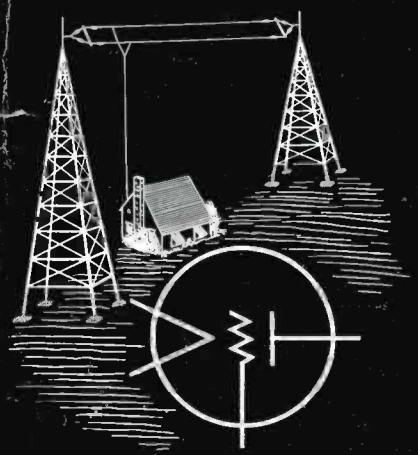
JANUARY, 1932

Radio Engineering



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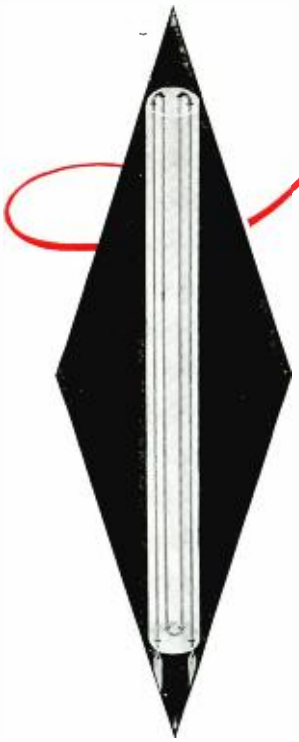
TWELFTH YEAR OF SERVICE

The Journal of the Radio and Allied Industries



Now . . . .

ANOTHER ACHIEVEMENT BY

ARCTURUS

New improvement IN AUTOMOBILE TUBES PERMITS USE WITH A.C. OR D.C.

Engineers and automotive set manufacturers have long felt the need for improved, more dependable automobile radio tubes.

Now — Arcturus meets that need with the Types 136A, 137A and 138A — utilizing a new non-inductive "M" filament. This is the *first* time an "M" filament has been used in indirectly heated cathode receiving tubes as a heater — *another Arcturus achievement.* These tubes are interchangeable with corresponding types.

In uniformity, serviceable life and performance these new Arcturus automobile tubes establish advanced operating standards. Besides permitting their use with a.c., the non-inductive filament eliminates fluctuations in current draw and banishes noisy reception.

The rugged design and compact size of these tubes, make the 136A, 137A and 138A especially fit the specifications for a universal receiver to operate on either a.c. or d.c.

We have already cooperated with a few set manufacturers in employing these tubes and will gladly send reliable manufacturers complete specifications and characteristics on request.

ARCTURUS RADIO TUBE COMPANY, NEWARK, NEW JERSEY

Exclusive Advantages of Arcturus Types 136A, 137A and 138A Tubes

1. An "M" filament is used instead of a coiled filament, providing a more rugged and dependable element.
2. The Arcturus "M" filament is non-inductive and reduces hum to a negligible factor, permitting these tubes to be used efficiently with a.c. as well as d.c. filament voltages.
3. Many of the failures in other types were due to the breaking down of the insulator because of the extremely high temperature of the coiled filament. The insulator used in these Arcturus Tubes withstands higher temperatures than 2600° centigrade, although maximum operating temperature is less than 1700° centigrade—providing a generous safety factor.
4. While the filament current varies appreciably with coiled filaments and fluctuates if the tubes are jarred (because of variable contact between the insulator and the filament), this condition is obviated in the "M" filament tubes. This filament is held securely in position throughout its length by a rugged insulator, which prevents shorts and leakages and insures uniform filament current that will not fluctuate even when the tubes are jarred. This is of special importance when tubes are connected in series, as for 110 volt d.c. operation.
5. The variable contact between the insulator and the coiled filament was responsible for noises in reception due to scraping. These noises are entirely eliminated by the new Arcturus construction.
6. Because of the uniform filament temperature insured by the "M" filament (elimination of "hot spots") the life of this filament is appreciably longer than coiled filament.
7. The 136A, 137A and 138A are interchangeable with the corresponding '36, '37 and '38 types and, like all Arcturus Tubes, these three types are quick-acting.

ARCTURUS

"The **BLUE TUBE** *with the* **LIFE-LIKE TONE**"

HAVE YOU TRIED

this way of making your product make money?

Too many factors enter into the building of a business to pin losses down to any one of them. But many radio manufacturers, among others, have found this out: that the *right material* can have a lot to do with swinging a losing product into a paying one.

And that is one good reason why Durez, the perfect molding compound, is being put to hundreds of new uses—not only in the radio industry, but in chemical fields, in the electrical world, in automotive, stationery, and even perfumery industries!

One interesting example of Durez' adaptability to the most recent problems is shown right in the illustration. Here is the Super-Thru—made by the Woodruff Company, of Meridian, Miss.—the only "complete lead-in and arrester which meets all requirements covering radio receiving set installations." Durez, as is so often the case, was selected especially for its high dielectric strength, its ease of molding, and its beauty of finish.

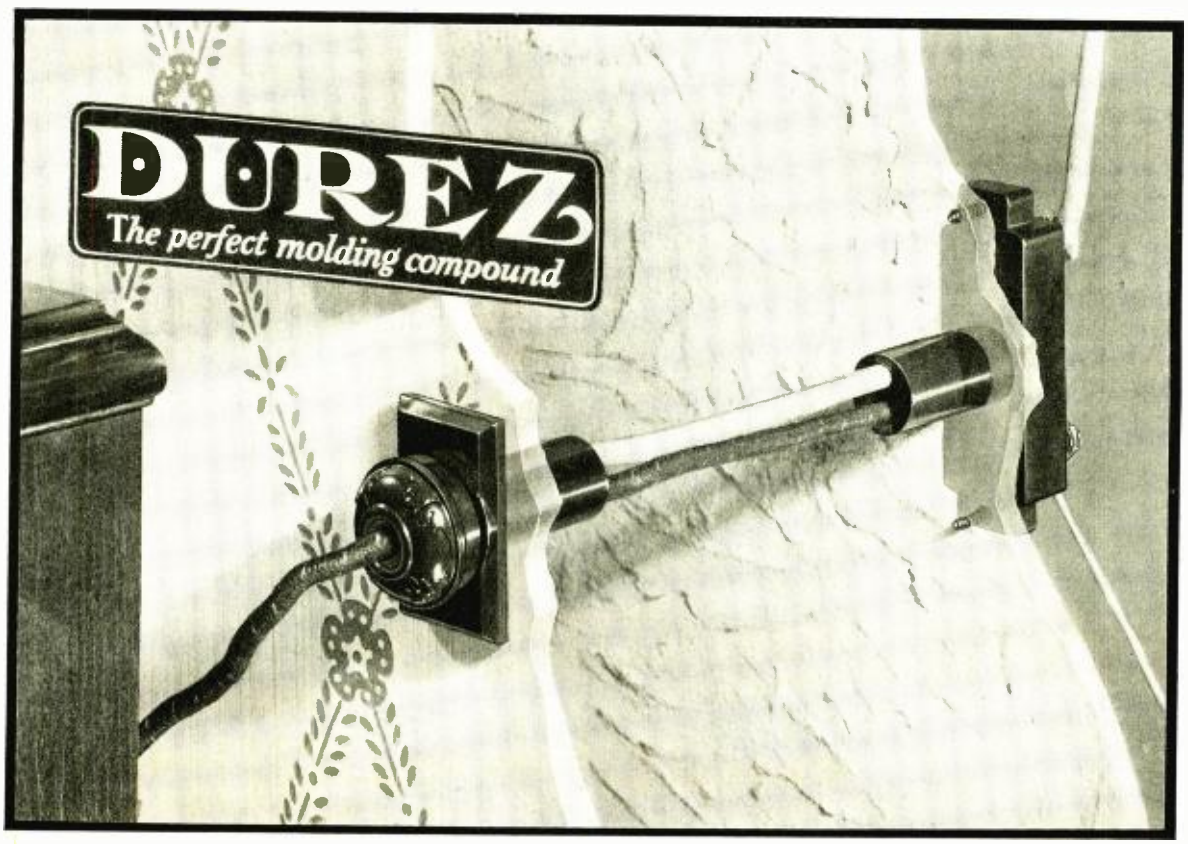
People who "do it with Durez"

The list of Durez users in the radio and allied industries alone reads like a "Who's Who" of business. Stewart-Warner, Delco, Turner Timer, Wagner Motor, Ford, Westinghouse, Telechron, USL Battery, Claude Neon—these are only a handful of hundreds of nationally known manufacturers who find Durez ideally suited to their needs.

These concerns use Durez because it makes a product that will not chip, rust, or corrode—that is molded in one operation without rubbing, stamping, turning, or polishing—that does all these things quickly and inexpensively! . . . Durez molded parts are strong, light, firm. Studs and inserts can be imbedded in the one molding process. Threads are molded in under closest commercial limits of accuracy.

What are you making that could be made better, more modern and perhaps at less cost, with Durez? We will be glad to show you how Durez fits into the plans of progressive manufacturers. We do not make the actual pieces, but supply raw material to molders who fill your order. Write for information and free booklet. General Plastics, Inc., 15 Walck Road, North Tonawanda, New York. Also New York, Chicago, San Francisco, and Los Angeles.

THE MAKERS OF DUREZ ARE ALSO THE MAKERS OF DUREZ INSULATING VARNISHES AND LAMINATED STOCK



RADIO ENGINEERING

Reg. U. S. Patent Office

Member, Audit Bureau of Circulations

Western Editor ULMER G. TURNER | *Editor* DONALD MCNICOL | *Managing Editor* F. WALEN

Vol. XII | JANUARY, 1932 | Number 1

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PLAIN TRUTH

WE never have seen and never expect to see times so bad that a manufacturer who makes the finest goods and sells them for the lowest price will fail to do a satisfactory business. The degree of his success must, of course, depend on the number of people who are informed as to the superior quality and low price of his product.

It certainly will be conceded that advertising is most effective when desire is least satisfied. It is difficult to interest a man in dinner after he has dined. Advertising is unquestionably being read with more avidity today than in years. It is making an even stronger impression and is exerting a more powerful influence on present or future sales than when people were buying everything they wanted, practically on impulse. From *The Wedge*, by Batten, Barton, Durstine & Osborn, Inc.

BRYAN S. DAVIS, *President*

JAS. A. WALKER, *Secretary*

Published Monthly by

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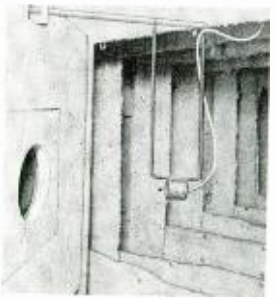
THE HAWLEY HALL OF FAME

These famous radio set and speaker manufacturers equip their speakers with Hawley Moulded Diaphragms

Magnavox
Utah
Stewart-Warner
Operadio
De Forest Radio Corp. of Canada
Lansing
Colonial
Northern Engraving
Jensen
Rola
American Bosch
Trans. Corp. of Am.
P. Smith Stamping
Oxford Radio Products
Best
Angsten
Quam-Nichols Co.
Majestic
Stromberg-Carlson
Crosley
Melber (Germany)
Sachenwerk (Germany)
Feldman (Germany)
Neufeldt & Kuhnke (Germany)
Platon Texido (Spain)

Such Overwhelming Preference *must be deserved!*

Accurate determination of magnetic and voice coil constants is a preliminary step toward improving speaker design.



Elaborate sound chambers are part of the Hawley laboratory equipment for obtaining accurate response curves on all types of diaphragms.

IS there a more convincing testimonial of manufacturing success in the radio and sound equipment industry than the Hawley "Hall of Fame"?

Such overwhelming preference for the Hawley Moulded Diaphragm must be deserved. The reason is found in the unparalleled perfection of the Hawley Diaphragm. Being moulded in one piece from mounting flange to apex, it achieves a new standard of performance which can never be equalled by the ordinary "pasted-up" diaphragm. The Hawley Process, plus Hawley Acoustical Engineering, is making an outstanding contribution to the production of better sound equipment.

Radio sets and speakers are easier to sell when equipped with Hawley Moulded Diaphragms because these diaphragms are engineered to fit the individual needs of each type of speaker unit. The famous radio set and speaker manufacturers, listed above, have standardized on Hawley Diaphragms to make sales easier for their dealers. Let us prove what Hawley Moulded Diaphragms can do to give your equipment a new sales advantage.

Hawley diaphragms are moulded in one piece from mounting ring to voice coil support. There are no strains in the diaphragm to cause distortion.

Hawley Diaphragms are made to any size or specification. Careful production tests assure perfect tone quality.

HAWLEY
MOULDED DIAPHRAGMS

PRODUCTS AND PROCESSES FULLY COVERED BY PATENTS AND APPLICATIONS

HAWLEY PRODUCTS COMPANY, 201 N. FIRST AVENUE, ST. CHARLES, ILLINOIS

Editorial

JANUARY, 1932

ELECTRICAL TRANSCRIPTIONS

NO longer ago than two years, for broadcasting purposes "canned" music was not only being severely criticized by the enlightened public but was in bad standing with the Federal Radio Commission.

In the intervening months canned music, under the new designation of electrical transcriptions, has outlived the handicap of an unpromising beginning and today in performance closely rivals the best of original presentation.

Any person not a carping critic who in recent weeks has heard from WOR and associated stations the broadcasts of the Gold Seal Orchestra under the direction of Henry Hadley, cannot in fairness find fault with the operatic orchestrations and vocal choruses sent out from record transcriptions.

Nothing could better register the advances made in the sound laboratories and studios during the past two years than the evident improvement in fidelity, and freedom from unwanted sounds of these recordings.

What may be said on the score of a lessened employment of orchestras for original presentations may be offset by the claim that the demand for high grade professional orchestras will improve, even though there be a decreasing need for the small, second rate aggregations.

▲

DUMPING COMMUNICATION

MUCH of the present economic disturbance in our country has been charged to "dumping" manufactured products. As the current sales curve dipped and continued downward, manufacturers sought to arrest the decline in their individual gross receipts by flooding the market with goods at prices leaving little or no profit. The demoralization and sales stagnation that later followed is history.

With reference to communication—in this instance commercial telegraph service—the major telephone interests have recently launched a national campaign designed to provide the public with additional telegraph facilities, using telephone company wires.

