NINTH YEAR OF SERVICE

# RADIO ENGINEERING

Vol. IX [illegible] Number 3

## IN THIS ISSUE



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The JOURNAL of the RADIO INDUSTRY

# *Surpasses even itself!*

Peerless Insulation today is a product of evolution. Every property possessed by the first sheet of Peerless has been developed and intensified by scores of improvements during the forty years this remarkable insulation has served industrial America.

The fabric as produced today has a much higher tensile strength. It easily folds with or across the grain without cracking at the fold. Absolute uniformity in thickness has been achieved, as well as a fine, even finish. A new chemical treatment has made it denser and harder, too, without impairing the high dielectric strength which has always characterized Peerless Insulation.

Check up on the service requirements of your products. If any of them need the advantages offered by Peerless, *use* Peerless; for only in this super-paper will you find all these desirable properties present in their relative importance.

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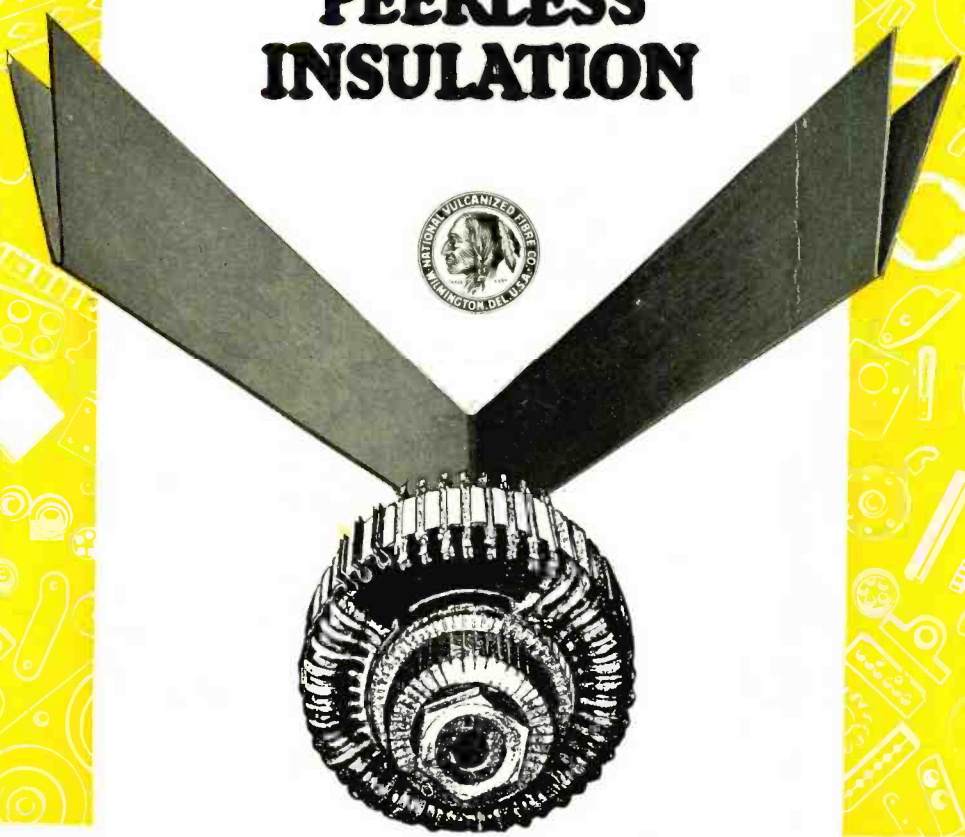

# COMPETITION *in* QUALITY *Pays*

There has been a steady increase in the amount of Formica used by the leading electrical manufacturers for many years.

This increase has been due in large part to the fact that cheaper, less reliable materials have been replaced.

By increasing their material costs, manufacturers have reduced costs due to service, replacement and trouble, by a larger amount.

Steadily growing use of this non-absorbant, uniform and dependable insulating material, is proof that it pays to use it.

Quick service from a centrally located plant on a quality material made by an organization of specialists.... that's what Formica offers.

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# RADIO ENGINEERING

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*Associate Editor*
AUSTIN C. LESCARBOURA

**Vol. IX** **March, 1929** **Number 3**


## *Contents*



## *Departments*



## Comment on Forthcoming Articles

WE are sure our readers will be pleased to learn that John F. Rider is to be with us again. Since the termination of his series of articles on "The Mathematics of Radio," Mr. Rider has been investigating the problems of servicing and the matter of its relation to the radio industry. His studies of this phase of the radio field have brought to light some very interesting conditions which, up to the present, have been overlooked.

Mr. Rider is incorporating his findings into a series of articles. He is at work on the first installment now and hopes to have it prepared in time for the April issue.

Our schedule includes a very fine article on die castings, as applied to radio manufacturing. The author undoubtedly has a warm spot in his heart for design and production engineers, for he has voluntarily provided valuable data on die casting problems, which, ordinarily, is not given out freely. The first part of the article covers the history of die casting and is very colorful in description.

An authority on condenser paper; on all paper, for that matter, is preparing a special article for RADIO ENGINEERING, covering important considerations involved in the testing and "determination" of condenser papers. This is a subject which should have the attention of every condenser, amplifier and set manufacturer; its importance is obvious. The article will be illustrated with numerous micro-photographs of typical specimens.

The first and only description of an entirely new audio-frequency amplifier system will appear in an early issue. The most interesting feature of this new amplifier is the total absence of the usual C-biasing potential. As a matter of fact, the circuit is a radical departure from general practise.—*Editor.*


*Published Monthly by*

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**New York City**

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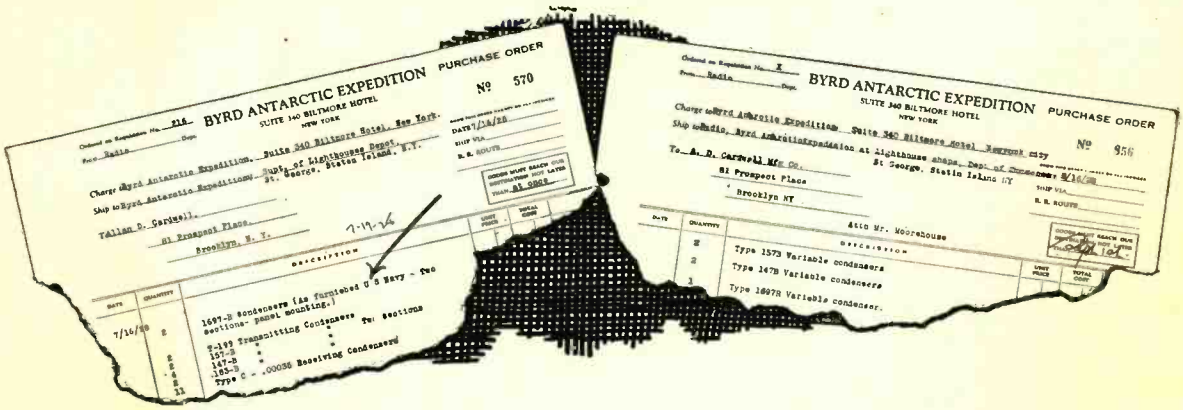
# *Selected and Ordered*

## BY THE HEADQUARTERS OF THE

# BYRD EXPEDITION




**We are authorized to state, without qualification, that *all* transmitting equipment *built by* the Byrd Expedition constructors is equipped with Cardwell condensers. Keeping BYRD in touch with the world, this equipment is daily transmitting thousands of words to the New York Times (WHD), also CARDWELL equipped, and in constant touch with the expedition.**

## CHOSEN BECAUSE THEY ARE

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**Transmitting Condensers For Powers up to 50 K.W. and More (Fixed and Variable) Receiving Condensers in all Standard Capacities**

**AS SIMPLE, RUGGED AND STRONG As condensers can be made**

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# The Allen D. Cardwell Mfg. Corp.

81 Prospect Street, Brooklyn N. Y.

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# EDITORIAL

*March 1929*

## WIRED RADIO

WITHIN a few months, Wired Radio, Inc., a subsidiary of the North American Company, will commence activities in Cleveland, Ohio. More than likely complete wired radio service will be instituted by June; the installation of equipment in the power houses and sub-stations is already under way.

It is the intention of the North American Company to extend wired radio service throughout the entire west and middle-west, or, in other words, wherever subsidiaries of the parent company are located.

The North American public utility network does not extend to the east. Eastern public utility companies are subsidiaries of the Electric Bond and Share Corporation. It is probable, however, that the North American Company will consider the licensing of eastern companies under their wired radio patents and lease them the necessary equipment. In such an event the wired radio network will eventually cover the United States.

The wired radio structure appears to be comparatively sound. Three programs will be transmitted simultaneously over the light wires on probable frequency bands of 25, 45 and 60 kilocycles. The consumer will be able to select any one of the three programs, during the hours of transmission, and will be assured of excellent reception. It is understood that single sideband transmission is to be employed.

If this new service proves a success, the transmission of programs will eventually be followed by television service. Synchronization is easily obtained on the service lines and there are no restrictions on the width of the frequency channel employed. Very good results are being obtained over the light lines, using a channel 100 kilocycles in width.

We have heard that some executives in the radio industry are viewing the wired radio situation with alarm. Personally, we see no good reason for anyone to get all lathered up about it. Nevertheless, the question arises as to what effect wired radio may have on radio broadcasting—or more generally, what effect it will have on the radio industry. Though we cannot answer the question fully, we can supply a few known facts.

The North American Company is principally interested in increasing the annual revenue of its subsidiaries. The company is not interested in the business from a manufacturing standpoint. All equipment is being built "on the outside" (for the most part, by radio manufacturers), and the wired radio receivers are to be leased in the same manner that a telephone is leased; the consumer paying so much a month for the use of the equipment, plus program services rendered. Furthermore, the transmitting equipment is to be leased to the public utility companies.

The North American Company is not desirous of competing with the radio industry; it is to their advantage that consumers continue the use of the radio broadcast receivers, as well as all other devices that consume current. The scheme loses a large amount of its profit-making possibilities in the event that wired radio were merely to replace the radio broadcast receiver. Profit lies in the addition of wired radio equipment, which also consumes current.

From all indications, the North American Company wishes to cooperate with the radio industry in any way it can, or in any way that it is allowed to cooperate. It is reported that arrangements have been made with one of our largest broadcast chains to have their programs re-broadcast over the wired radio network. The idea must be compatible to both organizations.

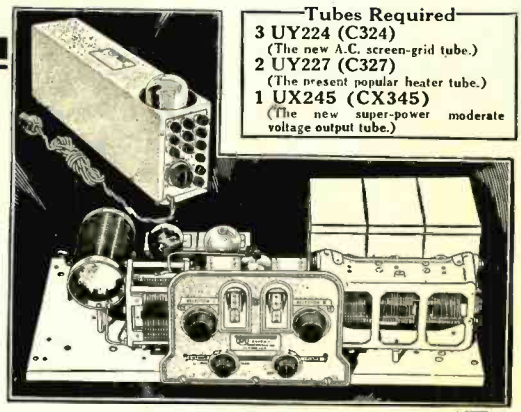
The public has an ungodly appetite for all instruments which will provide home entertainment. You can't stop them with a single instrument; they always come back for more. They can easily assimilate both radio and wired radio without becoming saturated. Besides, due to the fundamental natures of radio and wired radio, one cannot replace the other. They are more apt to assist each other. At any rate, why froth at the mouth?

M. L. MUHLEMAN, *Editor.*

# SM 1930 Reception Will be Different!

## Try It NOW and See—in the New

# S-M 720AC All-Electric Screen-Grid Six



**Tubes Required**
3 UY224 (C324)
(The new A.C. screen-grid tube.)
2 UY227 (C327)
(The present popular heater tube.)
1 UX245 (CX345)
(The new super-power moderate voltage output tube.)

## Know How Next Year's Best Will Sound

A SCREEN-GRID tube with A. C. heater-type filament, *nearly twice as good* as the wonderful UX222—and the '22 in S-M 1929 sets is enabling S-M setbuilders to get station after station never heard with common factory-built sets. . . A power tube with more than sufficient undistorted output capacity to fill the best dynamic speaker—yet *without* the high plate voltage required for the 250. . . Every refinement of precision manufacture as built into the tremendously successful 720 (D.C.) Screen-Grid Six—plus improvements which make the new 720AC All-Electric a set capable of far better reception, both as to distance range and selectivity, and tone quality as well, than even the original, never-yet-equalled, 720. . . Be the first on the ground with it! Get your order in at once to your S-M jobber or dealer.

Used with the new S-M 669 power supply, the 720AC is a complete all-electric receiver designed especially to bring out the extreme possibilities of these new tubes. Price, completely WIRED in 700 two-tone shielding cabinet, less tubes and power unit, $117.00. Component parts total $78.50; cabinet $9.25 additional. S-M 669 Power Unit, WIRED, $57.50.

S-M 720 receivers can be changed over at slight cost to the 720AC circuit.

## S-M Audios-Positively Guaranteed Superior

That same unchangeable purity and fidelity of tone, which has established S-M supremacy even more firmly this year than ever before, can be built into any receiver or amplifier by using the new S-M Clough-system audio transformers. Guaranteed absolutely and unconditionally to surpass, in their uniform amplification of all notes from 5000 down to 40 cycles, any other transformers obtainable on the American market at any price, these unique instruments make use of a principle totally different from anything used in standard transformer construction—built-in resonance to even out the amplification curve in the critical range which ordinary transformers weaken—and a circuit which keeps D.C. plate current entirely out of the transformer winding and thereby avoids the common injurious effect of hysteretic distortion. Amplification obtainable—running as high as 4½ to 1—is far higher than with any standard transformers of comparable tone quality.

S-M Clough system audios are now obtainable in a complete line, for both single and push-pull amplification, as follows:

255 and 256, for standard use in first and second stage respectively. Each....$6

225 and 226, similar to 255 and 256, but larger and slightly more perfect in both frequency characteristic and amplification ratio. Each.....$9

257 Push-Pull Input Transformer, to operate from one amplifier tube into two 171A, 210, or 250 tubes. Each..$7

227 Push-Pull Interstage Transformer, to feed from two 112A, 226, or 227 tubes into two 112A, 226, 227 or 171A, 210 or 250 tubes. Each.....$8

258 Tapped Output Impedance, to feed from two 171A tubes into any standard speakers. Each.....$5

248 Universal Output Choke to feed out of two 210 or 250 tubes into one to six or more standard speakers; provided with several impedance-matching taps. It will handle over 20 watts without core saturation. Open-mounted. Each $7

228 (248 in case like 227). Each.....$8

**For the New Tubes: S-M 335 Power Transformer**

This is the transformer used in the new S-M 669 power unit. It contains one 105 to 120 volt primary; one 5 volt, 2 ampere, rectifier filament winding; two 2.5 volt, 6 ampere, filament windings. Plate voltage with one '80 tube, 300 volts at 100 m.a. Provided with iron end terminal mountings, or (335U) in open mounting; either type $15.00.

*Are you getting the Radiobuilder, a monthly publication telling the very latest developments of the S-M laboratories? No. 10 (Mar. 1929) gives further details of the new 720AC. Send the coupon for free sample copy, or to enter your subscription if you want it regularly.*

*If you build professionally, but do not have as yet the S-M Authorized Service Station appointment, ask about it.*

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....No. 3. 730, 731, 732 "Round-the-World" Short Wave Sets
....No. 4. 223, 225, 226, 256, 251 Audio Transformers
....No. 5. 720 Screen Grid Six Receiver
....No. 6. 740 "Coast-to-Coast" Screen Grid Four
....No. 7. 675ABC High-Voltage Power Supply and 676 Dynamic Speaker Amplifier
....No. 8. Sargent-Rayment Seven
....No. 9. 678PD Phonograph Amplifier
....No. 10. 720AC All-Electric Screen-Grid Six.

Name.....

Address.....


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# The Vital Spot!

The filament must be right—that is the prime essential! Accuracy *plus* finest available material are absolutely required in the manufacture of better tubes—and, predicated upon such standards is

## GILBY FILAMENT WIRE

. . . . a product that provides a real contribution to the quality of a tube. Because of close manufacturing control, we can assure material that will be

(1) ACCURATE
(2) UNIFORM
(3) BRIGHT
(4) HIGHLY EMISSIVE
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Other Gilby Products assuring manufacturers of tubes and radio equipment maximum quality are:

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*for Better Regulation*

**GILBY RESISTANCE WIRE**
the best of its kind

**PURE NICKEL WIRE**

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Suitable samples of any material will gladly be supplied

RADIO MANUFACTURERS ASSOCIATION RMA MEMBER

## GILBY WIRE COMPANY

WILBUR B. DRIVER, *President*

NEWARK, NEW JERSEY

# TALKING POINTS!

YOUR job as an engineer is to produce a good radio set, of course; but today that task is also to turn out a product that will sell in a highly competitive market. Don't forget the sales end, beginning with your sales manager, then the distributor and jobber and finally the retailer. They are looking for talking points—something that will help sell—something different from other standardized sets—something *extra* or *better* or *refined*.

And that's where the Clarostat line can be of real help to you. It can inject some talking points into those new sets, so as to make your designs the merchandising successes which they must be.

## for instance:

### A-C HUM CONTROL

You cannot afford to take a chance on a hum background. Your public this season is highly tone conscious. Let a Hum-Dinger take care of that—an improved center-tap resistor, instantly adjustable with ordinary screwdriver by tester or service man, foolproof, sturdy, will outlast the radio set, compact, one-hole mounting, available in any resistance range. Usually cheaper than center-tapped transformer winding—and far better.

### VOLUME CONTROL

You must have a volume control, for a radio set without a volume control is like a car without brakes. The Volume Control Clarostat takes care of that. Compact. Simple. Foolproof. Long-lived. Inexpensive.

### TONE CONTROL

What a talking point! Imagine a loud-speaker that can be adjusted for tone as well as for volume. A rich, mellow, soft tone for orchestra selections; a sharp, crisp, penetrating tone for jazz and band selections. Our Volume Control Clarostat together with a simple condenser combination does the trick.

### REMOTE CONTROL

Imagine providing your set with a remote volume control, whereby loud-speaker rendition may be adjusted to any degree at the listener's finger tips. The Table Type Clarostat serves that purpose.

### VOLTAGE REGULATION

Whether line voltage, grid bias, plate voltage or filament voltage is to be adjusted, we have a Clarostat for the purpose.

Watch for the new Line Ballast Clarostat soon to be announced. You'll be surprised!

### AND ALL-ROUND BETTER RADIO

In addition to special talking points, the Clarostat line serves to produce better radio results. The fact that there are more Clarostats in use today than any other variable resistor proves the merit of our products. Also, we make fixed resistors for all purposes, just as we make variable resistors. We are quite unbiased in our engineering recommendations!

**WRITE** for engineering data regarding the entire Clarostat line of fixed, variable and automatic resistors. Better still, submit your resistance problems so that we may co-operate with you in their solution. Samples will be gladly submitted to any radio engineer engaged in design and production work for a recognized radio manufacturer.

**CLAROSTAT MANUFACTURING COMPANY, INC.**

*Specialists in Radio Aids*

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# CLAROSTAT

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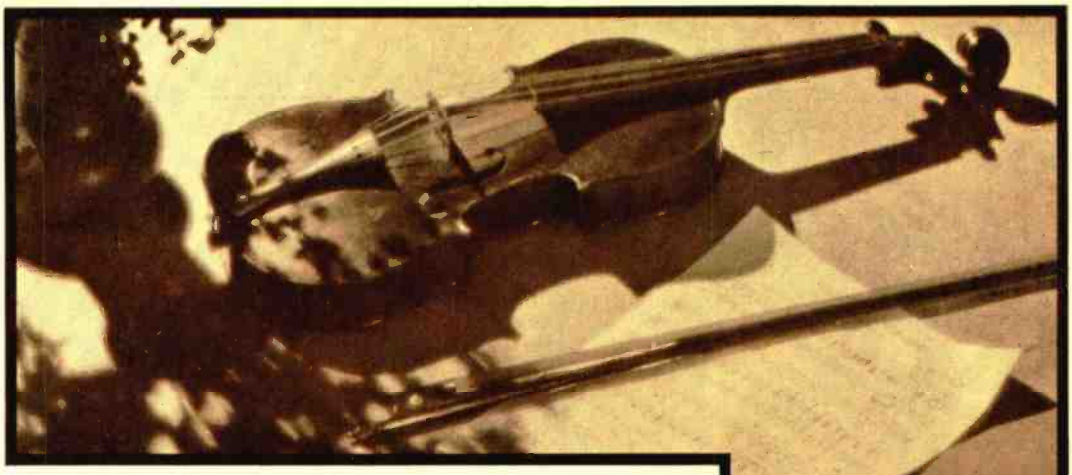

# Since radios became musical instruments

## *Transformers must meet new, exacting standards*

Now, we know it was but a semblance of a farflung voice that thrilled us in those early years of radio reception. Today, the novelty is gone—radio must be true and faithful in tone or it is not pleasing—it will not sell!

The wise custom builder or manufacturer knows that he must meet competition in the "audio end" of his product. Distance, selectivity—Yes. But above all—TONE!

Better tubes and better speakers play important parts in faithful reproduction—but transformers are sometimes neglected.

And the science of transformer building is a specialty in itself—it is a field too wide and varied to be handled successfully as a mere step in receiver manufacture. It is best left to an organization like "Sangamo" whose experience, research and precision manufacturing facilities guarantee the result.

Within the Sangamo Audio Line is found specially designed equipment to match specific types of tubes and speakers.


## SANGAMO ELECTRIC CO.

SPRINGFIELD, ILLINOIS, U. S. A.

*Manufacturers of Precision Electrical Apparatus for 30 Years*

SANGAMO

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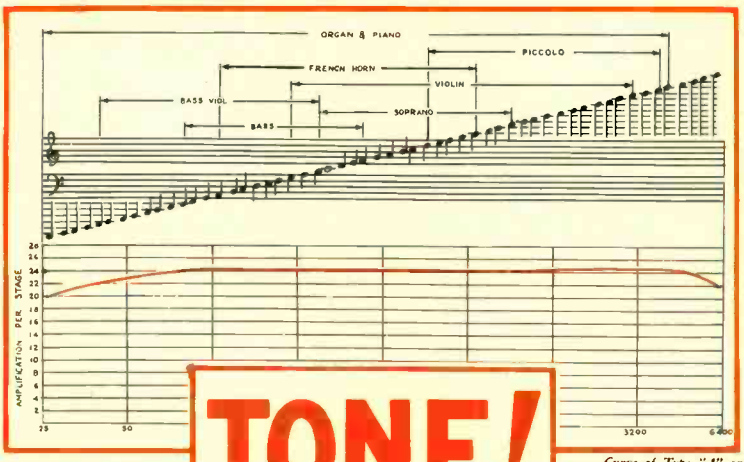



*Curve of Type "A" or Sangamo Straight Audio Transformer showing uniformity of amplification at all audible frequencies.*

# TONE!

# BETTER Transformers
## *for every radio need!*

### "X" Line Transformers

Type AX straight audio amplification . . . . . list price, $6.00

Type BX Push-pull Input unit . . . . . list price, 6.50

Type CX-171 Push-pull Output Transformer, for 171 or 250 power output tubes for cone speaker . . . . list price, 6.50

Type DX, same as CX except for 210 and 112 power tubes . . . . . list price, 6.50

Type HX Push-pull Output for 171 or 250 Power Output tubes to match the impedance of moving coil of Dynamic loud speakers . . list price, 6.50

Type GX, same as HX except for 210 and 112 power tubes . . . . . list price, 6.50

Type E output choke to match impedance of the various type power tubes . . list price, 5.00

### "A" Line Transformers

*Similar to X Line but with special core metal to give greater amplification at low frequencies*

Type A straight audio amplification . . . . list price, $10.00

Type B Push-pull Input Transformer for all tubes, list price, 12.00

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

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

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

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

Type F Plate Impedance for use as a choke to prevent oscillation and for impedance coupled amplifiers, list price, 5.00

**PIN THIS TO YOUR LETTERHEAD AND MAIL**

SANGAMO ELECTRIC CO., Springfield, Illinois, U. S. A. Dept. 342

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

☐ (*For dealers*) Please send data on Sangamo Condensers.

☐ (*For set builders*) Please send circulars describing your apparatus and latest audio hook-ups.

SANGAMO

# SANGAMO Condensers

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

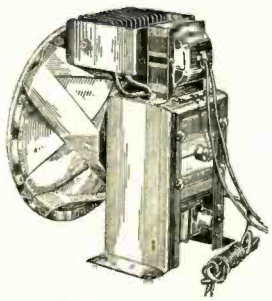
The standard line of Sangamo Fixed Condensers leave the factory tested to maximum variation of 10%.

## *NEW!*
## Condensers *for* Manufacturers


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

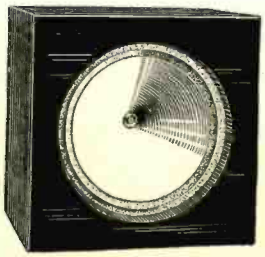
*Prices on request*

# *They Speak for Themselves*



DYNAMIC CHASSIS

Model 10, 110 volt A. C. 60 cycle; Model 12, 110 volt A. C. 25 cycle; Model 14, 110 volt Direct Current; Model 16, 6 volt D. C. Battery Type.



MODEL 5-B MAGNETIC

Built into a baffle box which measures 9¼" sq. x 7⅜" deep.

MODEL 5-C MAGNETIC

This is the bare Magnetic chassis without the box baffle. This measures 9" diameter, depth 5".

*All Temple speakers are available in table models—in most attractive cabinets.*

## *Temple Dynamic Speakers*

Temple Dynamics are better because of the unequalled engineering which is behind them—because of a more thorough knowledge of speaker manufacturing—because of a reputation for high grade speaker performance which has kept the Temple name among the leaders in the radio industry.

### *All Line Hum Eliminated*

Exclusive with Temple Dynamics is the fact that all semblance of line hum has been eliminated. The Temple System of Hum Elimination is a Temple development and found only in Temple Dynamics. A two-tone switch allows for reception with predominating bass or for reproduction in natural tone values.

## *Temple Magnetic Speakers*

Temple Magnetic Speakers fill the demand for quality reproducers, where tone of the highest order is demanded, but where the matter of insufficient receiver power or taste makes the purchase of a dynamic speaker inadvisable. True response, natural and pleasing tone, and an ability to please the most discriminating from the standpoint of performance makes this model one of the most popular in the radio field.

### *For Every Type of Installation*

Temple Magnetics are designed for new console installations. or for replacements—for bringing the tone of older receivers up to 1929 standards. The two types differ only in the fact that one model is housed in a box baffle, while the other is the bare chassis. Both are complete and ready for installation and are equipped with the famous Temple Double Action Unit.

