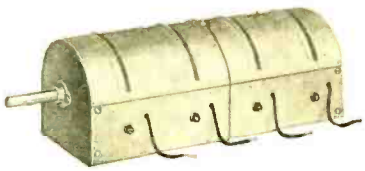
This particular hook-up was designed and perfected by one of the country's leading radio engineers for motor-car use or as a light-weight and efficient portable.

The Polymet Manufacturing Corporation, 829 East 134th St., New York City, will gladly send a copy of leaflet CL-1 on request.

FOUR GANG CONDENSER

The condenser, here illustrated, is manufactured by the Rochester Tool and Gauge Corporation, of Rochester, N. Y.

The compensator which is a part of each unit gives a variation in mmf. of approximately 40. Minimum capacity of the .0005 is 30 mmf. and .00135 is 24 mmf. The contour of the rotor is such that 40 per cent gives a kilocycle separation, the other 60 per cent a two-meter separation. The condenser will be furnished clockwise or counter-clockwise. The case of the condenser is made out of 3/32 in. sheet steel. The shaft supporting the rotors is 3/8 in. in diameter. This is held in



place by a split cone bearing in the front of the condenser. The rear of the shaft being supported by a thrust screw which supports a 3/16 in. diameter steel ball. The compensator of the condenser is adjusted from the outside of the shield and may be assembled on either the right or left-hand side. Flexible contact leads are furnished with all types of condensers. The shielding is so complete that there is absolutely no chance of the plates collecting dust nor does it need to have the bearings oiled for free action. The rotor and stator blades are made of a special hard sheet aluminum and are .032 in. thick.

NEW AEF AGENTS

The American Electric Fusion Corporation, Chicago, Illinois has just appointed R. D. Thomas & Co., of Philadelphia, Pennsylvania, as agents for AEF Spot, Seam and Tube Welders in Philadelphia and surrounding territory.

R. D. Thomas & Co. has a background of ten years of experience in welding equipment.

SELECTOR OF AUDIO FREQUENCIES (SAF)

The SAF 3, manufactured by Simplimus, Inc., Boston, Mass., is one of the most important advances in natural reproduction of sound since the advent of the talkies.

The SAF 3 is built to correct most of the defects encountered in present-day reproduction. It is designed to add brilliance and depth to reproduction. It will make the voice sound more natural and human, and the music more pleasing.

When playing an orchestra recording, the SAF 3 can take out the base horn without affecting the higher pitched instruments. It can also take out the high, shrilly notes without affecting the lows.

In voice reproduction the SAF 3 will eliminate the low drummy sounds which muffle the speech, and it will bring out the high frequencies necessary to clear articulation and pronunciation.

Full instructions how to attach accompany the SAF 3. It can be connected in a few minutes. Deliveries are immediate.

The SAF 3 Mixer will work with all makes of amplifiers and all makes of talking equipment.

POLYMET DEVELOPS NEW LINE OF RESISTORS AND VOLUME CONTROLS

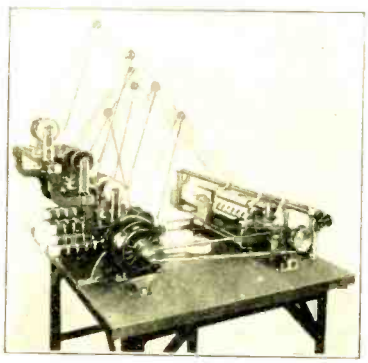
News of importance to the radio industry has come from 829 East 134th St., New York City, address of the Polymet Manufacturing Corporation, makers of Polymet condensers, resistors, coil windings, and magnet wires. This concerns the development of an entirely new line of carbon and wire-wound volume controls, including certain dual volume controls especially adapted for the radio set maker's use.

Another new development is in the Polymet wire-wound tubular resistors which are treated with a heavy coating of bakelite compound which will stand very high temperatures and offers excellent mechanical protection. New resistors of various types, and improved tapped voltage dividers round out this new Polymet line.

NEW COIL WINDING MACHINE

A new multiple coil winding machine with a capacity of twelve coil windings at a single operation, brought out by the Acme Electric and Manufacturing Company, of Cleveland, Ohio, is illustrated herewith. Wire sizes are from number 26 to 42.

The operation of the machine is accomplished through a double motor drive, and the main motor drives the winding spindle while the auxillary motor operates the feeding mechanism, spacing the wire so that a given number of turns are put on each layer.



At the end of the layer, through a cam mechanism, together with a mercury switch, the glassine paper is automatically inserted in the winding, and the machine winds another layer over this paper and then the operation continues.

ENGINEERING FACTS HAVE A UTILITY VALUE

VAN HORNE HAS NEW TIPLESS TUBE PROCESS

The Van Horne Tube Company possesses a unique patented construction feature for the production of the modern tipless radio tubes, and is the only independent company to possess such an individually original method.

The normally used means for providing the exhaust vent comprises a jet of compressed air which, when directed on the glass stem tube when red hot blows a hole through it.

In contrast, the Van Horne process is a mechanical one, utilizing a flexible metallic tube which, when removed after the stem is formed, leaves a properly sized and located aperture for exhausting.

Possession of this patented feature constitutes one of the most valuable assets owned by any independent in the tube manufacturing field and makes it possible to utilize tipless tube construction without infringement on other patents which may bear on this particular art.

NEW SHIELDED CONDENSER BY UNITED SCIENTIFIC LABORATORIES

The United Scientific Laboratories, 113 Fourth Avenue, New York City, have announced a new shielded condenser which they designate as type S.G. They claim the following advantages and features for this new unit.