It will cost a lot of money to establish the new service: the two large telegraph companies, already competing, have had to follow suit and incur large added expense in setting up new facilities.

At a time when telegraph earnings are so low that the Postal Telegraph Company's $1,000 bonds may be bought for $300 and when Western Union is selling below fifty dollars per share, and when, as is reported, twenty per cent of the telegraph companies' present facilities are idle due to reduced traffic, would not seem a good time to put these companies to large added expense. Of course, if due to new facilities, gross telegraph traffic can be increased in volume, and at profitable tolls for all three companies, then the changes will have been justified—but not, otherwise.

With reference to the joint competition of Western Union and Postal Telegraph with the telephone company, for telegraph message traffic, a Postal statement reads: "The telegraph needs of this country have been served over 75 years by the telegraph companies in the United States and they will continue to serve the telegraph needs with the most efficient progressive telegraph service in the world."

▲

A DECADE OF THE TUBE

IT is just ten years since H. J. van der Bijl's work on the thermionic tube was published. It is a tribute to the thoroughness of treatment of the tube in this book that the work has continued as a dependable guide to students of the three electrode tube during the past decade. In this work the mathematical treatment was in the main based on the characteristic equation

$$Ip = \alpha\left(\frac{Ep}{\mu} + Eg + \varepsilon\right)^2.$$

There is now, however, a widely sensed need for a new, up-to-the-minute technical work dealing with the modern multi-element tubes, and tubes having controllable characteristics, as well as those of special design and for special purposes.

Who will be the first qualified engineer writer to undertake the task?

Donald McNicol

Editor

On the Pilot assembly line they speedily run in Self-tapping Screws with pneumatic and electric screw drivers.

"Pilot Radio", too, uses the most Economical and Secure method of assembly

. . . adopted Self-tapping Screws right from start of receiver production

In selecting Self-tapping Screws for fastening parts to the chassis of "Pilot Broadcast and Short-Wave Equipment", the company's engineers followed a proven way to assembly efficiency.

That no other means of fastening offers equal assembly speed, economy and security has been convincingly demonstrated in the production of most well-known sets.

Compare Self-tapping Screws with other means of making fastenings! When you join sheet metal or make a fastening to sheet metal with these unique Screws you do no tapping . . . you have no tap plates to weld fast . . . there are no nuts to fumble. One *simple operation makes a secure fastening* and no special equipment or skill is required.

Fastenings made with Self-tapping Screws are *better*, too. Unbiased tests prove that these Screws hold better under tension, shear and vibration than either machine screws and nuts, or machine screws in tapped holes.

Whether you produce ten or ten thousand sets a year it will pay to investigate Self-tapping Screws. Economies do not depend on large production. When you send the coupon for full information . . . submit a description of one or more of your fastening jobs. Our Assembly Engineers will study them, and report whether you can use Self-tapping Screws to advantage.

Type "Z" Hardened Self-tapping Sheet Metal Screws
For joining and making fastenings to sheet metal up to six gauge; also aluminum, die castings, Bakelite, etc. Simply turn Screw into drilled, pierced or molded hale. It forms a thread in the material as it is turned in. Can be removed and replaced.

Type "U" Hardened Metallic Drive Screws
This type of Self-tapping Screw is used for making permanent fastenings to iron, brass and aluminum castings, steel, Bakelite, Durez, etc. Just hammer the Screw into a drilled ar molded hole. It forms a thread in the material as it is driven.

PARKER-KALON *Hardened* Self-tapping Screws

PAT. IN U. S. AND FOREIGN COUNTRIES

← **14 Unbiased Reports on Savings**.....**Scientists Explain Fastening Security** →

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

Tell us whether Self-tapping Screws can be used to advantage for assemblies described an attached sheet. Also send booklets on the Security and Economy af assemblies made with Self-tapping Screws.

Name and Co.----------

Address----------

A chronological history of electrical communication —telegraph, telephone and radio

▲

This history, beginning in the January, 1932, issue of RADIO ENGINEERING, will be continued in successive monthly issues throughout the year. The history is authoritative and will record all important dates, discoveries, inventions, necrology and statistics, with numerous contemporary chronological tie-in references to events in associated scientific developments. The entries will be carried along to our times.

▼

Part I

B.C.

2000 (1) Amber used as an ornament by the Phoenicians.

600 (2) Thales, father of Grecian geography, astronomy and philosophy, attributes the attractive properties of amber and lodestone to a "soul," or "spirit" dwelling within these substances.

429 (3) Plato describes the "Rings of Samothrace," (Magnetized iron filings).

287 (4) Theophrastus, who died in this year, recorded definite information relative to the attractive properties of amber and lodestone.

52 (5) Lucretius, of Rome, makes reference to the fact that the lodestone attracts iron filings.

A.D.

1269 (6) Peregrinus describes a practical mariners' compass.

1575 (7) Robert Norman, a compass maker of London, discovers the magnetic dip of the compass needle.

1600 (8) William Gilbert, in England, publishes his work "De Magnete."

1603 (9) William Gilbert dies.

1614 (10) Logarithms discovered by John Napier.

1620 (11) Edmund Gunter, in England, introduces the logarithmic scale, or slide rule.

1629 (12) Cabeo, an Italian Jesuit, describes and illustrates the polar arrangement of iron filings when subjected to magnetic attraction.

1646 (13) Word "electricity" first used—appearing in Sir Richard Browne's "Pseudodoxio Epedemica."

1655 (14) Otto Von Guericke, of Magdeburg, observes the transference of electrical action through a conductor, or semi-conductor.

1662 (15) Royal Society of England organized.

1672 (16) Von Guericke constructs a frictional electric machine.

1675 (17) Boyle, in England, amplifies experiments begun by Gilbert.

1676 (18) Roemer, observing eclipses of Jupiter's satellites, determines the velocity of light.

(19) Sir Isaac Newton, in England, constructs a practical glass-plate electrical machine.

1685 (20) Newton announces the laws of gravitation.

1686 (21) Otto Von Guericke dies. (Born Germany 1602.)

1691 (22) Robert Boyle dies. (Born in England 1627.)

1705 (23) Francis Hawksbee, in England, observes the resemblance between the electric spark and lightning.

1726 (24) Wood, in England, discovers that electricity can be conveyed through a long metallic conductor.

1728 (25) Stephen Gray distinguishes between conductors and insulators.

1733 (26) M. Dufay, in France, distinguishes between "vitreous" and "resinous" electricity.

1739 (27) Dufay dies. (Born in France 1698.)

1740 (28) Desaguliers defines certain laws of conductors and insulators.

1745 (29) Dean Von Kleist (October 11) exhibits a Leyden jar, the first form of electric condenser. Others identified with the discovery were Scheffner, Cunens and Muschenbroek.

1746 (30) Winkler discharges a Leyden jar through a long wire.

(31) Benjamin Franklin (July) attends a lecture on electricity, delivered in Boston by Dr. Spence, a Scotchman.

1747 (32) Dr. Watson, in England, transmits electrical impulses over a circuit two miles in length.

1748 (33) Franklin experiments with a circuit across the Schuylkill river at a point near Philadelphia.

1749 (34) Franklin identifies electricity and lightning as having common characteristics.

1750 (35) William Watson announces the discovery of platinum.

1752 (36) Franklin proves the identity of electricity produced by a frictional generator of electricity, and lightning.

(37) By means of a kite raised high in the air Franklin presents a path to earth for lightning discharges.

1753 (38) Charles Marshall, of Scotland, (February 1) sends to *The Scot's Magazine* a communication proposing the use of frictional electricity and a conducting wire as a means of transmitting intelligence.

1756 (39) De Romas, in France, repeats Franklin's experiments employing as a conducting medium for the discharges a thin wire interwoven with the anchoring string attached to the elevated kite.

1769 (40) Volta's first work on electricity published.

(41) James Watt, in England, secures a patent covering the invention of a steam engine.

1774 (42) Le Sage, of Geneva, Switzerland, employing a frictional generator, twenty-four conducting wires, and a pith-ball electroscope, transmits signals over short distances.

1775 (43) Volta, in Italy, announces the invention of the Electrophorous.

1777 (44) Coulomb, in France, invents the torsion balance.

1783 (45) Vincenti Lunardi (September) makes a balloon ascension in London.

(46) French balloonists cross the English Channel.

1785 (47) Coulomb establishes the fact that electrical action—attraction and repulsion—vary inversely as the square of the distance.

(48) Van Marum notes the peculiar smell which results from electric discharge (ozone).

1786 (49) Galvani, in Italy, discovers the twitching of a frog's legs when subjected to the action of an electric current.

1787 (50) Lomond, in France, transmits signals over a brass conducting wire, using a pith-ball electroscope as a receiver.

(51) William Watson dies. (Born in England 1715.)

1789 (52) Symington, in England, propels a boat by means of steam power.

1790 (53) Benjamin Franklin dies. (Born in United States 1706.)

1791 (54) Galvani publishes an account of his electrical experiments.

1792 (55) Volta makes extensive experiments following Galvani's discoveries in electricity.

1793 (56) Claude Chappe, in France, using static electricity for the purpose transmits signals between Paris and Lille.

1794 (57) M. Reiser, at Geneva, Switzerland, arranges a telegraph line employing thirty-six insulated wires—a wire for each character. At the receiving end, the characters being formed out of tin-foil strips, the signals being read as sparks pass between the strips of each letter, as selected at the transmitting end.

1795 (58) Tiberius Caballo, in England, transmits signals over a wire 250 feet long by means of Leyden jar discharges. Sparks sent at different intervals represent letters of the alphabet.

(To be continued)

SHAKEPROOF

Stronger than the bolt itself!

THE Shakeproof Lock Washer is far from being just an ordinary washer. It is a real engineering achievement—designed to hold any nut or screw absolutely tight. The patented twisted teeth are pitched at the exact angle that assures greatest efficiency. The number of the teeth required on each washer is accurately determined by exhaustive tests. The thickness of the material to be used is based on careful experiments to make certain that no failures can occur.

This scientific research has resulted in a Lock Washer that is actually stronger than the bolt itself. The spring developed in the twisted teeth is capable of supporting loads which would overcome the elastic limits of the bolt. This means that you can always depend on Shakeproof to give your product complete protection. Be sure to mail the coupon below for trial samples, today!

U. S. Patents:
1,419,564
1,604,122
1,697,954
1,782,387
Other patents pending.
Foreign patents.

SHAKEPROOF
Lock Washer Company
(Division of Illinois Tool Works)
2509 N. Keeler Ave. Chicago, Ill.

"It's the Twisted Teeth that LOCK"

Shakeproof representatives are located in the following cities

New York City Philadelphia Boston Pittsburgh Schenectady Cleveland
Detroit Toledo Cincinnati Birmingham, Ala. Dallas, Texas Milwaukee
Los Angeles Seattle San Francisco Toronto, Ontario, Canada

COUPON

Gentlemen: We want to test your Shakeproof Lock Washers. Kindly send us samples as indicated.

Type..... Size.....
Type..... Size.....
Firm Name.....
Address.....
City..... *State*.....
By..... *Title*.....

Announcing

THE SIXTH ANNUAL

RMA TRADE SHOW

AND 8TH ANNUAL CONVENTION

MAY 23-26, 1932

CHICAGO

THE ONLY OFFICIAL R M A TRADE SHOW—
RADIO'S BIG ANNUAL CONCLAVE

Held by and for the Industry—Advanced to May, for Early Trade

NOTE—The May, 1932, Trade Show is the only Radio Show sponsored by the RMA and under its management, for RMA members, Jobbers and Dealers.

IMPORTANT

Radio sales will be helped greatly by the 1932 Presidential Election Campaign!

The Republican and National Conventions are planned next June. Therefore, the annual "JUNE" trade show and Convention of the R. M. A. is being advanced to the week of *May 23rd, 1932*—for the Radio Industry to start early, before the Presidential nominating Conventions and Campaign.

Everybody in Radio will be at Chicago during the week of May 23rd.

This is the Radio Industry's own and largest annual meeting! Thirty thousand (30,000) square feet of Radio Exhibits in the Stevens Hotel. Public not admitted. For the trade only.

All Exhibitors *required* to show current merchandise —no vacant booths.

Twenty thousand (20,000) radio manufacturers, jobbers and dealers to attend.

STEVENS HOTEL

Reduced railroad rates—Special trains.

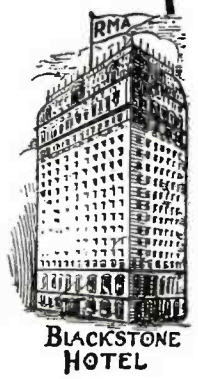
Official Hotels—Stevens Hotels and The Blackstone —together on Michigan Avenue.

Joint meetings—Radio Wholesalers Association, National Federation of Radio Associations and other industrial organizations.

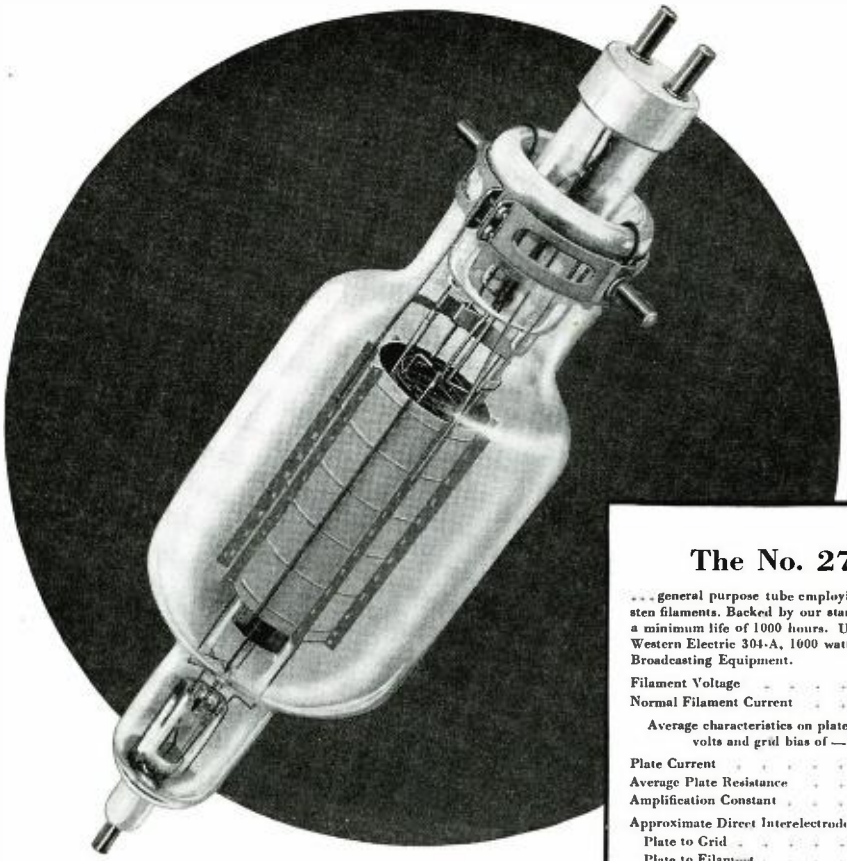
Invitation credentials for the Trade Show will be mailed about April 15th, 1932. *REMEMBER THE DATE—MAY 23rd—AT CHICAGO!*

RADIO MANUFACTURERS ASSOCIATION

11-W. 42ND ST. N.Y. CITY 32 W. RANDOLPH ST. CHICAGO



BLACKSTONE HOTEL



The LARGEST radiation-cooled tube made!