**TEMPLE CORPORATION**

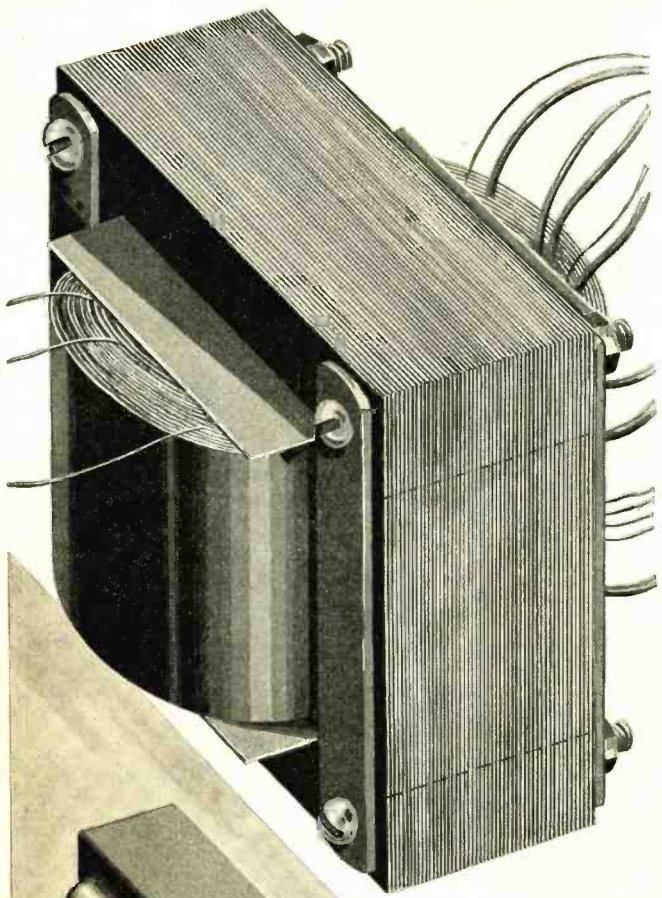
**5253 W. 65th St.** **Clearing Station**

**Chicago, U. S. A.**

*Temple speakers are made by the manufacturers of sensational*

**TEMPLE**

**TEMPLETONE** *Radio*



*and*

# PERFECT PERFORMANCE FOLLOWS

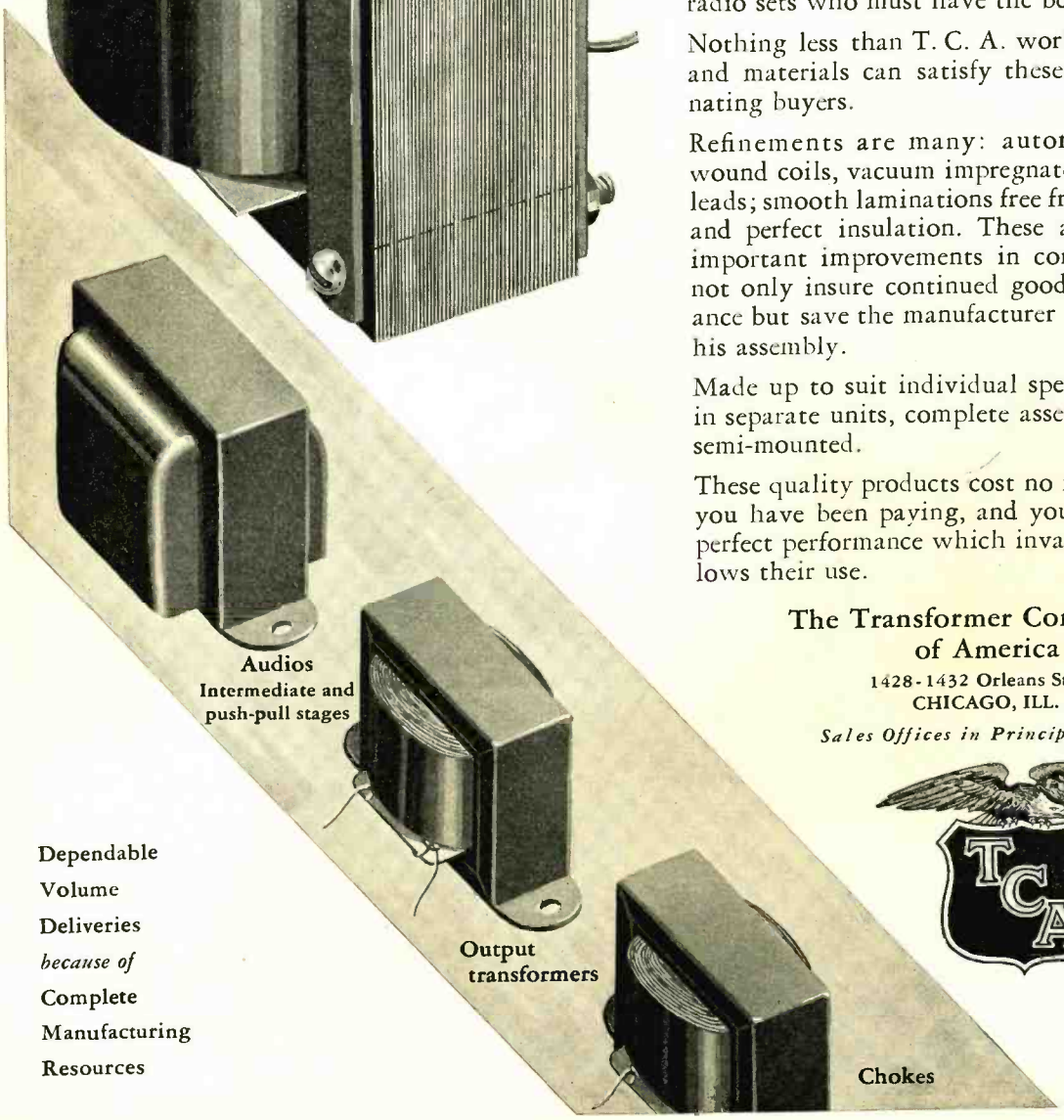
T. C. A. power transformers, like T. C. A. audio transformers, output transformers for dynamic speakers, and chokes, are built to standards critical enough to meet the most exacting in the industry. For among T. C. A. users are manufacturers of the world's finest radio sets who must have the best.

Nothing less than T. C. A. workmanship and materials can satisfy these discriminating buyers.

Refinements are many: automatically wound coils, vacuum impregnated; tinned leads; smooth laminations free from burrs; and perfect insulation. These and other important improvements in construction not only insure continued good performance but save the manufacturer money on his assembly.

Made up to suit individual specifications in separate units, complete assemblies, or semi-mounted.

These quality products cost no more than you have been paying, and you gain the perfect performance which invariably follows their use.

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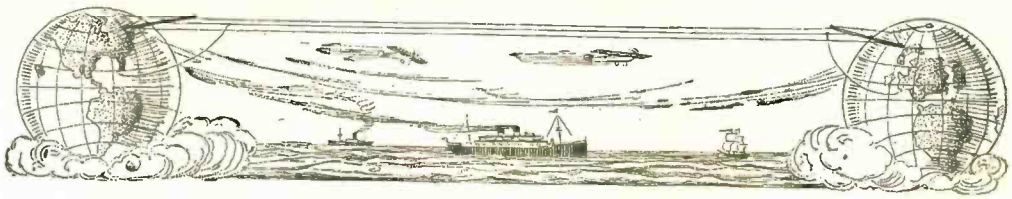
Manufacturing
Resources



# Light-Sensitive Cells

## *I. Construction of Alkali Metal Cells*

*By John Patton Arnold*

THE term *photo-electricity*, in its widest seuse, as Allen defines it, refers to "any electrical effect due to the influence of light." Within this meaning might be included such related phenomena as photo-chemical action, fluorescence and phosphorescence, phototherapy and the photo-electric theory of vision, photo-conductive effects in solids and photo-voltaic effects in liquids, and particularly the Hallwachs effect as exhibited in a certain type of light-sensitive cell. For the present, we are concerned with only the last.

In 1888, Hallwachs demonstrated that a body, negatively charged, loses that charge when ultra-violet light falls upon its surface; but, when positively charged, the body is not influenced by irradiation. This fact, coupled with the initial discovery of photo-electric action by Hertz in the previous year, led to the development of the modern alkali metal cell which now, among other things, is of considerable interest to the engineer who is engaged in problems of the talking moving picture and of visual communication systems.

The photo-electric cell of this type is designated in the patent literature as an "electron discharge device," thus classifying it with the thermionic vacuum tube which it somewhat resembles both in appearance and operation. The essential difference between the two is that, in the latter, electronic emission is due to the incandescence of a filament; in the former, to the release of electrons by light or other radiation.

The alkali metal photo-electric cell may now be defined as a light-operated and light-controlled electrical device, consisting essentially of an evacuated, transparent enclosure into which are inserted two electrodes—a cathode composed of an insulated, light-sensitive material which emits electrons from its surface when illuminated and an anode, whereby accelerating potentials may be applied in order that a convection current flows between the electrodes.

Ives[1] mentions the following considerations which the study of these cells entails: (1) the physical structure of the cell, (2) the nature and treatment of the light-sensitive material, and (3) the composition and pressure of the gaseous atmosphere.

### *I. Physical Structure*

The physical structure of cells will be treated more fully elsewhere in discussing various cell-forms: in this place we need only a few general facts in order to understand how the cells are prepared.

*THIS is the first of a series of four articles by Mr. Arnold, dealing with the design, development and application of all representative types of light-sensitive cells. This material is a condensed version of a lengthy treatise on the subject, to be published in book form later on.*

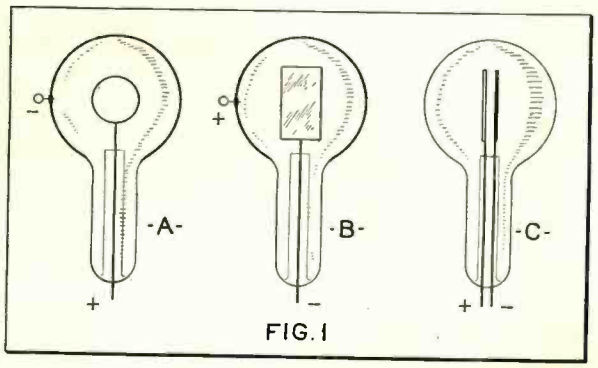
*We are sure the readers of* RADIO ENGINEERING *will find these articles of great interest and highly valuable as reference material—Editor.*

Since alkali metal cells have only within the past few years become something more than laboratory instruments, it is easy to realize that they have not been standardized to any degree comparable with the thermionic vacuum tube. For practical work, one can rely in most cases on the "average" characteristics of, for instance, the 201-A tubes, but cells of any particular style of design and construction present an individual problem. To obtain cells of like characteristics, it is necessary, therefore, to select them by direct comparison, as these characteristics are not reproducible as yet in the commercial manufacture of cells.

**Electrode Arrangement.** Classified according to their electrode arrangement, photo-electric cells may be conveniently described as (1) central anode, (2) central cathode, (3) central electrode, and (4) specialized types. In the modern types of commercial cells, the central anode arrangement is by far the most common; but the other types, which have different characteristics, are useful for certain applications for which they are particularly adapted.

The distinctive features of the first three types may be summed up as follows: central anode cells usually have a large light-sensitive surface, a much smaller anode, and require relatively higher potentials for satisfactory operation. The converse is true in the case of central cathode cells—low applied potentials, a smaller cathode surface, and a large surrounding anode. A cell with the two electrodes centrally disposed occupies an intermediate place between the foregoing types. These features may be observed in Fig. 1: (a) the central anode cell with the light-sensitive material deposited on the inner wall of the bulb; (b) the central cathode cell with the light sensitive material deposited on a central plate, the anode being a metallic film on the wall of the bulb, and (c) the cell with both electrodes close together in the center of the cell. The latter type, which is rather uncom-

On the right are illustrated the various electrode arrangements in the design of alkali metal cells; (A) central anode; (B) central cathode; (C) central electrode types. See Fig. 2 for the structure of (C).




[1] *Bell System Tech. Jour., Vol. 5. pp. 321–322; 1926.*

mon, is also shown in the photograph (Fig. 2).

Kunz and Stebbins[2] have studied the current-intensity relation in cylindrical cells using parallel electrodes and found the current proportional to the illumination over a wide range of values. This indicates an advantage to be found in cells in which both of the electrodes are centrally disposed and parallel to each other.

The data regarding electrode separation can best be studied elsewhere as this factor varies considerably with the type of cell. However, to obtain a better understanding of the physical structure, a few general facts on this subject will be mentioned here. Kemp[3] found for hydrogen, at a pressure of 2 to 3 mm. of mercury in a central anode cell, the optimum electrode separation was 5 to 6 mm. In a commercial gas-cell with two parallel central electrodes, the electrodes are placed about ¼-in. apart. In three central anode cells with the light-sensitive material deposited on the walls of bulbs ¾, 1¾ and 3 in. in diameter, the electrode distances are 3/16, ⅞ and 1½ in. respectively.

Glassware. The qualities demanded of the glassware are in regard to (1) resistance to chemical corrosion, (2) dielectric capacity, (3) light transmission characteristics and (4) the case of mechanical working. As to the first point, it is desired that the material will be able to resist contamination by the alkali metal during preparation. The insulating qualities should be such that excessive leakage currents do not flow across its surfaces. It must transmit the wavelengths of light to which the alkali metal is most responsive, i. e., mainly the shorter wavelengths. The case of mechanical desirability and the low cost of the material are advantages which will not be questioned.

The materials most frequently employed for the manufacture of cells are quartz, flint, uviol, pyrex, and soda glass. The unsuitable glasses are those which contain heavy metals; for instance, lead glass. Pyrex (a borosilicate glass) exhibits the qualities mentioned above to a satisfactory degree and is used quite extensively. The light transmission characteristics of this glass in the ultra-violet region are shown in Fig. 3.

The light aperture or "window" becomes a factor of importance in the design of photo-electric cells. In its simplest form it may be nothing more than a clear surface of the glass that composes the bulb. When the alkali metal is deposited on the inner walls of the glass, the window is cleared of the metal by the application of heat at the point selected. The alkali metal vaporizes and settles in the cooler parts of the bulb. The window can not be made too large; for it may collect electrical charges which will affect the operation of the cell. The radius of curvature of the window surface should also be considered, since errors may be introduced by non-parallelism of the incident beam of light.

Fig. 2. A potassium hydride, neon filled cell, with both electrodes centrally disposed. (Courtesy of Samuel Wein).

In the case of cells which are composed of the more common glasses, where such cells are exposed to ultra-violet light, it is possible to seal to the glass itself, by means of glass fluxes, a window of flint or quartz, this being less expensive than an entire cell using the latter materials.

[2] *Kunz and Stebbins Physics Review, Vol. 7, p. 62; 1916.*
[3] *Physics Review, Vol. 1, p. 274; 1913.*

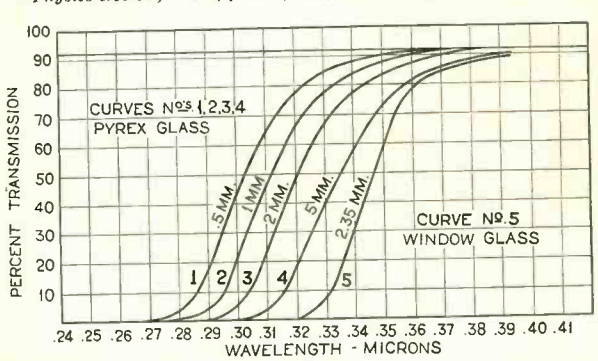



FIG. 3

Fig. 3. These curves show the light transmission characteristics of a typical glass used in the manufacture of alkali metal cells. (Courtesy of Corning Glass Works).

## *II. Nature and Treatment of the Light-sensitive Material*

The alkali metals—lithium (6.94), sodium (23.0), potassium (39.1), rubidium (102.9), and caesium (132.81)—as a group are the most active chemically of the elements, their relative activity increasing with the rising atomic weight. These metals, some of their compounds (especially the hydrides), and amalgams, are also very active photo-electrically. With the pure metals, the sensitivity to light of longer wavelength increases as the metal employed is more electro-positive, and this sensitivity lies mainly in the visible spectrum.

Potassium is commonly employed for the manufacture of commercial cells, as light-sensitive surfaces of this element are easier to prepare than either rubidium or caesium which have considerably lower melting points. Lithium and sodium have a maximum sensitivity in the violet or short-wave regions of the visible spectrum and hence are less satisfactory for "general purpose" cells than the other metals of this group. Fig. 4 shows the character of a potassium hydride surface.

Several methods of preparing uncontaminated surfaces of light-sensitive substances have been employed by various workers. These include processes of distillation, electrolysis, cathode sputtering, bombardment, the use of chemical solvents, etc. Some of the most usual methods of securing thin films of the alkali metals will be described briefly.

Distillation. Ives[4] describes the method of distilling potassium in a vacuum. "The cell in first baked to a temperature of 400 deg. C. for several hours while on the pump in order to drive out all traces of water vapor. The potassium for use in making up the photo-electric cells is first of all distilled in a vacuum into long glass tubes. In this preliminary distillation, the greater part of the absorbed gaseous impurities are removed. After the cell has been baked out on the pump, a piece of the glass tube containing potassium is broken off and introduced into the pump system. Between the point of introduction and the cell are a series of bulbs. The potassium after melting in vacuo is distilled successively through these bulbs and into the photo-electric cell, where it is condensed on the walls of the bulb. A window is then made in the cell by applying a small flame on the appropriate part. The next step is to introduce a small amount of pure hydrogen gas, which is permitted to enter from a reservoir on the system. This hydrogen goes through the system of bulbs through which the potassium has been distilled, which still contain a large amount of potassium, and is thereby cleaned of all traces of gases or vapors which might react

[4] *Bell System Tech. Jour., Vol. 5, p. 332; 1926.*

on the potassium in the cell. A glow discharge is then passed from a high voltage source, until, by illuminating the alkali metal surface and reading the current on a sensitive galvanometer, it is found that a maximum of sensitiveness has been attained. The hydrogen is then completely removed by long continued pumping. The final step in the preparation of the cell consists in the introduction of a small quantity of carefully purified argon. The argon for this purpose is held in

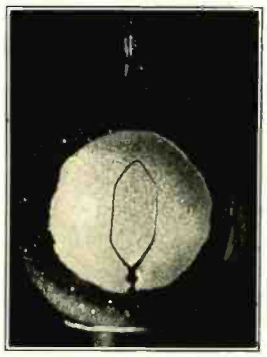


Fig. 4. A central anode photo-electric cell, showing the appearance of the light-sensitive surface; in this case potassium hydride. (Courtesy of G-M Scientific Co.)

a reservoir in which there is a pool of sodium-potassium alloy. By passing an electric discharge from this pool to an electrode through the gas, the argon is purified of all active impurities. It is introduced into the cell through the same series of potassium-coated bulbs already mentioned, the potassium in the meantime having been vigorously heated to drive off all occluded hydrogen, so that the gas when it finally reaches the photo-electric cell is entirely inert. The gas pressure is carefully adjusted while the cell is still on the pump so as to give an optimum effect, after which the cell is sealed off."

Ives[5] also obtains surfaces of sodium, rubidium and caesium by distillation. Sodium is introduced within the bulb as described above in the case of potassium. Rubidium and caesium are first distilled into short tubes with thin-walled bulbs at one end, and the bulb is broken after the tube is in the distilling system. The metals are then passed from one bulb to another in the distilling train until they finally reach the cell proper.

Schultz[6] deposits a film of silver on the inner walls of the bulb, cooling that portion with cold water or ice during the distillation of potassium on the film. The cylindrical part of the tube is heated (from 160 to 240 deg. C., depending on the alkali metal used) by means of an electric heating coil as the distillation proceeds. Hydrogen is then introduced by heating a strip of palladium in a side tube and the hydride of the metal is formed by applying 550 volts d-c across the terminals of the cell, the cathode being connected through a 3,000-ohm resistance to the negative side of the source of potential. Upon closing the circuit for a few seconds, the alkali metal is converted to a hydride. The hydrogen is then pumped out, and argon or helium introduced. The gas pressure is now regulated to give a maximum galvanometer deflection when the cell is exposed to light.

Kunz[7] recommends 280 volts in the case of rubidium for converting that metal to a hydride.

Cornelius[8] has prepared caesium and rubidium by first drying caesium or rubidium chloride by melting it in contact with dry hydrochloric acid gas. Fourteen grams of the chloride were mixed with 2.5 grams of calcium and placed in an iron boat in a combustion tube of Bohemian glass. A violent reaction occurs between the Ca and the chloride when the temperature rises. The calcium and the salts spread out and condense together with the alkali metal in the cooler parts of the tube. This mixture may be prevented by using a plug of asbestos and iron wire which will only allow the alkali metal to pass through it to the cell which is attached to the combustion tube. After the cell is exhausted with a Gaede pump, hydrogen is introduced by means of palladium which had been used as a cathode in a solution of three parts water and one part $H_2SO_4$. When a current is passed through the cell, the palladium absorbs a large amount of hydrogen which is given off again by heating the dry metal. A glow discharge in this atmosphere of hydrogen converts of the alkali metal to its hydride and its surface then appears greenish-gray, or bronze, in color.

Bidwell[9] distills rubidium and caesium from the corresponding chlorides by heating with pure metallic calcium in a vacuum. On heating to about 400 deg. C. in a long pyrex tube, the reaction sets in, causing a glow to extend throughout the whole mass, while the metals condense in the cooler parts of the tube. Redistillations at temperatures much lower than those at which the reaction occurred serve to purify the metals.

**Electrolysis.** Warburg[10] suggested that sodium could be deposited electrolytically through glass into Geissler tubes. Burt[11], who uses this method for making photo-electric cells, accredits Hull with the idea of employing thermionic emission.

A simple method of making a sodium cell from an ordinary incandescent lamp is described by Burt, (Fig. 5). The base is removed from a 40- to 60-watt metal-filament lamp of the type which has a soda glass bulb—an essential condition. The lamp is inverted in an iron crucible containing molten sodium nitrate, and the filament is lighted from a 110-volt source through a resistance. Either direct or alternating current may be employed as the filament acts as a rectifier. An electrode of heavy copper wire, or merely a wire fastened to the edge of the crucible, is connected through a milliammeter to the positive side of the line.

When the filament is lighted, the emitted electrons are drawn to the walls of the bulb under the influence of the electric field. The electrons neutralize the sodium ions in the soda glass. The atoms formed are vaporized by the heat of the lower part of the bulb and the sodium is, therefore, deposited on the cooler upper walls. The molten salt supplies the ions which travel through the glass and are neutralized at the inner surface of the bulb. After securing a contact with the sodium surface and using the unlighted filament as an anode, one has an elementary photo-electric cell. The commercial process used by this investigator in making commercial cells is, of course, much more refined.

It is pointed out that any source of sodium ions may be employed, but sodium nitrate, which melts at 312 deg. C., is well below the melting point of the glass and is sufficiently high

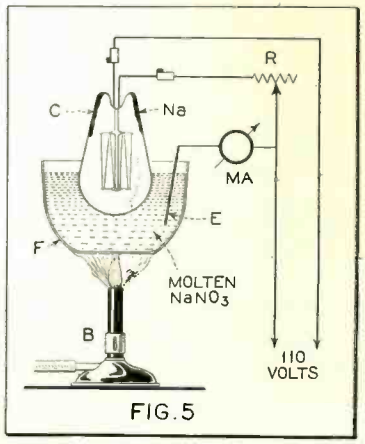



FIG. 5

A simplified method of preparing a cell by depositing sodium within a bulb by electrolysis.

enough to permit a large electrolytic current to flow.

Burt was unable to deposit lithium or potassium successfully within a soda glass bulb, but Zworykin[12] was able to do so with potassium through a potash glass without corrosion or embrittling the glass itself.

Bidwell[13] prepared lithium surfaces

[5] *Astrophys. Jour., Vol.* 60. *p.* 209 ; 1924.
[6] *Astrophys. Jour., Vol.* 38. *p.* 187 ; 1913.
[7] *Physics Review, Vol.* 7, *p.* 62 ; 1916.
[8] *Physics Review, Vol.* 1, *p.* 16 ; 1913.
[9] *Physics Review, Vol.* 23, *p.* 357 ; 1924.
[10] *Wied. Ann., Vol.* 21, *p.* 622 ; 1884 ; *Vol.* 40, *p.* 1 ; 1890.
[11] *Jour. Opt. Soc. Am., Vol.* 11, *p.* 87 ; 1925.
[12] *Physics Review, Vol.* 27, *p.* 813 ; 1926.
[13] *Physics Review, Vol.* 23, *p.* 357 ; 1924.

from lithium chloride by electrolysis of the fused salt. Previously, the chloride was found to contain traces of sodium, iron, magnesium and calcium, but after the electrolysis only a trace of the sodium remained, the other impurities having been eliminated in the reaction. The electrolysis was carried out in a nickel crucible with an Achison graphite anode and an iron loop for a cathode. These electrodes were separated by a partition of fused quartz instead of the usual asbestos board which introduced impurities.

Solvents. The preparation of lithium surfaces was found to be somewhat of a task by Seiler[14] due both to the danger involved in distilling the metal and to the difficulty of obtaining a solute for it. Dr. A. G. Loomis suggested that the lithium should be dissolved in aethylamine. The necessary condition for its solution is that the aethylamine be absolutely dry and that a trace of ammonia is present. Metallic lithium was poured into the dry aethylamine and was dissolved after about ten hours, the clear liquid having become a deep blue color. This solution was poured into the cell and the aethylamine pumped out, leaving a uniform film of lithium. Argon gas was then inserted aud the bulb sealed off.

[14] *Astrophys. Jour., Vol. 52, p. 129; 1920.*

### *III. Composition and Pressure of the Gaseous Atmosphere*

The photo-electric effect may be observed both *in vacuo* and in gases at various pressures. On this account, alkali metal cells are usually classified in this respect as high vacuum or gas-filled cells. The vacuum cell is exhausted to a degree comparable with the best vacuum obtainable with modern apparatus. In the gas-filled cell, in which purified helium, argon, krypton, neon, etc., is introduced, the pressure is adjusted to the point of greatest sensitivity and for a moderate glow discharge. An inert gas is employed that will not react with the alkali metal, but still serves the purpose of amplifying the photo-electric current due to the ionization of the gas by collision. The kind of gas selected for this purpose is not of major importauce, but the adjustment of its pressure to the critical point of greatest sensitivity is an essential condition.

Ives[15] states that "the amplifying effect of the gaseous atmosphere increases with the pressure up to a maximum and then decreases," and that the optimum pressure depends upon the dimensions of the inclosure and the nature and kind of gas employed. This pressure is usually a few tenths of a millimeter of mercury. Koller[16] also mentions that the pressure ranges from .02 mm. of mercury in large cells to 1 mm. in small cells.

Kemp[17] found for hydrogen—which, as well as nitrogen, has been used, although less successfully than other gases—that a pressure of two to three mm. secures the highest sensitivity with an electrode separation of 5 to 6 mm.

As the magnification of the photo-electric current due to ionization of the gas may be one hundred-fold or more, as Hughes[18] reports, it is the common practice to adjust each cell individually to the critical pressure in the manner described in discussing the preparation of the light-sensitive surfaces in the foregoing pages.

In the succeeding articles of this series, we will consider the characteristics of these cells, their operation and applications, as well as the various cell-forms of this and other types of light-sensitive instruments.