Completely shielded stators with section shields protruding beyond the grid ends of the stators to eliminate every possible chance of coupling.

Individually grounded rotor wipe phosphor bronze contacts and extra heavy steel frame rigidly reinforced by section separators.

Minimum compensators of novel construction have a ground potential on the adjusting screw. This greatly facilitates balancing because the process of balancing is not affected by screw-driver or hand capacity.

Three brass bearings, including center bearing, are all line reamed insuring smooth rotor action and long life.

Bosses are arranged so that the condenser can be mounted on either bottom or side.

All metal parts are heavily cadmium plated to prevent tarnish and corrosion. Uniform precision spacing of rotors and stators permits tracking to within ½ of 1 per cent on any part of the scales.

The heavy drawn dust-proof cover completely encloses the unit. This gives additional rigidity to the entire assembly and makes a neat and compact job that improves the mechanical appearance of any set in which this new condenser is incorporated.

A NEW GAS-FILLED THERMIONIC RECTIFIER TUBE

High voltage d-c. power for the operation of radio transmitters has in most cases been obtained from d-c. electric generators, or through rectification of alternating current by means of high-vacuum tube rectifiers or mercury-arc rectifiers.

A new line of hot-cathode mercury-vapor rectifier tubes has been introduced by General Electric-Westinghouse-R. C. A., known as UX-866, UV-872, UV-869 and UV-857, which combine the advantages of the high-vacuum tube with the low and nearly constant arc-drop of the mercury-arc rectifier.

The idea of introducing a gas into a tube in order to neutralize the space charge is old, but with the exception of the Tungar rectifier there seems to have been but a limited application of the principle. The new tubes operate in the presence of gas at a low pressure (1-30 microns Hg) and are capable of operating at relatively high voltages. The presence of gas at high pressure gives adequate protection from cathode evaporation and the more serious trouble, cathode disintegration by positive ion bombardment. At low pressures the protective action against cathode evaporation is negligible. The new tubes operate on the principle that cathode disintegration may be entirely avoided if the arc-drop is maintained below a definite critical value; that is, at about fifteen volts.

The UX-866 operates on 2.5 volts, filament, five amperes, with a peak inverse voltage of 5,000 and a peak anode current of 0.6 ampere. UV-857 operates on five volts, filament, sixty amperes, with a peak inverse voltage of 20,000 and a peak anode current of twenty amperes.

A-C.-OPERATED PHONOGRAPH PICKUP IN PORTABLE FORM

A recent innovation in the musical field is a small portable phonograph with electrical pickup, operating on the usual a-c. electric light outlet, and developed by the Stevens Manufacturing Corporation of Newark, N. J.

The electric motor for the turntable operates in conjunction with a small transformer and special rectifier which supplies a direct current of 4½ volts and up to 180 milliamperes. There is positively no trace of a-c. hum in the entire assembly. The various components are mounted in a black leather carrying case. The motor is suspended on springs directly under the turntable, while the rectifier assembly is secured to the bottom of the carrying case. An electric phonograph pickup of unusually good characteristics completes the apparatus, which is capable of exceptionally fine reproduction when employed in conjunction with a satisfactory audio amplifier and loudspeaker.

A NEW STRIPER

A new striper, for continuous striping with lacquer, paint and aluminum bronze has been brought out by the Paasche Airbrush Company, 1909 Diversey Parkway, Chicago.

This striper has many uses in the manufacturing industries, making for improved appearance of products and for economy in production.

ONE WRAP INSTEAD OF TWO

TWIN TAPE, manufactured by The Dexter Rubber Co., Goshen, N. Y., eliminates the necessity of separate rubber and friction tape for wrapping wire joints. This tape, supplied through jobbers, is supplied in 2, 4 and 8 ounce rolls in standard widths.

LOFTIN-WHITE AMPLIFIER KIT, BUILT BY ELECTRAD

It has just been announced that Electrad, Inc., have cooperated for the past year with Edward Loftin and S. Young White, inventors of the direct-coupled amplifier bearing their name, in the production of a complete kit for the construction of this revolutionary circuit.

The Electrad, Loftin-White Amplifier, designated as the "A245," contains all parts except tubes, including a drilled metal chassis, self-contained a-c. power supply, special resistances and all accessories.

Utilizing one —24 screen-grid tube, one —45 output tube and one —80 rectifier, the assembled amplifier gives amazing undistorted volume and purity of tone, owing to its complete freedom from audible frequency discrimination, which limits the usefulness of old type amplifying systems.

The Electrad L-W Amplifier is designed primarily for use as a phonograph amplifier, but with the addition of a conventional coupling device it can be connected to various radio tuners, thus affording almost limitless uses in the hands of experimenters. A unique feature of this amplifier is the method of neutralizing a-c. hum by the simple adjustment of a Potentiometer.

GREATER EYE VALUE FOR VAN HORNE TUBES

The Van Horne Tube Company has completed development of a new type tube design which is known as the Van Horne "Ring Type" construction. This is in the form of a gold-plated ring or band which is incorporated in the tube assembly between the top of the base and the glass bulb.

This metal ring acts as a separator between the tube base and the glass bulb proper, and functions as a heat radiator, thus tending to keep the temperature, and consequently the electrical characteristics of the tube at a more uniform value. It also eliminates the unsightly features incidental to the cementing of the tube base to the glass bulb by preventing any of the cement from oozing out and making an unsightly line of demarkation between the top of the base and the glass bulb proper.