The No. 279-A

. . . general purpose tube employing thoriated tungsten filaments. Backed by our standard guarantee of a minimum life of 1000 hours. Used normally with Western Electric 304-A, 1000 watt Radio Telephone Broadcasting Equipment.

Filament Voltage	10 volts
Normal Filament Current	21 amperes
Average characteristics on plate voltage of 3000 volts and grid bias of —200 volts	
Plate Current	350 amperes
Average Plate Resistance	1800 ohms
Amplification Constant	10
Approximate Direct Interelectrode Capacities	
Plate to Grid	17.9 mmf.
Plate to Filament	7.9 "
Grid to Filament	15.4 "
Maximum Operating Plate Voltage	3000 volts
Negative Grid Bias for above Plate Voltage	275 volts
Continuous Plate Dissipation	1000 watts
Peak Plate Dissipation	1200 watts
Maximum Overall Length	21 11/16 ins.
Diameter of Bulb	6 ins.

The Western Electric 279-A—largest radiation-cooled tube on the market—is just one more proof of Western Electric leadership in sound transmission equipment. Uniform characteristics, sturdiness and long life are built into all Western Electric tubes—from the peanut tube to the giant water-cooled power-tube. That's why leading broadcasting stations use Western Electric tubes exclusively! Make Western Electric electronic equipment your standard.

GRAYBAR ELECTRIC CO. R.E.-1-32
Graybar Building, New York, N. Y.
Gentlemen: I would like information on the following electronic equipment: .....
.....
.....
Tubes I am now using are: .....
.....
NAME .....
ADDRESS .....
CITY ..... STATE .....

Western Electric
ELECTRONIC EQUIPMENT
Distributed by GRAYBAR *Electric Company*

RADIO ENGINEERING

Production, Administration, Engineering, Servicing

JANUARY, 1932

Continuous, instantaneous radio signaling system for police cars

By JOHN DUNSHEATH

IN an eastern state, in one month recently, forty-six robberies of gasoline filling stations occurred. In only one of these cases was an arrest made. The state concerned has only a printing telegraph system of inter-station police signaling. How different is the situation in Detroit, Mich., as reflected by the following entry in the police blotter:

"December 29. No. 55 scout car. 8:30 p. m. Patrolman Glenn Averill and Patrolman Leon Risher, driving on East Jefferson, saw man running east on Jefferson and at the same time received radio call that Standard Oil Company filling station at Meadowbrook and Jefferson had just been held up. Averill and Risher chased fleeing man, placed him under arrest, and took him to the gas station where he was identified by the attendant as the stick-up man. Money taken was found on the man."

Police protection is effective when policemen are spread out over the area in their charge. Policemen provided with automobiles can travel quickly from point to point. Policemen in automobiles which are equipped with radio receivers have their availability for crime detection and crime prevention multiplied many times.

Police radio systems have gained widespread popularity because of the success attained by cities using them. New records of the Federal Radio Commission made available recently disclose that in approximately 70 cities such services now are being maintained, while another 10 cities have construction permits to install such services, and that more than a score such applications are pending.

The systems usually constitute one or more transmitters strategically located at police headquarters within particular cities. Police automobile cruisers, equipped with receiving sets, and carrying usually a crew of patrolmen, are assigned particular "beats" within each city. These cars as a rule are equipped with sawed-off shotguns, tear gas bombs, machine guns, and other light arms. When a report of a crime is received at police headquarters, the word is flashed over the radio, and the patrol car closest to the scene speeds to it with all possible dispatch. In many instances the culprits have been apprehended before they leave the premises.

Because of the great demand for police radio service, the Commission has set aside eight channels in the continental band for allocation to police departments. The assignments and power have been so staggered as to accommodate every city and town in the country with such service. Filing of an application by a municipality for such a service means practically automatic approval, provided the equipment is of such a character as not to cause interference.

Fig. 1. Radio transmitter and microphone at police headquarters.

Michigan State Police Radio

Capture of 197 police fugitives, recovery of 1,498 stolen automobiles with a value close to a million dollars, and the locating of 160 missing persons are credited to the Michigan State police radio installation during the first year of its operation which ended in October. These figures do not include those for the Detroit police system which operates independently.

Starting with six radio-equipped cars, the system has been expanded during the year until at present there are 65 cars on the state highways 24 hours a day, each equipped with the Sparton set that has been adopted. Every sheriff's office in the state is likewise equipped, thus extending cooperation to local authorities.

Of the 5,482 messages broadcast from the State police station at Lansing, Mich., 611 directed cruisers to the scene of crimes and accidents. The high efficiency of the service may be judged from the fact that this number of calls resulted in the following arrests:

Breaking and entering, 13; escaped prisoners, 26; kidnappings, 8; chicken thefts, 3; larceny, 20; murders, 5, and robbery armed, 41. This number included emergency calls only. Additional messages regarding wanted men and previous crime brought the total number of arrests up to 521.

Commenting on the results of the first year and what is expected in the fu-

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One of the most useful and efficient applications of radiophone signaling is that now being extended in police service. For this work mobile radio has no near competitor.

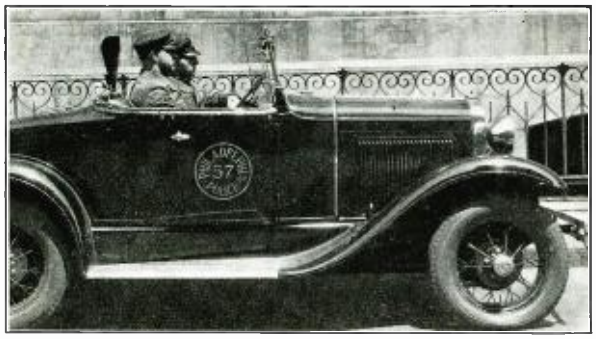

Fig. 2. Cruising police car in continuous touch with headquarters by radio (Philadelphia, Pa.)

ture, Oscar G. Olander, Commissioner, gave out the following statement:

"When the station first was opened, it was more in the nature of an experiment. We were not adequately prepared to obtain fullest results from this new weapon. We started with receivers in only a half dozen cars. Today, there are 65 radio-equipped cruisers on the highways night and day, and every sheriff in the lower peninsula has a receiver in his headquarters in order that he may join at once in all state-wide man hunts.

"This first year has proven the value of this new implement in war on crime. It has brought about the arrest of bank robbers, armed bandits, kidnappers, murderers and other criminals within a few hours after their description had been broadcast."

This highly modernized crime-fighting signaling service carries a powerful challenge to gangland. When the opening of the international convention of police chiefs recently established St. Petersburg, Florida, as the temporary police headquarters of the world, one of these radio cars was the principal center of attraction. Law-enforcement officers who examined the cruiser were impressed by the unusual completeness of its equipment for successfully combating the operations of criminals.

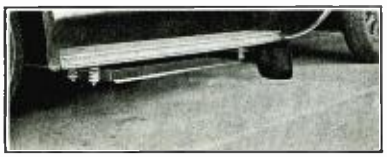

Fig. 3. Police car with receiving antenna underneath runningboard.

On the right front fender is a specially designed Perfection stop light, which enables the cruiser's pilot to spotlight the occupants of a suspicious looking car, while affording the police officers the protection of darkness. When this light flashes on, the words "stop-police" on the lens serve both as an official warning and a means of identification.

Most conspicuous among the car's offensive armament is a Thompson machine gun, a highly efficient weapon when serious trouble starts. In addition the cruiser carries a 12-gauge Winchester riot gun, a 30-36 Remington rifle, tear gas bombs, Federal hand grenades, danger flares, Pyrene fire extinguisher and a first aid kit. A Perfection bullet-proof shutter protects the radiator against the volleys from hostile guns, and non-shatter glass is used throughout.

Radio Has Proved Its Worth in the War on Crime

Police chiefs of the United States agree that radio is of the utmost usefulness in battling crime, and their statements are of special significance in view of the petition of Commissioner E. P. Mulrooney for the installation of a short-wave system to cope with gangsters in New York.

What Police Chiefs Say

"RESULTS OUR EXPERIENCE IN USE OF POLICE RADIO VERY SATISFACTORY. HAVE FORTY-THREE CARS EQUIPPED INCLUDING SIX COUNTY SHERIFFS CARS ARRESTS DIRECTLY DUE RADIO EQUIPPED POLICE CARS FIRST SIX MONTHS TO JUNE THIRTIETH TOTAL TWO THOUSAND TWO HUNDRED SIXTY. AMONG THEM ELEVEN MURDERERS, ASSAULT WITH INTENT TO KILL TWO HUNDRED FORTY-FIVE, DRUNKEN DRIVERS ONE HUNDRED FORTY-FOUR, AND ONE HUNDRED TWENTY-SIX BURGLARIES, EIGHTY-SIX ROBBERIES, THIRTY-SIX HIT AND RUN DRIVERS, THIRTY-FIVE PROWLERS. FIRST LONG CHASE AND TWO OFFICERS KILLED IN LONG CHASE (REFERRING TO THE RECENT NEW YORK MURDER OF OFFICERS) LIKELY WOULD HAVE BEEN ELIMINATED IN THAT OUTLYING RADIO CARS COULD BE DISPATCHED TO HEAD BANDITS OFF. ALL CARS COULD BE NOTIFIED INSTANTLY.

"MICHAEL. F. MORRISSEY, CHIEF POLICE, INDIANAPOLIS, IND."

"OUR EXPERIENCE HAS PROVEN THAT POLICE RADIO

Fig. 4. Radio equipped automobile of type employed by Michigan State police.

IS ESSENTIAL TO THE PROPER FUNCTIONING OF THE MODERN POLICE DEPARTMENT IN VIEW OF THE PRESENT DAY METHODS EMPLOYED BY CRIMINALS WE ARE NOW TRIPLING THE NUMBER OF RADIO CRUISERS.

"GEO. J. MATOWITZ, CHIEF POLICE, CLEVELAND, OHIO."

"WE FIND THE SHORT WAVE RADIO IN POLICE WORK INDISPENSIBLE IN THIS CITY.

"L. M. CISEGFRIED, CHIEF OF POLICE, KANSAS CITY, MO."

Eavesdropping

It is stated that officials of the government are aiding the police in the study of methods whereby eavesdrop-

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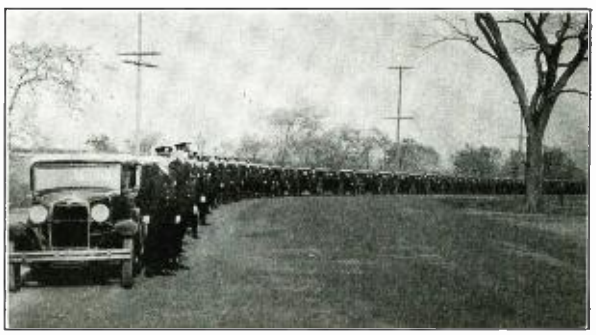

Fig. 5. 103 automobiles recently purchased by Detroit, Mich., police department, thirty of them equipped with radio receivers.

The design and acoustics of broadcast studios

By SYLVANUS J. EBERT*

Interiors of modern broadcast station studios must be designed with a view to undistorted transmission and exclusion of undesired sounds

THE design and acoustical problems encountered in the construction of the present-day radio studio differ from the conditions first met in the early days of broadcasting.

The first factor to be given reflection is the location of the building in which the studio, or studios, are to be constructed. It is desirable to have it on a well-known street and accessible to the performers. The space chosen for the studios should be free of metal columns, and structural supports. When the studios are to be erected in a building under construction the plans of the structure can be modified to fit the specifications of the room dimensions. If a finished building is to be occupied it is advisable to choose a space for the studios in the upper portion of the building, preferably the top floor.

It should be emphasized that the studios may be built in any desired part of a building and may give excellent results if constructional expense is not a factor. The size and number of studios needed should be determined from the standpoint of economical and efficient handling of all types of programs, and with the intention of minimizing the delay between them. For this reason, it is necessary to have at least two studios, so that while one studio is being used for actual broadcast purposes, the artists who are to appear next on the program may prepare themselves in the second studio. The actual dimensions of the rooms should follow closely the ratio 2-3-5 for height. width, and length, respectively, for best acoustical considerations. There is no shape which will make the acoustics of a room, but a bad shape can easily ruin it. Curves should be avoided because of their tendency to distribute the sound unevenly. It has been found from experience that rectangular-shaped rooms have the most desirable proportions.

An adherence to the room-ratio formula given, will assure good acoustical as well as aesthetic conditions in the completed studio if we remember that the length of the studio should not be more than twice the width, and that the ceiling height be not less than one-third the short floor dimensions.

Room Construction

We have briefly considered the dimensions, size and location of studios, but far greater consideration must be given the subject of room construction, sound proofing, and acoustics. A studio to be satisfactory for broadcast purposes must be entirely sound-proof. An understanding of how sound is transmitted by walls and floors will give a picture of the complexity of the problem of entirely insulating a studio. There are a variety of paths by which interfering sound may enter or leave a studio; briefly they are: by air transmission, by diaphragm action, and by structural transmission. To prevent the entry or exit of sound by air transmission it is necessary to have absolutely no openings in the studio, such as door key-holes, cracks around the doors and windows, etc. Transoms and air vents should be lined with sound absorbing material to damp the vibrations of the metal, and prevent ventilating blower and studio sounds from passing through them for any distance. Sound absorbing baffles should be installed in both the supply and exhaust ends of the ventilation ducts. Where possible each room should be equipped with a separate duct, and with an individual temperature and ventilation control, which is important since large groups of artists greatly affect the temperature and humidity of the studio. It must be remembered that the most elaborate schemes for the sound-proofing of a studio may be entirely defeated by failing to obstruct a few aerial paths, and in particular by not properly sound-proofing the ventilation system.