*(To be continued)*

[15] *Bell System Tech. Jour., Vol. 5, p. 324; 1926.*

[16] *Popular Radio, Vol. 13, p. 299; 1928.*

[17] *Physics Review, (2) Vol. 1, p. 274; 1913.*

[18] *Bulletin, Nat'l Res. Council, Vol. 2 (2), p. 104: 1921.*

# Reducing Noise in Broadcast Receivers

## *The Use of the Long-Lost Resonance Wave Coil, Band-Pass Filters and the Recently Heralded Power Detector*

*By R. Wm. Tanner**

THIS article is written for the benefit of those whose location is such that static, interference from power lines, nearby broadcast or telegraph stations or other extraneous noises are found to be troublesome.

The writer has been doing a great deal of work on the interference problem during the past few months and has had considerable success.

The resonance wave coil, as applied to the elimination of static and interference, was one of the first "stunts" tried. This was developed by engineers of the U. S. Army Signal Corps back in 1920. Receivers were built, using this device, which resulted in very little static getting through to the output. Complete shielding of the set and batteries was, of course, necessary.

While it is possible to build a resonance wave coil for the modern receiver which will bring the static far below the signal level, the results of the Signal Corps sets cannot be duplicated in practice due to the lack of complete shielding and the use of battery substitutes.

* WSAD.

### *Resonance Wave Coil Circuit*

A practical circuit is shown in Fig. I. The resonance wave coil, LI, is

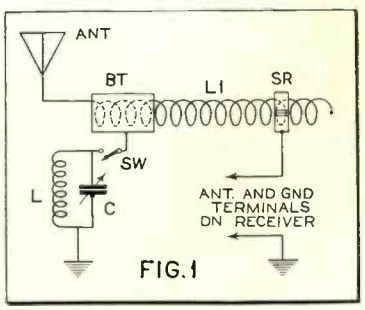



FIG. 1

Resonance wave coil and circuit connections. L-C is a rejector circuit.

a single layer of fine wire wound on a fairly long form, with one end connected to the antenna. The other end is left open. BT is a stationary close-fitting brass or copper tube about one-third the length of LI. This is connected to a tuned trap or rejector circuit, L-C, and thence to the ground. SR is another metal tube which goes direct to the aerial terminal of the receiver and is movable over the unused portion of LI. This tube must be slit.

If the guard tube, BT, was directly grounded, all of the static would be removed as well as all of the signals. Fortunately, it is possible to insert a rejector circuit between BT and the ground in such a manner that all waves, except the one to which L-C is tuned, go to the ground. However, do not consider this in the same light as the ordinary wave trap.

### *Operation of Wave Coil*

When a wave strikes the antenna the effect will be to put a number of voltage peaks along the resonance wave coil, if such is properly designed with a natural period well above the broadcast band. By sliding SR along the coil, a point will be reached where

the signal strength will be at a maximum, providing the rejector circuit is tuned to the same wave as the receiver. At this point static and other noises will be at a minimum.

While shielding the resonance coil and rejector circuit is desirable, it is not absolutely necessary, except possibly in some of the southern states where static is usually very bad.

Unless the A- and B-eliminator transformers are provided with electrostatic shields between the primaries and secondaries, best results will not be obtained, due to the fact that the supply line has some antenna effect. Unfortunately, few manufacturers build such transformers.

### *Construction of Wave Coil*

A resonance wave coil for use with broadcast receivers may consist of a bakelite or cardboard tube three inches in diameter and twelve inches long, wound with No. 30 S. C. C. or S. S. C. wire over the entire length. A layer of thin, tough paper is placed over the winding and a copper tube four inches long fitted snugly to the antenna end. The sliding tube is also of copper about one-half to one inch wide. The two ends should not join, a one-quarter inch separation being about right. This should be made to fit so that it slides easily over the coil.

To be efficient, the rejector circuit must be of very low resistance. This means that the coil, L, will be wound with large wire and the condenser of low-loss construction. Sixty turns of No. 18 enamel wire on a three-inch form shunted by a good .005 mfd. variable condenser will just about cover the broadcast band.

The operation of a resonance wave coil is not at all difficult. During the initial tuning, the L-C circuit should be cut out by opening the switch, SW. Tune the receiver in the regular manner and then close SW. Adjust C for greatest signal strength and a minimum of noise and then slide SR over the coil until the best point is found. The latter must be changed for each signal although when hunting for stations it may be set at any position.

When interference is not bad, the resonance coil and associated parts may be cut out and the antenna connected direct to the receiver. A switch may be used to short out the equipment.

### *Band-Pass Filter*

Another method of noise reduction that was tried was the use of a band-pass filter. This is applicable only to superheterodynes. To put a band-pass filter in the r-f end is almost out of the question, due to the many variable condensers necessary.

It is remarkable the small amount of interference that gets by the filter. Tube noises and mush are practically eliminated, as well as the selectivity increased.

The intermediate frequencies in use in the present-day supers vary anywhere between 500 and 30 k-c, therefore it will be impossible to state the values for the inductances and capacities. It might be well to say, however, that the coils may be of the same type as the intermediate frequency transformers employed in the amplifier, with the primaries removed. If the transformers are of the untuned type it will be necessary to unwind about half of the secondary turns and employ a semi-variable condenser of .0005 mfd. capacity to tune to resonance with the amplifier.

If the transformers are of the tuned type, they may be used as they are, except that the primary should be removed. The two series condensers, C and $C_1$, should be of the midget type, with a capacity of .0001 mfd.

In operation, the three shunt circuits will most likely be adjusted to a slightly lower frequency than the i-f amplifier, and the series condensers set at a point giving the proper degree of selectivity.

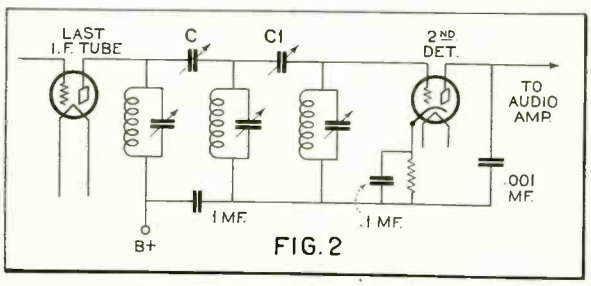


FIG. 2

Circuit of a band-pass filter for a superheterodyne. The filter increases the selectivity as well as reducing tube noises.

Care must be taken in the mounting of the inductances to so space them that their fields do not interact on one another or on the i-f transformers. Shielding will probably have to be resorted to if the coils are over 1½ inches in diameter. A diagram of connections is shown in Fig. 2.

### *Hum Reduction*

It would hardly be fitting to conclude this article on noise reduction without saying a few words in regard to the hum in a-c receivers, especially those employing the 226 tubes in the r-f amplifier.

Most of this hum is due to the use of two audio stages. The small amount present in the first stage is amplified greatly by the second. If the detector could be made to produce from 10- to 25 volts at its output only one audio stage would then be necessary, not only giving less hum but also a great deal less distortion. This may be accomplished very easily by operating the detector on the lower portion of the grid voltage-plate current curve. The plate voltage is increased to 180 and the grid bias to 40 volts.

The sensitivity is reduced somewhat, since the detector does not operate efficiently as an audio amplifier, but can be brought up to normal by an additional r-f stage.

### *Use of Power Detector*

When used as a power detector, the 227 has a plate impedance 7 or 8 times higher than with a grid leak and condenser. This is far too high to work into the primary of an ordinary transformer. Either resistance or impedance coupling will be necessary. A shunt-feed system, using an auto-transformer, is well adapted for this purpose and gives a much greater gain. Sometimes it is possible to flatten out the frequency characteristics of the regular transformer by connecting across the primary, a resistance of from 25,000 to 100,000 ohms.

A circuit for power detector and audio amplifier is given in Fig. 3. The grid bias is obtained from a 2,000-ohm resistor, connected from the cathode to the B negative. The plate voltage will have to be increased to approximately 220 in order to obtain 180 volts between the cathode and plate.

By employing this method of detection the hum is reduced to a point that is just barely noticeable in the loudspeaker.

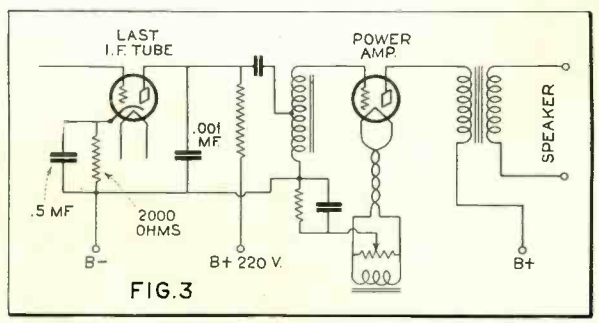


FIG. 3

Circuit of power detector and power amplifier. A substantially high grid bias is used on the detector, supplied by the voltage drop across the 2,000 ohm resistor.

# The Kyle Condenser Reproducer

*Practical and Theoretical Discussion of a New Electro-Static Speaker of Interesting Design*

*By Colin Kyle, A.B.**

THE announcement of the Kyle condenser type radio loud speaker formally introduces the "most direct conversion of electrical energy into sound."

As the name implies, the speaker consists of two metallic plates separated by a special dielectric, called Kylite, a substance named after the inventor. The unit is immersed in a bath of low-current high-voltage electrical energy. In order to provide the high voltage necessary to charge the surfaces of the speaker a device known as a polarizer, consisting of a small transformer to provide 450 volts, a blocking condenser, and a rectifier tube, is employed. A tube of the 201A type is used for rectification, delivering three to four milliamperes of current, which is ample to electrically charge the speaker.

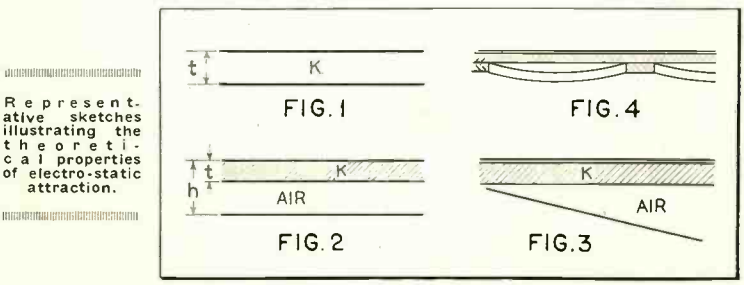
### *Adaptable to any Receiver*

The polarizing device which is a part of the complete speaker makes the unit adaptable to any standard radio receiver regardless of the type of tubes used.

The design and shape of the condenser-type loud speaker for use with present day receiving sets may take the form of a tilt-top table, a tapestry hanging on the wall, a fireplace shield or a living room screen. Its thinness makes it adaptable to many unique designs.

Since the thickness of the new speaker is approximately one-eighth of an inch, its use in factory made sets means the ability to use smaller consoles than are now required to conceal all the accessories.

The front panel or the top of a table model radio set of the future may incorporate a condenser type reproducer so that there need be no visible evidence of a loudspeaker.




Representative sketches illustrating the theoretical properties of electro-static attraction.

### *Theoretical Elements*

A. Electro-static attraction in a condenser: The force between the plates of a flat plate condenser with a single dielectric medium filling the space between them, as in Fig. 1, is given by the expression

$$F = \frac{A\,V^2\,K^2}{8\pi\,t^2} \qquad (1)$$

Where A=area of plates, V=potential difference between them, K=dielectric constant of the medium between the plates, and t=distance between them.

If, as in Fig. 2, the plates are spaced a distance $h$ and the space between them is partly filled with a slab of dielectric of thickness $t$ and dielectric constant K, and the remainder by air, the force is given by the equation

$$F = \frac{A\,V^2}{8\pi\left\{h - t\left(1 - \frac{1}{K}\right)\right\}^2} \qquad (2)$$

It is seen that (2) reduces to (1) in the case where h=t. If we let h=nt, (2) reduces to (3)

$$F_n = F_1 \frac{1}{\{1+(n-1)K\}^2} \qquad (3)$$

For the dielectric used in the Kyle reproducer we have K=3 approximately, so assuming this value we can find how the force varies as we change the relative thickness of the dielectric and air layers. We find that

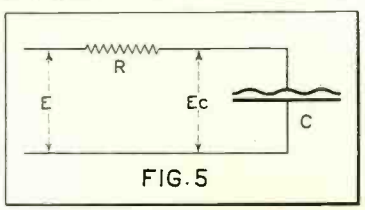
$$F_2 = \frac{1}{16}F_1 \qquad F_4 = \frac{1}{100}F_1 \qquad (4)$$

$$F_3 = \frac{1}{49}F_1 \qquad F_5 = \frac{1}{169}F_1$$

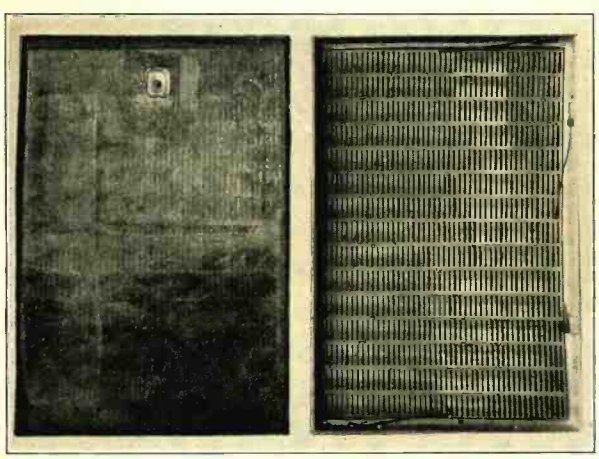
That is, if the air film is of the same thickness as the dielectric the force is 1/16 as great as if both plates were in contact with the dielectric, and so on.

In the Kyle reproducer we have a situation similar to that shown in Fig. 3, where the air space is wedge-shaped. Referring to the above it is seen that the useful force is confined to a rather narrow region near the point of contact.

B. Action of Kyle Reproducer: The Kyle reproducer is shown diagrammatically in Fig. 4. It consists essentially of a perforated metal back plate $a$ having corrugations or other undulated surface, a flexible dielectric diaphragm $b$ stretched over this back plate so as to bridge across the de-




Generalized diagram serving to illustrate the voltage division between a condenser and resistance.



Close-up views of a Kyle condenser speaker section. Left; front of unit. Right; rear or inside of unit.

** In collaboration with W. D. Crozier, Ph.D., F. W. Kranz, Ph.D., Paul E. Sabine, Ph.D., and V. Ford Greaves, Chief Engineer, United Reproducers Corp. These men participated in the development of the speaker, in the Newcombe-Hawley Laboratories.*

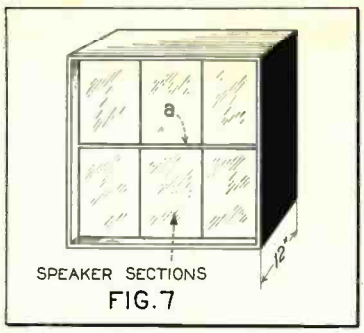


FIG.7

Speaker sections mounted in a baffle in the form of a rectangular box.

pressions, and a thin, flexible conduction coating *c* cemented or otherwise secured to the surface of the diaphragm opposite the back plate.

As shown, the useful electrostatic force is localized chiefly along a narrow zone adjacent to the points of contact. As the diaphragm is attracted under the influence of the electrostatic force the area of contact is increased and the diaphragm rolls down the slopes of the depressions. The air space is still wedge shaped near the point of contact so the attracted area moves down the slope also. The reproducer owes its efficiency to the fact that we have this wedge-shaped air space which permits a large force to be exerted and at the same time allows a large amplitude of motion.

**C. The biasing voltage:** As shown, the attraction between the back plate and flexible diaphragm may be expressed in the form

$$F = M\,V^2 \qquad (5)$$

Where M is a constant and V is the potential difference between the plates. This is a law of force which is analogous to the law in the magnetic telephone receiver and the thermophone and so it appears that a permanent biasing potential is required in the magnetic receiver and as a d-c heating current is required in the thermophone.

To illustrate, we shall take the case of an applied direct voltage and two alternating voltages. The force acting between the plates is then given by the equation

$$F = M\,(V_o + V_1 \cos pt + V_2 \cos qt)^2 \qquad (6)$$

$V_o$ being the direct voltage, $V_1$ and $V_2$ being the maximum values of the alternating voltage, p and q being their respective angular velocities. Reducing (6) we get,

$$F = M\,(V_o^2 + \tfrac{1}{2}V_1^2 + \tfrac{1}{2}V_2^2) \qquad (a)$$

$$+M(\tfrac{1}{2}V_1^2 \cos 2pt + \tfrac{1}{2}V_2^2 \cos 2qt) \qquad (b)$$

$$+M(V_1 V_2 \cos[p+q]t + V_1 V_2 \cos[p-q]t \qquad (c)$$

$$+M(2V_o V_1 \cos pt + 2V_o V_2 \cos qt) \qquad (d)$$

$$(7)$$

Part (a) represents a steady component of the force which draws the diaphragm away from its neutral position but does not contribute to the sound.

Part (b) represents alternating components of the force of frequencies double those of the impressed alternating voltages and which therefore introduce double frequency distortion into the sound.

Part (c) represents alternating components of the force with frequencies which consist of sums and differences of the incoming frequencies considered in pairs, and which introduce the corresponding distortion into the sound.

Part (d) represents the alternating components of the force which correspond to the impressed voltage and which produce the desired sound.

Consideration of the coefficients of the terms in (b) and (c) as compared with (d) shows that the predominance

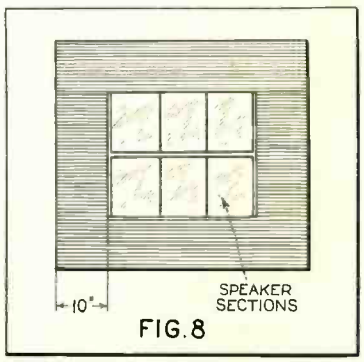


FIG.8

The speaker sections mounted in a flat baffle.

of the desired sound represented by (d) over the undesired sound from (b) and (c) depends on the predominance of $V_o$ over $V_1$ and $V_2$. If $V_o$ is large compared with $V_1$ and $V_2$ then $2V_o V_1$ and $2V_o V_2$ are large compared with $V_1 V_2$, $\frac{1}{2}V_1^2$ and $\frac{1}{2}V_2^2$. In other words, the direct biasing voltage $V_o$ must be large compared to the amplitudes of the alternating voltages in order that the resulting sound wave forms may be a reasonably good representation of the wave forms of the alternating voltages.

Since the coefficients in (d) contain $V_o$ as a factor, the efficiency as well as the tone quality depends on $V_o$. With a given amplitude of alternating voltage the amplitude of the force varies directly with $V_o$ and the energy output varies directly with $V_o^2$.

**D. Voltage division between a condenser and resistance:** We will now consider the bearing of output circuit characteristics on the performance of the condenser speaker. Consider first the circuit of Fig. 5, which, as far as the alternating current characteristics are concerned, is approximately equivalent to the output circuit of a vacuum tube working into a condenser speaker directly. Eq. (8) is the expression for $\frac{Ec}{E}$, considering C as a pure capacity.

$$\frac{Ec}{E} = \frac{1}{\sqrt{\omega^2 R^2 C^2 + 1}}, \quad \omega = 2\pi f \qquad (8)$$

Plotting $\frac{Ec}{E}$ as a function of frequency for different values of RC we get the curves of Fig. 6.

It is therefore seen that of we measure the response of a condenser speaker maintaining a constant voltage across it this response curve may be modified by multiplying its ordinates by the respective ordinates of the proper curve in Fig. 6, so as to give the response when used in a circuit similar to Fig. 5.

## *Back Plate Design*

**A. Contour of surface:** An extensive series of experiments has led to the form of back plate which is being used at present. In order to successfully reproduce low frequency sounds it is necessary to have a large portion of the diaphragm moving with a considerable amplitude. On the other hand, the force on the diaphragm depends on the length of the wedge shaped air space which increases with the number of points of contact. The present design is a compromise in which the greater linear contact length is used which will permit of satisfactory frequency response. For certain special purposes, such as for announcing systems, where it is possible to sacrifice some of the extreme low frequencies the dimensions can be

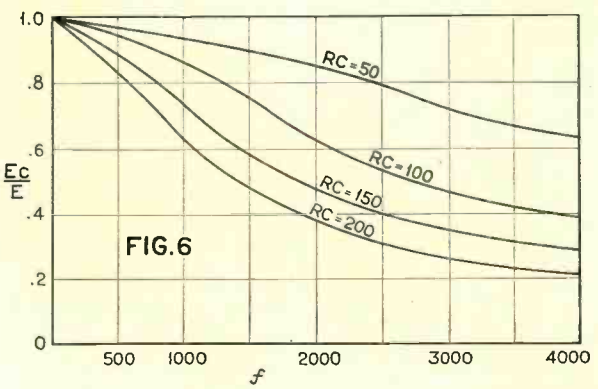


FIG.6

Frequency curves of condenser speaker with different values of RC, plotted against voltage in branch circuit.

modified to give greater efficiency over the more limited range.

The design of these plates depends also to some extent on the biasing voltage to be used. The present plate has been designed to use from 500 to 600 volts as it has been found that voltages of this order are necessary to secure satisfactory efficiency and tone purity. There is no danger of shock as this circuit carries practically no current.

**B. Air venting:** In order to secure freedom of motion of the diaphragm it is necessary that the back plate be perforated to permit free passage of the air in and out of the space between it and the diaphragm. There is some latitude permissible in the way of doing this but in practice it has been found that the conditions are satisfactorily met by a row of slots down the center of each trough, the slots running at right angles to the direction of the trough.

**C. Curvature:** To insure that the diaphragm remains in close contact with the crests of the corrugations the plate is made slightly convex toward the diaphragm.

**D. Weight and nature of material:** It is necessary that the plate be fairly stiff. If the stiffness is low enough so that the plate may resonate at a low frequency it may develop sufficient amplitude to throw the diaphragm away frm the crests of the corrugations and so produce a rattle or buzz.

The kind of metal which is used in the back plate is not very important but questions of cost seem to limit it to steel or aluminum.

### *The Diaphragm*

Referring to equation (2) it is seen that in order to get a large force it is necessary that the dielectric be as thin as possible. It must also have a high dielectric strength.

The diaphragm material which has been developed for this speaker is a composition called Kylite. It is about .005" thick and has a flexibility approximately equal to that of rubber dam. Its dielectric strength is over 2,000 volts and so gives a good margin of safety.

### *The Metal Coating*

The metal coating on the front surface of the diaphragm is sufficiently flexible so that no appreciable stiffness is added. Beaten leaf is perhaps the most satisfactory material but a sprayed metal coating is sometimes used.

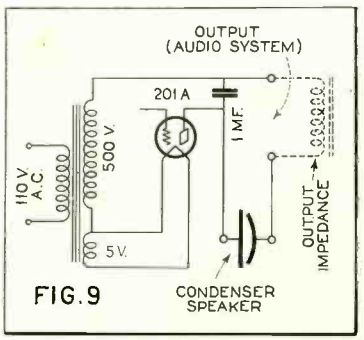
### *Mounting*

A. Baffles: The performance of any loudspeaker is improved by use of an appropriate baffle. The Kyle reproducer requires less additional baffle than a small cone because its own area acts as a partial baffle. To reproduce satisfactorily the lowest frequencies of which the speaker is capable it is desirable to have a baffle which adds a margin of at least 10 inches around the edge of the reproducing unit. This may be in the form of a rectangular box as shown in Fig. 7 or flat as shown in Fig. 8.

The form of Fig. 7 is more practicable on account of its compactness, though it is possible that there may be a very slight resonance in the cavity back of the speaker. This resonance can be minimized by mounting the reproducer units in the center of the baffle box but this is often objectionable as they take up space which it may be desired to use for a power pack or radio set.

B. Blocking of rear of speaker: It is necessary that considerable freedom be left behind the Kyle reproducer sections for movement of the air. The rear of the reproducer should not approach closer than 6 inches to a solid wall, but the space back of it can be utilized for a radio set and power pack provided that they do not fill up the area too solidly.

C. Resonance in mountings: Care must be taken that nothing in the baffle or speaker mounting resonates appreciably with a natural period in the audible frequency range. Things which are likely to do this are such as wooden cabinet panels, sheet metal parts in the radio set chassis, and loose joints between various parts. An exceptionably objectionable resonance comes in occasionally if a large area Kyle reproducer is solidly supported all around its periphery. In this case the whole speaker itself is likely to vibrate as a diaphragm and attain



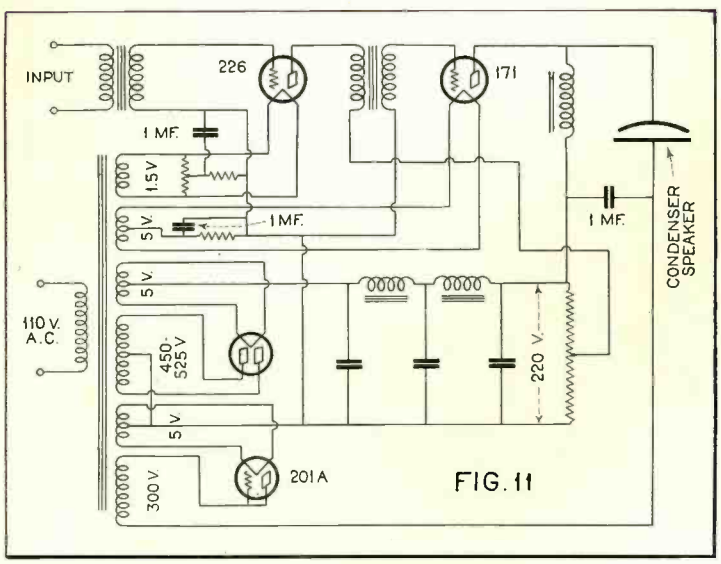

Circuit of the condenser speaker polarizer. The grid of the 201-A can be tied to the plate.

sufficient amplitude to cause the Kylite to be thrown away from the back plate and produce a buzzing sound. The remedy for this condition is to divide the speaker by a stiffening member as indicated by *a* in Fig. 7, or to use braces attached to the center of the speaker. The speaker may also be mounted in damping material at the edges.

For the speaker sections to be used most effectively they should all be in approximately the same plane, the plane facing the normal position of the listener.

### *Circuits*

**A. Impedance matching:** As ordinarily hooked up, the circuit using the condenser speaker may be considered as analogous to that of Fig. 5, where R is the output impedance of the amplifier and a constant input voltage is being applied at E. The capacity C of the speaker averages about .004 microfarad per 8"x12" section. Referring to the curves of Fig. 6 it is seen that we can alter the frequency response of the combination by changing the value of the product RC. We can change R by changing the output tube or by using a transformer between it and the speaker, and we can change C by using different numbers of sections in the speaker or for special purposes by connecting groups of sections in series-parallel. This is not very desirable for most installations as it complicates the biasing circuit somewhat. It may be mentioned that we




Standard amplifier circuit, with full-wave rectifier, with the addition of a polarizer for the condenser speaker.

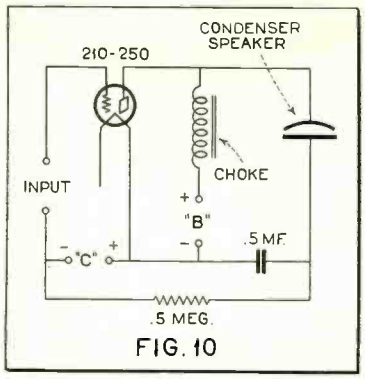


FIG. 10

The simplest circuit arrangement. No polarizer is used in this case.

can increase R by merely inserting an auxiliary resistance in series with the speaker. This is not very desirable as we thereby improve the frequency response only at the expense of efficiency.