Aside from these technical features the use of the ring makes for a much better appearing tube, thus enhancing the merchandising value of the product.

The new construction has met with great favor among the trade and many expressions of unqualified approval testify to its enthusiastic reception in the merchandising field.

ROLLER-SMITH ANNOUNCEMENTS

The Roller-Smith Company, 233 Broadway, New York, N. Y., makes the following announcements:

Mr. M. W. Seymour is now associated with the New York office as a Sales Engineer. Mr. Seymour is a graduate of Brown University and for several months prior to his connection with the New York office he was located at the Company's works in Bethlehem, Penna.

Mr. H. D. Stier, 101 Marietta Street, Atlanta, Ga., now represents the Roller-Smith Company in the States of Alabama, Florida, Georgia, North Carolina and South Carolina.

H. N. Muller Company, First National Bank Bldg., Pittsburgh, Penna., now represents the Roller-Smith Company in Western Pennsylvania, West Virginia and the Youngstown District in Ohio. Associated with Mr. H. N. Muller are Mr. H. E. Ransford and Mr. F. E. Harper.

COLONIAL RADIO AND VALLEY APPLIANCES ANNOUNCE COMBINE

A significant news item of the day in the radio industry comes in the form of an official statement from Dr. Fulton Cutting, chairman of the board of the Colonial Radio Corporation, of Long Island City, who authorizes the public announcement of the combine of the interests of his corporation and Valley Appliances, Inc., of Rochester, N. Y. The latter concern, headed by W. S. Symington, has for several years been engaged in the manufacture of speakers and other products.

The officers and directors of the new Colonial Radio Corporation are as follows: President, W. S. Symington; Vice-President, in charge of sales, Fred G. Carson; Treasurer, E. J. Millin; Comptroller, R. E. Frederickson. The board of directors, of which Fulton Cutting is the chairman, includes Donald Symington, who is president of the Baltimore Trust Company, C. J. Symington, William C. Schmidt, W. S. Symington and Fred G. Carson.

In addition to its influence as one of the factors working toward stabilization of the radio industry, this progressive move is important to manufacturers, jobbers and dealers alike in that it combines the engineering production and financial resources of two strong corporations and makes possible still greater service for all concerned. Each division of the new corporation will continue to be operated as an independent unit, but the facilities of both will be greatly augmented.

STROMBERG-CARLSON SALES

Sales of Stromberg-Carlson receivers during the first seven days in February have borne out indications gained during January by exceeding sales of a similar period in February, 1929, according to Lloyd Spencer, Sales Manager of Gross-Brennan, Inc.

"Orders on the new phonograph combinations have exceeded all expectations," said Mr. Spencer, "the factory at the present time being far behind in production. A special sixteen-page section in one of the large New York dailies, devoted exclusively to Stromberg-Carlson is another indication of good business."

WALTER PIERCE OF EVANSTON HEADS MIDWEST

Walter Pierce of Pierce Radio Shop, Evanston was unanimously elected as President of Midwest Radio Trades Association at a meeting of the Board of Directors held recently.

Mr. Harry Alter of the Harry Alter Company has been President of the Association since last June. Mr. Alter resigned and Mr. Walter Pierce was elected to succeed him.

The election of Mr. Pierce was very fortunate as it places at the head of the local radio trade association a radio dealer of many years experience who is also well acquainted with all phases of association work.

Mr. Harry Simmons was elected as Secretary to the place vacated by John M. Redell, Jr., recently deceased.

The MidWest Radio Trades Association is starting on an active campaign for the betterment of the radio industry in Chicago and metropolitan area and with Mr. Pierce at the helm, the Association is bound to succeed in their activities.

NEW OXFORD DYNAMIC SPEAKERS

The Oxford Radio Corporation, of 3200 West Carroll Avenue, Chicago, last month announced new additions to its comprehensive line of electrodynamic speakers. In one instance Oxford engineers have developed a universal transformer with tapped connections, permitting connection to radio receiving sets having various outputs. By means of this transformer direct connection can be made in two -50 tubes in push-pull, two -45 tubes in push-pull and two -71-A tubes in push-pull, as well as to sets arranged for use with magnetic speaker or using the conventional output chokes.

Oxford also furnishes special transformers to meet any other conditions, as in the case of powerful theatre equipment employing two No. 250 tubes in parallel and for other amplifying devices with exceptionally high-powered outputs.

HOME "TALKIE" OUTFIT IN PRODUCTION

For the benefit of those movie enthusiasts who now have home moving picture projectors, the Stevens Manufacturing Corporation of Newark, N. J., has designed a small home "talkie" outfit. This assembly incorporates an electric phonograph turntable, an electrical pickup, a powerful audio amplifier, a Stevens super-dynamic speaker, and an a-c. power supply that furnishes current for the operation of the entire assembly. The equipment is in actual production and available to the public at the present time.

In addition to its use as a home sound reproducer, the same chassis has been incorporated in an ingenious record demonstration phonograph for music dealers. Through its all-electric operation and simplicity of design, this practical console makes possible the demonstration of phonograph records with a minimum of effect and a maximum of effect.

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 72.

ADAPTERS:
Lynch, Arthur H., Inc.

ALUMINUM:
Aluminum Co. of America
Fairmont Manufacturing Co.

ALUMINUM, SHEET:
Fairmont Mfg. 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.
H. J. L. Laboratories
Radio Receptor Co., Inc.
Samson Elec. Co.