The transmission through walls and partitions of sound arriving through the air may take place in two ways. First, the sound may set the walls or partition as a whole to vibrating, like a diaphragm, and so create sound-waves on the opposite side; secondly, the sound may be absorbed by the wall material and then by condensation and rarefaction work its way from particle to particle until finally it is communicated to the air on the opposite side. In most cases the greater part of the sound transmitted by a wall is by diaphragm-like action, the effect being most pronounced for studios with thin walls and resonant periods, as the gap between the source of the sound and the material generally is too great for true acoustical conduction through the material itself.

It should be borne in mind that a room which is acoustically correct and absorbs all sound is not necessarily sound-proof, but may be delivering the sound to an adjoining room or hallway. To prevent such a phenomenon the room should have walls sufficiently massive and rigid to be practically immune to vibration, and should be built as a room within a room, the inner one mechanically insulated against vibration from the outer, and the outer, of course, supported on the steel structure. The only contacts between the inner room and the structure should be resilient so that any vibration in it is not transmitted to the rest of the building. The most effective method is to have the inner walls and ceiling suspended by metal spring clips. When the inner wall vibrates the springs absorb the vibration and it is not carried into the building structure. This system, when properly applied, takes care of diaphragmatic action as well as sounds caused by actual impact. Nails or screws should never pass from the in-

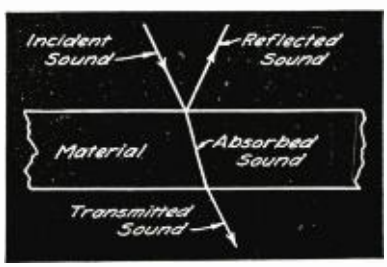

Fig. 1. Reflection. absorption and transmission of sound.

*Radio engineer WSUI, State University of Iowa; graduate N. R. I.

ner wall to the outer, and in cases where connection cannot conveniently be avoided, full use should be made of insulating bushings and washers. Where springs are not used to isolate the inner and outer walls, studs can be used with strips of felt or other insulation at both ends. In no case should the connections between walls be rigid. A similar system of sound-proofing should be installed in the floor. Where steel spring clips are used they should support the wooden sleepers; the floor then laid upon the sleepers. The space between the main floor foundation and the top of the wooden sleepers can be filled with light sound-absorbing material. An alternative floor arrangement would be to float the sleepers upon several layers of sheet-felt or other insulation and then isolate the inner floor from the sleepers in like manner, the space between floors being filled with slag wool or slag-bestos.

Walls

The external or main walls of the studios are usually made of terra-cotta, brick, sheet iron, lead, or hard material which is not vibrant. The ceilings are treated the same as the walls. Where the recommended spring clips are used they should be fastened to the main ceiling and uphold metal lath to which is fastened rough plaster. The plaster is covered with another acoustical plaster or inner studio acoustic treatment. The space between the main ceiling and the floating ceiling is filled with absorbing material, such as hair-felt or slag-wool. This latter material is also applied to the area between the floating wall and the structural wall. It is frequently found that the described ceiling arrangement is too elaborate and a simpler one is desired. In the latter case, slag-wool slabs may be nailed to the underside of the ceiling joists, and

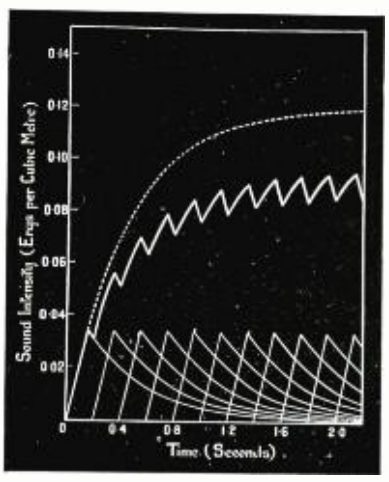

Fig. 2. Reflection curve for syllable speech in a room of low absorption power (Echhardt)

the ordinary lath and plaster ceiling applied to fillets of wood nailed through the insulation to the joists to receive it. Fibrous plaster slabs may be used instead of the lath and plaster ceiling. Hair-felt, celotex, or fibre board should be applied to the area between the two ceilings as in the first arrangement. It has been found that using layers of different absorbent material increases the effectiveness and the overall absorption coefficient of the materials. Under no circumstance should the nails pass through all the layers of absorbing material, but each layer should be fastened only to the one above it.

Doors and windows should be constructed on the same principle as the walls, namely have a floating and a rigid partition. Both should fit perfectly and be practically air-tight when closed. Most of the doors in use are painstakingly constructed and use special hardware fixtures to assure tight closure. Windows should have a pane of glass in the main structural partition and one in the floating partition. Rigid contact between the glass panes must be avoided and the panes set in a felt-like material. In the new National Broadcasting Company studios in Chicago the windows consist of three pieces of glass of varying thicknesses, one built in the main partition and the other two in their respective floating partitions. Using glass panes of different thicknesses increases the attenuation and entirely eliminates any trouble which could arise from the natural period of vibration of the individual panes.

The third class of sounds which may be considered in the construction of a studio is that of structure-borne. Whether arising from motors, machinery attached to the main steel work of the building, musical instruments in contact with floors or steel work, or outside noise imparting vibrations to the steel work of the building, it is necessary to break up the continuity of the structure for effective insulation. Constructing the studios in the form of a room within a room helps immensely. However, the simplest place to break up the continuity is at the source. Motors and machinery, whether on spring supports or otherwise, should be insulated from the floor by substantial layers of materials, such as cork, felt, or rubber. Very heavy machinery should be specially insulated and placed on a separate foundation. In extreme cases laminated combinations of felt and cork can be inbedded in cement floors before hardening commences, as a bedding for foundations and columns. Insulating material can also be employed between columns, girders, cross-beams, etc., to counteract the transmission of sound and break up the continuity.

Ventilating ducts should be insulated from the walls and, if necessary, from the ventilating fans by means of a length of flexible tubing. Metal piping, such as conduit, should not enter the studio from the outside. Where such entry cannot be avoided it is desirable to set the pipes in some insulating material within the wall cavities so that vibrations cannot easily be communicated to the walls from the pipes, or to the pipes from the walls. Electrical wiring for studio lighting should be brought from the external wall to the inner floating partition by means of flexible shielded leads. Studio lighting should come from overhead and be of sufficient strength to enable the artists to read fine print with ease. Wall plugs should be located at convenient places in the studio and means provided for supplying power to instruments consuming greater wattage than the ordinary studio lighting circuits will safely carry. Wall lights add greatly to the beauty of a studio and can be installed where desired. The fixtures should be made of heavy material immune to vibration and without natural periods of vibration within the audible range.

It is sometimes desirable to place the associate studio control rooms, such as monitor booths, observation rooms, reception rooms, and main control rooms around the studios so as to isolate the latter more completely from external noises. Program producing studios should not be immediately adjacent to each other and all neighboring rooms connected with the broadcast station should be acoustically treated. Constructing a vestibule in front of each studio entrance helps greatly in preventing sound entering through the studio door while passing "in and out" during a program. The vestibule should be designed to have a sound absorption coefficient as high as possible.

Sounds Inside Studio

We have briefly discussed the construction and design of the studio structure proper, but of equal importance is the action of sound inside of the studio itself and the proper usage of the absorbing material for optimum microphone pickup. Sound generated in a studio proceeds outwards in spherical waves from the source to the walls where it is reflected, absorbed, and transmitted as shown in Fig. 1.

The reflected sound then proceeds to a second wall where it is again reflected, absorbed and transmitted, and so on, until its energy is all absorbed or transmitted. These phenomena which occur when speech or music are produced in the studio, and which consist of wave-trains of definite lengths, which overlap in a certain prescribed way, must be reproduced at the ear of the listener or picked up by the microphone in

the original sequence of transmission. Otherwise, a distorted and often very unsatisfactory version of the original composition is heard. When it is considered that sound travels about 1,100 feet a second, depending upon temperature, it may be seen that a studio of ordinary size is almost immediately filled with sound because of the many reflections. For instance, in a room 20 feet square, the number of reflections per second between opposite walls is 1,100 divided by 20 or approximately 55. The number is really greater than this since the sound that goes into the corners is reflected much more frequently than that out in the middle where the distance between walls is greater. This slow decadence of the sound to inaudibility after the original driving force is removed, is called the reverberation time. Reverberation time, or period of reverberation as it is also called, is dependent on the volume of the room, intensity and frequency of the emitted sound, and ability of the walls, floors, ceiling, and room furnishings to absorb sound. All absorbent material in a studio contributes to what is called its "total absorbing power." A square foot of perfect or 100 per cent absorption is referred to as a sound absorption unit. The standard or perfect unit is an open window as it absorbs all sound. If we take the measurement of each surface exposed to sound in the studio and multiply it by its absorption coefficient, then the sum of these coefficients will give the total absorption power of the studio.

Professor W. C. Sabine in 1900 published a formula for calculating the reverberation time of a room. As a result $T = \frac{.05\ (V)}{a}$ or reverberation time is equal to five hundredths of the room volume divided by the total absorption. Technically, this formula represents the time required for the sound intensity to be reduced 60 decibels per second because of absorption.

It might seem that the universal cure would be to provide sufficient dampening or absorbing power at the boundaries of the studio to eliminate all reverberation, but here psychological, or rather aesthetic considerations enter. It is a known fact that a short prolongation and blending of musical sounds is desirable. Speech, like music, consists of a fundamental frequency and various overtones, but unlike music should not be sustained for appreciable length of time. Figs. 2 and 3, show the growth and decay of sounds emitted in two rooms of the same size, but of different absorbing power. In both cases the sound was emitted at the rate of five syllables per second with a separation of one-hundredth second between syllables. The reverberation curve for syllabic speech in the room with low absorbing power, Fig. 2, indicates a piling-up of sound and a relatively small intensity change between syllables, which leads to indistinctness.

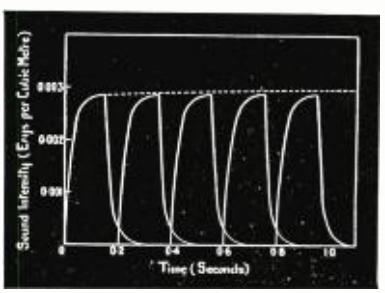

Fig. 3. Reverberation curve for syllable speech in a room of high absorption power. (Echhardt.)

In Fig. 3, the absorbing power is excessive, the reverberation period being one-third of a second. Articulation in the latter case would be extremely distinct, but as noted the intensity would be reduced. A studio with such non-reverberant conditions is rarely found in practice, and for sound other than speech would be entirely unsuitable.

A number of observers have made estimates of the preferred studio reverberation conditions for both music and speech and Fig. 4, with a few alterations, is the result of these investigations when plotted in the form of a curve. As all materials absorb a different amount of sound at different pitches the absorption of materials is considered at a certain standard pitch. The reverberation time is calculated at the same pitch or range of pitches if a curve is plotted.

The curve in Fig. 4, was plotted using a 1,000 cycle sound source. The reverberation time for 512 cycles, the standard calibration pitch one octave above middle C on the piano, is approximately 7.5 per cent greater than for 1,000 cycles. For instance, the optimum reverberation constant for a studio with a volume of 99,000 cubic feet (Fig. 4) is 1.1 second.

For the same studio actuated by a 512 cycle note the time is 1.183 seconds. As a rule it is impossible to decide on a definite optimum reverberation period for a studio as it may be varied much to suit the taste of the performing artist and listener. However, the times given will always give satisfactory results for rooms from which all kinds of programs are to be broadcast. Experiments conducted in studios located at the State University of Iowa have led to interesting results. Using an oscillograph with a special camera attachment, sensitive condenser microphone, and special amplifier, pictures were taken of the reverberation time of sounds in different studios. The oscillograph, a Westinghouse portable of the Duddell or electromagnetic type, capable of recording a true picture of waves and transients of frequencies up to 1,200 cycles and with a slightly less accuracy up to 10,000 cycles was operated into a photographic camera using Eastman super-speed, 35 mm., motion-picture film. Because the camera was turned by hand and varied the film speed slightly, a General Radio 377 low frequency oscillator was used to record a 1,000 cycle time line on the film. The oscillator accurate to within 20 cycles permitted an accurate estimate to be had of the reverberation time recorded on the film. Trouble was had at first in receiving sufficient amplitude for the recording of the sound waves picked up by the microphone without recording an accompanying a-c. ripple; later when special shielding precautions were taken the ripple was not noticeable at the operating amplitude of the amplifier.

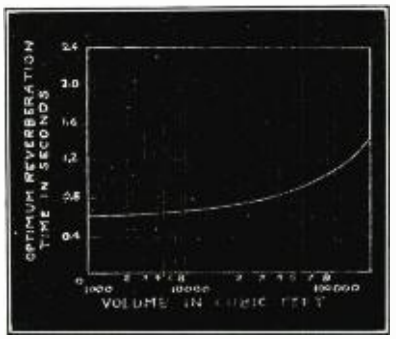

Fig. 4. Absorption coefficient versus volume curve for all-purpose studio.

In Fig. 5, a picture is shown of the reverberation time in a specially treated room satisfactory for speech only. The 1,000 cycle time line is seen above and the author's voice, used as the sound source, below. The sound emitted was "AH", and as noted from the picture is close to 1,000 cycles. The studio was built in the form of a box within a box, both partitions being composed of sheets of ¾ inch celotex. The studio has a high absorption factor as seen from Fig. 5, the reverberation time being .162 second, and serves the purpose for which it was intended, but it is far from sound-proof. This low reverberation period was possible because of the smallness of the room, it being only 100 feet square, and the high absorption power of the material in the interior. Fig. 6, is a record taken under identical conditions as Fig. 5, but with the studio door open.