With the present type of 8"x12" units a value of about RC = 65 (R being expressed in ohms and C in microfarads) gives the flattest frequency response for a small speaker of four 8"x12" sections, while RC-100 gives the best result on a speaker of, say, six sections. The difference is due mainly to the fact that the high frequencies emerge in a beam and that the beam is narrower with the larger speaker. The higher value of RC gives less total response in the high frequencies but on account of the fact that they are more effectively concentrated on the listener in the usual listening position, the effect is practically the same.

If an exceedingly large speaker is built the beam effect becomes rather objectionable if the sections are all used in the same plane. A 24-section speaker was found to give good response over an angle of about 30° using a value of RC = 180 but outside of this angle the high frequencies were low in intensity.

If the front of the speaker is set on a curved surface instead of flat the beam effect can be utilized to cover just the horizontal angle desired, keeping the vertical divergence small. The sound can then be focussed to cover the auditors without projecting a large proportion toward the ceiling. When used in an auditorium there is some effect in reducing the reverberation as the total energy input into the room for a given loudness to the auditors is smaller than it would be if the sound were projected uniformly in all directions, the sound being projected toward a good absorbing surface, the audience.

A 90-section speaker was built on these principles to cover a horizontal angle of about 90°. It was found that the best frequency response was secured with RC = 60.

In matching the speaker to an amplifier the characteristics of the amplifier, of course, have an important bearing. For example, if the amplifier has a rising response characteristic toward the high frequencies it is possible to use a higher value of RC than if it were flat.

B. The Biasing Potential: As shown, the force on the diaphragm at the desired frequencies is proportional to the product of the biasing potential and the alternating input voltage. This means that the energy output with constant input is proportional to the square of the biasing voltage. Practically this is only true within limits. If the biasing voltage is carried too high the diaphragm is drawn tightly against the back plate and placed under considerable tension. The result is a decrease in efficiency, rather than an increase, especially on the low frequencies. With the units constructed as at present a biasing voltage of 500-600 is as high as should be used.

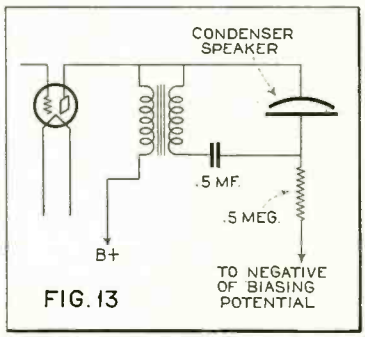


FIG. 13

Connections to the speaker when an output transformer is in the circuit.

### *Appropriate Circuits*

Figs. 9 to 13 illustrate circuits applying the Kyle reproducer. Fig. 9 is the circuit of the biasing unit which is used with the individual speaker to be attached to any radio set. As shown, the unit is only operative when connected to an output device giving a closed d-c path for the passage of the biasing charge. If there is a condenser in the output circuit a 0.5 megohm grid leak is connected across the output terminals to carry this charge.

It will be noted that no filtering circuit is included. This is possible because no current is used in biasing the speaker. The charge on the speaker builds up until the voltage reaches that of the peak after which no current flows and no hum is perceptible.

The 201-A tubes shown as rectifiers in the biasing units have proven to be entirely satisfactory. They have stood a life test in excess of 6,000 hours of continuous operation.

Fig. 10 shows the simplest connection possible, no auxiliary apparatus whatsoever being used. If the connection to —C is used the impedance between +C and —C should be small or else the circuit of Fig. 13 should be used. To use this connection the sum of the B and C voltages should be greater than 500 volts.

Figures 11 and 12 show means of adapting the power packs of amplifiers to furnish biasing voltage in excess of that furnished in the plate voltages. The diagrams are not intended to show all the possibilities by any means but only to illustrate the requirements.

Fig. 13 shows how the output circuit is modified in any of the hookups when it is desired to use a transformer between the tube and speaker. This transformer should be especially designed for this use, particularly with the view of making the coupling between primary and secondary as close as possible and keeping the resistance of the windings small. If the coupling is not close the secondary will resonate with the capacity of the speaker at a certain frequency. This frequency is usually between 100 and 200 cycles and so is rather objectionable. If the resistance in the windings is too great the high frequencies will be weakened.

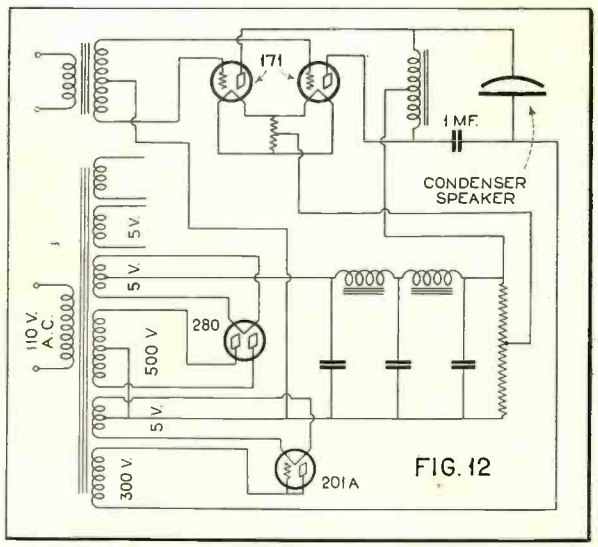


FIG. 12

A standard 171 push - pull amplifier circuit adapted to the condenser speaker. A polarizer circuit is added, using a 201-A as the rectifier.

# A Remote Tuning Control for Radio Receivers

*An Automatic Tuning System, Employing Push Buttons, Which Operates Directly on the Gang Condensers*

*By Walter Faas*

THE automatic remote tuning control to be described consists of two distinct units; the actuating mechanism, which becomes an integral part of the radio set, and the push button control unit.

The operating mechanisms shown in the accompanying illustrations are constructed in linear form, which is most satisfactory if the control is viewed as an accessory. However, it can also be constructed in circular form if the unit is to be incorporated in the radio set, as a part of the chassis.

The station selector control box contains a volume control, in the form of a variable resistance, a push button to turn off the radio receiver and eight station selector buttons. A greater number of station selector buttons can be included if eight are not sufficient.

The encased operating mechanism is shown in Fig. 1, mounted on the back of a Radiola 18. The same mechanism, with the case removed, is shown in Fig. 2. It will be noticed that a small motor is mounted on the extreme left of the base.

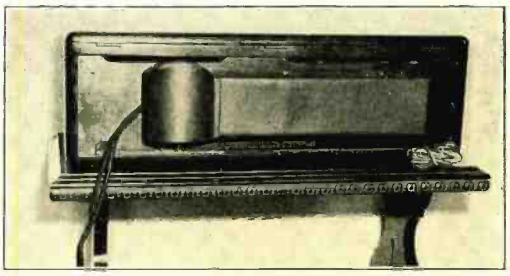
Another model of the remote control unit is illustrated in Fig. 3. This model employs a solenoid instead of a motor as the source of power. The push button control box is also shown in the illustration of Fig. 3. Small tabs are placed opposite each button and are marked with the stations, designating letters.

### *Installation*

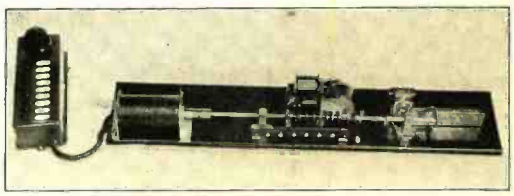
Installation is compartively simple. The operating mechanism is bolted to the back of the radio cabinet or console, as in Fig. 1. A pulley and spring attachment is fastened to the free end of the gang condenser shaft inside the set. To this pulley and spring is attached a flexible steel cable. The cable passes through a hole drilled in the back of the set and is attached to the free end of the movable control shaft in the operating mechanism.

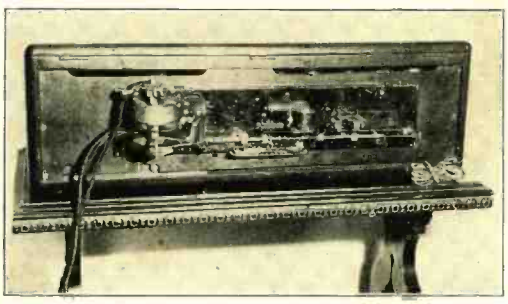
*THE automatic remote tuning control for radio receivers described in this article is the result of considerable research work. It embodies a number of very interesting design features and equals, if not surpasses, the automatic carriage release and reset system employed in the Hooven electric typewriter.*

*The remote tuning control demonstrated employed a motor rather than a solenoid as the fundamental actuating unit. The control automatically sets or re-sets the gang condensers with practically no noise and remains accurate—Editor.*



Right: Fig. 1. The operating mechanism of the remote tuning control mounted on the back of a Radiola 18. The unit is easily installed and demands no particular changes in the receiver.





Above: Fig. 3. View of the original operating mechanism, using a solenoid, and the station selector control box. Note the row of push-buttons and station tabs.
Left: Fig. 2. The operating mechanism shown in Fig. 1 with the case removed. Note the driving motor at the extreme left.

The type of volume control and likewise the connections to the volume control are entirely dependent upon the nature of the receiver. The connections from the control box break into the primary circuit of the power transformer in the receiver.

### *Details of Operation*

The operation of the mechanism can best be understood by reference to the illustration of Fig. 3. The movable control shaft heretofore mentioned is arranged to slide through the solenoid mounted on the extreme left of the base. The end of the control shaft is connected by flexible means to the pulley and spring on the gang condenser shaft, so that when the control shaft travels towards the left, through the center of the solenoid, the flexible cable is pulled along and unwinds from the pulley and consequently revolves the gang condensers. When the control shaft moves towards the right the condenser-rotors move back to neutral position under power of the spring tension, and the flexible cable winds up on the pulley.

It is seen, then, that if we are to pass a current through the solenoid the control shaft will be pulled through and, therefore, the gang condenser will rotate. When we break the current through the solenoid the control shaft will return to its normal position by virtue of the spring tension on the condenser shaft.

Now we come to the point of accurately controlling the movement of the control shaft so that it can be stopped at any desired point.

There are two other solenoids grouped together on the base. One solenoid operates a locking mechanism and the other solenoid operates a release mechanism.

A series of small discs, a number equal to the number of station selector

buttons on the control box, are mounted on the movable control shaft and in front of the locking mechanism. See Fig. 3.

When the set is first turned on, from the control box, by pushing any one of the station selector buttons, the solenoid pulls the control shaft towards the left to its maximum distance of allowable travel. At this point the gang condensers in the receiver are at maximum setting and under spring tension. The control shaft then travels towards the right under the power of the spring tension on the condenser shaft. A travelling arm on the control shaft runs over a series of contacts, each of which is connected to a station selector button. When the traveling arm reaches the contact in circuit with the button pushed, the circuit to the locking solenoid is closed and a finger moves out. The disc on the control arm which corresponds to the setting on the receiver drum dial, for the station desired, runs up against the finger and the control bar is stopped short. The receiver is then in tune with the desired broadcast station.

### *Electrical Operation*

A more accurate idea of the operation can be obtained from the schematic diagram of Fig. 4.

The station selector buttons (8) are so arranged that only one button can be down at a time. The pressing of any one of the buttons momentarily closes contact (9) and starts the motor which pulls the control shaft over to maximum position. When the control shaft reaches the maximum position a mechanical arm throws switch (7) from the motor circuit over to the branch circuit containing the release and locking solenoids (5) and (6). Free of the motor power, the control shaft, which carries the traveling contact (2), starts moving back under the power of the spring tension. As soon as the arm (2), which travels along contact segment (3), reaches that particular segment in the circuit with the button which has been pushed down, the circuit to solenoid (6) is closed. The finger on the core of this solenoid is consequently pushed out to meet the oncoming disc. When the two strike, the control shaft is stopped. (It is understood that each of the afore-mentioned discs is set to correspond to a particular dial setting.) As soon as the core in solenoid (6) is pushed out the circuit of the solenoid is opened through spring contact (4) which immediately closes the circuit to the release solenoid (5).

When another station selector button is pressed down, the first button springs back to its normal position and likewise, since contact (9) is always closed momentarily, the release solenoid (5) has its core pulled in, which in turn releases the locking mechanism on solenoid (6). The release of solenoid (6) again operates the spring contact (4) and opens the circuit to release solenoid (5).

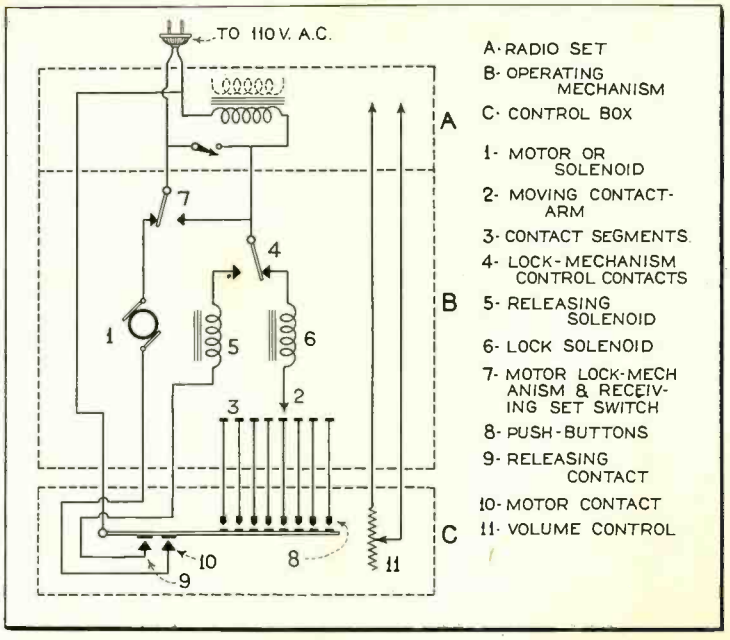



Fig. 4. Schematic diagram, and legend, of the remote tuning control. Contact 10 is the "off" push-button on the station selector control box. See Fig. 3.

The control shaft can now move along until it again reaches its normal position or to any other predetermined stop, depending on the station selector button pressed down.

Contact (10), in Fig. 4, is the "off" button. Pressing this button turns off the radio set and returns the control mechanism to normal position.

### *General Details*

It is interesting to note that if the mechanism is locked on a station of intermediate wavelength and that the next station desired is on a higher wave, the mechanism first returns the gang condenser to its neutral position and starts working down from maximum. However, if the next station desired is on a shorter wave, the mechanism merely travels down the predetermined distance, in which case the motor, or drive solenoid, is not in use.

A scale is arranged on the movable control shaft, corresponding to the scale on the drum dial of the radio receiver. This simplifies the task of setting the small discs or stops to their proper positions.

The radio can always be turned on at the set switch and manually tuned, when desired. The spring attachment, which provides the necessary tension to return the condensers to a "neutral" position when the remote control is being used, does not prevent the condensers from maintaining a set position when tuned by hand.

With the present system it is practical to wire a house so that the radio receiver can be tuned from any number of remote points. The control boxes can be paralleled and left in circuit, or a single control box employed, if provisions are made for plugging it into convenient wall outlets.

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## RADIO RECEIVER TROUBLE DUE TO CONNECTION WITH POWER OR LIGHT CIRCUITS

WITH the increasing use of 110-volt public service lines in the operation of radio receivers, there has developed a situation which can be met only by recognizing that pole line power and light wires occupy the same exposed position as antenna wires.

When public service wires are used as antennas for receivers, through the medium of any of the antenna plug-in devices, or to supply power for filament or plate, or both, of tubes, the receiver is subject to all of the damage and fire hazard that it is subject to, if directly connected to an antenna wire mounted on the roof or in any exposed position out-of-doors.

The power company at its own end of the lines, at the generating station, employs lightning arresters to safeguard generators and auxiliary apparatus within the station. Much of the mysterious trouble in radio receivers connected in any way with lighting circuits has been discovered to be due to lightning disturbances brought into the receiver by way of the light wires.

Radio engineers and service men are recommending that a properly designed and dependable lightning arrester be connected in circuit between the 110 volt outlet and the radio receiver.

# The Engineering Rise in Radio

*By Donald McNicol*

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

PART X

## *Polarized Waves*

From the time of Marconi's early trials in 1896, until Franklin's inquiry of 1919 into the properties of short waves, the whole tendency in service operation was to work toward longer wave lengths, as experience had shown that long waves performed more regularly through varying day and night conditions, and were less subject to fading. Thus, years before the time arrived when there was a shortage of available radio channels, the large commercial radio telegraph companies, having a choice, selected the very long waves for long distance working.

When broadcasting radiophone stations began to multiply beginning in 1921, all of these had, perforce, to accommodate themselves to the wave lengths already assigned to public service, those ranging from 200 to 600 meters. The long waves for radio telegraph purposes had been systematically examined and exploited, and the amateur range below 200 meters, was, following the advent of broadcasting, critically explored as discussed in previous paragraphs.

The engineers who had for years been identified with the development on a large scale of long wave signaling, in the five years (1922-1927) gave a considerable amount of attention to the study of the broadcast range of frequencies. E. F. W. Alexanderson, in America, in 1925-1926, studied the behavior of propagated waves, from a new angle.

In Chapter 5, on the subject of antennas, a description is given of studies made by Artom, in Italy, in 1903, with a view to sending out circularly and elliptically polarized waves, the result of which was the development by him, and by Bellini and Tosi, of systems of directive signaling which in time had useful applications. Assuming that in earth-bound, long-wave technique the transmitted waves are vertically polarized by virtue of the vertical, earthed antenna, it occurred to Alexanderson that in view of the performances in short-wave working, the subject of horizontally polarized waves was worth investigating.

By means of square loop radiators, mounted vertically and tuned to a wave length of fifty meters, Alexanderson aimed to regulate the phase and direction of the currents so that the composite antenna would produce unidirectional radiation in the plane of the loops. In a test organized for this purpose, Alexanderson[19] discovered that one of the loops had by accident been reversed in connection, out of which mishap came the discovery that while the currents in the vertical sections were in such direction as to neutralize each other, the two top conductors carried current in the same direction, and these latter being horizontal it was concluded that the very effective radiation observed (as actuating a distant receiver) was horizontally polarized. Soon, various antenna forms for horizontally polarized radiation were placed in service, the findings indicating that in most cases horizontal transmission and reception with short waves is superior to the older methods using vertical polarization.

It is remarkable how in each new attack on theories of electric wave

STUART BALLANTINE

propagation recourse is had to the terminology of optics. The language of A. J. Fresnel, the French optician (1788-1827) in use in 1927 to explain theories of Hertz wave propagation, is either a tribute to the completeness of the French physicist's theories of refraction and polarization in optics (forty years before Clerk Maxwell) or a commentary on the inadequacy of specific terminology applicable to modern electrical and radio engineering.

In using optical terms, particularly "polarization," writers dealing with theories of electric wave propagation have to remember that the electric field is vertical only near the surface of the earth, and that a horizontally polarized magnetic field exists only near the ground.

The very material gain in knowledge of radio transmission phenomena made in the year 1924 and following years, included useful information about the practicable signaling range of radio waves of various lengths. The knowledge that very long, and very short waves are best for long distance signaling, and that certain intermediate wave bands are limited in their distance reaching possibilities, transferred from problems of antenna design some engineering details which belonged elsewhere.

It may well be realized that from the very beginning of the art the thought was ever to the fore that the problems both of transmission and reception were largely matters of antenna design. Throughout the two decades prior to 1924 a continuous attack on the problem was maintained out of which a very great deal of important and valuable engineering information accrued.

Some of the earliest constructive antenna engineering in America was done by John Stone Stone and Oscar C. Roos, prior to 1905, and in later years.

As was the case in other departments of radio research, the needs of war, following the year 1914, directed to the engineering of the antenna the thought of skilled investigators. Between 1915 and 1923, particularly, antenna engineering of outstanding importance was accomplished by G. W. Pierce, Edward Bennett, Stuart Ballantine and L. J. Peters, in America.

In the antenna investigations conducted prior to 1924, objectives were to determine the most efficient and effective design of antennas for the range of wave lengths over which the radio telegraph transmitters and receivers then mainly used were operated.

Professor Edward Bennett, of the University of Wisconsin, in 1916, in a technical paper, discussed the subject of *high* versus *low* antennas, and two years later presented a paper before the Institute of Radio Engineers, with the title: "Feasibility of the Low Antenna in Radio Telegraphy." These papers and others of similar import marked the end of the period during which some practicians held to the notion that signaling by radio over very long distances would be best served by antennas of great heights.

## *"Beam" Radio*

In the very beginning of the art Mr. Marconi undertook to send out *directed* transmission by means of metal parabolic reflectors mounted behind, and close to, the sending spark-gap, but at that time there was no way of producing accurately electric waves short enough for this purpose.

[19] *Polarization of Radio Waves. Journal, A. I. E. E. July,* 1926, *p.* 636.

In 1916, in Italy, Marconi again took up this subject and with the use of a coupled spark transmitter produced waves of two meters in length. With the apparatus at that time available satisfactory demonstrations of directive transmission were possible over a range of but six miles. A year later, in England, Marconi continued experimentation, employing an improved compressed-air spark-gap transmitter, and a three-meter wave. Quite evident directive effects were noted up to a distance of 20 miles. Following this, in 1919, C. S. Franklin, of the Marconi Company, began the short-wave developments previously mentioned.

In 1919, of course, vacuum tube transmitters were at hand, simplifying materially the task of producing short waves. By employing reflectors at both sending and receiving stations, and fifteen-meter waves, telephone conversation was carried on over a distance of 97 miles.

In 1922, the Marconi Company's engineers had carried directive radio forward to a state where signaling (telegraph) had been successful up to a distance of 2,500 miles, using short waves and metallic reflecting screens; the transmitting power used being very considerably less than when no reflectors were used over the same distances.

In the meantime, for the purpose of distinguishing between the original and the modern attempts to set up directive systems of radio transmission, the accomplishments of 1922, resulted in the introduction of the term "Beam Radio." Using the beam system commercial stations are now in operation between England and some of the distant commonwealths.

In the specifications of 1924 for the beam radio service between England and the dominions, embraced in what has been called "The Imperial Chain," the beam is defined as having a width of 30 degs. outside of which the strength of the radiation must not exceed 5 per cent. of that at the axis.

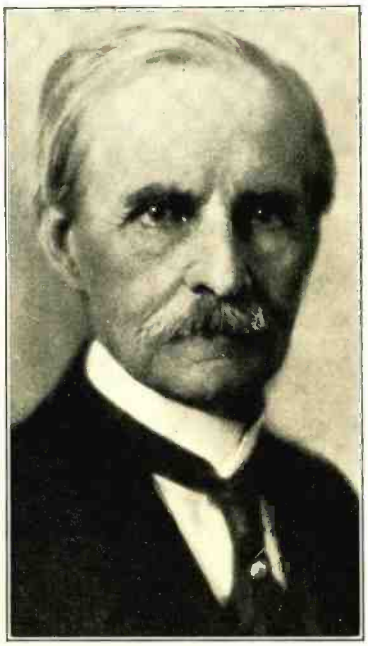
## CHAPTER 9

### *Static Interference*

THE problem of excluding from radio receiving systems electrical effects caused by atmospheric electric disturbances particularly, has been with the art since Marconi's first coherer-operated relay gave its first click. At the start it was well understood that the huge sparks of lightning produced electromagnetic waves of various wave lengths, and it was anticipated that electric waves so produced would immediately encounter radio antennas, producing therein electric currents which would momentarily actuate receiving systems.

Obviously, there is no known way of curbing the production of lightning, and there seemed little likelihood of being able to shield radio antennas from electric waves produced by lightning, while at the same time maintaining the antennas in the path of radio signals sent out from distant stations.

As previously recorded, the large commercial radio telegraph installations are designed with regard to transmitting power so that at the receiving station incoming signals from corresponding transmitters are, in general, considerably stronger than parasitic currents reaching the receiver, due to atmospherics. There are employed, also, directive antennas which favor the desired signal, and receiving antennas having physical lengths approximately the same as the length of the received waves, thus being selective to the signal wave.



DR. J. H. ROGERS

Throughout all of the radio development recorded herein the problem of disturbances in receivers originating in extraneous sources has continued as an ever-present, troublesome reality.

Practically all of the workers on other phases of radio development; particularly, Stone, Fessenden, Pickard, deForest and Austin in America; Braun, in Germany; Brown, in England, and Bellini and Tosi, in Italy, gave to the subject of disturbance-elimination continuous thought. In the design of transmitters, receivers and antenna systems the idea was ever uppermost that if possible some element should be incorporated which would at least mitigate the nuisance of interference.

From the date of Marconi's first experimental signals across the Atlantic, in 1901, until the invention of amplifying radio receivers twelve years later, the continuous effort made to set up a commercial message-carrying service met with poor success. A factor which contributed largely towards the failures; to the intermittent nature of the service, was that of static disturbances. Prior to 1920, static interference with radio signals was a serious consideration to those engaged in carrying on commercial radio telegraph service; army and navy communication; amateur radio telegraphy, and experimental radio telephony. With the advent of broadcasting, the public, in hundreds of thousands, soon learned something about the difficulties experienced by the engineers who for twenty-five years had been engaged in attempts to establish radio telegraph service of a character which in reliability and accuracy might be expected to offer an alternative, competing facility. The submarine telegraph cables had been in use across the Atlantic since 1865, and were rendering dependable and rapid service; service of a grade which could not be rendered by a radio system hampered by extraneous interferences which garbled the intended signals.

An heroic attempt was made by the American, British, German and French engineers identified with the trans-Atlantic radio telegraph to devise ways and means of setting up a dependable service, and a patient public, while according a measure of support, put up with a very inferior telegraph service. Up to the year 1916, little of real value had been accomplished in limiting the disturbing effects of static, so far as the long-wave trans-Atlantic circuits were concerned. The disturbances were most severe in the summer months, and displayed daily variations in intensity; being at a minimum between sunrise and noon and increasing considerably to a maximum at sunset, from that time forward remaining practically constant until shortly before sunset. The situation was that from June to October reasonably good reception in America from the continuous-wave high-power stations in England and Germany was possible only between sunrise and noon of each day; during the rest of the day varying from poor to impossible.

It may well be understood that unending inquiries, investigations and surveys were set afoot with a view to learning the nature of parasitic currents and their sources, and of devising methods by means of which they might be suppressed, or at least reduced in interfering manifestations.

Roy A. Weagant, a graduate of McGill University, Montreal, Canada, entered the service of the American Marconi Company, in 1912, and within a few years thereafter under his direction a comprehensive survey was made of the subject of static effects.

It had for several years been recognized that static disturbances are of different sorts; apparently due to a variety of causes. In addition to the effects produced in receiving systems due to local lightning storms, three other types of disturbance were early noted; designated as "grinders," "clicks," and "hissing." These terms were adopted by W. H. Eccles, in Eng-

land, who had devoted a considerable amount of time to the study of the phenomena.