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

ARRESTERS, LIGHTNING:
Jewell Elec. Inst. Co.

BASES, SPEAKER:
American Felt Co.
Booth Felt Co.
Western Felt Company

BASES, VACUUM TUBE:
(See Tube Parts)

BEARINGS, RADIALL:
Chicago Gear Works

BENCHES, STEEL WORK:
Standard Pressed Steel Co.

BINDING POSTS:
General Radio Co.

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

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

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

BUTTS:
Scovill Mfg. Co.

CABINETS, METAL:
Aluminum Co. of America
Metal Specialty Co.

CASTINGS:
Fairmont Mfg. Co.

CELLS, PHOTOELECTRIC:
National Carbon Co., Inc.

CEMENT, LOUD SPEAKER:
Maas & Waldstein Co.

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

CHASSES
Aluminum Co. of America
Metal Specialty Co.

CHOKES, AUDIO FREQUENCY:
American Transformer Co.
Ferranti, Inc.
General Radio Co.
Jefferson Electric Co.
Polymet Mfg. 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, POWER:
American Transformer Co.
Dongan Elec. Mfg. Co.
Ferranti, Inc.
General Radio Co.
Jefferson Electric Co.
Polymet Mfg. Corp.
Transformer Corp. of Amer.

CLAMPS, GROUND:
Scovill Mfg. Co.

CLIPS, SPRING:
Electrad, Inc.
Scovill Mfg. Co.

CLOTH, WIRE:
(See Wire Cloth)

COIL FORMS:
General Radio Co.

COIL WINDING:
Acme Wire Co.
Dudlo Mfg. Co.
Inca Mfg. Co.
Polymet Mfg. Corp.
Rome Wire Co.

COILS, CHOKE:
Acme Wire Co.
Dudlo Mfg. Co.
Ferranti, Inc.
Jefferson Electric Co.
Polymet Mfg. Corp.
Rome Wire Co.
Westinghouse Elec. & Mfg. Co.

COILS, IMPEDANCE:
Acme Wire Co.
Dudlo Mfg. Co.
Ferranti, Inc.
Polymet Mfg. Corp.
Rome Wire Co.

COILS, INDUCTANCE:
Acme Wire Co.
Cardwell, Allen, D., Mfg. Co.
General Radio Co.
Hammarlund Mfg. Co.
Inca Mfg. Co.
Rome Wire Co.

COILS, MAGNET:
Acme Wire Co.
Dudlo Mfg. Co.
Inca Mfg. Co.
Polymet Mfg. Corp.
Rome Wire Co.

COILS, SHORT WAVE:
General Radio Co.
Hammarlund Mfg. Co.

COILS, TRANSFORMER:
Acme Wire Co.
Dudlo Mfg. Co.
Polymet Mfg. Corp.
Rome Wire Co.

CONDENSER PARTS:
Aluminum Co. of America
Ferranti, Inc.
Metal Specialty Co.
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.
Igrad Condenser & Mfg. Co., Inc.
Polymet Mfg. Corp.
Potter Co., The
Sprague Specialties Co.
Thomas Engineering & Mfg. Co.

CONDENSERS, ELECTROLYTIC:
Amrad Corporation
Sprague Specialties Co.

CONDENSERS, FILTER:
Acme Wire Co.
Aerovox Wireless Corpn.
Amrad Co.
Condenser Corp. of America
Dongan Electric Mfg. Co.
Dubilier Condenser Mfg. Co
Igrad Condenser & Mfg. Co., Inc.
Polymet Mfg. Corp.
Potter Co., The
Sprague Specialties Co.
Thomas Engineering & Mfg. 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.
Polymet Mfg. Corp.
Potter Co., The
Sprague Specialties Co.
Thomas Engineering & Mfg. Co.

CONDENSERS, MIDGET:
Cardwell, Allen D. Mfg. Co.
General Radio Co.
Hammarlund Mfg. Co.
Polyment Mfg. Co.
Scovill Mfg. Co.
Sprague Specialties Co.
United Scientific Laboratories

CONDENSERS, MULTIPLE:
Cardwell, Allen D. Mfg. Co.
Hammarlund Mfg. Co.
Scovill Mfg. Co.
United Scientific Laboratories

CONDENSERS, NEUTRALIZING:
Hammarlund Mfg. Co., Inc.
Polymet Mfg. Corp.

CONDENSERS, VARIABLE TRANSMITTING:
Cardwell, Allen D. Mfg. Co.
General Radio Co.
Hammarlund Mfg. Co.

CONDENSERS, VARIABLE:
Cardwell, Allen D. Mfg. Co.
Frost, Herbert H., Inc.
General Radio Co.
Hammarlund Mfg. Co.
Scovill Mfg. Co.
United Scientific Laboratories

CONNECTORS:
Cornish Wire Co.
Scovill Mfg. Co.

CONTROLS, CURRENT:
Allen Bradley Co.
Central Radio Laboratories
Polymet Mfg. Corp.
Shallcross 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:
Scovill Mfg. Co.

CORDS, EXTENSION:
Acme Wire Co.
Anaconda Wire & Cable Co.
Cornish Wire Co.
Polyment Mfg. Co.

COUPLINGS, FLEXIBLE:
Chicago Gear Works
Hammarlund Mfg. Co., Inc.

CUSHIONS, SPEAKERS:
Western Felt Co.