It can be seen from the picture that part of the sound passed through the open door and was reflected from the hard cement walls outside and returned to reinforce the decaying sound in the studio. The reverberation time, however, is practically the same as with

the door closed. It has been mentioned that the studio was acoustically correct, but not soundproof, and Fig. 7, shows the sound which passed through the partitions and actuated a microphone located one foot from the outer wall.

The time necessary for the sound to decay to zero was shown to be .162 second inside of the studio and .027 second on the outside. In Fig. 8, we have a recording of a sound taken in a studio which has a reverberation time of .58 second. The inner and outer partitions were constructed of wooden lath and acoustic plaster, the inner being covered with one inch hair felt covered over-all with velvet drapery. In size this second studio greatly exceeded that of the first, being ten times as large, and having a volume of 10,000 cubic feet. Because of the length of the film used to record the entire reverberation period only the final .171 second of the total decay is shown. The character, frequency, and intensity of the sound used in these experiments were very closely related, in fact as close as possible, considering that the human voice was used as the sound source.

In each of the rooms the acoustical material was permanently installed and although other materials were introduced and placed in the studio to change the reverberation time the results were in proportion to the difference in the absorption coefficient of the added material. In modern broadcast studios, means are provided to vary the reverberation time as desired. Several of the new National Broadcast Studios in Chicago have folding panels on the walls permitting part of the wall treatment to be turned to the wall and exposing a less absorbing surface.

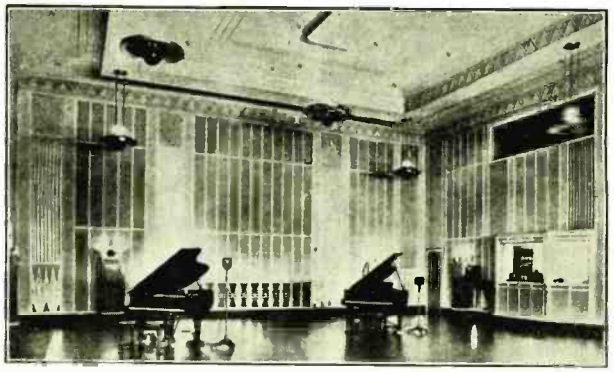

Fig. 9. Studio E, National Broadcasting Company, Chicago.

Fig. 9, shows the interior of studio E, of the National Broadcasting Company in Chicago. Where large orchestras and a variety of programs are broadcast from the same studio, the panels provide a desirable control of the reverberation time. The absorbent material used on the walls and ceiling of a studio may vary from acoustic plaster and tiles, to hair felt, celotex, balsam wool, flax-li-num, cork, or quilted material. The floors of the modern studios are made of wood and covered with a material such as compressed cork, special linoleum compositions, or other material which has the property of deadening the sound of footsteps, moving of chairs, etc. The older studio floors were covered with a thick carpet and for some reason or other it seemed an essential part of the room. However, it was unsanitary and in constant need of attention due to cigarette burns, loosening of edges, and opening of seams. Today, with the walls and ceilings properly treated and large parallel reflecting surfaces draped, the need of special floor covering no longer exists.

It has often been mentioned that sound dampening material should have the same absorption power for all the frequencies within the audible band, which is true; however, few, if any, materials have this property. Manufacturers of acoustic materials have found it advantageous to advertise their product by showing graphs of the absorption power of their material at the various frequencies of interest. This has been helpful to the ordinary layman and to the expert, but emphasis must be placed on the difficulty of receiving the desired results solely on the absorption curve basis, as the final results will invariably differ with each application. It has been found that most materials absorb less sound at the low and high frequencies than they do near the middle frequencies, which favors our viewpoint that an acoustical treatment be used that will reduce as little as possible the natural effective absorption of the studio walls. This may be more clearly understood if we mention that frequencies below 240 cycles are partly absorbed by transmission through the floating partition to the acoustic treatment or structural wall behind, also by impact against the floating wall causing it to actually move under the sound pressure. Both methods of absorption cause the lower sound frequencies to dissipate and change into heat. In supplementing these two methods, if we apply an acoustic treatment which has a high porosity and is movable, the deficiencies of the material will somewhat be corrected. In general, experience shows that most

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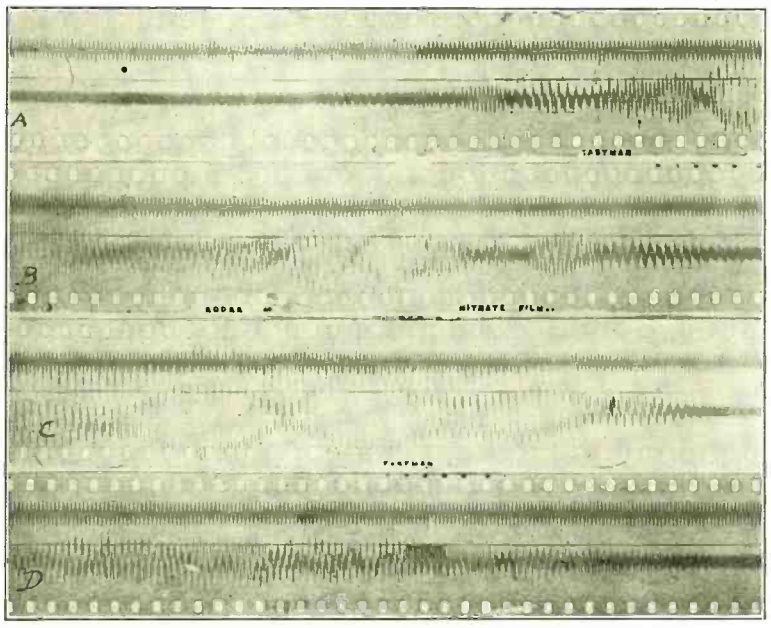


A. Fig 5. Oscillograph recording of the reverberation time in a studio of low absorption power.
B. Fig. 6. Recording of the reverberation time in a studio with the door open and hard surfaces outside.
C. Fig. 7. Recording of sound passed through a studio wall and actuating a microphone located outside.
D. Fig. 8. Recording of reverberation time in a studio of minimum absorption power.

The radio monitoring station at Grand Island, Nebraska

BENJAMIN WOLF
Manager of the Frequency Monitoring Station

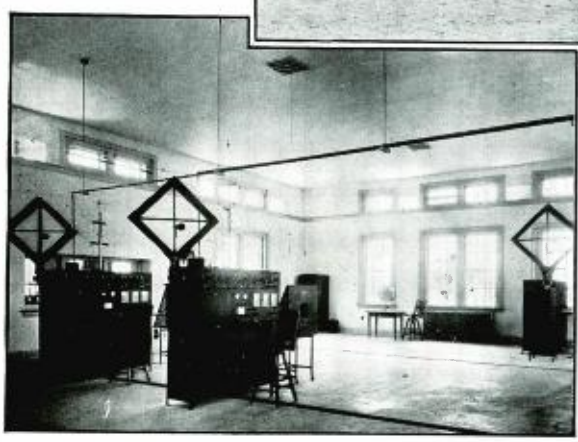
CONFUSION on the air of the days of broadcasting's infancy is a painful memory to most of us. Now, with our 600-odd broadcasting stations spread intelligently and conveniently over the dial, we are inclined to give the matter little thought. To the inquiring mind, however, it must have occurred that the task of keeping stations to their allotted wavelengths is a difficult job.

Not that wilful violation of federal radio regulations is a practice common to the broadcasting stations. It's just that, with so many stations on the air, some sort of effective supervising is necessary to prevent chaos. Send 600 capable and well-meaning motorists up various lanes to a crossroads where a traffic officer is on duty and no congestion is likely to occur. But take away that officer and a snarl will result that it will take many policemen to untangle. The broadcasting situation is much the same. There has to be a traffic officer. It is the duty of this officer to set aright stations which are interfering with other stations through variations in wavelengths. In most cases, this is unintentional, due to faulty equipment, and the station is instructed to make corrections. In the event of an intentional variation, the station would in all probability be ordered off the air.

Checks U. S. Stations Regularly

The radio traffic officer is stationed near the town of Grand Island, Nebraska. His official title is Radio Frequency Monitoring Station. This station is capable of listening, and does listen, regularly, to practically all broadcasting stations in the United States, as well as a considerable number of foreign broadcasters. Aside from its routine duty of keeping a constant check on U. S. broadcasting stations, Grand Island performs numerous other special services for the Government. It is prepared, for example, to report on wireless transmission in practically any country on the globe.

To function successfully, such a station obviously must be equipped with the finest receiving apparatus and must, in addition, be extremely favorably situated. One reason for the location of the radio frequency monitoring station at Grand Island was, of course, its proximity to the geographic center of the country. But



Above—General view of the station, showing a part of the antenna system. The beacon is to warn night-flying trans-continental air-mail pilots to steer clear of the area. Left—Intermediate and low frequency receivers. Right—Screened measuring booths, precision clock, and high frequency receivers. The signal energy is transmitted to the measuring apparatus within the screened booths by means of a conductor enclosed in metal tubing.

entirely.

Two other reasons stand out plainly in favor of keeping the antenna coil insulated from the chassis. The first is an old, old story about which there is no dispute. Two grounds are usually worse than one. By providing only one good ground, the dissipation of antenna energy will be prevented, and stronger signals will result. The other reason is that an isolated antenna coil lends itself to the use of a counterpoise; an instrument of great value in noisy locations. Because of the high capacity to ground encountered in electric sets a counterpoise is of little or no value. The use of a counterpoise in noisy locations is very beneficial, since the field of the antenna can be greatly restricted and the system placed in a location remote from the noise area. A simple arrangement which has been used with great advantage is shown in Fig. 3. The feed wires will largely balance out whatever interference they collect.

Carrier Wave Hum

There is a fourth value to this arrangement, and it concerns that much argued subject of carrier wave hum so prevalent in many receivers produced in the last two years. While there are many causes for hum heard when the receiver is tuned to a carrier wave, one of the most mystifying is the type which is heard only on a few stations. The first thought of many is to blame the broadcast station for poor filtering. Investigation shows that this certain type of hum occurs with only a few makes of receivers and only on certain models. Another point of note is that with the same model, or even the same set, the results are entirely different in another location.

In some locations, no hum is heard at all. The explanation for this peculiar behavior is quite simple. It has been found that the trouble is caused when a portion of the signal in the antenna takes a ground path through the power pack and the power line. The layout and design of some power units is such that the reactance to ground varies 120 times per second due to the action of the rectifier and the transformer windings associated with it. This causes a portion of the carrier to be modulated and produces the "carrier wave hum." Tests indicate that the hum is most severe when the reactance of the normal ground and the power path ground are comparably the same. Upon this last statement hangs the reason why the hum is more prevalent on some stations than others, since the impedances will be comparable only over a small band of frequencies.

Many peculiarities of this type of trouble have been noted, but the point of chief interest is that this trouble occurs simply because of the dual ground paths. When the antenna coil is not connected to the chassis, this troublesome ground path is removed. For maximum benefit the antenna coil and connecting wires should present a minimum of capacity to the chassis.

Many servicemen have found a remedy for this hum trouble in placing a simple capacitive filter across the power cord to the set with the midpoint connected to the receiver ground post. It is evident that the success of this remedy lies in providing a low impedance path around the rectifier.

In conclusion, it has been noted that in the case of electric receivers the practice of grounding the low potential side of the antenna coil to the chassis leads to difficulties due to the coupling afforded to the power supply system. Removal of this common connection results in four distinct benefits with no serious detriment noted. At least one large corporation has already adopted this suggestion and is making use of it on a current model.

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Chicago radio-electrical show, Jan. 18-24, 1932

EXHIBIT and demonstration rooms will be maintained at the Congress Hotel, Chicago, by manufacturers during the forthcoming Chicago Radio-Electrical Show, Jan. 18-24, 1932, it has been announced by G. Clayton Irwin, Jr., general manager of the combined trade and public exposition.

Here, manufacturers will hold sales conferences with jobbers and dealers to evolve sales plans which will overcome the handicap imposed by the record breaking warm weather of the autumn.

The Institute of Radio Service Men will hold its January convention concurrently with the show and like the National Broadcasting Company and Columbia Broadcasting System, will make the Congress Hotel its headquarters.

The public will be received at the Coliseum where, for the past nine years, the annual show has been held.

So great a response has been received from the trade that the show management has found it advisable to perfect plans whereby dealers, jobbers and manufacturers may transact business without interruption by the public, as is done at the New York Radio-Electrical World's Fair. Trade Show hours will be maintained at the Coliseum from 12 to 2 p. m. each day, beginning Tuesday, Jan. 19.

In selecting new merchandise, dealers and jobbers long ago learned to be governed by what, in the show business, is called "lobby comment." A keen observer quickly learns what the public will buy just by keeping eyes and ears open when the products on display are undergoing inspection by the public. That's why members of the trade congregate in little groups, adjacent to the displays of manufacturers whose lines they are considering during public show hours.

An avalanche of mail from the trade continues to be received at show headquarters. The letters come in response to those sent out by the show management to ascertain the opinions of the trade on various matters in connection with the Secondary Selling Season. They're all alike in making the statement, "I'll be at the Show." Many exhibiting manufacturers, too, have been advised that the trade will come to Chicago in January to transact business.

"The sustained and persistent effort to sell radios during the Secondary Selling Season which will be launched nationally by the show, and will continue well into the spring is heartening to the trade," said Mr. Irwin. "Dealers and jobbers everywhere were quick to realize the advantages to be derived from carrying on after the holiday slump instead of relaxing their efforts and waiting for another autumn to roll around before going after business again."

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HUNGARY ERECTING STATION

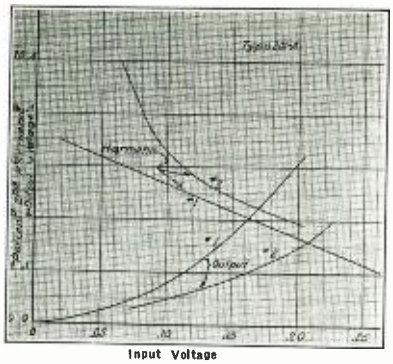
THE transmitting station now under construction at Szekesfehervar, Hungary, with the receiving station located at Tarnok, Hungary, will primarily be a high-powered short-wave commercial radio telegraph station, the first one of this kind in Hungary, designed to maintain a regular direct wireless telegraph service with the United States and other countries overseas. According to present plans, it will be ready for operation about the summer of 1932. The exact wavelength, frequency, and call letters have not yet been determined. The transmitters now under installation will have a power of 20 kw. each. The Hungarian Postal Administration will be in charge of the station. This station, although primarily a radio telegraph station, will be used, when plans are worked out, for exchange on the short waves of international broadcasting, and also for wireless telephony.