In transocean radio telegraph working the grinders were by far the greatest cause of interference with message signals. Generally, both grinders and clicks were in evidence, but it was noted that in the summer months when disturbances were at maximum, as the grinders increased in violence the clicks tended to diminish in severity. The hissing sounds were less in evidence and were due to discharges between antenna and earth, in grounded systems.

Although the determinations made by Weagant were the result of experience with waves ranging from 5,000 to 10,000 meters long, later checking showed that when waves much shorter were used the results were practically the same. It was early learned that currents induced in a radio receiver, from atmospheric sources, have a period and damping determined by the electrical constants of the receiver circuits. A receiver adjusted to give maximum response to intended signals was, unfortunately, adjusted to give maximum response to intercepted atmospheric currents.

As early as 1905, Fessenden had introduced what appeared to be a "bug catcher" for static. He called the system an "interference preventer." The antenna circuit extended to two branches, each coupled to a common secondary circuit, the latter including the detector and translating telephone receiver. Each of the primary branches included an adjustable condenser by means of which one of the other of the branch leads to ground could be detuned, with respect to the frequency of the incoming signals; the thought being that in the detuned branch, while the signaling current would be reduced, the current due to static would not be materially retarded, but would neutralize, or cancel out, the current due to static flowing in the opposite leg, which latter was tuned to the frequency of the intended signal. In the years following, many variations of this type of interference eliminator were proposed, but the general experience was that "bug traps" set to catch unwanted impulses were not sufficiently descriminating, the result being that the desired incoming signals were considerably reduced in strength, an effect not at all desired.

H. J. Round, in England, introduced a "balanced" detector arrangement which at least had the advantage that it limited the upper level of sound produced in the telephone receiver. A receiving system was designed so that it would not respond to currents of an intensity much above that developed in the antenna by the incoming signal. By this arrangement currents exceeding in strength those due to the incoming signals were excluded.

Naturally, much thought was given to the subject of antenna design, with the hope that an array might be discovered which would be highly selective for the desired signal, excluding frequencies higher and lower than that of the signal; whether the undesired waves originated in static sources or in other radio transmitting systems. Antenna systems made up of associated loops, and various forms of horizontal, ungrounded antennas, were for long known to have directional properties, and in later years in the operation of broadcast receivers including effective amplifying elements, loop antennas, without earth connection, were found to exclude all but strictly local disturbances.

Clearing up the mystery of static was not a simple undertaking to which known electrical engineering principles could be applied. H. M. Airy, early in 1911[1], suggested that much of the disturbance experienced originated in the upper atmosphere, due to electron arrival from outer space, and Pickard, in 1912[2], discussed the probable relation between ionization conditions in the upper atmosphere and electric wave phenomena.

In long distance radio operations it was early discovered that all of the disturbances observed in receiving systems did not originate in lightning discharges. L. W. Austin pointed out that a brilliant lightning flash hardly provides a disturbance twenty miles away. On the other hand, Pickard held to the idea that much of the interference originates in the tropics; in southern lightning discharges, the electric waves thereby created being reflected back and forth between the upper refracting atmosphere and the earth.

The whole problem was one which was baffling in its manifestations. The effects were capricious, elusive. As late as 1919, C. L. Farrand[3], in America, advanced the idea that the origin of static is at the center of the earth, the radial propogation of static charges to the surface of the earth affecting all stations substantially in the same manner.

Weagant's extensive inquiry into the subject led to the conclusion that static disturbances of the predominating grinders type behaved as though due to heterogeneously polarized, electromagnetic highly damped waves propogated in a direction perpendicular to the earth. Antenna systems designed by him were said to retain a good working margin of the received antenna current, while largely excluding currents due to static.

As the need was for receiving systems which would provide static-free reception of long waves from European stations, and as such receiving systems should preferably be erected near the coast line, in open country, the needs of dimension of the structure could be made to accord with the theoretical limitations. For this purpose Weagant had set up two single-turn loop antennas 400 feet high, each with a base line 1,000 feet long, the centers approximately 5,000 feet apart. The loops were mounted in the same plane and the line connecting them was in a direction toward the sending station in Wales from which it was intended to receive. The four wires from these large external loops were at the station connected to a selecting system resembling the Pickard and Bellini-Tosi arrangements described in Chapter 5.

From test observations Weagant assumed that the grinder noises were caused by electric charges travelling perpendicularly to the earth's surface, either from below or above the antenna, and by employing a mile-long, double-loop antenna placed in line with the direction of reception he hoped to secure the following advantage. Signals arriving at the loop nearest the transmitting station would affect the receiver a fraction of a second before current developed in the loop farthest away from the transmitter could reach the receiver, while the currents generated by static charges would be set up in both loops at the same instant. The static currents would be in phase, while the e.m.f.'s generated by the signal waves would be out of phase. While the two-loop arrangement was found to have marked advantages in the reduction of grinder noises, to reduce disturbances due to clicks it was found necessary to add a third loop in the center. Clicks, it developed, result from horizontally propogated stray currents, and not from vertically moving charges such as produce grinder noises.

### *Static Control Urgent*

The attack on the static problem was widespread. Investigators in all countries maintained continuous watch over its manifestations as noted in radio receiving systems. In Germany H. G. Moller and M. Bauemler, and in France, H. de Bellescize, were in the forefront of those engaged in studying the causes and effects of the undesired impulses.

With the entry of the United States into the Great War the necessity immediately arose for dependable radio telegraph communication with England and France. The submarine cables naturally were subject to interruption from enemy submarine activites. In America in 1917, additional, new radio receiving stations on an extensive scale were established along the Atlantic coast. At these stations systems of static elimination designed by Pickard, Weagant, L. W. Austin and C. H. Taylor were variously tried, all of which served the purpose better than the older systems in use, enabling the station managements to carry on a fairly satisfactory radio telegraph service between America and stations of the Allies abroad.

[1] *The Electrician, London, April 14, 1911, p. 29.*
[2] *Before the New England Wireless Society, Dec. 7, 1912.*
[3] *Proceedings, Inst. Radio Engineers, October, 1920, p. 395.*

### *Buried Antennas*

The practice of operating radio receivers by current due to a potential difference between an elevated antenna and the earth was based on Marconi's early successful operations, and on electrical engineering reasoning as applied in conductor communication. Antennas insulated in space, with one extremity connected to a wave responsive device, either directly or by coupling, the other terminal of the device or coupler attached to the earth, constituted an assembly of gear that was understandable in its functioning. But, with the elevated antenna plainly in a position to intercept all vagrant electrical effects passing or circulating in its immediate vicinity, it was not likely that the possibilities of the Pickard, or Dieckmann cage would be overlooked: nor likely that it would not occur to some investigator to try out the wave intercepting capability of a bare or insulated conductor laid directly on the surface of the earth, and, also, laid in a trench in the earth's surface, one or more feet deep.

Obviously, such a receiving antenna would not gather as much of the energy sent out by a given transmitter as would an elevated antenna located in the same place, but it might gather sufficient energy from transmitting stations not too far away, to be of use in special applications. And, undoubtedly, a buried antenna would be less affected by static and other extraneous disturbances native to the atmosphere above ground.

In Germany, as early as 1912, Kiebitz, Mosler, Hausrath and Braun reported experiments with this very object in view. In America, J. H. Rogers, at the same time or a little later, carried out an elaborate series of experiments to determine the availability of buried antennas for reception and transmission. Still earlier, (1909) George H. Clark, of the United States Navy conducted experiments with underwater antennas, but due to the fact that only the crystal detector, without amplifying accessories, was employed in the receiver the results obtained were not encouraging.

Rogers, in 1916, had in operation an experimental system of underground antennas at his private radio station at Hyattsville, Maryland. One buried conductor was 1,400 feet long, with the receiving apparatus connected at its center. Various other lengths of conductor were tried out, and antennas were laid in various directions, and at various depths, from a few inches to several feet.

The Rogers' underground antennas were studied and experimented with, intermittently, throughout a period of two years by officers of the United States Navy communication service, and the reports[1] showed that with such antennas it is possible to receive efficiently signals at any wave length, long or short, provided amplifying receivers are used in connection therewith. The underground antenna was found to have directive properties in that signals coming at right angles to a given conductor, or pair of conductors, are excluded, while signals from a parallel direction are received with maximum intensity. Disturbances following violent lightning storms were found to have but immaterial effect on the buried antennas. For army and navy uses, and for particular short-distance commercial working, antennas of this type have had useful applications.

Still another ambitious attempt to develop a receiving antenna to meet the war emergency, was that due to E. F. W. Alexanderson, known as the "barrage receiver." The system embraced a 'bridge' type of receiver in association with a highly directional combination of aperiodic antennas, with unilateral directional characteristics, on the principle of the early Pickard, and Bellini-Tosi systems. By means of phase-shifting devices and differential coupling of the associated antennas to a common receiving set, the incoming signals from a given direction were to some extent balanced out.

The public's use of radio receivers to intercept broadcast voice and instrumental entertainment, largely increased the avenues through which the static-producing agencies might project discord into the affairs of men—and women. Radiophone receivers designed for long distance reception, employing outdoor, elevated antennas are subjected to the attack of static due to atmospherics, in the same way as long distance radio telegraph systems. Sensitive receivers employing loop antennas, mounted indoor, are fairly free from attack, except from discharges resulting from violent local lightning flashes. Where a four tube receiver with an outdoor antenna is the reception equivalent of a six or an eight tube receiver employing an indoor loop antenna, there is a reason why outdoor antennas continue to be used in the majority of installations. True, the outdoor antenna "picks up" much more static than an indoor loop, but antenna wire is much less costly than additional tubes and batteries.

The broadcast listener's average receiver is subjected to atmospheric disturbances, to wave interference from a multiplicity of transmitting stations, re-radiation from neighboring receivers, and to a host of inductive disturbances resulting from defects in electric light and power transmission lines, and to spark effects occurring in electrically operated office or household appliances in service in the immediate neighborhood of the receiver.

So far as broadcast listeners are concerned some progress has been made in the design of radio receivers which discriminate with a fair degree of satisfaction between the transmission it is desired to hear, and disturbances from extraneous sources. This is a subject to be considered under the head of receiving sets.

*(To be continued)*

[*Note: In the second paragraph, under the sub-head "Magnetic Detectors," page 36, December, 1928 issue, the date* "1889" *should be* "1899."]

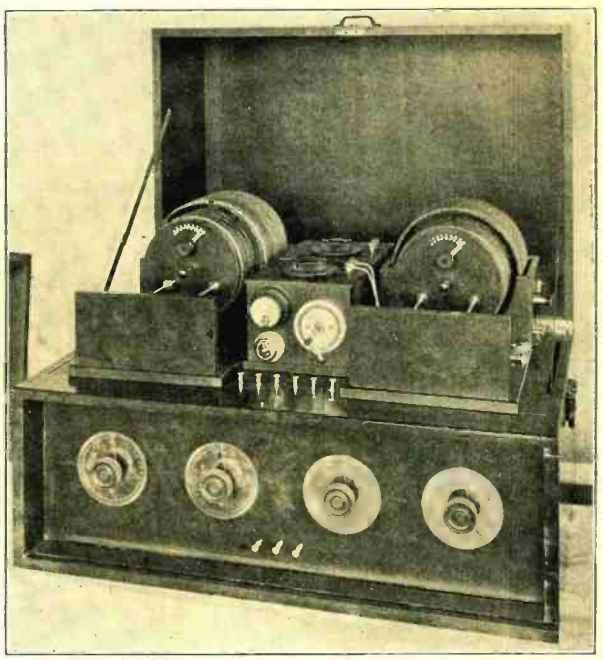


Fig. 13. An early radio receiver with a "barrage" section, incorporating bridge circuits and used in conjunction with directional antennas to reduce objectional interference.

[1] *"Short Wave Reception and Transmission on Ground Wires (subterranean and submarine) By A. Hoyt Taylor. Proc. Inst. Radio Engineers, August,* 1919.


# Centralized Radio Systems

*Both Audio- and Radio-Frequency Systems Available to Meet Requirements of Either Transients Without Sets or Tenants With Their Own Sets*

CENTRALIZED radio has been evolved out of the necessity of accommodating dozens and sometimes hundreds of radio listeners under one roof. In the case of the hotel or hospital, with its transient listeners-in, the problem has been one of supplying radio programs from a central radio receiver, in sufficient variety, and range of volume to meet individual needs and tastes. In the case of apartment houses and apartment hotels with their more permanent tenants, the problem has been one of suitable antenna and ground accommodations for the many receiving sets where obviously a jungle of antennas on the roof, and lead-ins on the walls are both unsightly and inefficient.

### *Audio-Frequency System*

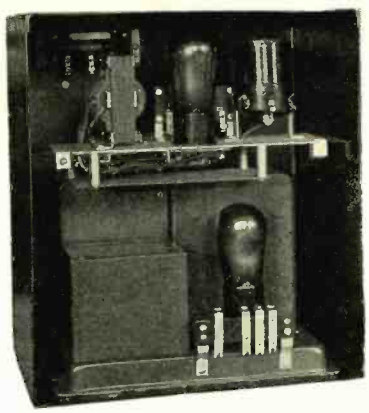
For the transient listener-in, there has been developed some highly specialized equipment in the form of a centralized radio receiver, an efficient distribution system, and suitable outlets and sound-reproducing equipment for each room, apartment or ward. The engineering staffs of the Radio Corporation of America and its associates, the General Electric and the Westinghouse companies, have succeeded in developing equipment that ideally meets the requirements of *audio* centralized radio. This is not to be confused with a conventional radio receiver and amplifier, connected with scattered loudspeakers or head-phones throughout a building, for the parallel ceases after the basic principle.

The special 100-A speaker, for wall mounting. A volume control and channel selector switch are included.

The audio centralized radio equipment takes the form of the necessary units mounted in standard switchboard form. One receiver, with amplifying equipment, distribution and outlet equipment, constitutes one channel. One channel is required for the reception and distribution of one program. However, more than one complete unit can be employed, and as many as four channels can be installed so that the listener-in may choose any one of four simultaneous programs.

A typical audio centalized radio channel installation comprises a receiver, a monitoring loudspeaker panel, one to three amplifier units depending upon the distribution system, and a control panel, all mounted on a vertical steel rack. The equipment is operated from the usual electric lighting circuit, so that no batteries are required. The receiver is of the conventional broadcast type, somewhat modified, with a-c tubes. The power amplifier comprises two 250 power tubes arranged in push-pull amplification, with an output of about 10 watts. Different volume levels may be obtained by means of different taps, so that from up to 200 loudspeakers may be operated on a single amplifier unit, or from 2000 to 3000 head sets. If the load exceeds 10 watts, additional amplifier units may be added. The distribution circuits from each amplifier are separated elec-

Left: Interior of r-f amplifier for individual installations of the radio-frequency distribution type. Right: Interior of a master radio-frequency amplifier unit of centralized radio equipment.



trically, so that trouble in one circuit will not effect others. A distortion indicator serves to indicate when the

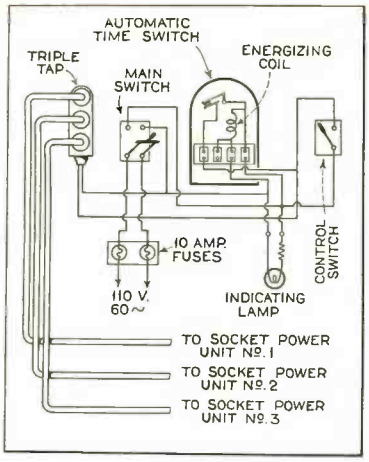
power amplifier is being overloaded, so that the operator can correct this condition by reducing the volume.

### *Fundamental Details*

The operation of the centralized radio receiver is reduced to the simplest terms. The receiver for each channel is tuned to a given station, and the tuning dials locked in position, to prevent tinkering. A time clock switch starts the programs at any designated hour, and turns them off at night, without attention. The centralized radio equipment may be placed in the superintendent's quarters, alongside the telephone switchboard, behind the desk of the hotel, in the office of the hospital, or anywhere that space is available. Phonograph records can be played, in the absence of programs.

From the centralized radio unit, the distribution wiring leads to all parts of the building. The wiring should be of a permanent character, in shielded iron conduit, lead covering, metal moulding, or flexible conduit (BX), in accordance with best electrical practice. This wiring leads to suitable outlets. The individual installations may take various forms. One is a loudspeaker mounted flush in the wall, with volume control and selector switch for controlling volume and selection of programs. Another type is a wall-plate with jack for the plugging of loudspeaker or head-phones, with or without volume control and selector switch.

The audio centralized radio system is obviously best suited to the requirements of hotels, hospitals and other institutions with transient guests, since it permits the enjoyment of radio programs without the bother of individual radio sets. Convenient as this system may be, however, it is not always



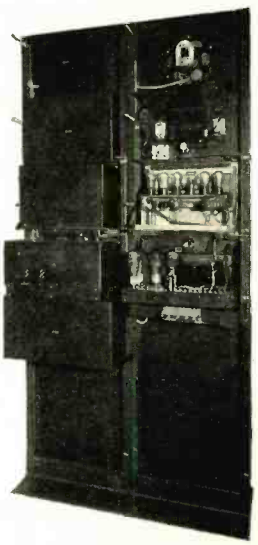

Above: Circuit connections of centralized system of the audio-frequency distribution type.

Left and Right: Front and rear views of twin-channel panels for the a-f distribution system.

acceptable to those who possess a radio set and wish to do their own radio tuning. Obviously, there is need for some centralized radio system which will bring *all* radio waves to the individual receivers in many apartments, to take the place of the haphazard antennas and troublesome interplay between closely packed receivers.

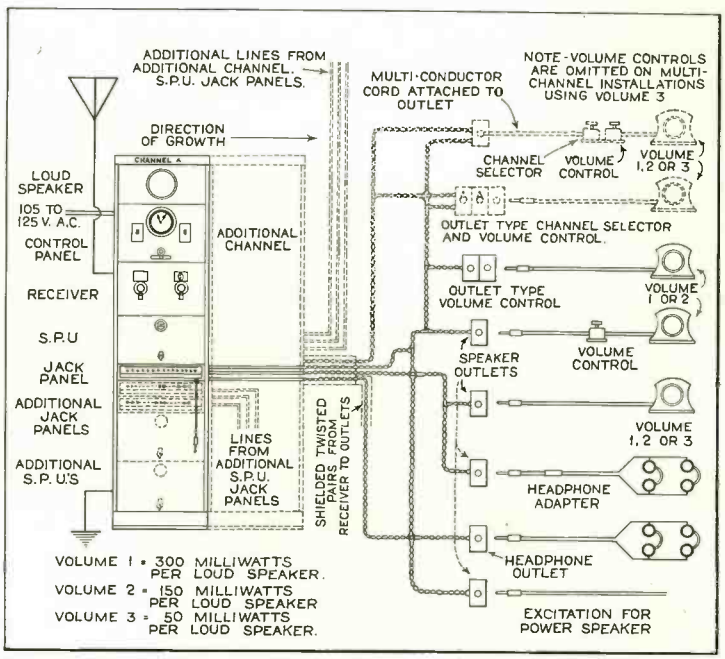
### *Radio-Frequency System*

In this connection, the engineering staffs of the Radio Corporation of America, and its associated companies, borrowed a page from their commercial receiving practice long followed in transoceanic and marine communication, where a single antenna, many miles long, is made to operate a num-



ber of receivers without diminution of efficiency or the introduction of interference. This principle of radio-frequency coupling between antenna and receivers has been made the foundation of a new and remarkable *radio-frequency* centralized radio system, which will prove a boon to progressive architects and apartment house owners.

In the RCA multiple-receiver antenna distribution system, there is no centralized radio receiver, since each listener-in is expected to furnish his own. However, there is a common




Circuit diagram of control panel; audio-frequency distribution system, and channel wiring. This is one channel only; additional channels may be added.



Left: Table type channel selector switch. Right: Table type volume control.

antenna of ambitious proportions for utmost efficiency, which serves all the receivers in the house. The radio-frequency energy intercepred by the antenna is distributed by means of a suitable wiring system throughout the building.

Taking the place of the dozens of antennas usually strung over a city roof, one efficient antenna some 50 to 75 feet above the roof is erected. The short lead-in from the antenna is brought to a battery of central coupling units, generally located in a penthouse. From each coupling unit a line of metal conduit, enclosing the radio-frequency cable, transmits the energy picked up by the antenna, down through the building. In each apartment an extension coupling unit transfers the radio-frequency energy to the radio set, through the medium of a suitable wall outlet. Any type of radio set, requiring antenna and ground connections, may be operated. The wall-plate is provided with a switch to operate the B-eliminator and coupling tube in the extension coupling unit, as well as with an outlet for the socket-power receiver.

### *R-F Transmission Line*

The distribution system, it will be noted, is not a mere lead-in. It is strictly a radio-frequency transmission line. The distribution system does not pick up additional signals or interference. Its length has no influence on wave length. The tenant on the ground floor of a twelve-story apartment house enjoys the same reception as the tenant on the top floor. There is an absolute minimum of background noise, so that the reception is comparable with that of the open country. Because of the coupling units, there can be no interaction between various radio sets.

The central coupling units on the roof comprise coupling tubes and B-eliminators. There is a central coupling unit for each "riser" or transmission line. There must be an extension coupling unit, with coupling tube and B-eliminator, for each radio set. As many as ten extension coupling units may be placed on one "riser." In cases where a building is more than ten stories high, an additional transmission line or "riser" is employed to meet the requirements.

# A New Signal Relay

*By C. T. Burke**

A NEW type sensitive signal relay has been developed which has a number of very interesting points. The instrument is illustrated in Fig. 1.

A permanent horseshoe magnet provides the field and forms a protecting shield about the coil and reed. The coil is mounted about midway of the sides of the magnet and the reed fixed near the toe. The distance from the center of the poles to the point where the reed is secured is 2¼ inches. The contacts with adjusting screws complete the instrument. An unusual feature of this relay is the distance between the pole pieces—0.47 inch. This wide separation provides a uniform field in the region through which the reed moves. The effect of this is to make the adjustment of the reed to the neutral position less critical.

In operation, the adjusting screws, which determine both the position of the reed in the field and its travel, are adjusted so that the reed takes up the neutral position in the field. The location of the neutral position will shift somewhat as a result of an average current in the coil, and in the case of high speed signals of considerable intensity, this shift may be comparatively large. With the reed in the neutral position, a signal (which may for convenience be supplied by an interrupter) is impressed on the relay coil. The contacts of the coil are adjusted so that the reed strikes evenly without chatter on either side. This adjustment may be made with a sounder, but it can be greatly facilitated by means of a visual type oscillograph.

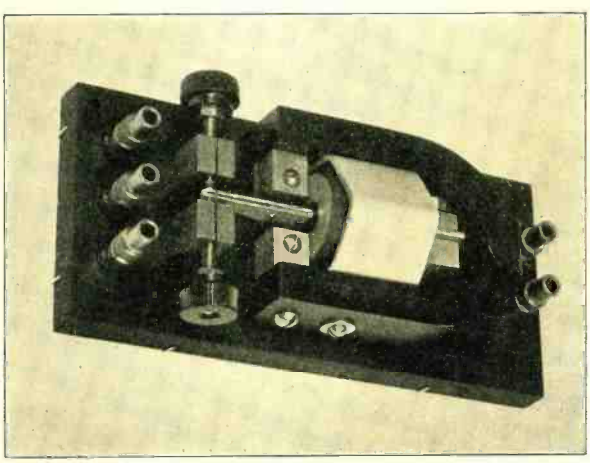
*Figure 2*

The minimum operating current of the relay is one milliampere in the signal circuit, and it will follow impulses of frequencies as high as 125 cycles per second. The tungsten contact points will break one ampere without burning.

A relay of this type has many uses in the laboratory, as well as in the commercial communication field. The high sensitivity attained permits the use of the relay with little amplification for the actuation of chronographs from time signals, signal recorders, or other apparatus where remote control by means of radio, carrier or low-frequency current impulses is desired. Rectification is, of course, required where the impulse current is of high frequency.

The mechanical simplicity and ruggedness of the relay particularly recommend it for uses where little attention can be given to the apparatus.

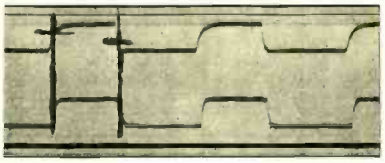
* *Engineering Dept., General Radio Co.*



The new signal relay. The d-c resistance of winding is 1500 ohms and its inductance of the order of 3.8 henrys at 990 cycles. Effective resistance at 990 cycles is 6350 ohms. Inductance measurement made without measuring current through coil, so that value gives only order of magnitude.

*Figure 1→*
*Figure 3*

*←Figure 1*
*Figure 4*



The operation of the relay is best illustrated by a few oscillograms. The oscillograms of Figs. 1 to 9 were taken on a string oscillograph, using the recently developed double stringholder which permits simultaneous viewing of the current in both the coil and the contact circuits. The oscillograms are all arranged with the coil current at the top and time proceeding from left to right. The zero current lines are at the botttom. The timing lines on the films mark 0.04-second intervals. Fig. 2 shows the effect of a very badly adjusted relay. The effects of chattering and bouncing are very marked. The relay fails entirely on many impulses. For contrast, Fig. 3 shows a well ad-

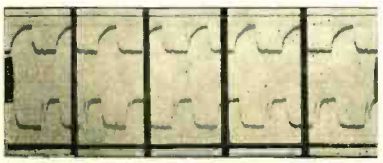


*Figure 8*

justed relay. A firm contact without any trace of bounce is made on each throw of the reed. The trace of the coil current shows plainly the gradual building up due to the inducrance of the coil. The contact current shows no change until the coil current reaches a critical value, then rises almost at once to its final value. The effect is to give a sharper signal on the contract side than on the coil side. This would not normally hold true in signal circuits, where the inductance of instruments would slow down the growth and decay of current. Such effects may be minimized by means of condensers properly placed. The important fact in connection with the relay is that its action is quicker than the normal growth of current in the circuit. The impulse on the contact side is slightly longer than that on the coil side, due to the fact that the contact current remains at full value until the coil current has decayed to critical value for the relay at this adjustment. The tendency of the contact to stick closed is plainly shown by the fact that the current required to hold the contact closed is less than that required to close it.

Fig. 4 was made using the other contact so that an increase in coil current breaks the contact. A good relay adjustment with both contacts working similarly is indicated. The same gradual growth of current as occurred in Fig. 3 will be observed. The contact stays open some time after the coil current drops. This lag is due to the sum of two effects. First, the reed does not start to move until the current drops to the critical value; and second, the contact is not made until the reed has traveled from contact to contact, i. e., the open-circuit period includes the travel time. The closed-circuit period, however, (Fig. 3) includes no travel time. On this particular record the lag is somewhat excessive, and suggests that the back contact is not perfectly adjusted, a possibility that other oscillograms show to be a fact.

Fig. 5 was made by allowing the vibrator on the interrupter to come gradually to rest. The successively shorter intervals are interesting in showing how the relay will respond to short impulses and ragged waveforms. Nowhere does the coil current record an impulse not recorded in the contact circuit. The slight chattering caused by irregularities in the coil current are interesting.

Figs. 6 and 7 are for a higher frequency of signal impulses. Both oscillograms are for the front or closed-circuit contact. No chattering or bouncing is indicated, even with the relay speeded up.