DIALS:
Crowe Nameplate & Mfg. Co.
General Etching & Mfg. Co.
Hammarlund Mfg. Co.
Scovill Mfg. Co.
United Scientific Laboratories

DIALS, DRUM:
Hammarlund Mfg. Co.
United Scientific Laboratories

DIE-CASTINGS:
Allied Die-Casting Corp.

DIES:
Willor Mfg. Corp.

DYNAMOTORS:
Electric Specialty Co.

ESCUTCHEONS:
Crowe Nameplate & Mfg. Co.
General Etching & Mfg. Co.
Scovill Mfg. Co.

EXPORT:
Ad. Auriema, Inc.

FELT, ACOUSTICAL:
American Felt Co.
Booth Felt Co.
Western Felt Co.

FELT, PACKING:
American Felt Co.
Booth Felt Co.
Western Felt Co.

FILAMENTS:
(See Tube Parts)

FILAMENT CONTROLS, AUTOMATIC:
Amperite Corp.
Lynch, Arthur H., Inc.
Polymet Mfg. Corp.

FOIL:
Aluminum Co. of America
Lehmaier, Schwartz & Co., Inc.

FRICTION TAPES:
Mitchell Rand Mfg. Co.

GALVANOMETERS:
Ferranti, Inc.
General Electric Co.
General Radio Co.
Jewell Elec. Inst. Co.
Westinghouse Elec. & Mfg. Co.

GEARS:
Chicago Gear Works

GENERATORS:
Electric Specialty Co.
Janette Mfg. Co.

GETTER MATERIAL:
(See Tube Parts)

GRID LEAKS:
(See Resistances, Fixed)

HEADPHONES:
Amplion Co. of Amer.

HINGES:
Scovill Mfg. Co.

HORNS:
Amplion Co. of Amer.

INDUCTANCES, TRANSMITTING:
General Radio Co.

INSTRUMENTS, ELECTRICAL:
Ferranti, Inc.
General Electric Co.
Jewell Elec. Inst. Co.
Westinghouse Elec. & Mfg. Co.

INSULATION LAMINATED:
Electrical Insulation Corp.
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.
Monowatt Elec. Corp.
National Vulcanized Fibre Co
Synthane Corp.
Westinghouse Elec. & Mfg. Co.

INSULATION, REFRACTORY:
The Stupakoff Labs.

INSULATION, VARNISHED:
Acme Wire Co.

JACKS:
Carter Radio Co.
Electrad, Inc.
General Radio Co.

KITS, TESTING:
(See Testing Kits)
General Radio Co.
Jewell Elec. Inst. Co.

LABORATORIES, TESTING:
Electrical Testing Labs.
Wireless Egert Engineering, Inc.

LACQUER, WOOD:
Maas & Waldstein Co.

LACQUER, METAL:
Maas & Waldstein Co.

LACQUER, ENAMEL:
Maas & Waldstein Co.

LAMINATIONS:
Lamination Stamping Co.
Willor Mfg. Corp.

LAMPS, MINIATURE:
National Carbon Co., Inc.

LAMPS, PANEL:
National Carbon Co., Inc.

LEAD-INS:
Electrad, Inc.

LOCK WASHERS:
Shakeproof Lock Washer Co

LUGS:
Scovill Mfg. Co.
Shakeproof Lock Washer Co.

MACHINERY, TUBE:
American Transformer Co.
Arrow Mfg. & Machine Co., Inc.
Frank Cswerwenka
Central Scientific Labs.
Eisler Electric Co.
Int'l Machinery Works, Inc.
Lepel High Frequency Labs.

MACHINES, SPECIAL
Willor Mfg. Corp.

MAGNESIA, TUBES:
The Stupakoff Labs.

MAGNESIUM:
Aluminum Co. of America.

METAL RADIO PARTS:
The Metal Specialty Co.

METALS, RARE:
Fansteel Products Co., Inc.
American Electro Metal Corp.

METERS:
Ferranti, Inc.
General Electric Co.
Jewell Elec. Inst. Co.
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
(See Insulation, Moulded)

MOTORS:
Electric Specialty Co.

MOTOR-GENERATORS:
Electric Specialty Co.

MOUNTINGS, RESISTANCE:
Electrad, Inc.
Lynch Mfg. Co., Inc.
Polymet Mfg. Corp.

NAMEPLATES:
Crowe Nameplate & Mfg. Co.
General Etching & Mfg. Co.
Scovill Mfg. Co.

NICKEL SILVER:
National-Harris Wire Co.
Riverside Metal Co., The

NUTS:
Shakeproof Lock Washer Co.

OHMMETERS:
General Radio Co.
Weston Elec. Instr. Co.

OSCILLOGRAPH:
General Radio Co.

PACKING PADS, CABINET:
American Felt Co.
Booth Felt Co.
Western Felt Co.

PACKING MATERIAL:
Holed-Tite Packing, Inc.

PANELS, COMPOSITION:
(See Insulation, Moulded)

PANELS, METAL:
Aluminum Co. of America
Metal Specialty Co.
Radio Receptor Co., Inc.
Scovill Mfg. Co.

PAPER, CONDENSER:
Dexter, C. H. & Sons, Inc
The Old Masters Paper & Pulp Corp.

PAPER, CONE SPEAKER:
Seymour Co.

PARTS, SCREW MACHINE:
Standard Pressed Steel Co.

PHONOGRAPH MOTORS:
(See Motors)

PHOSPHOR BRONZE:
Baltimore Brass Co.
National-Harris Wire Co.
Riverside Metal Co.