Detector distortion at low input voltages

By H. A. Brown, G. W. Pickels and C. T. Knipp*

IN recent years more and more attention has been paid to the distortion of the modulated wave signal by the detector or demodulator device. While much has been done to secure undistorted detection at input potentials above one volt, little or no effort has been directed toward securing low distortion at input potentials of the order of one-tenth of a volt. The trend in investigation and development work has been toward multistage tuned radio-frequency reception because it has been shown that when a sinusoidal input voltage having an amplitude of 1.5 volts is impressed on the grid of a simple anode type rectifier such as the UX-201-A tube, the anode current will possess a double frequency or second harmonic component of the alternating portion of the anode current whose amplitude is less than 5 per cent of that of the fundamental or signal input frequency portion. That is, the pulsating anode current will contain an alternating portion of amplitude A_1 at the input signal frequency, and a second harmonic component of amplitude A_2 where $A_2 = .05\,A_1$. Higher order harmonic components were found to be small compared to the second harmonic component[1]. The value of 5 per cent for the second harmonic component has been generally recognized as the upper limit for reasonably good reproduction from audio amplifiers and the same practical upper limit of distortion of the signal will also be recognized for detector performance on signal potentials modulated about 50 per cent.

At first thought it would seem as if



Input Voltage

Fig. 2.

efforts to obtain low distortion detection at low input voltages were unnecessary, since modern broadcast receivers incorporate a multi-stage tuned radio-frequency amplifier capable of furnishing audio-frequency modulated radio-frequency potentials of more than one volt to the detector. However, it should be possible to simplify the radio receiver by providing fewer stages of tuned radio-frequency amplification. using band-selector tuning to obtain proper sharpness of resonance combined with equal reception of all necessary sidebands for good fidelity of tone. The output of a detector excited by less than 0.1 volt would have to be used for excitation of a two-stage audio-frequency amplifier, the first stage using a screen-grid or "variable-mu" voltage amplifier tube.

In the field of amateur radio reception multi-stage tuned radio-frequency amplifiers are not feasible and the voltage delivered to the detector is low. Hence, low distortion low input detectors are quite desirable in this field. In the field of commercial radio telephony and in marine and aviation services where the receiving operator uses telephone receivers, low input voltage detectors are used.

With the foregoing in mind an experimental investigation was undertaken to determine what degree of distortion would be encountered when using low input voltages to excite the various well-known types of modern triode and tetrode vacuum tubes as detectors.

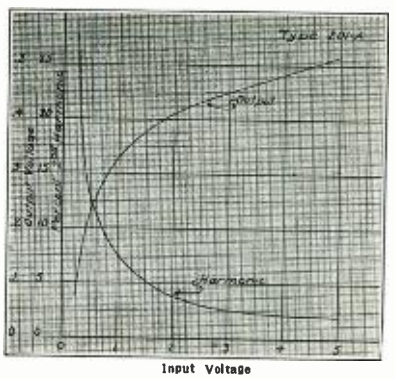
Method of Making Measurements

In order to quantitatively measure the degree of distortion of the signal voltage waveform by a detector it is necessary to measure either the amplitude of the harmonics present in the detector output when the input voltage is sinusoidal or to measure the effective value of the total harmonic residue of the detector output voltage. The first method requires a wave analyzer of some sort while the second requires a Belfils bridge in which the fundamental is balanced out completely.

The first investigator referred to used the Belfils bridge while the second used a wave analyzer and plotted only the second harmonic as a percentage of the total output voltage. In the investigation about to be described the Belfils bridge was used to eliminate the fundamental component and a calibration voltage at a frequency equal to that of the second harmonic was used to calibrate the output-amplifier-indicator device so that errors due to impedance drops through the bridge arms at the second harmonic frequency would be eliminated.

The method of doing this will be made clear in the following description of the procedure. The total output voltage of the detector was measured by an output-amplifier-indicator or voltmeter arrangement, and the second harmonic component next measured with the same apparatus after balancing out the fundamental as above mentioned. The arrangements for making the measurements are shown schematically in Fig. 1.

An oscillator provided a modulating voltage of 800-cycles which was filtered to eliminate as much harmonic residue as possible. This output excited a carefully designed push-pull power amplifier, whose output was fed through a low-pass filter C. The output, contain-



Input Voltage

Fig. 3. Grid leak in megohms. (Input volts .52).

*University of Illinois.

[1] *Stuart Ballantine: Proc. I. R. E. Vol. 17, p. 1153, July, 1929. Also F. E. Terman and N. R. Morgan: Proc. I. R. E. Vol. 18, p. 2160, Dec., 1930.*

An engineering investigation of the distortion characteristics of detector tubes at very low input potentials.

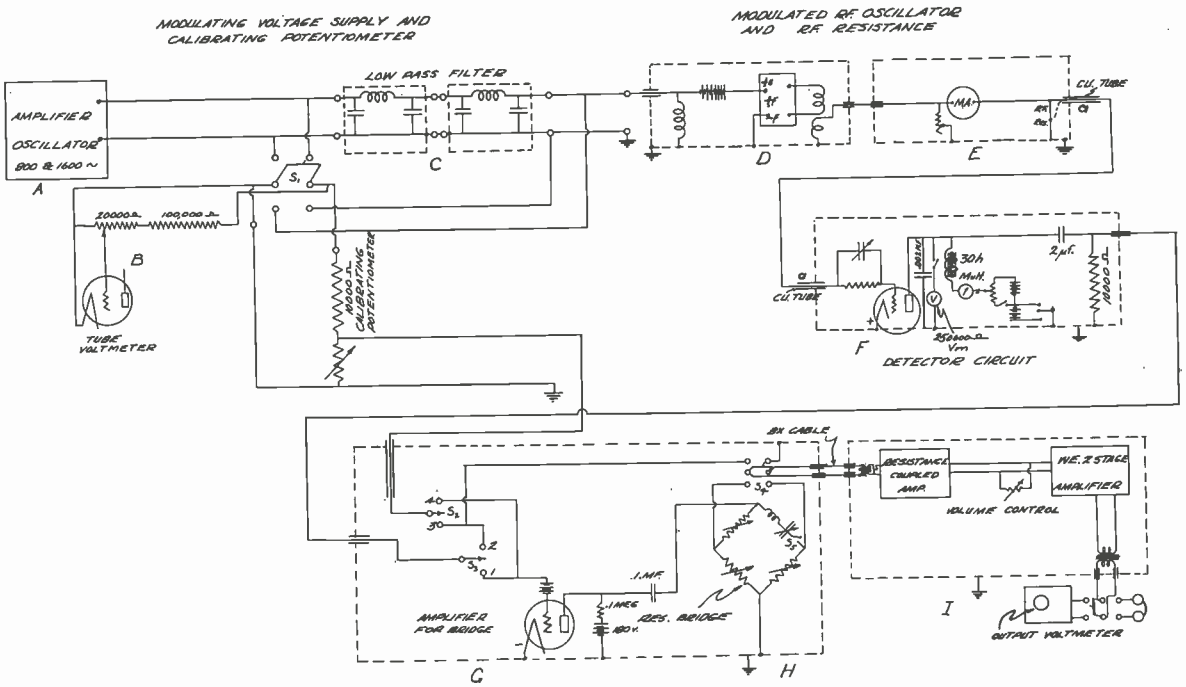


Fig. 1. Setup of circuits for detector investigation.

ing an immeasurably small volume of harmonic, was used to modulate the 1,000 kc. oscillator D. Care was taken to operate this oscillator at the midpoint of the straight line portion of its output current-plate supply voltage characteristic, and with only sufficient superimposed 800 cycle modulating voltage to obtain 50 per cent modulation. Current from a pickup coil coupled to this oscillator passed through a measured "link resistor" at E to ground so that a known sinusoidally modulated radio-frequency potential could be applied to the detector under test, shown at F. The audio-frequency output voltage was impressed through a 2 mf. condenser upon a 10,000-ohm load resistor (in case of the triode detectors), and the drop across this excited the amplifier-voltmeter apparatus at I when switch S_3 was in position 2 and switch S_4 thrown upward. The output meter reading was noted for a certain excitation of the detector under test, after which S_1 was closed downward, S_3 opened and S_2 closed on point 3. The potentiometer or voltage divider was then adjusted until the output meter at I gave the same reading as for the detector output. The voltage determined from the reading of the tube voltmeter B and the potentiometer at the right was then equal to the total effective detector output voltage.

The tube voltmeter was essentially quadratic so that waveform errors were small. Next S_2 was opened, S_3 closed on point 1 so that the distortionless amplifier G was excited and its output impressed on the Belfils or "resonance" bridge. No appreciable distortion could be detected in this amplifier using a UX-171A type tube. S_4 was closed downward and the bridge adjusted until the fundamental tone disappeared from the telephone receiver shown at I. The second harmonic and higher harmonic output was usually small compared to the total output so that the gain of the amplifiers at I had to be increased so as to get a reading of the output voltmeter. For calibrating on this second harmonic reading, oscillator A was set at 1,600 cycles; the first filter cut out and S_1 closed upward. The output voltage is then impressed on amplifier G by closing S_2 on 4, leaving S_4 closed downward. The potentiometer to the right of B was again adjusted until the same reading was obtained as for the second and higher harmonics of the detector output. During this calibration the Belfils bridge was left untouched after having been adjusted to eliminate the fundamentals as previously explained. The switch S_5 is left closed during all these operations. It is used only when testing the screen-grid tetrode type of detector, as will be described presently.

When testing screen-grid detectors the 10,000-ohm load resistance in compartment F was removed and a three megohm resistance had to be substituted for best results. due, of course, to the extremely high a-c. plate resistance of this type of tube when used as a detector at low input voltages. It was also necessary to measure the detector output voltage by leaving S_4 in the down position and cutting out the Belfils bridge by opening switch S_5. Thus the output of the detector excited amplifier G whose grid was always biased negative, 22 volts, and the input impedance to G was, of course, too high to seriously affect the proper detector output impedance of .3 megohms. For the measurement of the second and higher harmonic component S_5 was again closed and the Belfils bridge balanced as before.

It should be noted that the bridge is grounded at the point between the two ratio arms so that the two diagonal points connected to S_4 must be above ground potential and must have the same admittance to ground. This required the use of a balanced shielded input transformer to feed the resistance coupled amplifier at I. The dotted lines in the figure indicate the shielded compartments. which consisted of heavy-gauge copper boxes with tight-fitting lids. The boxes E and F were adjacent so that points *a a* were the same, that is, a small copper tube led from E into F. The connections of the detector input across the r-f. link resistance were as short as possible so as to avoid errors due to inductive drop.

Results of Tests

The results of quantitative measurements of per cent second harmonic with varying input voltage to the detector are shown in Fig. 2. As indicated, this is the type 201A vacuum tube detector. It will be noted that for an input voltage of approximately 0.25 volts the per cent second harmonic, or the distortion as it will be called, is below the allowable limit of 5 per cent. At input potentials of less than 0.1 volt, the distortion comes higher than allowable for good results. In this test as well as with the succeeding tests the grid circuit reactance, that is, the grid condenser and grid leak resistance, were varied for the best results. This amounts to about 5 megohms resistance and between 150 and 350 mmf.

In no case was the bias grid providing so-called anode detection as satisfactory as the circuit just mentioned. Fig. 3 shows the effect of varying the grid leak resistance. In all the tests in this investigation the modulated radio-frequency oscillator was adjusted for 1,000 kc.

Fig. 4 shows the results of test on two types of alkali vapor detector tubes, the one marked "K-Na" being a one-ampere tungsten filament type 201 amplifier tube into which the molecular alloy of potassium and sodium was introduced by distillation. Both of these tubes give efficient detection with low input voltages, of the order of 10 millivolts.

For input voltages at which measurements could be made with the apparatus described they do not show high output as detectors. It will be noted that the per cent harmonic is much lower for this latter type tube than for the type 200A caesium vapor type. This result was obtained by adjusting the plate battery voltage to the best value for each input voltage. The K-Na tube becomes grossly over-modulated at input potentials above 0.15 volts.

Several tubes of these types were tested, but no marked improvement on the performance shown in Fig. 4 was obtained. Optimum values of grid capacitance and leak resistance were used

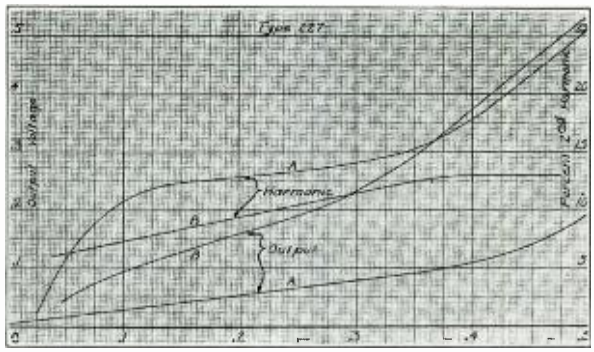


Fig. 5. Test on -227 type tube.

in every measurement. Fig. 5 shows results of tests on the conventional heater tube type 227 when circuit conditions were adjusted for the best output and lowest distortion for input voltages below 0.15 volts. At higher input voltages, beyond the range of that shown, the distortion may be again reduced by using different potentials and circuit

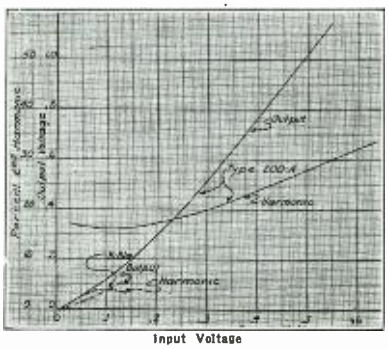


Fig. 4.

conditions. Interesting results were obtained with the type UX-200 soft detector when output voltage becomes very low, making it inefficient as a low input voltage detector, however the per cent harmonic being kept below the allowable limit for a wide range of voltages by properly adjusting the plate battery voltage, as shown.