Fig. 8 shows the back or open-circuit contact at high speed. The bouncing evident here reveals the faulty adjustment of this contact which Fig. 4 led us to expect.

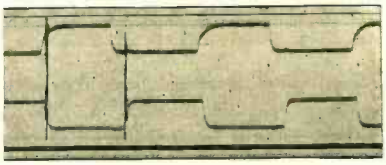


Fig. 9 was made with the front and back contacts tied together, so that current flowed when the reed was in contact with either side. The open-circuit spaces on this record represent the time taken by the reed to travel across the gap. It will be noted that alternate spaces are comparatively large. Comparison with the other records reveal this to be due to the faulty adjustment of the back contact already observed.

The time of transit of the relay is an important characteristic, since it has a direct bearing on the speed of signal which may be followed. Comparison with the timing lines on the film which are spaced 0.04 second

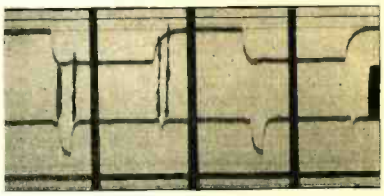
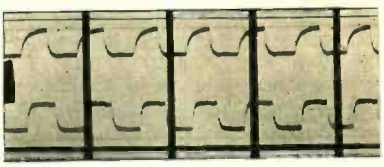


*Figure 9*

apart shows that the shorter travel time was about 0.002 second and the longer about 0.008 second. The difference in time indicates that the reed was not exactly in the neutral position, and had a greater restoring force on one side.

It is interesting to note that the shorter time interval corresponds to a velocity of about 0.02 mile per hour, and an acceleration of about 20 miles per hour per second.



*↑*
*Figure 6*
*Figure 5→*

*↑*
*Figure 7*
*←Figure 5*

# A New Automatic A-C Voltage Regulator

*Designed and Constructed to Replace the Power Transformer in a Standard A-C Set*

*By Kasson Howe**

A BASIC problem in the design of electrical apparatus, maintaining a constant voltage output within narrow limits under varying line voltage input, is solved in the design of a new form of automatic, instantaneous A-C voltage regulator, developed and perfected after two years of research work. The new regulator, characterized by prominent electrical engineers as entirely new in principle, finds one of its most important and immediate applications in the manufacture of electric radio receivers, where the rise and fall of incoming line voltage has been a vexing problem for the radio engineer. The new unit maintains a remarkable degree of accuracy in output voltages to the receiver over the range from 95 volts to 140 volts input. If the input voltage rises above the 140 volt figure, control becomes negative and output voltages fall below normal, thereby insuring safety to all elements in the electric radio set.

There are almost countless other important uses for the device, in the opinion of H. K. Kouyoumjian, E. E., development engineer on the regulator. In the motion picture industry, the regulator answers the long felt want for a device to keep the film printing lamp filament at a constant temperature. Unequal lighting during printing has been a great problem. In fact, the printing varies as the sixth power of the voltage variation. Now that talking pictures are with us, the solution of the problem of uniform print intensity assumes added importance, since quality reproduction and freedom from "sound blotches" have a marked effect on the audience's acceptance of sound programs.

Certain electric motor applications demand constant motor speed. The regulator in modified form will be a precision motor starter and controller. In A-C train lighting systems, the regulator will do away with the annoying dimming of lamps while the train is starting, or the load varying.

## Models for Radio

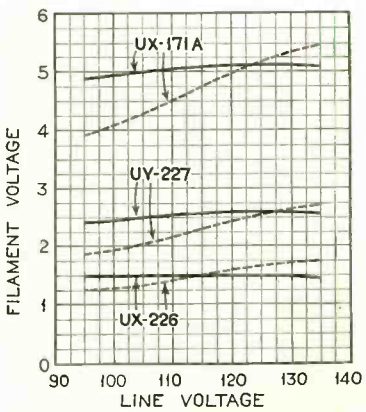
For radio use in electric receivers with the A-C type tube, the device is very little larger than the usual power supply transformer which it replaces. Its use will call for no larger or more complicated receivers, and rather than adding to the cost of manufactured sets, should actually result in lower production cost by allowing lower rating of component parts such as condensers and resistors.

* *Engineer, Ward Leonard Electric Co.*

The accuracy of output voltage control, as well as the advantages of the new form of regulator, are best shown by the series of curves accompanying this article. It will be noted that with the regulator in the radio circuit, the tubes are always performing at peak efficiency, regardless of incoming line voltage. The booster action of the regulator on low voltage is especially worthy of note.

## General and Technical Data

The A-C Voltage Regulator is a means for obtaining a voltage output constant within narrow limits under varying voltage input. Like the conventional transformer, the regulator consists of primary and secondary windings and a special core shape employed to produce regulation. Unlike transformers, the placement of windings in respect to the others and the cross-section of




This series of curves were taken with a standard A-C set. The dotted lines show the filament regulation with the ordinary transformer, the heavy lines with the voltage regulator installed.

the core have very marked effects upon the design of the regulator. Design and construction, too, is affected by the results desired.

**Primary and Secondary.** Primary and secondary windings are employed to give any desired transformation.

**Rating.** The regulator may be designed for any K. V. A. output desired.

**Power Factor.** The power factor of the regulator, taken at normal line voltage, varies with the range and degree of regulation required. In general, the higher the permissible per cent. regulation, the better the power factor.

**Efficiency.** Properly designed and constructed, the regulator has an efficiency comparable with a transformer designed for equivalent duty. As with transformers, the Regulator efficiency depends upon low copper and iron losses.

**Wave Distortion and Harmonics.** Oscillograph tests show a secondary wave form distortion of approximately 5 to 10 per cent., depending on ranges of regulation.

**Connections.** The connections of the windings are different from those of the usual transformer.

**Construction.** Core construction and winding placement are different from those of the usual transformer. Both core construction and windings are subject to considerable variation to meet the requirements of various classes of control.

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## SILVER SOLDERS IN RADIO LOUDSPEAKERS

*By R. R. SHUMAN*

THE armature of a loudspeaker is subject to violent and continuous vibration, varying with the frequencies. For this reason the problem of making a serviceable joint between the steel suspension spring and the silicon steel armature has presented considerable difficulty. Soft solder was found to disintegrate under the vibration, and hard or spelter solder required so high a brazing temperature that it weakened the metal contiguous to the weld. For the same reason electric or acetylene autogenous welding was found undesirable.

A practical solution to the problem was finally found in the use of silver solder, made up of mixtures of silver alloyed with various base metals.

Silver solders not only make strong joints, with an average tensile strength of 50,000 lbs. per sq. in., but they have a malleability or toughness that withstands sharp and prolonged vibration. This is why silver solders are used for joining the ends of band saws. In the brazing operation they flow more freely than spelter solders, penetrate more quickly and thoroughly, and so little is required that joints are neat and sightly. Silver solders are applied with an oxy-acetylene or gas and air torch at 1325 to 1600 degrees Fahrenheit, varying with the composition used.

These and other characteristics have led the United States government to make obligatory the use of silver solders for certain parts of airplanes for government service.

# Radio Color Curtains

## *The Use of Fixed and Mobile Color Patterns in Radio Receiver Design**

PEOPLE have long associated color and music. The theatre, first to realize the practical value of their combination, has for many years successfully applied color to music. An orchestral offering at the theatre is made all the more enjoyable because of the beautiful and changing colors of the light accompanying it. The play of colored lights on the curtains of the stage lend further enchantment to the music.

Color curtains have now been worked out for console-type radio receivers and the results obtained are very effective.

Fig. 1 shows the arrangement and parts necessary to produce the mobile color. In Fig. 1, (A) is a small induction motor with its output shaft revolving at 1 R.P.M. It is fastened to the side of the cabinet with a little bracket. Coupled to the motor output shaft is a small pulley and the colored cylinder. (C), the cylinder on the right, is driven by means of a small belt running to the pulley to which it is fastened. The pulley on the right is approximately one-half the diameter of the driving pulley, so that the cylinder on the right rotates at about 2 R.P.M. This speed produces a very slow change in colors, but if a still slower speed is desired the pulleys may be reversed, which will change the speed ratio of 1 to 2 R.P.M. to 1 to ½ R.P.M. Both of these speeds were found to give very good effects.

The slow rotation of the cylinders permits the use of a very small motor but necessitates some reduction gearing such as a worm and gear. Some motors, such as the General Electric 110 volt a-c, 60 cycle, 10″ fan motor already have a reduction gear attached to them for the purpose of oscillating the fan. Replacing the lug on the oscillator with a small pulley or even filing a groove in this lug with a rat tail file makes this motor very suitable for the job.

* *Development of the Engineering Dept., Edison Lamp Works, Harrison, N. J.*

It was found that small universal-type motors were not satisfactory due to interference with the radio from sparking at the brushes.

In combination phonographs and radios the motor used to turn the phonograph disc can be used also to drive the color cylinder by attaching suitable reduction gears or pullies.

The lamps (D) are mounted inside the cylinders on removable brackets.

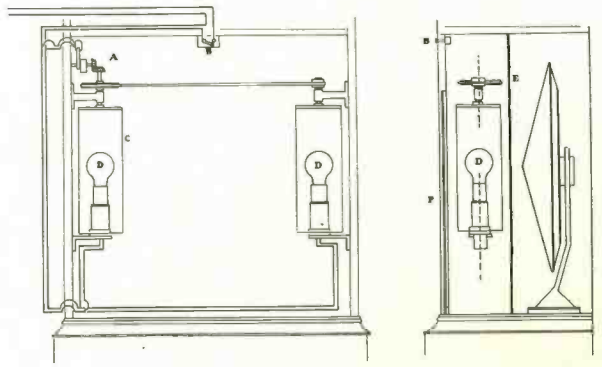



Fig. 1. Layout and details of the mobile color curtain, designed for installation in a console set. A small induction motor is used to revolve the cylinders.

A 25 watt, 115 volt inside frosted Mazda lamp gives ample light. (B) is a push-pull type switch for turning the lights and motor on and off. It is fastened to the top of the speaker compartment and its shank projects through a small hole in the framework of the grill. One advantage of the push-pull type switch is that it can be mounted so the lights are automatically turned off when the doors of the console are closed.

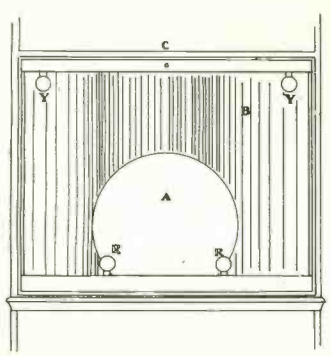
The color cylinders can be made of glass and painted with colored lacquer. Preferably, however, some more indestructible and lighter material should be used such as Protectoid, Rhodoid or colored gelatine.

The simplest color arrangement on the cylinders would be to have three panels on each; one red, one green and one blue. Provisions for a yellow panel are felt to be very worth while because in addition to yellow the various shades of pale green and the oranges will be obtained.

With the changing color all but the center portion or window of the grill is blocked off on the back with black paper. On the back of this center window is fastened a curtain of pleated white silk. The pleats are ½-in. in size. The original brown silk grill cloth of wide weave is left on. With the lights off, the appearance of the grill is the same as it was before the lighting was installed.

In Fig. 1, a curtain (E) of thin black gauze is hung directly in back of the cylinders and extends all the way across the speaker compartment, preventing the interior and the loudspeaker from being visible when the lights are turned on. The grill is readily removed. The lighting arrangement will take up about four inches. The cylinders need be only three inches in diameter and a clearance of a half-inch to both front and back curtains will add another inch. The amount of space required for the lighting as shown by Fig. 1, is exaggerated to show the arrangement of the parts in greater detail.

Fig. 2 shows the arrangement of parts for the fixed color curtain which incorporates the suggestion of a miniature stage. A channel frame, approximately three inches wide and one inch deep, supports the sockets, lamps, wire, switch, curtain and figures for this arrangement, or in other words, the entire lighting arrangement is incorporated on this frame. The frame then slides into the cabinet and is held in place by four screws or pegs. In Fig. 2, (C) is a push-pull switch, (B) is a pleated white silk curtain, and (A) the group of figures. The two top lamps are yellow and the bottom ones red. They are the new 10 watt, 115 volt, S-11 bulb intermediate screw base decorative lamps and can be obtained in a wide variety of colors.



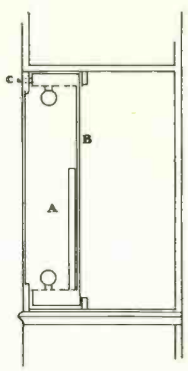




Fig. 2. Details of the fixed color curtain, installed in a console set. The space (A) is allotted to a group of figures.

# NEWS OF THE INDUSTRY

## MANSON AND HANOVER, VICE PRESIDENTS OF STROMBERG

RAY H. MANSON, Chief Engineer, and Edward A. Hanover, Purchasing Agent of the Stromberg-Carlson Telephone Manufacturing Company were elected Vice-Presidents at the annual meeting of the Board of Directors, Thursday, February 28. The promotion of the two men is in recognition of their service to the company and the added responsibilities they have taken on because of rapidly expanding business.

Mr. Manson, who is regarded as one of the outstanding telephone and radio engineers in the country now becomes Vice-President in charge of engineering. He joined the Stromberg-Carlson Company in 1916 as Chief Engineer and has been one of its directors since 1924. Mr. Hanover, who is Purchasing Agent for the company becomes Vice-President in charge of manufacturing. He has been with the Stromberg-Carlson Company since 1902 and has been one of its directors since 1924.

The company will begin to move into its new $1,500,000 plant next month, Mr. McCanne declared at the meeting. The removal to the new plant will take the larger part of three months, as it will be done gradually so as not to interrupt production.

## C. H. STONE JOINS JENKINS & ADAIR

Mr. Carrington H. Stone, formerly Assistant Chief Engineer of the Radio Division, Stewart-Warner Speedometer Corporation, Chicago, is now associated with Jenkins & Adair, 1500 N. Dearborn St., Chicago, engineers of talking picture and public address systems. Mr. Stone has been active in radio since 1909, and during the war was first lieutenant of the Signal Corps (Radio). He was a member of the Hoover Radio Conference and is Chairman of the Socket Power Devices Committee of the Radio Manufacturers Association.

## DR. RAFFERTY JOINS ZENITH

Dr. Frank A. Rafferty, A.B., M.S., former Director of the Radio Research Laboratories of Villanova College, Villanova, Pa., has joined the staff of the Zenith Radio Corporation's research engineers. Dr. Rafferty has spent practically all the years of his life in research and invention. In addition to the vast wealth of technical knowledge and experience, gleaned in these many years of toil, he brings with him an enthusiasm that bids fair to be a stimulus to greater effort and accomplishment.

## HEALD APPOINTED CHIEF ENGINEER OF THORDARSON

Mr. Chester H. Thordarson, president, has announced the appointment of Merwyn Heald as chief engineer of the Thordarson Electric Manufacturing Company. This appointment is in accordance with the policy of the management to select men for executive positions from within the organization. Mr. Heald possesses a background of experience and training which have ideally equipped him for the office of chief engineer.

Prior to Mr. Heald's activity in the production and research laboratory of the Thordarson plant, he was retained by the Robertson-Davis Company of Chicago as chief engineer. His engineering degrees were conferred at the Engineering School of Northwestern University, where he was awarded membership in the honorary scientific fraternity Sigma Xi, and in Phi Beta Kappa, honorary scholastic fraternity.

## SPARKS-WITHINGTON ESTABLISH PATENT DEPT.

The Sparks-Withington Company, manufacturers of the Sparton Radios and Automobile Horns, has established a patent and legal department under the supervision of Mr. Theodore J. Scofield, who for many years has been in charge of the Research and Development Departments of the company; and Mr. T. C. Browne, who has recently become connected with The Sparks-Withington Company, and whose long experience includes research work for a number of laboratories and for the government during the war. The work of this department will be carried on in cooperation with the regular patent counsel of the company.

**DOMINIC F. SCHMIT**

**Chief Engineer, E. T. Cunningham, Inc.**

## FRESHMAN ELECTS COL. C. M. TICHENOR VICE-PRESIDENT

The election of Colonel C. M. Tichenor, well known in both the automobile and electrical fields, as Vice-President in Charge of Production, has just been announced by Clarence A. Earl, President of the Chas. Freshman Co., Inc., and Chairman of the Board of Directors of the Freed-Eisemann Radio Corporation. This announcement closely follows that of the leasing of the new Freshman plant at Clifton, N. J., where complete production of Freshman and Freed-Eisemann radio sets and speakers will be handled under one roof.

Colonel Tichenor has been in the manufacturing business for over 22 years, during which time he has gained an extensive acquaintance with both the automotive and electrical fields. He was formerly connected with Gray & Davis, Boston, Mass., following which he served as Vice-President and General Manager of the Universal Pressed Steel Co., of Detroit, Mich. During the war, he served in the U. S. Army, where he organized the Aircraft Engine Inspection Section of the Signal Corps, and also assisted Col. H. B. Joy in selecting mechanics for the French aviation service. In addition, Colonel Tichenor was entrusted with selecting the personnel for the aviation base at Romorantin, France—a task which involved the examination of some 7,000 men and the erection of huge buildings for the assembly of aircraft.

At the close of the war, Colonel Tichenor returned to civilian life and became Assistant General Manager of the Pierce Arrow Motor Company, where he was in charge of production. Prior to his connection with the Freshman Company, he was Works Manager of the Kellogg Switchboard & Supply Co., of Chicago, manufacturers of telephone apparatus, radio sets and tubes.

## W. H. OGLE APPOINTED FEDERAL PLANT SUPERINTENDENT

William H. Ogle, formerly in charge of production and stores, has been made plant superintendent of the Federal Radio Corporation, Buffalo, N. Y.

Mr. Ogle is widely experienced in such executive capacities, having formerly been in charge of production and accounting for the Heywood-Wakefield Co., one of the most successful furniture manufacturers in Buffalo. Subsequently he was plant manager for two years, at the Brantford, Ont., plant of the Blue Bird Corporation, Ltd., manufacturers of electrical appliances. He later became secretary-treasurer of the company, which has its American headquarters in St. Louis.

## RCA TO INCREASE VACUUM TUBE PRODUCTION

Production of vacuum tubes for the Radio Corporation of America in 1929 will exceed the output of 1928—a record-breaking year—by 150 per cent, according to an announcemnt made today by J. L. Ray, Vice-President in charge of sales.

To handle this increased production, Mr. Ray said, factory facilities at Bloomfield, N. J., Newark, N. J., and Cleveland, Ohio, are being enlarged and reorganized. Plant additions will bring the total floor space employed in tube production alone to 18.0 acres when the maximum schedule is reached.

Five thousand and eighty men and women are now engaged in the manufacture of vacuum tubes for RCA, exclusive of the laboratory forces. New and improved machinery is being installed which will not only speed the production of tubes but will reduce the variable human factor and increase the accuracy and precision of manufacture.

"We are often asked," Mr. Ray said, "whether increased production and the improvement of tube manufacturing methods will result in further reductions in RCA tube prices. In the past the Radio Corporation of America has made a practice of passing on to the consumer the benefits of factory economies and increased sales, voluntarily reducing the retail price of vacuum tubes which are in general use from $7.50 to $1.50."

### *Price Reductions*

Price reductions ranging from 10 cents to a dollar, on ten types of Radiotron vacuum tubes in wide general use, were announced on February 15th by the Radio Corporation of America. Radiotron UX-226 is reduced 25 cents, to $2.00; UY-227 is reduced a dollar, to $3.00; UX-280 is reduced 75 cents, to $3.50; UX-281 is reduced 25 cents, to $7.25; UX-112-A is reduced 25 cents, to $2.50; UX-250 is reduced 50 cents, to 11.00; UX-199 is reduced 25 cents, to $2.00; UX-171-A is reduced 25 cents, to $2.50; UX-200-A is reduced 50 cents, to $3.50; and UX-201-A is reduced 10 cents, to $1.40.

Similar price reductions have been made by E. T. Cunningham, Inc.

## BADGER APPOINTS NEW SERVICE MAN

Badger Radio Corporation, Milwaukee, Wis., has appointed Warren Isenring, Service Contact man. Mr. Isenring is very well schooled on the technicalities of radio, and will use his knowledge to further aid service for Majestic dealers.

## INTERNATIONAL RESISTANCE CO. EXPANDS

Due to the general prosperity of the radio industry and the popular demand for metallized resistors in A-C radio sets the International Resistance Company, of Philadelphia, manufacturers of metallized resistor filament and Durham resistor units, reports a marked expansion in its production facilities.

"Our plant has been increased from time to time this past season," states Francis R. Ehle, President of the International Resistance Company. "Our office, where the clerical work is done, is at 2006 Chestnut Street. Our filament factory occupies a three-story building at 135 North 22nd Street, where during peak production 30 to 35 operators are required in this highly specialized work. Our laboratory is located in the same building. Our assembly plant for the completed units, which we manufacture under the Durham label, is at 23rd and Arch Streets, where at peak times some 65 operators and factory men are occupied in producing nothing but resistors.

## EAGLE ELECTRIC MFG. CO. EXPANDING

Due to the steady increase in business of the Eagle Electric Mfg. Co., of Brooklyn, N. Y., who have been manufacturers of electrical specialties for the past 10 years, they have found it necessary to acquire an additional plant space of 5,000 sq. feet bringing their total to 35,000 sq. feet of working space, covering three entire floors.

With these increased facilities, they are prepared to take care of this year's expected large volume of business with even greater efficiency and satisfaction to their distributing agencies.

## WEXTARK WALTHAL CONSOLIDATION

Announcement was made recently by Walter H. Nussbaum, President of the Walthal Electric Corporation, of the consolidation with the Wextark Radio Stores, Inc., of Chicago.

This merger will create the largest distributing and merchandising organization in the radio industry.

Comprehensive plans covering various phases of the radio industry throughout the United States are being formulated.

The Walthal organization has stores from Yonkers to Brooklyn throughout New York and are at present one of the outstanding radio chain organizations in the East. These stores do a large business in the sale of high grade radio sets for cash and on installment in addition to probably selling more radio parts and accessories than any other store in this territory.

It is expected that this merger will greatly augment the facilities of the Walthal chain.

Walter H. Nussbaum, President of the Walthal stores, together with the other personnel will continue operations as heretofore.

## DE FOREST ORGANIZATION ISSUES "THE GRID"

An attractive house organ known as "The Grid" is now being published by the De Forest Radio Company, of Jersey City, N. J., for DeForest distributors, dealers and prospective dealers who request it.

"We want to make 'The Grid' just as newsy, interesting and helpful as possible," states H. C. Holmes, Director of Sales of the DeForest Radio Company. "There will be explanations of sales policies, advertising and selling suggestions, personal items, editorials, and a column for the use of those who wish to express themselves on some apropos subject. Occasionally, we will reproduce some attractive window display and comment on why it was successful. There will also be a review of all the publicity releases with a schedule of the current month's advertising. Beginning with March, 'The Grid' will be published regularly the first of every month," concludes Mr. Holmes.

The first issue of "The Grid," dated February, 1929, is devoted largely to the program of the DeForest Sales Conference held during January 22, 23 and 24.

## DE FOREST ANNOUNCES TWO NEW DISTRICT MANAGERS

Two new district managers are announced by H. C. Holmes, Director of Sales of the DeForest Radio Company, Jersey City, N. J. The company has appointed Guy C. Kowfeldt, of 529 South Seventh Street, Minneapolis, Minn., as District Sales Manager in that territory, and E. F. Coghlin, of 10 High Street, Boston, Mass., as District Sales Manager in the Boston territory.

## PERRYMAN OPENS NEW SALES OFFICE

The Perryman Electric Company, Inc., announced the opening, March 1, 1929, of a sales and service office in the McCormick Building, 332 South Michigan Avenue, Chicago.

Mr. R. B. Lacey, Western Sales Manager, will be in charge.

The present policy of distributing Perryman Tubes through wholesale channels will not be changed. It is hoped, however, that both jobbers and dealers will avail themselves of the opportunities for better service which the opening of this office affords.

## THORDARSON MANUFACTURING FACILITIES DOUBLED

In order to take care of the constantly increasing demand for its transformers for radio and other electrical purposes, the Thordarson Electric Manufacturing Company has announced the acquisition of an additional building adjoining its present factory, thus increasing its manufacturing space over 100 per cent. The combined factory site now occupies half a city block, facing on Huron, Kingsbury and Larrabee Streets, Chicago. The seven floors of these two buildings represents a total manufacturing space of a quarter million square feet.

In anticipation of the present expansion, the maintenance department has been actively engaged in constructing many special full automatic coil winding machines and other manufacturing equipment on which the company holds exclusive patents. It is stated that production in the original plant is not being disturbed during the process of establishing the new factory.

As a means of establishing more intimate contact with its manufacturer and jobber customers in the Michigan, Ohio, Western New York and Western Pennsylvania territory, the Thordarson Electric Manufacturing Company has recently opened a branch office at Cleveland, Ohio.

Mr. C. M. Hendricks, who has been serving the greater part of this territory for the Thordarson organization as a sales representative, has been appointed branch manager with offices located at 520 Citizens Building, Cleveland.

## O. W. RAY ACQUIRES A. C. NEON TUBE CO.

Purchase of the A. C. Neon Corporation of 122 Greenwich St., New York, signalizing his entry into the radio tube business was effected last week by Oscar Willard Ray, for fifteen years well known in the music and radio industries. Mr. Ray has been elected president of the concern and is now setting up its management policies, including the expansion of sale of a line of all-purpose tubes for the national trade.

The A. C. Neon concern has been active in the general tube industry for about a year with manufactnring facilities in Newark, N. J. James Watters, who has been in charge of sales, continues as vice-president under the new regime and Walter Bullock, engineer, is secretary while the treasurer is Herbert Asher, the company's counsel.

O. W. Ray is widely known in the radio field, having been for six years an official of the Aeolian Co. and originally in charge of its Radiola distributing division as well as music rolls and Vocalion records, while more recently for a year he was vice-president of the Silas E. Pearsall Co., New York, radio dealer. He entered the industry fifteen years ago at Boston as the first distributor of Emerson records and Q. R. S. music rolls in New England. Mr. Ray is a graduate civil and mechanical engineer and is the inventor of the Ray Placable Volt Light Construction.

## TRADE PROMISES BETTER SERVICE MEN

Michael Ert, of Milwaukee, President of the Wisconsin Radio Trade Association and vice-president of the Federated is father of a plan which will be considered by the national radio dealers and wholesalers at their annual meeting. With little change, the plan has been in practice in Milwaukee for a year and a half with complete success.

It provides, first for the examination, grading and registry of all radio service men; and in addition furnishing an opportunity whereby service men may obtain actual training in radio under competent instructors.

"With at least 25,000 radio outlets all over the country, many stores are doing as best they can with untrained men," says Mr. Ert in explaining the plan. "The crying need for technically trained men is obvious. Heretofore service work of necessity has been done by the chaps who have built a few sets but who have little fundamental radio knowledge. Our duty to radio fans is to provide a brand of service which will reach the peak in performance of their radio receivers and I feel sure that such a plan will be operative very soon."

## EBERT CO. MANUFACTURING RADIO CABINETS

Announcement has just been made that the Ebert Furniture Company, of Red Lion, Pa., is now offering a line of quality radio cabinets at popular prices. At the same time, the news is given out that A. Irving Witz and Martin J. Polikoff have been appointed national sales agents for the Ebert line. These men are both pioneers in the radio field.