PHOTOELECTRIC CELLS:
(See Cells)

PICK-UPS, PHONOGRAPH:
Amplion Co. of Amer.
Electro-Acoustic Prod. Co.
Hardwick, Hindle, Inc.
Jensen Co.

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PLUGS, ATTACHMENT:
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General Radio Co.
Polymet Mfg. Corp.

PORCELAIN TUBING:
The Stupakoff Labs.

POTENTIOMETERS:
Allen-Bradley Co
Central Radio Laboratories
Electrad, Inc.
General Radio Co.
Polymet Mfg. Corp.
United Scientific Laboratories

POWER UNITS, A-:
Jefferson Electric Co
Radio Receptor Co., Inc.

POWER UNITS, B-:
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General Radio Co.
Jefferson Electric Co.
Thordarson Electric Mfg. Co.

POWER UNITS, A-B-C:
Dongan Elec. Mfg. Co.
General Radio Co.
Jefferson Electric Co.
Thordarson Electric Mfg. Co.

POWER UNITS, PARTS FOR:
Acme Wire Co.
American Transformer Co.
Dongan Elec. Mfg. Co.
Ferranti, Inc.
General Radio Co.
Jefferson Electric Co
Lynch, Arthur H., Inc.
Polymet Mfg. Corp.
Thordarson Electric Mfg. Co.
Transformer Co. of Amer.

PRESSED METAL PARTS:
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PUBLIC ADDRESS SYSTEMS:
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Samson Elec. Co.

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Chicago Gear Works

PUMPS, HIGH VACUUM:
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Scovill Mfg. Co.

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DeJur-Amsco Co.
Polymet Mfg. Corp.

RELAYS:
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Leach Relay Co.

REPRODUCERS, TALKING MOTION PICTURES:
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Allen-Bradley Co.
Central Radio Laboratories
Clarostat Mfg. Co.
The Daven Corp.
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Electro-Motive Co.
Ferranti, Inc.
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General Electric Co.
Hardwick, Hindle Inc.
International Resistance Co.
Lynch, Arthur H., Inc.
Polymet Mfg. Corp.
Superior Resistor Corp.
The S. S. White Dental Mfg. Co.

RESISTANCES, VARIABLE:
Allen-Bradley Co.
Central Radio Laboratories
Clarostat Mfg. Co.
Electrad, Inc.
Frost, Herbert H.
General Electric Co.
Hardwick, Hindle, Inc.
International Resistance Co.
Lynch, Arthur H., Inc.
Polymet Mfg. Corp.
Shallcross Mfg. Co.

RHEOSTATS:
Allen-Bradley Co.
Central Radio Laboratories
Electrad, Inc.
Frost, Herbert H.
General Radio Co.
Polymet Mfg. Corp.
United Scientific Laboratories
Westinghouse Elec. & Mfg. Co.

SCREW MACHINE PRODUCTS:
Aluminum Co. of America
National Vulcanized Fibre Co.
Scovill Mfg. Co.
Standard Pressed Steel Co.
Synthane Corp.

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Parker-Kalon Corp.

SCREWS, DRIVE, HARDENED METALLIC:
Parker-Kalon Corp.

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Hammarlund Mfg. Co., Inc.

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Carter Radio Co.

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Lynch, Arthur H., Inc.

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Kester Solder Co.
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Oxford Radio Corp.

SPAGHETTI:
(See Wire, Spaghetti).

SPEAKER PARTS, METAL:
The Metal Specialty Co.

SPEAKERS:
Amplion Corp. of Amer.
Electro-Acoustic Prod. Co.
Jensen Radio Mfg. Co.
Potter Co., The
Transformer Co. of Amer.

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Chicago Gear Works

STAMPINGS, METAL:
Aluminum Co. of America
Metal Specialty Co.
Scovill Mfg. Co.

SUBPANELS:
Formica Ins. Co.
General Radio Co.
National Vulcanized Fibre Co.

SWITCHES:
Electrad, Inc.
Ferranti, Inc.

TABLES, STEEL WORK:
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TAPE, INDUSTRIAL:
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Johnson and Johnson

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TESTERS, B-ELIMINATOR:
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Weston Elec. Inst. Co.

TESTING INSTRUMENTS:
Ferranti, Inc.
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General Radio Co.
Jewell Elec. Inst. Co.
Radio Products Co.
Westinghouse Elec. & Mfg. 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:
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TOOLS:
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TRANSFORMERS, AUDIO:
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Jefferson Electric Co.
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Samson Elec. Co.
Thordarson Electric Mfg. Co.
Transformer Corp. of America

TRANSFORMERS, B-POWER UNIT:
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General Radio Co.
Jefferson Electric Co.
Radio Receptor Co., Inc.
Samson Elec. Co.
Thordarson Electric Mfg. Co.
Transformer Corp. of America

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Radio Receptor Co., Inc.
Samson Electric Co.

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General Radio Co.
Jefferson Electric Co.
Thordarson Electric Mfg. Co.
Transformer Corp. of America

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Radio Receptor Co., Inc.
Samson Elec. Co.
Thordarson Electric Mfg. Co.
Transformer Corp. of America

TRANSFORMERS, POWER:
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General Radio Co.
Jefferson Electric Co.
Polymet Mfg. Co.
Radio Receptor Co., Inc.
Samson Elec. Co.
Thordarson Electric Mfg. Co.
Transformer Corp. of America

TRANSFORMERS, R. F., TUNED:
Cardwell, Allen D. Mfg. Co.
Hammarlund Mfg. Co., Inc.