The most important and most practical results were obtained from the standard heater type screen-grid tubes, using a biased control grid instead of the grid leak and grid condenser. It will be noticed that at low input voltages relatively high output voltages and fairly low per cent second harmonic are obtained. These tests were obtained for an output circuit resistance of some 3 megohms. To obtain low distortion at high input voltages the a-c. plate resistance is, of course, lower and the output resistance must be lowered for the proper impedance match.

Various other circuit conditions are necessary to make for proper performance with input potentials greater than 1 volt. Fig. 6 shows typical tests with the same circuit adjustments for a slightly different heater type screen-grid tube.

The type 551 detector tube seems to perform better at a convenient low input potential of about 0.03 volt.

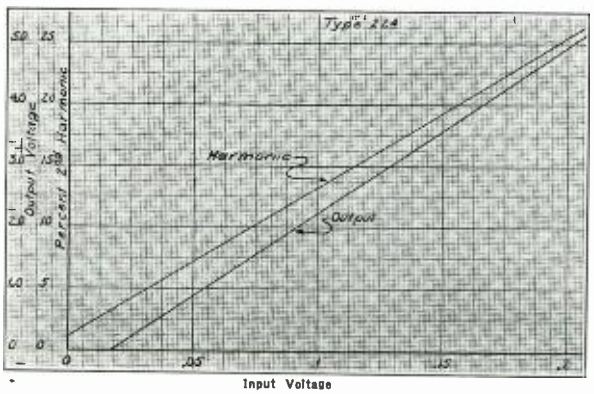


Fig. 6. Test of a heater type screen-grid tube.

Conclusion

In the light of some of the former measurement work done, previously referred to in this paper, it was rather hard to reconcile some of the results of these tests, particularly the accomplishment of low distortion operation at low input voltages. With this in mind measurements were repeated again and again, the results varying somewhat, as much as 20 per cent due to small uncontrollable variations of detector characteristics and test conditions. The results in general, however, are thought to be conclusive. This low distortion operation at low input voltages could be expected when it is remembered that certain detectors under certain conditions can be made so sensitive that the straight line portions of their characteristics are reached at low input potentials.

The writers feel that there is no doubt but what the screen-grid detector consisting of the standard heater type tetrode, would be very satisfactory in a radio receiving apparatus using very little radio-frequency voltage amplification, and using, of course, two stages of high gain, high quality audio-frequency amplification.

Class "B" audio power amplifiers †

By CLYDE L. FARRAR*

OF a number of possible modulation systems in use for modulating a radio transmitter, plate modulation is almost universally used, especially in United States broadcasting stations. The so-called low level modulation systems being at the present time most in favor. By low level modulation is meant modulation at lower power level and this modulated radio frequency amplified by one or more linear power amplifiers. In contrast to this, high modulation takes place in the output stage and the modulators are then called upon to furnish an audio frequency power to the power amplifier equal to the station rating if 100 per cent modulation is to be obtained.

In plate modulation the modulators are so coupled that the audio-frequency output of these tubes is fed into the plate circuit of the radio-frequency power amplifier. Hence the modulators are essentially audio-frequency amplifiers and must be designed as such. In the usual plate modulation system the modulators are impedance coupled to the power amplifier, hence, must be operated as class A amplifiers.

Class A Amplifiers

By class A amplifiers is meant that the output of the tube is essentially an amplified reproduction of the input voltage. Therefore, a class A amplifier must be so biased that considerable plate current flows without grid excitation. Class A amplifiers are characterized by low power output, low efficiency, but with practically zero grid input. That is, the grid should in most cases be negative. On the other hand class B amplifiers remove to a greater extent the power output limitation.

Class B Amplifiers

By class B amplifier is meant one which is so biased that plate current flows only when the grid is excited. When no signal is impressed on the grid the plate current is zero, or nearly so. This means that the tube is biased nearly to or at the cutoff point. Class B amplifiers are characterized by relative high power outputs and high efficiency. However the output is no longer a reproduction of the input. If the grid is excited by a sine wave of voltage, plate current will flow only during the positive half of the wave. However the grid may be driven positive provided the tube supplying the grid can deliver the power required by grid of the class B amplifier with little change in waveform. Under these conditions the output then consists of a series of half sine waves.

The maximum efficiency of a class A amplifier is 50 per cent. This may be easily shown as follows. The general equation for the efficiency of an amplifier is:

$$\text{eff.} = \frac{100\ (E_B - E_{min})I_p}{2\ E_B\ I_{av}}$$

where I_p is the peak plate current, E_B plate voltage, E_{min} is the minimum plate voltage applied to the plate and is equal to $E_B - I_pZ$ where Z is the impedance of the load reflected through the transformer. I_a is the average plate current. This gives the general equation.

$$\text{eff.} = \left(1 - \frac{E_{min}}{E_b}\right) \frac{\frac{1}{T}\int_0^T ip \sin\omega t\,dt}{\frac{1}{T}\int_0^T ip\,dt}$$

For the case of class A operation ip and i_{av} will be equal to I_s where I_s is $\frac{}{2}$ the plate saturation current, although this may give a current i_p which will cause overheating. The efficiency is then equal to the following for class A operation.

$$\text{eff.} = 50\left(1 - \frac{E_{min}}{E_b}\right) \text{per cent}$$

which approaches 50 per cent as a maximum from which we can see that the maximum value of fundamental frequency current cannot exceed the average plate current and that the average plate current must not vary during a cycle.

For class B operation the plate current will be considered for only ½ cycle, since no plate current will flow during the time the grid is most negative. We then have

$$ip = I \sin\omega t \text{ for } \tfrac{1}{2} \text{ cycle.}$$

$$\text{eff.} = \left(1 - \frac{E_{min}}{E_b}\right) \frac{\frac{1}{T}\int_0^{\frac{T}{2}} I \sin^2\omega t\,dt}{\frac{1}{T}\int_0^{\frac{T}{2}} I \sin\omega t\,dt}$$

where t is the period or $\frac{1}{f}$ where f is the frequency.

$$\text{eff.} = 100\left(1 - \frac{E_{min}}{E_b}\right)\frac{\pi}{4} \text{ per cent}$$

which approaches 78.5 per cent as the grid bias is increased to cutoff.

In the general case E_{min} will be from 20 to 30 per cent of E_b. This factor is governed largely by the value of plate voltage with the grid positive which is required to give the peak current. The maximum efficiency is governed there-

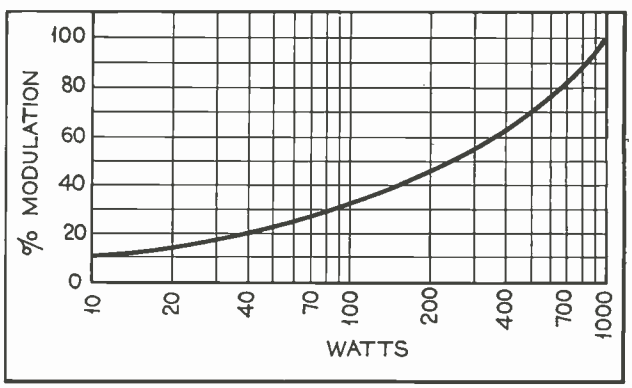


Fig. 2. Audio power required to modulate the output of a 1,000-watt transmitter, assuming an oscillator efficiency of 50 per cent.

†Research Paper No. 256, Journal Series.
*Ass't Professor of Elec. Eng., University of Arkansas.

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An instructive engineering analysis of the performance of class A and class B amplifiers used in radio broadcast stations.

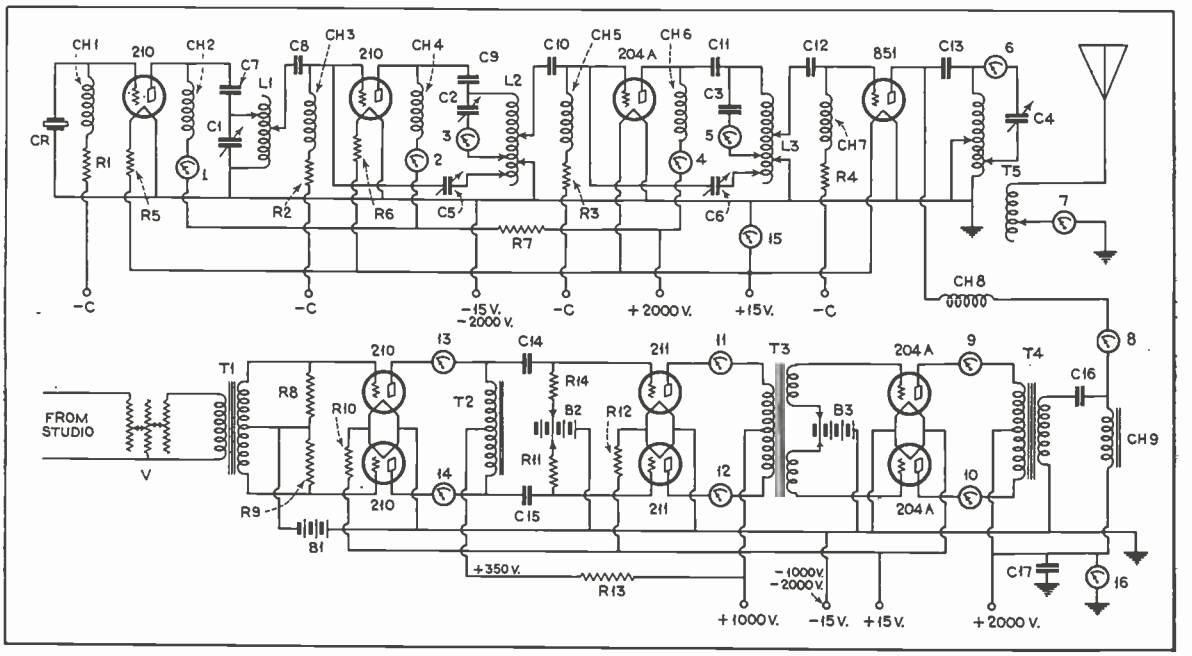

Fig. 1. Transmitter circuits.

fore by the minimum value of plate voltage required to give the peak current. An ideal tube is one in which the grid would not have to be driven very far positive in order to obtain the required plate current. The farther the grid is driven positive the greater the grid power, hence the exciting power is increased and at the same time the plate voltage should be low in comparison to the average value.

Efficiency of 50 per cent in the case of class A amplifiers can never be reached because of the curvatures of the lower part of the characteristic curve. Efficiencies of 20 per cent being approximately the maximum then can be attained, for example, a type UV 851 operated as a class A amplifier has an undistorted output of 100 watts with a d-c. input of 750 watts or an efficiency of 13.5 per cent, although this efficiency may be increased by raising the plate voltage and driving the grid somewhat positive.

Class B amplifiers are not limited by curvature except near plate saturation, hence, the output can be made very high and efficiencies of 60 per cent are not difficult to obtain in the larger tubes. Class B amplifiers have heretofore been used only as radio-frequency amplifiers since their output consists of essential one-half sine waves, and could be connected to a tuned circuit and under these conditions the output would be sinusoidal.

If, however, two tubes are operated in push-pull and the two tubes have identical characteristic curves, there can be obtained from these two a complete sine wave output from a sine wave input. This method of connection will enable a sinusoidal output to be obtained from a sinusoidal input and therefore can be used for audio-frequency amplification.

Large Audio Power

This system of obtaining large amounts of audio power has been used since 1927 at a radio station to modulate a 1000 watt transmitter. A schematic wiring diagram of this transmitter is shown in Fig. 1. As can be noticed from this figure the output of these two tubes is coupled into the power amplifier tube by means of a push-pull transformer. The secondary feeds through a condenser to a series choke coil in order to keep the d-c. out of the push-pull transformer.

By using a transformer to couple the modulators into the power amplifier, the output of the modulators to be easily matched into the power amplifier, thus removing from consideration the voltage ratio between the modulators and the modulated tubes, as this ratio can be easily adjusted by the output transformer.

As an example of this system it has been found possible to properly modulate the output of a 1000 watt transmitter by means of 2 U V 204A tubes assuming a 1000 watt transmitter. The curve of Fig. 2 shows the audio power required to modulate the output of a 1000 watt transmitter using the high level modulation system.

Assuming that an average modulation of 60 per cent is to be obtained and that the efficiency of class B amplifiers is taken as 78.5 per cent (the maximum under this system) the average heating of the 2 U V 204A tubes will be 61.5 watts per tube. Each tube will be delivering a peak output of approximately 360 watts or an average of 180 watts. Each tube must of course carry the entire load of ½ cycle. Therefore each tube must supply 360 watts for ½ cycle or peak power of 720 watts in order to obtain 60 per cent modulation. Each tube must then supply a peak power of 720 watts at 2,000 volts, or a peak input power of 906 watts. The peak current is 450 milliamperes or an average current of $\frac{450}{\pi}$ or 143 milliamperes. The plate dissipation will be 143 x 2,000 x 21.5 = 61.5 watts or well within the tube limitation. Again assume 100 per cent modulation the audio power must be power of 2,000 watts with a peak input power of 2,540.

A peak current of 1,270 milliamperes or an average current of 405 milliamperes with a plate dissipation of 405 x 2,000 x 21.5 or 173 watts. Of course, the plate dissipation will be approximately double this value, since these figures are for 78.5 per cent efficiency or the maximum, but with a plate dissipation of 350 watts a 204A will not be greatly overloaded, since peaks of 100 per cent modulation will last only a very short length of time.

Without overloading the U V 204A's it is possible to modulate a 1000 watt transmitter to a percentage of 86 per cent. The U V 204A tube is not necessarily the best type of tube to use

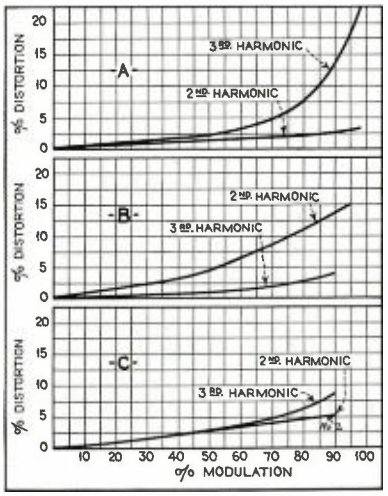

Fig. 3. A. Per cent harmonic, second and third, in antenna output. Input frequency 200 cycles. B. Per cent harmonic, second and third, antenna output for 100 ma., unbalance in modulation. C. Per cent harmonic, second and third, in output for 20 ma., unbalance in modulation. (Fundamental frequency 200 cycles per second)

since the grid must be driven quite positive to obtain the required power but it is possible to obtain this power without the output deviating very far from a linear function.