The Ebert Furniture Company has been making dining room furniture, china cabinets, secretarys, silver chests, etc., since 1854 and have won a high reputation among the trade for their care in selecting and seasoning their wood and for real "old-world" craftsmanship. Now they are turning this same skill towards making radio cabinets.

The Ebert plant extends over 3½ acres—is geared up to produce over a million dollar business annually. The plant operates on a straight line production system—only the best type of experienced craftsmen are employed—the factory is under the direct supervision of Frederick J. Ebert, Secretary and Treasurer, and Herman A. Ebert, Vice-President. These men represent the second generation in Ebert cabinetmaking—their fathers having started the business seventy-five years ago in the same location at Red Lion, Pa.

Because of their years of experience, their ample plant equipment and skilled labor, and access to source of raw materials, the Ebert Furniture Company is in an excellent position to manufacture high grade radio cabinets on an economical basis for the Eastern market.

A. Irving Witz was one of the pioneers in serving as a factory representative in the East for various radio interests. He was at one time Eastern representative for Bremer-Tully Manufacturing Company and later national Sales Manager for Gardiner-Hepburn. He has since been identified as Eastern Sales Manager for the Webster Company, of Chicago, and the Fidelity Radio Corporation, of Salt Lake City. Mr. Witz is also Vice-President in charge of sales of the Argon Tube Corporation, of Newark, N. J.

Martin J. Polikoff has been associated with the music and radio trade for over eleven years. He originally represented the W. W. Kimball Co., of Chicago, and later served as Sales Manager of the Piano and Phonograph Division of the Philadelphia branch of the Rudolph Wurlitzer Corporation. In 1924, Mr. Polikoff entered the radio field as one of the pioneer cabinet men, acting as a general sales representative for the Pooley Co. After severing connections with this firm, Mr. Polikoff has been acting as a manufacturers' agent for a number of well-known companies in the radio field, such as Showers, of Bloomington, Ind., Radio Master Corporation, of Bay City, Mich., and the Perryman Electric Co., Inc., of New York City.

## GOTHAM SECURES NEW COIL LINE

The Gotham Engineering and Sales Company, located at 50 Church St., New York City, have been appointed National Sales Representatives for the products of Transcontinental Coil, Inc., of Newark, N. J.

Transcontinental Coils are manufactured for both short wave and broadcast receivers, and the complete line embraces coils for all the popular receivers. A specialty is the winding of coils for manufacturers of complete receivers, and many of the best known radio sets utilize the products of Transcontinental.

In addition to their present offices in New York, the Gotham Engineering and Sales Co. will shortly announce the opening of sales offices in Chicago and other principal cities to facilitate the sale of Transcontinental Coils.

The Gotham outfit are at the present Eastern representatives for the Potter Company, manufacturers of paper condensers, and Precise Products, Inc., of Rochester, makers of variable condensers, friction drives and drum dials.

## DE FOREST NOW SHIPPING AUDIONS FROM F. O. B. POINTS

J. W. Garside, President of the DeForest Radio Company, of Jersey City, N. J., now announces a new service that will greatly facilitate shipments on DeForest Audions to all parts of the United States.

"F. O. B. shipping points," states Mr. Garside, "have been established in the following cities: Jersey City, Chicago, Los Angeles, Dallas and Atlanta. Consigned stocks of audions are being carried at these various points so as to reduce transportation costs and to provide ample stocks on which dealers can draw without loss of time. Dealers throughout the territories served by these key outlets are going to find this new feature of greatest value."

## SYNTHANE IN PRODUCTION

Synthane Corporation at Oaks, Pennsylvania (near Philadelphia), has completed the erection of its plant, and is now in production of laminated Bakelite products in sheets, rods, tubes and fabricated parts.

The plant, built solely for the production of laminated Bakelite materials, is of the most modern construction, and special equipment of up-to-date machinery has been installed throughout. It is located on the Pennsylvania Railroad System and has adequate facilities for quick delivery.

National advertising will carry the message of Synthane Corporation to the electrical trade throughout the country.

Synthane Corporation is represented by H. G. Blauvelt, Tribune Building, New York; J. B. Rittenhouse, 32-40 South Clinton Street, Chicago; and C. E. White and Company, Bulkley Building, Cleveland.

## GILBY INSTITUTES ENAMELING PLANT

The Gilby Wire Company, Newark, New Jersey, are installing equipment for covering their complete line of resistance wires with enamel, and cotton and silk. Heretofore it has been the custom among manufacturers of resistance wire to send the bare wire to outside manufacturers for enameling, cotton covering and silk covering.

The demand for enameled copper wire has been so tremendous that service on enameling of resistance wire has been very unreliable. With their own facilities, Gilby Wire Company will have both quality and production under their own control.

Production is expected to be started within the next two or three weeks.

Mr. L. P. Finley has recently been appointed manager of the Chicago office of Gilby Wire Company at 217 North Desplains Street. His territory will cover Indiana, Illinois, Wisconsin, Michigan and Minnesota. Mr. Finley is an electrical engineer, and is well informed on the uses of Gilby products, including resistance wire, pure nickel, and nickel alloys in various forms.

Gilby are strengthening their technical staff for production and research work, and have engaged the services of Mr. Sidney Schein, who has been for many years chemical engineer for the General Electric Company. Mr. Schein has specialized in the production of materials for use in incandescent lamps and radio tubes.

## AMERICAN REPRODUCER CORP. PLANNING LARGE PRODUCTION

The American Reproducer Corporation, of Jersey City, N. J., are tooling up their plants for the production of their new electrodynamic speakers which are to be marketed under the trade name Amervox.

The officials of the American Reproducer Corporation are: Joseph Lopiano, President; G. M. Barcy, Vice-President; Edward Gunther, Secretary; William Gluck, Patent Adviser; Eugene Letch, Chief Engineer and A. C. Agresti, Office Manager.

## J. D. JORDAN JOINS GRIGSBY-GRUNOW

J. D. Jordan, formerly Chief Engineer of the Ken-Rad Corp., has joined the engineering staff of Grigsby-Grunow Corp., in Chicago.

## J. R. WUERTZ JOINS KEN-RAD

J. R. Wuertz, formerly of the Westinghouse Electric & Manufacturing Co., has joined the staff of the Ken-Rad Corp. It is reported that he will replace J. D. Jordan, who has resigned his position with that company.

## CARTER MOVING TO NEW QUARTERS

The Carter Radio Co., of Chicago, are moving to their new quarters at 407-415 So. Aberdeen St., where they will occupy a total of 50,000 square feet of floor space, approximately three times the space originally occupied.

Mr. J. H. Kraehenbush has been promoted to the position of Sales Manager, taking the place of Mr. McWeeney.

## ARCTURUS PLANS LARGE EXPANSION

Immediately following the over-subscription of 300,000 additional shares of common stock and the listing of the company's common shares on the New York Curb market, Arcturus Radio Tube Co., of Newark is planning an extensive expansion of its production facilities, according to Chester H. Braselton, president.

Although the company went into quantity production only last October with its quick-action, long-life, A.C. radio tubes, the business grew so rapidly that five plants in Newark and Harrison with approximately a thousand employees averaged for January and February over 14,000 tubes daily. Capital obtained through the new financing is largely to be used in providing increased production facilities.

## NEW EDITOR FOR GENERAL RADIO EXPERIMENTER

Starting with the next issue, the General Radio EXPERIMENTER will have for its Editor, John D. Crawford, who joined the Engineering Department of the General Radio Co. on February 1.

Mr. Crawford is a graduate of the Massachusetts Institute of Technology and for the past two years has been Assistant Managing Editor of The Technology Review.

## SMILEY JOINS BREMER-TULLY

Mr. Richard E. Smiley, formerly assistant general sales manager of the Atwater Kent Manufacturing Company, has resigned his position to assume new and larger responsibilities as general sales manager of the Bremer-Tully Manufacturing Company of Chicago.

## ABBOTT APPOINTED "EVEREADY" SALES MANAGER

H. Curtis Abbott of Chicago, nationally known in the fields of radio and music, has been appointed sales manager of the radio division, National Carbon Company, Inc., makers of Eveready radio sets.

Mr. Abbott is a graduate of Yale and has had many years of experience in the radio business. He has made an enviable record in sales with the Crosley Radio Corporation, where he was general sales manager. During his connection with Crosley, Mr. Abbott directed the activities of 166 distributors and more than 18,000 dealers representing every community in the country.

Before his affiliation with Crosley, Mr. Abbott was sales manager, radio division, Kellogg Switchboard and Supply Company of Chicago. Previously, he had been assistant to the president of Lyon & Healy, Inc., of Chicago, the world's largest music house.

Last year, Mr. Abbott was vice-chairman of the National Electrical Manufacturers Association.

## POLYMET ANNOUNCES OPENING OF EXPORT DIVISION

Increasing foreign business has necessitated the opening of an Export Division by the Polymet Manufacturing Corporation.

This department of the company will be under the direction of Mr. Arthur Rock, well-known in the radio and export fields, with offices at 154 Nassau Street, New York City.

## "VOGUE NONPAREILS" APPOINTS METROPOLITAN AGENTS

Mr. Paul Conners, General Manager of the Allan Mfg. Co., in announcing the completion of their new plant, located at Harrison, N. J., which will increase their output ten-fold above their present production, also announces the appointment of new New York Metropolitan Area Agents. The Vogue Nonpareil Sales Company of New York, as it will be called, will have the specialized services of two prominent radio tube men, well known in the New York Metropolitan Area, Messrs. Leo. Friedman, and J. Earl Simonds. Mr. Friedman, one of the executives of Radio Station WMCA, in addition to his executive duties there will concentrate his efforts on the promotion of Vogue Nonpareils in conjunction with Mr. Simonds who has been associated with him over a long period. Mr. Friedman, for a period of almost three years was Metropolitan Area Representative for "Magnatrons" which he introduced to the New York market successfully. Mr. Simonds has been instrumental in the development of many special features in radio tubes, among them the shelf-base which in conjunction with Mr. Friedman he successfully sold to the trade.

## NATIONAL ELECTRIC PRODUCTS COMPANY

The National Electric Products Company, of Waukegan, Ill., successors to the old Pfanstiehl Radio Co., are manufacturing the "National Seven Tube A-C Set" and also a line of variable condensers and other radio parts.

John L. Nelson is President of the newly formed organization and K. E. Rollefson is Vice-President and Chief Engineer.

## STEVENS CO. TO MOVE TO NEWARK

After some thirty years in the loft building at 46-48 East Houston Street, New York City, the Stevens Manufacturing Corporation, manufacturers of Stevens loudspeakers and Burtex diaphragms, are about to move to larger and more modern quarters at 46-48 Spring Street in Newark, N. J. Two buildings, connected by bridges and containing over 80,000 square feet of floor space, will accommodate both the office and the factory of the Stevens organization, as well as the research and engineering laboratory, after April 1st.

## RADIO AND ASSOCIATED STOCK QUOTATIONS

| Company | Jan. 3 | Feb. 4 | Mar. 6 | Company | Jan. 3 | Feb. 4 | Mar. 6 |
|---|---|---|---|---|---|---|---|
| Acoustic Products | 18½ | 14 | 9⅝ | Ken-Rad | .... | .... | 36½ |
| All-Am. Mohawk | 35½ | 35 | 27 | Kolster | 75½ | 68½ | 61⅛ |
| American Bosch | 42 | 41⅜ | 56⅞ | Magnavox | 11½ | 9 | 9 |
| Arcturus | .... | .... | 26⅝ | Radio (Com.) | 394¾ | 393 | 388 |
| Brunswick | 52⅜ | 52⅜ | 49⅞ | Raytheon | 59 | 60 | 55 |
| CeCo Mfg. | 60½ | 83 | 67½ | Sangamo | 37¼ | 42¾ | 40½ |
| Crosley | 117 | 185 | 112¼ | Sonatron | .... | n. 43½ | 37¾ |
| De Forest | 25½ | 23⅝ | 21 | Sparks-Withington | 180 | 175 | 178 |
| Dubilier | 9 | 11 | 8¼ | Steinite | .... | .... | 39 |
| Erla | 14⅜ | 19½ | 14 | Stromberg Carlson | 31 | 30⅞ | 31 |
| Fansteel | 12½ | 17 | 12⅞ | Stewart-Warner | 123⅝ | 141 | 135⅛ |
| Formica | 30 | 34¾ | .... | United Reproducers | .... | .... | 35 |
| Freed-Eisemann | 5 | 3⅞ | 2⅜ | Utah | .... | .... | 26½ |
| Freshman | 11⅞ | 9¾ | 8⅞ | Tower | 8¾ | 16 | .... |
| General Elec. (Com) | 245¼ | 251 | 237 | Union Carbide (Com.) | 206⅞ | 220 | 212 |
| Gold Seal | 25 | 38 | 66 | Victor (Com.) | 152¼ | 155¾ | 155¾ |
| Grigsby-Grunow (new) | 148⅞ | 168½ | 170 | Westinghouse | 143 | 164¼ | 152⅞ |
| Hazeltine | 48 | 46½ | 44⅞ | Weston (Com.) | 22⅞ | 22 | 25¾ |
| Kellogg | 17¾ | 17½ | 14½ | Zenith (new) | 54 | 59¾ | 50¼ |


# Supreme Musical Performance – "Built To Exceed Your Expectations"

IT IS significant that the manufacturers of the world's finest radio receivers have almost universally turned to Thordarson for their power supply and audio transformers.

Thordarson power supply transformers exhibit an efficiency of design, an abundance of power and a constancy of performance that practically eliminates the necessity for service calls.

Thordarson audio transformers provide a fidelity of tonal reproduction that renders the finished receiver a musical instrument of the highest calibre.

If you seek the ultimate in radio performance, insist on Thordarson transformers.

THORDARSON ELECTRIC MFG. CO.
*Transformer Specialists Since 1895*
Huron, Kingsbury and Larrabee Streets
CHICAGO, ILL.

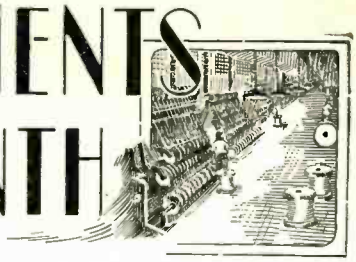

*Thordarson products have been chosen for incorporation in Federal Ortho-Sonic Radio Sets because we have always been certain that we would receive a quality of product entirely in keeping with the high standard set by us for Federal receivers.*

Lester E. Noble
*President, Federal Radio Corporation*

# THORDARSON RADIO TRANSFORMERS

SUPREME IN MUSICAL PERFORMANCE

# NEW DEVELOPMENTS OF THE MONTH



## UX-245 POWER TUBE

A NEW power amplifier tube for supplying large undistorted output to the loudspeaker, has been announced by the Radio Corporation of America. Radiotron UX-245, as the tube is designated, is capable of delivering a power output equal to that of the UX-210, but at a plate voltage not exceeding 250 volts. It is not interchangeable with the UX-171-A or any other power amplifier Radiotron.

The new tube can be used only with apparatus especially designed for it, and is intended for use in the last audio amplifying stage of power line operated sets which supply not more than 2.5 volts to the last audio socket, as well as proper grid and plate voltages.


The new UX-245 power tube.

The filament in the new UX-245 is of the coated ribbon type which assures great strength and high emission. To keep the exceedingly high plate current of this Radiotron from the loudspeaker windings, it is essential to use some form of loudspeaker coupling such as an output transformer or a choke coil and condenser.

The characteristics of the UX-245 follow:

| | | |
|---|---|---|
| Plate Voltage | 180 | 250 Volts |
| Negative Grid Bias | 33 | 50 Volts |
| Plate Current | 26 | 32 Milliamperes |
| Plate Resistance | 1950 | 1900 Ohms |
| Mutual Conduct'ce | 1800 | 1850 Micromhos |
| Amplification Factor | 3.5 | 3.5 |
| Undistorted Power Output | 750 | 1600 Milliwatts |
| Filament.Volts | 2.5 | 1.5 Amperes |

Max. Overall, Length 5 5/8" 2 3/16" Diam. Base, Standard large UX.

## NEW ARCTURUS POWER AND SCREEN-GRID TUBES

In recognition of the tendency to standardize on 2.5 volt a-c tubes, the Arcturus Radio Tube Company of Newark, N. J., announces two important additions to their line in the development of the type 145 and 122, respectively power and screen-grid tubes.

The power tube has an undistorted power output of 1.7 watts under the following normal operating conditions:

| | |
|---|---|
| Plate potential | 250 volts |
| Grid bias | −50 volts |
| Filament voltage | 2.5 volts |
| Filament current | 1.5 amperes |
| Amplification constant | 3.5 |
| Mutual conductance | 1900 micro-mhos |
| Plate resistance | 1850 |

The undistorted power output of this new tube is equal to that of the 210-type of tube and is secured at much lower plate voltages. Also, the low plate impedance improves the tone quality when outputting into readily available load circuits.

The characteristics of the screen-grid tube are as follows:

| | |
|---|---|
| Heater potential | 2.5 volts |
| Heater current | 1.75 amperes |
| Plate potential | 180 volts |
| Shield grid potential | 75 volts |
| Control grid bias | 1.5 volts |
| Amplification constant | 400 |
| Plate resistance | 400,000 ohms |
| Mutual conductance | 1000 micro-mhos |

The 122 tube is of the heater cathode type and is mounted in the UY five-prong base. The control grid, as is usual, is brought out to a cap on the top of the tube.

## RAYTHEON HIGH-VOLTAGE RECTIFIERS

With the introduction of two new high-voltage rectifiers known as the Series S type, the Raytheon Manufacturing Co., of Cambridge, Mass., believes it has made a distinct contribution to the radio art. These half-wave rectifiers are claimed to be unequalled in reliability, simplicity and performance.


Left: Raytheon "Ray S" tube.
Right: Raytheon "Ray SX-866"

Raytheon type Ray S rectifier is designed to supply from 2000 to 3000 volts and direct current up to 300 milliamperes, and is especially adapted, with proper filters, for supplying the plate voltage of X-852, X-860, V-861 and V-204A transmitting tubes.

Raytheon type SX-866 is designed for supplying 1500 to 2000 volts at currents up to 250 milliamperes, with suitable filters, and is especially adapted for supplying the plate potential for X-210, X-852, X-860, V-211 or V-203A transmitting tubes.

Both the Ray S rectifiers combine the high efficiency and reliability of the mercury arc with the simplicity and sturdiness of the thermionic types of rectifiers. For greater life and stable performance, a very rugged, indirectly heated cathode is utilized. Outstanding features of these rectifiers are constant low voltage drop, high potentials, high current, high efficiency, and a stable plate supply with key up or key down.

The Ray S retails at $25.00, while the Ray SX-866 retails at $12.50.

## THE TRUTONE "SI-LEN-SER"

The Trutone Radio Sales Company, of 114 Worth Street, New York, have introduced a new form of interference eliminator,


The Trutone "Si-Len-Ser."

known as the "Si-Len-Ser." It is in the form of a filter block which uses specially designed coils for its manifold purposes. It also employs two condensers which are grounded at the common lead. The device is about five inches high and weighs 4½ pounds, the wire carrying most of the weight.

Besides eliminating outside electrical interference not caused by aerial pick-up, the Si-Len-Ser will abolish all heterodyning due to electric leaks, or stop interference from household appliances which operate on the house current. Moreover, the Si-Len-Ser is likened to the radio set in that it is easily attached to the electric light socket and the plug of the receiver, or the plug of the household apparatus may be placed in this new device.

Coming out of the condensers and leading to the top of the Si-Len-Ser is a ground wire. The device will perform satisfactorily in many cases without this ground lead. Any common ground connection such as a cold water pipe or radiator can be employed.

## UTAH REMOTE CONTROL FOR RADIO RECEIVERS

An automatic remote control tuning device for radio receivers which removes all necessity of placing dials, switches and knobs upon the panel, has been developed by the Utah Radio Products Co., Chicago. Through the use of this device the radio receiver may be controlled from an easy chair in the living room, dining room, bedroom or any other point in the home, any number of controls being used. If through the living room control, station WGN for instance is tuned in, the user may go to a control in another room of the house and tune another station, such as WLS. Station WGN, which was tuned in the living room is automatically disconnected and the entertainment from WLS is immediately heard.

The remote control box, through which the radio receiver is operated, is small and compact and may be held in the palm of one's hand. It contains two knobs, one a station selector, the other a volume control. On the selector knob, any one of ten stations, either DX or local, may be dialed. It is possible to secure DX tuning, also for stations not listed on the selector dial, as two auxilliary tuning buttons are provided, allowing much finer tuning than is possible through the ordinary hand control.

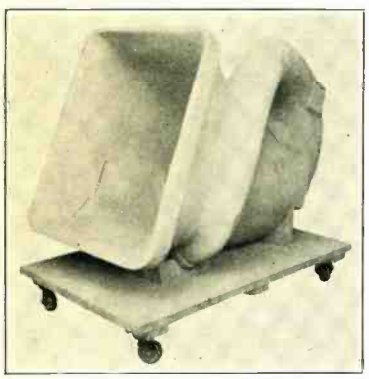
The mechanism of the automatic remote control tuning device is simple and may be mounted easily and economically on manufactures' present-day receivers. The device automatically turns on the set, lights the tubes and tunes. When the dial is turned to the "off" position, it automatically de-tunes the station and turns off the tubes.

A new and unique type of electric motor has been developed as an important part of this new tuning device. It is a reversible brushless motor that causes no noise or disturbance while tuning. The entire automatic mechanism is encased in a small metal container, approximately 3"x7"x7", which lends itself easily to cabinet installations and presents no engineering problem for the manufacturer who wishes to adapt it to his present chassis design. The Utah Radio Products Co. plans to limit the licensing of this automatic remote control tuning device to only those firms manufacturing high quality receiving sets.

## ULTRATONE AIR COLUMN SPEAKER

The Ultratone Manufacturing Co., Inc., of 1046 West Van Buren St., Chicago, have placed on the market a new air column horn which is particularly adaptable to public address and theatre use.

The ultratone horn is made of a gypsum composition, the air column being 18 inches long, inside, suitable for a dynamic or magnetic unit, or with the same size bell, with a 12-inch air column, suitable for any dynamic unit to be fitted up behind.



Utratone Air Column Speaker

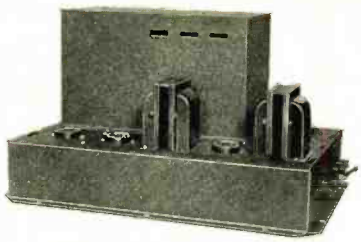
The horn is mounted on a small truck so that it may be moved from place to place if desired, or the truck may be unfastened and the horn installed permanently.

It is claimed by the manufacturers that the Ultratone Horn, equipped with a good speaker unit, is entirely satisfactory for supplying ample volume for a theatre with a seating capacity of three thousand.

## ELECTRO-ACOUSTIC AMPLIFIERS

The Electro-Acoustic Products Co., 55 East Wacker Drive, Chicago, are presenting a highly specialized line of electro-acoustic amplifiers, for microphone, electrical recording reproduction, and radio.

The amplifier described in these paragraphs is the Electro-Acoustic EAP-60 general purpose amplifier. This amplifier has many unique features worthy of mention. It is resistance coupled, three stages, with a 250 tube in the output stage. This accounts largely for the excellent frequency range this amplifier has. It is claimed that not only does it extend down below sixty cycles, but also to the "overtone" range of seven thousand cycles, which is so very important in getting reproduction of voice and music that is realistic and natural in every detail.



Electro-Acoustic EAP-60 Power Amplifier

The power output is over five watts of undistorted audio frequency power. The output impedance is low and two standard electrodynamic speakers may be connected in parallel without inviting distortion. Field current of fifty to forty milliamperes can be supplied to one or two speakers of the 110 volt d-c. type. When magnetic or electrostatic types of speakers are used the binding posts to which the fields would be connected remain disconnected. The fields do not act as part of the filter system. Therefore, it is not necessary to substitute a choke or resistance, when no field current supply is required.

Another distinctive feature is the input impedance, which is 500,000 ohms, so that the amplifier may be used with any source having an impedance anywhere from 100 to 500,000 ohms. This permits the use of pick-ups, or transformers of either low or high impedance without introducing distortion. Particularly is this ideal for a radio station monitor, as the amplifier may be connected to a telephone line, or radio-frequency coil, without alterations. Also, by selecting a recommended type of volume control, no less of high frequencies will be experienced at low volume.

Electro-Acoustic amplifiers are designed so that two or more amplifiers may be connected in parallel and supplied from a single source (pick-up or radio) without distortion or loss of volume. This is particularly valuable where banks of amplifiers are used in hotel and apartment house installations.

No a-c. hum is discernable when the amplifier is used with even the best electro-dynamic speakers. A slight hum can be heard only when listening within three inches of the speaker.

The 250 tube in the output stage is preceded by two input stages to build up the low amplitude of the pick-up or radio set, to the eighty-five volts necessary for full power output. Two 281 tubes supply six hundred volts to the filter system.

## DUBILIER BLOCK FOR 250 AMPLIFIER

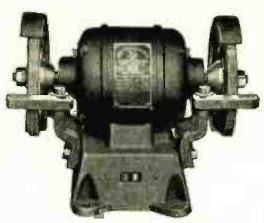
In order to meet the high-voltage requirements of the 250 power amplifier and power supply circuit, the Dubilier Condenser Corporation, of New York City, has introduced the Dubilier Type PL 1152 condenser block. This block contains one 2 mfd. 1000-volt section, two 4 mfd. 600-volt sections, and two 1 mfd. 200-volt sections, or a total capacity of 12 mfd. The terminals are at the top of the case for convenient wiring and soldering.

This block is intended for the Thordarson 250 power amplifier circuit and corresponding circuits.

## U. S. TOOL 6" GRINDER

A new six-inch grinder that is said to give promise of being one of the most popular in the "U. S." line, is now being announced by The United States Electrical Tool Company, Cincinnati, oldest builders of portable electric drills and grinders.

Although listing at only $34.50, it embodies ball bearings of a widely known make, heavy nickel steel spindle, a powerful ¼ H. P. motor of 3450 R. P. M. load speed, a fine and a coarse wheel 6"x½"x½", adjustable tool rests, and complete electrical connections.



U. S. Tool 6" Grinder

This "U. S." Grinder is furnished regularly for 110 volt, 60 cycle current from light socket. However, it can also be furnished in 220 volt, two and three phase, also in 110 and 220 volt direct current at slightly additional cost.

## DONGAN 250 POWER TRANSFORMER

The Dongan Electric Manufacturing Co., of 2995 Franklin St., Detroit, Mich., are marketing a heavy-duty power transformer to accommodate the demands of one or two 250 power tubes.

The transformer, listed as No. 7568, is designed for full-wave rectification, using two 281-type rectifier tubes, and will supply ample B and C power for any multi-tube receiver and power for a single 250 tube or two 250 tubes in push-pull.

The list price of the Dongan No. 7568 power transformer is $13.50.

## DE FOREST 471A AND 471B AUDIONS

Recognizing the need for a battery-operated as well as an a-c operated power tube, the DeForest Radio Company of Jersey City, N. J., is now producing the 471A Audion essentially for a-c operation, and the 471B essentially for battery operation.