TRANSFORMERS, STEP-DOWN:
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Radio Receptor Co., Inc.

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See (Machinery, Tube.)

TUBE, PACKING:
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TUBE PARTS:
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Buffalo Wire Works Co., Inc.
Callite Products Co., Inc.
Cleveland Wire Cloth & Mfg. Co.
Fansteel Products Co., Inc.
General Plastics, Inc.
Gilby Wire Co.
Goat Radio Tube Parts Inc.
Lepel High Freq. Labs.
Nat'l.-Harris Wire Co.
Newark Plate Laboratories
Newark Wire Cloth Company
The Stupakoff Labs.
Synthane Corp., Inc.
(See Parts, Tube.)

TUBE TESTERS:
(See Testers, Tube)

TUBES, A.C.:
Arcturus Radio Co.
Cable Radio Tube Co.
De Forest Radio Co.
Hyvac Radio Tube Co.
Marvin Radio Tube Corp.
National Carbon Co., Inc.
Perryman Electric Co.
Sylvania Products Co.
Televocal Corp.

TUBES, RECTIFIER:
Arcturus Radio Co.
Cable Radio Tube Co.
De Forest Radio Co.
Hyvac Radio Tube Co.
National Carbon Co., Inc.
Perryman Electric Co.
Sylvania Products Co.
Televocal Corp.

TUBES, SCREEN GRID:
Arcturus Radio Co.
Cable Radio Tube Co.
De Forest Radio Co.
Hyvac Radio Tube Co.
National Carbon Co., Inc.
Perryman Electric Co.
Sylvania Products Co.
Televocal Corp.

TUBES, TELEVISION
See *(Cells, Photoelectric.)*

TUBING, NICKEL:
National-Harris Wire Co.

TUBING, REFRACTORY:
Stupakoff Labs, Inc.

TUBING, VARNISHED:
Alpha Wire Corp.

UNITS, SPEAKER:
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Jensen Radio Mfg. Co.
Wright DeCoster, Inc.

UNIVERSAL JOINTS:
Chicago Gear Works

VARNISH:
Maas & Waldstein Co.

VOLTAGE REGULATORS:
(See Regulators)

VOLTMETERS, A. C.:
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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:
American Felt Co.
Aluminum Co. of America
Booth Felt Co.
Electrical Insulation Corp.
Scovill Mfg. Co.
Shakeproof Lock Washer Co.
Synthane Corp.
Western Felt Co.

WAXES, IMPREGNATING:
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Cochrane Chemical Company

WAXES, INSULATING:
Candy and Co.
Cochrane Chemical Company

WAXES, SEALING:
Candy and Co.
Cochrane Chemical Co.

WIRE, ANTENNA:
Acme Wire Co.
Alpha Wire Corp.
Anaconda Wire & Cable Co.
Cornish Wire Co.
Dudlo Mfg. Corp.
National Vulcanized Fibre Co.
Roebling, J. A., Sons Co.
Rome Wire Co.

WIRE BALLAST:
National-Harris Wire Co.

WIRE, BARE & TINNED COPPER:
Alpha Wire Corp.
Anaconda Wire & Cable Co.
Cornish Wire Co.
Dudlo Mfg. Corp.
Roebling, J. A., Sons, Co.
Rome Wire Co.
Spargo Wire Co.

WIRE CLOTH:
Buffalo Wire Works Co., Inc.
Gilby Wire Co.
Cleveland Wire Cloth & Mfg. Co.

WIRE, COTTON COVERED:
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Anaconda Wire & Cable Co.
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Dudlo Mfg. Corp.
Polymet Mfg. Corp.
Roebling, J. A., Sons Co.
Rome Wire Co.

WIRE, ENAMELED COPPER:
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Alpha Wire Corp.
Anaconda Wire & Cable Co.
Cornish Wire Co.
Dudlo Mfg. Corp.
Polymet Mfg. Corp.
Roebling, J. A., Sons Co.
Rome Wire Co.

WIRE, FILAMENT:
American Electro Metal Corp.
Callite Products Co., Inc.
Cornish Wire Co.
Fansteel Products Co., Inc.
Gilby Wire Co.
National-Harris Wire Co.

WIRE, HOOK-UP:
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Alpha Wire Corp.
Cornish Wire Co.
Dudlo Mfg. Co.
Roebling, J. A., Sons, Co.
Rome Wire Co.

WIRE, LITZENDRAHT:
Dudlo Mfg. Corp.
Roebling, J. A., Sons Co.
Rome Wire Co.

WIRE, MAGNET:
Acme Wire Co.
Anaconda Wire & Cable Co.
Dudlo Mfg. Corp.
Inca Manufacturing Co.
Polymet Mfg. Corp.
Rome Wire Co.

WIRE, MOLYBDENUM:
American Electro Metal Corp.
Callite Products Co., Inc.
Fansteel Products Co., Inc.

WIRE, PIGTAIL:
Dudlo Mfg. Corp.
Roebling, J. A., Sons Co.
Rome Wire Co.

WIRE, RESISTANCE
Alloy Metal Wire Co.
Anaconda Wire & Cable Co.
Fansteel Products Co., Inc.
Gilby Wire Co.
National-Harris Wire Co.

WIRE, SILK COVERED:
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Alpha Wire Corp.
Anaconda Wire & Cable Co.
Cornish Wire Co.
Radio Wire Corp.
Roebling, J. A., Sons Co.
Rome Wire Co.