The 471A audion is designed as an amplifier for use in the last or output audio stage. This audion permits large volume without distortion, due to its low output impedance. The plate voltage may run between 90 and 180, and the C bias between 16.5 and 40.5 volts. The filament current is .5 ampere, which makes this tube especially desirable in the a-c operated set, where current consumption is not a prime factor.

The 471B audion is similar to the 471A in the matter of plate, grid bias and low output impedance. However, the filament current has been reduced to .25 ampere, which makes this audion most desirable for storage-battery operation, or again in series-filament socket power operation.

## NEW ARCTURUS A-C DETECTOR TUBE

The Arcturus Radio Tube Company of Newark, N. J., announces the development of an improved 2.5 volt, five prong a-c detector tube in their 127A tube, replacing their type 127.

The new tube has been designed in special recognition of the many circuits and receivers specifying a 2.5 volt heater cathode tube in the radio and audio frequency amplifiers in place of the familiar but less satisfactory 26 type of tube. The interelectrode capacity of this new tube has been reduced to a minimum. The peculiar requirements of neutrodyne circuits have received particular consideration in the design of this new tube.

The heater of the Arcturus 127A is identical with that of the former 127 tube, which tests have shown to have a life well in excess of five thousand hours.

## NEW KOLSTER "BRANDES" RECEIVERS

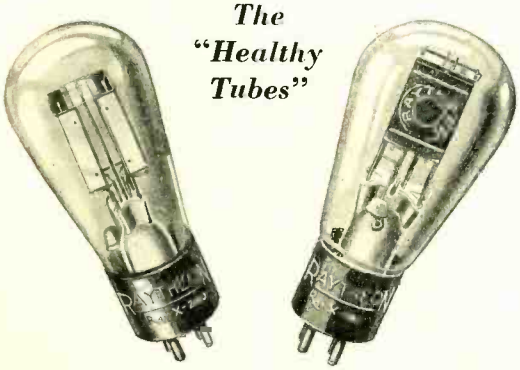
A new line of radio receiving sets that will enter the low-priced market has just been announced by the Kolster Radio Corporation through a newly formed subsidiary company, The Brandes Corporation. Three models are being manufactured. They are a table type receiver at $85, known as model B-10; a console or floor model at $135, known as model B-11, and another of the floor type at $165, known as model B-12. Prices west of the Rockies slightly higher. The set chassis for the three models is the same, a six-tube, 60 cycle, 100-120 alternating current receiver with three stages of tuned radio frequency, detector and two stages of audio amplification. Type 327 tubes are used in all stages except the last audio, where the 371-A power tube is used. Rectification is accomplished with the full-wave type 380 tube.

Both floor model receivers have dynamic speakers built in, and the table model set may be used with either a magnetic or dynamic reproducer.

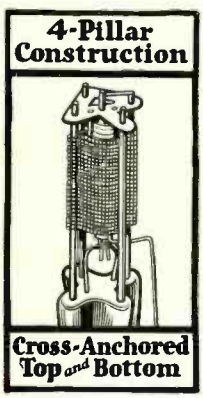
Another feature of all the Brandes models is that they are equipped with jacks for plugging in a phonograph pick-up, allowing the playing of records through the speaker.

# Two Notable Types of Raytheon LONG LIFE RADIO TUBES

*The "Healthy Tubes"*



*Tube Health and Long Life*




*Result from this Construction*

THERE is a Raytheon "Healthy" Tube for every need. The two types shown above are but indicative of the surpassing efficiency and longevity of every type in the Raytheon line.

The same unique inner construction that permanently holds the tube-elements in their correct relative positions is used in all Raytheon A.C. types.

It not only extends the effective life of the tube, but it also eliminates microphonic noises and improves reception generally.

RAYTHEON MFG. COMPANY
Cambridge, Mass.

# ARMOR
GUARANTEED
## RADIO TUBES

All Standard Types


ARMSTRONG ELECTRIC CO.
187-193 Sylvan Ave.
NEWARK, N. J.

*Still Growing*

## 12,000 sq. ft. Additional Floor Space added to

VOGUE NONPAREIL

# Tube Plant

Here you have conclusive proof of the rapidly increasing demand for Vogue tubes. In addition to our present plant we have taken over 12,000 square feet of floor space in one of the buildings of the Clark Thread Co., located at East Newark, N. J. Enough new Eisler automatic equipment has been installed to increase our production to approximately 12,000 tubes daily.

**JOBBERS NOTE.** We can conscientiously state without fear of contradiction that not one Vogue jobber was left high and dry for tubes during the shortage that prevailed in the past season. Likewise 1929 promises to be a repetition of this same condition. We absolutely assure those jobbers that tie up sufficiently early on this profit-producing line this year that they will have our unquestionable cooperation in keeping them supplied with merchandise. The same 100% guarantee prevails.

*Write or wire now for further information.*

ALLAN MANUFACTURING CO.
HARRISON, N. J.
Los Angeles: 487 Chamber of Commerce Bldg.

# Buyers Directory of Equipment 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 advertisements—see index on page 64.

**ADAPTERS:**
Carter Radio Co.
Lynch, Arthur H., Inc.

**ALUMINUM:**
Aluminum Co. of America

**ALUMINUM FOIL:**
Aluminum Co. of America
Reynolds Metals Co., Inc.

**AMMETERS:**
General Radio Co.
Jewell Elec. Inst. Co.
Westinghouse Elec. & Mfg. Co.
Weston Elec. Instrument Corp.

**AMPLIFIERS, POWER:**
General Amplifier Co.
General Radio Co.
Skidmore, W. K., & Co.

**ANTENNAE, LAMP SOCKET:**
Dubilier Condenser Mfg. Co.

**ARRESTERS, LIGHTNING:**
Jewell Elec. Inst. Co.
Westinghouse Elec. & Mfg. Co.

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

**BINDING POSTS:**
Eby, H. H. Co
General Radio Co.

**BRACKETS, ANGLE:**
Scovill Mfg. Co.

**BRASS:**
Copper and Brass Research Assn.
Scovill Mfg. Co.

**BROADCAST STATION EQUIP'T:**
Cardwell, Allen D., Mfg. Co.
General Radio Co.

**BUTTS:**
Scovill Mfg. Co.

**CABINETS, METAL:**
Aluminum Co. of America.
Copper and Brass Research Assn.

**CELLS, PHOTOELECTRIC:**
Burt, Robert C.
Raytheon Mfg. Co.

**CERIUM:**
Cohn, Sigmund.

**CHARGERS:**
Benwood-Linze Co.
Elkon Co.

**CHASSES**
Aluminum Co. of America.
Copper and Brass Research Assn.
United Scientific Laboratories, Inc.

**CHOKES, AUDIO FREQUENCY:**
American Transformer Co.
General Radio Co.
Silver-Marshall, Inc.
Thordarson Elec. Mfg. Co.

**CHOKES, RADIO FREQUENCY:**
Cardwell, Allen D., Mfg. Co.
General Radio Co.
Silver-Marshall, Inc.

**CHOKES, B ELIMINATOR:**
American Transformer Co.
Dongan Elec. Mfg. Co.

General Radio Co.
Silver-Marshall, Inc.

**CLAMPS, GROUND:**
Scovill Mfg. Co.

**CLIPS, SPRING:**
Scovill Mfg. Co.

**COIL FORMS:**
General Radio Co.
Silver-Marshall, Inc.

**COILS, CHOKE:**
Acme Wire Co.
Dudlo Mfg. Co.
Westinghouse Elec. & Mfg. Co.

**COILS, IMPEDANCE:**
Acme Wire Co.
Dudlo Mfg. Co.

**COILS, INDUCTANCE:**
Acme Wire Co.
Aero Products Corp.
Cardwell, Allen, D., Mfg. Co.
General Radio Co.
Hammarlund Mfg. Co.
Silver-Marshall, Inc.

**COILS, MAGNET:**
Acme Wire Co.
Dudlo Mfg. Co.

**COILS, RETARD:**
Hammarlund Mfg. Co.

**COILS, SHORT WAVE:**
Aero Products Corp.
General Radio Co.
Hammarlund Mfg. Co.
Silver-Marshall, Inc.

**COILS, TRANSFORMER:**
Acme Wire Co.
Dudlo Mfg. Co.

**CONDENSER PARTS:**
Aluminum Co. of America
Scovill Mfg. Co.

**CONDENSERS, BY-PASS:**
Acme Wire Co.
Aerovox Wireless Corpn.
Allen-Bradley Co.
Carter Radio Co.
Condenser Corp. of America.
Dongan Electric Mfg. Co.
Dubilier Condenser Mfg. Co.
Fast, John E. & Co.
Sangamo Elec. Co.
Wireless Specialty Apparatus Co.

**CONDENSERS, FILTER:**
Acme Wire Co.
Aerovox Wireless Corpn.
Allen-Bradley Co.
Carter Radio Co.
Condenser Corp. of America.
Dongan Electric Mfg. Co.
Dubilier Condenser Mfg. Co.
Fast, John E. & Co.
Sangamo Elec. Co.
Wireless Specialty Apparatus Co.

**CONDENSERS, FIXED:**
Acme Wire Co.
Aerovox Wireless Corpn.
Allen-Bradley Co.
Carter Radio Co.
Condenser Corp. of America.
Dongan Electric Mfg. Co.
Dubilier Condenser Mfg. Co.
Fast, John E., & Co.
Sangamo Elec. Co.
Wireless Specialty Apparatus Co.

**CONDENSERS, MIDGET:**
Cardwell, Allen D. Mfg. Co.
General Radio Co.
Hammarlund Mfg. Co.
Scovill Mfg. Co.
Silver-Marshall, Inc.
United Scientific Laboratories

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

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

**CONDENSERS, VARIABLE:**
Cardwell, Allen D. Mfg. Co.
DeJur-Amsco Co.
General Radio Co.
Hammarlund Mfg. Co.
Scovill Mfg. Co.
Silver-Marshall, Inc.
United Scientific Laboratories

**CONNECTORS:**
Carter Radio Co.
Scovill Mfg. Co.

**CONTROLS, ILLUMINATED:**
Hammarlund Mfg. Co.
Silver-Marshall, Inc.

**CONTROLS, VOLUME:**
Carter Radio Co.
Central Radio Laboratories
Clarostat Co.

**CONVERTERS:**
Cardwell, Allen D., Co.
Electric Specialty Co.

**CONVERTERS, ROTARY:**
Electric Specialty Co.

**COPPER:**
Copper & Brass Research Assn.
Scovill Mfg. Co.

**CURRENT CONTROLS, AUTOMATIC:**
Radiall Co.

**DIALS:**
Hammarlund Mfg. Co.
Scovill Mfg. Co.
Silver-Marshall, Inc.
United Scientific Laboratories

**DIALS, DRUM:**
Hammarlund Mfg. Co.
Silver-Marshall, Inc.
United Scientific Laboratories

**DYNAMOTORS:**
Electric Specialty Co.

**ESCUTCHEONS:**
Crowe Nameplate & Mfg. Co.
Scovill Mfg. Co.

**EXPORT:**
Ad. Auriema, Inc.

**FILAMENTS:**
Cohn, Sigmund.
Gilby Wire Co.

**FILAMENT, OXIDE COATED:**
Independent Laboratories, Inc.

**FILAMENT CONTROLS, AUTOMATIC:**
Lynch, Arthur H., Inc.
Radiall Co.

**FOIL:**
Aluminum Co. of America
Reynolds Metals Co., Inc.

**GALVANOMETERS:**
General Radio Co.
Jewell Elec. Inst. Co.
Westinghouse Elec. & Mfg. Co.

**GEARS:**
Chicago Stock Gear Wks.

**GENERATORS:**
Electric Specialty Co.

**GETTER MATERIAL:**
Cohn, Sigmund.
Gilby Wire Co.

**GRID LEAKS:**
Aerovox Wireless Corpn.
Allen-Bradley Co.
DeJur-Amsco Co.
Hardwick, Hindle, Inc.
International Resistance Co.
Lautz Mfg. Co.
Lynch, Arthur H., Inc.

**HARNESSES, A-C.:**
Carter Radio Co.

**HEADPHONES:**
Amplion Co. of Amer.

**HINGES:**
Scovill Mfg. Co.

**HORNS:**
Amplion Co. of Amer.

**INDUCTANCES, TRANSMITTING:**
Aero Products, Inc.
General Radio Co.
Radio Engineering Laboratories.
Silver-Marshall, Inc.

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

**INSULATION LAMINATED**
Formica Insulation Co.
General Electric Co.
National Vulcanized Fibre Co.

**INSULATION, MOULDED:**
Bakelite Corp.
Formica Insulation Co.
General Electric Co.
General Plastics Co.
National Vulcanized Fibre Co.
Westinghouse Elec. Mfg. Co.

**INSULATION, VARNISHED:**
Acme Wire Co.

**IRON, MAGNETIC:**
Reid, David, Jr.

**JACKS:**
Carter Radio Co.
Eby, H. H., Co.
General Radio Co.

**JACKS, TIP:**
Carter Radio Co.
Eby, H. H., Co.

**KITS, SHORT WAVE:**
Aero Products, Inc.
Lynch, Arthur H., Inc.
Silver-Marshall, Inc.

**KITS, TELEVISION:**
Insuline Co.
Lynch, Arthur H., Inc.

**KITS, TESTING:**
General Radio Co.
Jewell Elec. Inst. Co.

**KITS, TRANSMITTING:**
Aero Products, Inc.

**LACQUERS:**
Zapon Co., The

**LABORATORIES:**
Electrical Testing Labs.

**LAMINATIONS:**
Lamination Stamping Co.
Willor Mfg. Co.

**LEAD-INS:**
Electrad, Inc.

**LOCK WASHERS:**
Shakeproof Lock Washer Co.

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

**MAGNESIUM:**
Aluminum Co. of America.

**MAGNETS:**
Reid, David, Jr.

**METERS:**
General Electric Co.
Jewell Elec. Inst. Co.
Westinghouse Elec. & Mfg. Co.
Weston Elec. Instr. Co.

**MICROPHONES:**
Amplion Co. of America
Westinghouse Elec. & Mfg. Co.

**MOLDING MATERIALS**
Bakelite Corp.
Formica Insulation Co.
General Plastics Co.
National Vulcanized Fibre Co.
Westinghouse Elec. & Mfg. Co.

**MOTORS:**
Electric Specialty Co.

**MOTOR-GENERATORS:**
Electric Specialty Co.

**MOUNTINGS, RESISTANCE:**
DeJur-Amsco Co.
Lynch, Arthur H., Inc.

**NAMEPLATES:**
Crowe Nameplate & Mfg. Co.
Scovill Mfg. Co.

**NICKEL:**
Cohn, Sigmund

**NUTS:**
Shakeproof Lock Washer Co.

**OSCILLOGRAPH:**
Burt, Dr. Rob't C.
General Radio Co.

**OSCILLOSCOPE:**
Burt, Dr. Rob't C.
Westinghouse Elec. & Mfg. Co.

**PANELS, COMPOSITION:**
Formica Insulation Co.
Westinghouse Elec. & Mfg. Co.

**PANELS, METAL:**
Aluminum Co. of America
Scovill Mfg. Co.

**PAPER, CONDENSER:**
Dexter, C. H. & Sons, Inc.

**PAPER, CONE SPEAKER:**
Seymour Co.

**PHONOGRAPH MOTORS:**
(See Motors)

**PHOTOELECTRIC CELLS:**
(See Cells)

**PLATES, OUTLET:**
Carter Radio Co.

**PLATINUM:**
Cohn, Sigmund

**PLUGS:**
Carter Radio Co.
General Radio Co.

**POWER PACKS, UNITS FOR**
Acme Wire Co.
Lynch, Arthur H., Inc.

**POWER UNITS, A-:**
Elkon, Inc.

**POWER UNITS, B-:**
Dongan Elec. Mfg. Co.
General Radio Co.
Silver-Marshall, Inc.
Thordarson Electric Mfg. Co.

**POWER UNITS, A-B-C:**
Dongan Elec. Mfg. Co.
General Radio Co.
Silver-Marshall, Inc.
Thordarson Electric Mfg. Co.

**POWER UNITS, PARTS FOR:**
American Transformer Co.
Dongan Elec. Mfg. Co.
General Radio Co.
Thordarson Electric Mfg. Co.

**POTENTIOMETERS:**
Allen-Bradley Co.
Carter Radio Co.
Central Radio Laboratories
DeJur-Amsco Co.
General Radio Co.
United Scientific Laboratories

**RECEIVERS, ELECTRIC:**
United Scientific Laboratories.

**RECTIFIERS, DRY:**
Benwood-Linze, Inc.
Elkon, Inc.
Kodel Elec. & Mfg. Co.

**REGULATORS, VOLTAGE:**
DeJur-Amsco Co.
Radiall Co.

**RELAYS:**
Cardwell, Allen D., Mfg. Co.

**RESISTANCES, FIXED:**
Aerovox Wireless Corp.
Allen-Bradley Co.
Carter Radio Co.
Central Radio Laboratories.
DeJur-Amsco Co.
Hardwick, Hindle Inc.
International Resistance Co.
Lautz Mfg. Co.
Lynch, Arthur H., Inc.

**RESISTANCES, VARIABLE:**
Allen-Bradley Co.
American Mechanical Labs.
Carter Radio Co.
Central Radio Laboratories.
Hardwick, Hindle Inc.
International Resistance Co.
Lynch, Arthur H., Inc.

**RHEOSTATS:**
Carter Radio Co.
Central Radio Laboratories.
DeJur-Amsco Co.
General Radio Co.
United Scientific Laboratories.
Westinghouse Elec. & Mfg. Co.

**SCHOOLS, RADIO:**
National Radio Institute.
Radio Institute of America

**SCREW MACHINE PRODUCTS:**
Aluminum Co. of America
National Vulcanized Fibre Co.
Scovill Mfg. Co.

**SHIELDING, METAL:**
Aluminum Co. of America.
Copper and Brass Research Assn.

**SHIELDS, TUBE:**
Carter Radio Co.

**SHORT WAVE APPARATUS:**
Cardwell, Allen D., Co.
General Radio Co.
Lynch, Arthur H., Inc.
Silver-Marshall, Inc.

**SOCKETS, TUBE:**
Eby, H. H., Co.
General Radio Co.
Lynch, Arthur H., Inc.
Silver-Marshall, Inc.

**SOLDER:**
Chicago Solder Co.
Westinghouse Elec. & Mfg. Co.

**SOUND CHAMBERS:**
Amplion Co. of Amer.
Jensen Radio Mfg. Co.
Rola Co., The

**SPAGHETTI:**
(See Wire, Spaghetti).

**SPEAKERS:**
Amplion Co. of Amer.
Jensen Radio Mfg. Co.
Rola Co., The

**STAMPINGS, METAL:**
Aluminum Co. of America
Scovill Mfg. Co.

**STEEL, MAGNETIC:**
See (*Iron Magnetic.*)

**SUBPANELS:**
Formica Ins. Co.
Westinghouse Elec. & Mfg. Co.

**SWITCHES:**
Carter Radio Co.
General Radio Co.
National Vulcanized Fibre Co.
Westinghouse Elec. & Mfg. Co.

**TAPPERS**
Eastern Tube and Tool Co.

**TELEVISION PARTS:**
Allen-Bradley Co.
Clarostat Co., Inc.
Insuline Co.
Lynch, Arthur H., Inc.

**TESTERS, B-ELIMINATOR:**
General Radio Co.
Jewell Electrical Inst. Co.

**TESTERS, TUBE:**
General Radio Co.
Jewell Elec. Inst. Co.

**TESTING INSTRUMENTS:**
General Radio Co.
Jewell Elec. Inst. Co.
Westinghouse Elec. & Mfg. Co.
Weston Elec. Instrument Corp.

**TESTING KITS:**
Jewell Elec. Inst. Co.

**TESTING LABORATORIES:**
Electrical Testing Labs.

**TINFOIL:**
Reynolds Metals Co., Inc.

**TOOLS:**
Eastern Tube and Tool Co.

**TRANSFORMERS, AUDIO:**
Dongan Elec. Mfg. Co.
Ferranti, Ltd.
General Radio Co.
Sangamo Elec. Co.
Silver-Marshall, Inc.
Thordarson Electric Mfg. Co.
Transformer Co. of America.

**TRANSFORMERS, B-POWER UNIT:**
Dongan Elec. Mfg. Co.
Ferranti, Ltd.
General Radio Co.
Sangamo Elec. Co.
Silver-Marshall, Inc.
Thordarson Electric Mfg. Co.
Transformer Co. of America.

**TRANSFORMERS, FILAMENT HEATING:**
Dongan Elec. Mfg. Co.
General Radio Co.
Silver-Marshall, Inc.
Thordarson Electric Mfg. Co.
Transformer Corp. of America.

**TRANSFORMERS, OUTPUT:**
Dongan Elec. Mfg. Co.
Ferranti, Ltd.
General Radio Co.
Sangamo Elec. Co.
Silver-Marshall, Inc.
Thordarson Electric Mfg. Co.
Transformer Corp. of America.

**TRANSFORMERS, POWER:**
Dongan Elec. Mfg. Co.
Ferranti, Ltd.
General Radio Co.
Silver-Marshall, Inc.
Thordarson Electric Mfg. Co.
Transformer Co. of America.
Westinghouse Elec. & Mfg. Co.

**TRANSFORMERS, R. F., TUNED:**
Cardwell, Allen D. Mfg. Co.
Silver-Marshall, Inc.

**TUBES, A. C.:**
Allan Mfg. Co.
Arcturus Radio Co.
Armstrong Elec. Co.
Ceco Mfg. Co.
De Forest Radio Co.
Gold Seal Elec. Co., Inc.
Perryman Electric Co.

**TUBES, RECTIFIER:**
Allan Mfg. Co.
Arcturus Radio Co.
Armstrong Elec. Co.
Ceco Mfg. Co.
Gold Seal Elec. Co., Inc.
Perryman Electric Co.
Raytheon Mfg. Co.

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

**TUBES, VACUUM:**
Allan Mfg. Co.
Arcturus Radio Co.
Armstrong Elec. Co.
Ceco Mfg. Co.
Gold Seal Elec. Co., Inc.
De Forest Radio Co.
Perryman Electric Co.
Raytheon Mfg. Co.

**UNITS, SPEAKER:**
Amplion Corp.
Jensen Radio Mfg. Co.

**VOLTMETERS, A. C.:**
General Electric Co.
General Radio Co.
Jewell Elec. Inst. Co.
Westinghouse Elec. & Mfg. Co.
Weston Elec. Instrument Corp.

**VOLTMETERS, D. C.:**
General Electric Co.
General Radio Co.
Jewell Elec. Inst. Co.
Westinghouse Elec. & Mfg. Co.
Weston Elec. Instrument Corp.

**WASHERS:**
Aluminum Co. of America
Scovill Mfg. Co.
Shakeproof Lock Washer Co.

**WIRE, ANTENNA:**
Acme Wire Co.
Dudlo Mfg. Corp.
National Vulcanized Fibre Co.
Roebling, J. A., Sons, Co.

**WIRE, BARE COPPER:**
Dudlo Mfg. Corp.
Roebling, J. A., Sons, Co.

**WIRE, COTTON COVERED:**
Acme Wire Co.
Dudlo Mfg. Corp.
Roebling, J. A., Sons Co.

**WIRE, ENAMELED COPPER:**
Acme Wire Co.
Dudlo Mfg. Corp.
Roebling, J. A., Sons Co.

**WIRE, FILAMENT:**
Cohn, Sigmund
Gilby Wire Co.

**WIRE, HOOK-UP:**
Acme Wire Co.
Dudlo Mfg. Co.
Roebling, J. A., Sons, Co.

**WIRE, LITZENDRAHT:**
Dudlo Mfg. Corp.
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WILLIAMS PRESS, INC., NEW YORK—ALBANY

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# Everybody Demands Power

***—and after you have heard the best you will Insist upon Tone Value too.***

A few years ago we thought the then current radio reproduction was wonderful—but today that type of un-real reception is as old-fashioned and antiquated as a storeroom, one reel, flickering movie.

It's just barely possible that a few years from now we shall write the same description about today's radio. But it doesn't seem likely. It is hard to imagine more actual reproduction of the human voice or musical orchestration than you can have now from a receiver built up around UX 250 Tubes using Dongan Power Parts. Once you hear that kind of Radio you will be satisfied with nothing less. For the ownership of that kind of Radio gives you a front row seat in all the famous hotels and concert halls of these United States.

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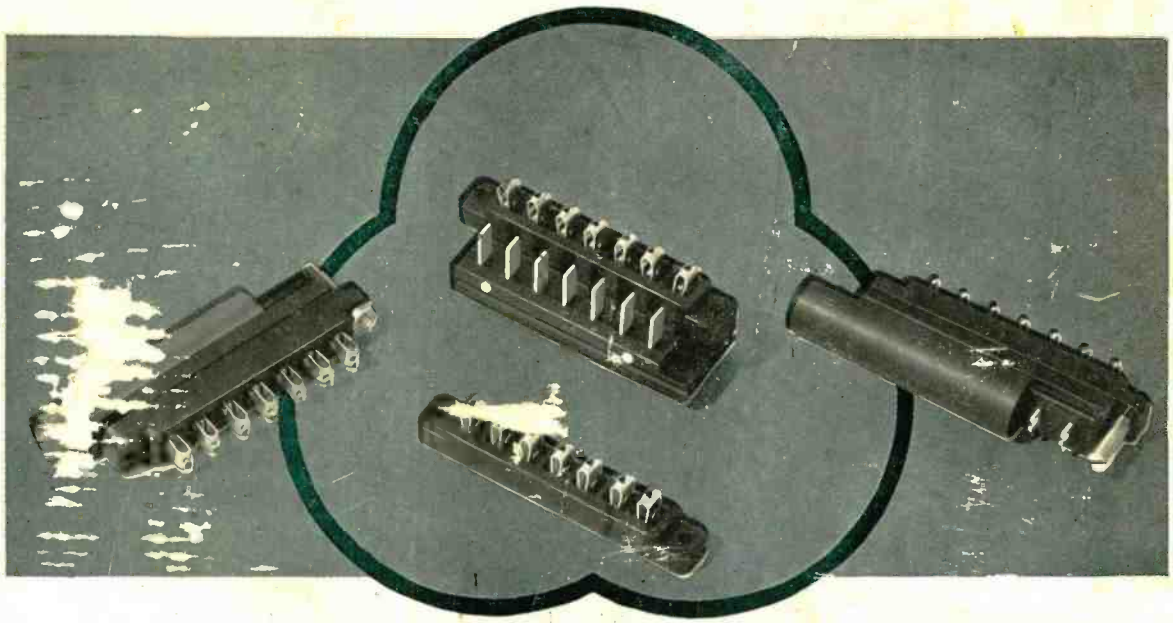

Radio connector plugs of Bakelite Molded. Made by Bell Manufacturing Co., Boston.

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WHEN a fibre material was used for making Bell connector plugs, several machine operations were necessary to complete each part. Through the use of Bakelite Molded all machining has been eliminated—reducing the cost—and [illegible] superior p[illegible] of uni[illegible] dim[illegible]olded.

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