WIRE, SPAGHETTI:
Acme Wire Co.
Alpha Wire Corp.
Cornish Wire Co.
Rome Wire Co.

WIRE, TANTALUM:
Fansteel Products Co., Inc.

WIRE, TINNED COPPER:
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Anaconda Wire & Cable Co.
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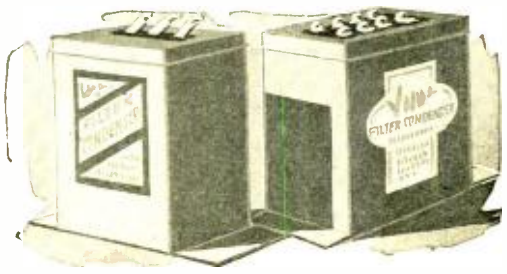

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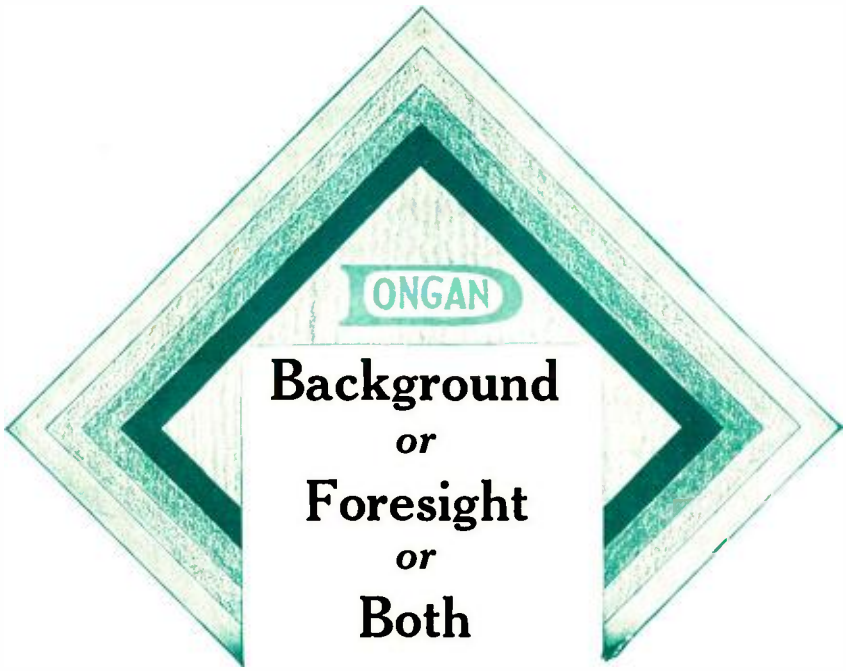

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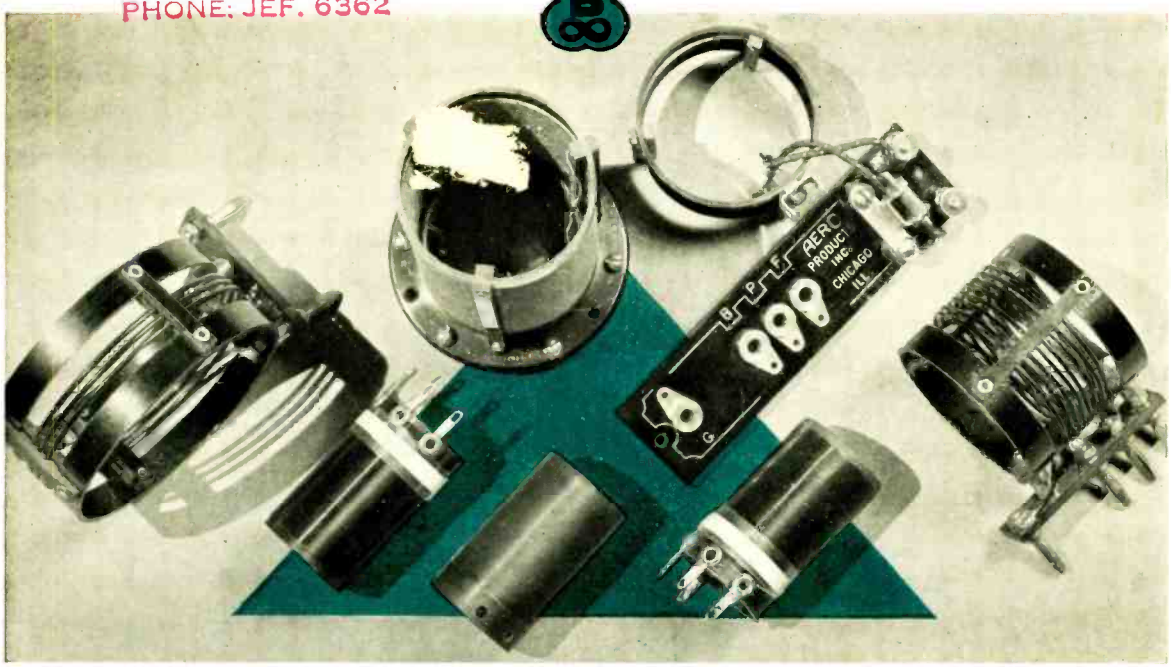

Radio Frequency Coils and threaded coil form of Bakelite Molded, made by Real Equity Shop, Chicago, Ill.
Short and high wave coils of Bakelite Laminated, made by Aero Products, Inc., Chicago, Ill.

Eighty threads to the inch

hair line accuracy possible with Bakelite Molded

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