Distortion

In order that the distortion may be kept to a small value each tube should have the same characteristic curve and the tubes driving the grid of the power amplifier must supply the grid current with little change in waveform. And that the effective grid series resistance be small in comparison with the grid resistance during grid current flow. These conditions are easily met in practice. Fig. 3 shows the per cent harmonic, second and third, introduced in the output circuit of the transmitter for various per cent modulation. An inspection of these curves will show that the second harmonic distortion is quite low, reaching a value of 2.5 per cent at 95 per cent modulation. On the other hand the third harmonic distortion is large for this particular run. This large third harmonic distortion was caused by a too high effective grid resistance, which caused the effective grid voltage to drop when the grid became positive and drew current. During that run the tubes driving the modulators were coupled to the modulators by the so-called choke coil condenser resistance coupling, the grid resistance having a value of 5000 ohms, with a transformer coupling substituted for the resistance coupling the third harmonic was reduced to the value of curve No. 2, which gives a third harmonic distortion of 8 per cent at 100 per cent modulation. As the plate currents became more unbalanced the second harmonic distortion increased very rapidly, while the third harmonic remained essentially the same.

It should be remembered that the total per cent distortion is not the sum of the second and third harmonics but the square root of the sum of the squares. As for example: for balanced plate currents the fundamental as read by the distortion meter was 175 milliamperes while the second harmonic was 2.15 milliamperes and the third 5 milliamperes. The per cent being 1.25 per cent and 2.86 per cent respectively. The total per cent distortion being

$$100\sqrt{\frac{2.15^2+5^2}{175}} = 3.12 \text{ per cent.}$$

Fig. 4 shows the overall frequency characteristics of the same transmitter for per cent modulation of 75 per cent. In obtaining these curves 2 U V 849 tubes were used as amplifiers instead of U V 204A discussed above. Later tests show that the conditions are essentially the same as before when using U V 204A tubes.

Frequency Response

The actual shape of the frequency response can be modified over rather wide ranges by inserting various values of coupling capacities between the output transformer of the modulators and the plate choke coil of the power amplifier. The circuit was designed to have a gradually rising characteristic since practically all receivers have a drooping characteristic. This variation being a total of 3 db.

It is possible to operate tubes as modulators at somewhat higher voltages than normal without lowering the normal life. This is possible because the average plate current is a function of the grid excitation and hence the plate heating is a function of the grid excitation and since in audio-frequency amplification a large proportion of the time the grid excitation is low the average heating will be lower.

The maximum power is limited only by the peak plate current, and as long as the plate current and applied voltage are increasing linearly the output will contain no more harmonic than a class A amplifier. As the plate current saturation is approached the power output tends to increase at a slower rate than the increase in grid voltage. This results in a flattening out of the output wave which corresponds to an increase in odd harmonic content. However, third harmonic distortion is less troublesome than second harmonic, hence a greater per cent of third harmonic can be tolerated, that is, the per cent distortion allowable for odd harmonic distortion is somewhat greater than for even, particularly second harmonic.

Harmonics Distortion

Second harmonic distortion is introduced whenever the peak values of the two tubes differ in value. This gives an unsymmetrical wave which of course contains a large proportion of even harmonics. However, methods have been found for reducing this distortion to a low value.

A properly designed class B amplifier will contain no more distortion than a class A amplifier of the same power output. This output will be obtained at a much lower cost. Distortion caused by unequal plate currents corresponds to the distortion of a class A amplifier whose average plate current is allowed to vary during operations.

A class B amplifier is capable of delivering a high output on an overload, as for example, at first 2 U V 851 tubes were used to modulate a 1000 watt transmitter and on heavy surge being applied to the grid a 3½ ampere circuit

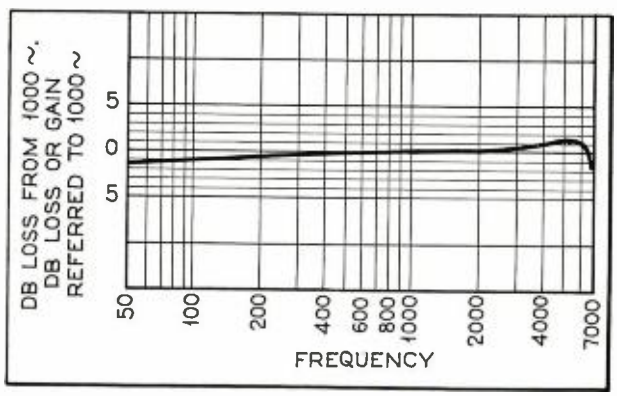

Fig. 4. Overall frequency transmission of station KUOA at 80 per cent modulation.

breaker would be tripped on a 2000 volt circuit. When these tubes were used as modulators the plates never showed color which showed that they were not heavily loaded. The present U V 204A tubes used will operate at normal plate heating only on sustained notes such as orchestra or pipe-organ selections, and under usual conditions show little or no color.

The class B audio-frequency amplifier is especially adapted to high-level modulation as it is in this system high audio power is required, although for all cases of high audio power this system will result in a low cost amplifier. In most cases the audio power is most expensive to obtain and in the main has been the reason for the use of the low level modulation.

The capacity of various tubes for modulation using this system may be found if their maximum power output without overloading is known. The following table gives an idea of the approximate power that can be obtained from the common type of power tubes used in push-pull class B amplifiers without exceeding their normal plate dissipation.

U V 210	25 watts
U V 250	40 "
U V 211	200 "
U V 204A	700 "
U V 849	1020 "
U V 851	3000 "

Therefore, 2 U V 851 should be able to modulate a 5000 watt transmitter to an average modulation of approximately 80 per cent and could no doubt supply the required 5000 watts for 100 per cent modulation without severe overloading.

The plate supply is called upon to supply a current varying from zero to π times the average plate current, hence, the regulation of such supply must be very good otherwise the E_{min} will be low and the efficiency will suffer. In these tests motor-generators have been used although a-c. rectified power could be used, if the mercury vapor tubes were used as rectifiers and the choke coils had a low resistance. In general the grid voltage should be supplied by means of a battery as the grid current becomes quite large. One of the conditions for a low value of distortion is that the average grid voltage should not change. And in these experiments a battery was used to supply the grid voltage.

In comparing class A and class B amplifiers, the output of the class A amplifier is limited by the plate heating and seldom by emission since the tube is operated at a low efficiency. On the other hand the output of a class B amplifier is limited practically by the plate current saturation curve and usually not by the plate heating. In audio-frequency amplification the tubes may be greatly overloaded since the average current will vary over wide limits and hence the average current over a period of time will not be great. In the case of class A amplification the overload on strong signal is limited by distortion while the overload power output of a class B amplifier is limited by the saturation current and is sustained by plate heating.

In actual operation the average modulation of the transmitter can be roughly judged by the color of the tubes and in a musical selection where the average modulation is the same. The operator can adjust the input for the required percentage of modulation by observing the color of the modulator plates.

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Can inventive genius be organized?

By Gilbert P. Simons

IN attempting to form a patent pool in the radio industry the United States Government has come to grips with that most elusive of human spirits, the inventive genius. The pool, which is rather decoratively referred to as the "Electronic" Foundation in the preliminary proposals, was suggested by a group of interested companies. The group includes four large companies which collectively control more than three thousand patents. Many of these patents have been licensed out to manufacturers on royalties averaging about seven per cent of the wholesale price and in addition certain companies have received a minimum guarantee of about $100,000 a year on fundamental patents from single licenses.

These companies proposed that they and other companies should pool all their patents and that these be placed under the control of a board of three trustees, one of whom would represent the grantors of patents, one the licensees and one the general public. Rumor has it that the minimum guarantees will be reduced—some say to $5,000 and others to $25,000 a year. A reduction of the royalty rate is also under consideration.

The potential value of such a pool to the companies who own the patents, the manufacturers who are the licensees and the general public is obvious, but after examining the preliminary proposals one is at a loss to discover wherein the inventor can hope to secure any positive values from the so-called Electronic Foundation. (This name, of course, will not do, as it already has been preempted by another commercial undertaking.) The Department of Justice has publicly said that "the creation of such a pool is a matter that requires careful consideration, both as to detail and as to its effect upon the industry."

Speaking in broad terms it would seem the attempt must be made if the present chaotic condition of the industry is to be ameliorated to reconcile certain apparently irreconcilable human factors. For example it is generally agreed that inventors are not business men nor are they primarily concerned with money values. On the other hand the larger corporations now holding fundamental patents, and the manufacturers, thinking chiefly in dividend values, have obvious advantages over inventive mentality in the negotiations which attend the commercialization of inventions. The highly individualistic inventive genius is often out-manoeuvered by powerful and "practical" executives.

The extent to which this age-old antagonism can be minimized by the establishment of the patent pool will depend in large part on how thoroughly disinterested the three trustees remain. If a majority of them are the type of business men who are adherents of the principle of organization, it may well be that the Foundation will assume an attitude which fails to weigh properly the significance of the non-commercial, inventive mentality. The dangers of such a situation cannot be over-estimated.

The history of radio's development is a curious commentary on the value of inventive genius blooming not in well-staffed and meticulously organized laboratories of large corporations, but rather in the old traditional and romantic setting of poverty, enthusiasm and poor equipment. One wonders whether or not an organization can be formulated that will protect the highly individualistic genius—and one wonders what will happen to radio if his contributions are not handled with care.

It has been suggested that the Foundation set up laboratories for independent research engineers or establish an organization in which they will receive the type of cooperation given the scientists employed by commercial organizations.

Production peaks and valleys

By Austin C. Lescarboura

What shall we do to level our production activities throughout the year for a better distribution of overhead costs?

LATE in September we visited the plant of a prominent radio parts manufacturer and found the wheels turning most vigorously. Indeed, this factory, by no means a small one, was working at full blast, with some three hundred employees on the payroll. There were no signs of a worldwide business depression in the humming atmosphere of this factory.

A month and a week later we visited the same plant. The scene had changed entirely. The work rooms were practically silent. They were all but deserted. The atmosphere was discouraging, reflecting in a telling way the general predicament of worldwide business. Where one short month before there had been feverish activity and enthusiastic production, there now remained idle equipment, a mere handful of workers engaged in unnecessary salvaging operations, and ominous silence.

If the foregoing case were an isolated one, we could well afford to dismiss it with the caustic remark that here is poorly planned production. But the condition is by no means confined to one or even a few radio parts manufacturers. All through the industry we find this madhouse condition of enormous activity for a short period, followed by long periods of inactivity. In a long experience in radio your writer finds that this production problem has become so prevalent and so sinister that no one but a veteran radio manufacturer has any idea of what to expect. Most veteran radio manufacturers seem to have accepted or at least resigned themselves to a shorter and shorter peak production period followed by an immediate stagnation so sudden in its advent that only the experienced can at all divine what has happened. To the inexperienced, it always looks like the end of everything, whereas it is only part of a well-defined cycle.

Every year the radio production season becomes shorter and shorter as the general business recession takes its toll and the surfeited market fails to recover its buying power. There is still a great unfilled demand for radio materials, but that demand must remain unfilled until the potential buyers are once more at work, and the depleted reserves of the working man, who is today's best radio customer, are again in existence.

In the meantime, the conditions that have been the curse of the radio industry even in the best of times have exerted their wicked influence with manifold effect. Lack of proper marketing data, followed by more or less complete absence of controlled production, has resulted in a supply far in excess of demand, with the resultant dumping or unloading of excess stocks at any price. Nothing has been done by the industry as a whole to spread the greatly curtailed demand among legitimate manufacturers and also to extend the production activities throughout the year. The production peaks and valleys have been further aggravated by the general business recession. The 1931 production season, so far as radio parts are concerned, has been of less than six weeks' duration. Indeed, in many of the plants we have visited the season seems to have been less than one month. Some have hoped for a second production peak before the end of the year, since the first peak came many weeks sooner than the corresponding peak of last year. It is our modest opinion, however, that the first rush has been the last real rush of the year. While set manufacturers may have placed their orders sooner than last year, so as to spread their own production over a longer period, they have bought cautiously, preferring to play short rather than long on the probable public demand.

What Next Year?

Next year's production peak may be even shorter than one month, while the volume may be correspondingly less, except if many manufacturers are squeezed out of business, leaving the field of battle to the stronger factors. In certain quarters there are ample indications of a steadily increasing squeeze being applied on the smaller and weaker manufacturers. Prices are being steadily reduced, with engineers and production men working overtime trying to lower production costs to a point where profits can be realized on quoted prices. Some mighty ingenious equipment is being introduced in bringing about startling reductions in costs. Such equipment is expensive, since it is frequently developed by the manufacturer for exclusive use. The smaller and weaker manufacturers, unable to develop their own equipment, are being left behind in the race towards still lower prices. The age-old law of the survival of the fittest is at work in the radio industry.

All of which means that the production problem cannot be solved by collective action, due to the several elements involved. Since its inception the radio industry has attracted just enough opportunists to make it impossible ever to place the business on a basis of mutual co-operation. It is impossible, even if it were legal, to get any sort of planning in this industry so long as its control rests in the hands of present leaders. Therefore, it becomes necessary for each individual and each company to take care of the problem as an individual matter, for otherwise the law of the survival of the fittest will solve the problem in the most expeditious but not necessarily the most pleasant manner.

Individual Solutions

So let us stop decrying practices and conditions. We cannot alter them. We cannot eliminate them. We cannot count on collective action. To stay in any branch of radio today, we must face the general conditions such as they are, and work out individual solutions.

On the present basis, many parts manufacturers have plants equipped to take care of a peak load for about six to ten weeks, with but 20 to 30 per cent of that peak business continuing through the rest of the year. This means that ample equipment must be on hand for the peak load, together with the necessary trained personnel. That the situation is ridiculous on the basis of sound business, goes without saying. Yet it exists. Radio set manufacturers are accustomed to having more than ample parts manufacturing facilities at their beck and call. The surplus of plants makes it impossible for any one manufacturer to refuse to accept the short production peak season. Excessive competition plays entirely in favor of the buyers.

Sane Promotion

Upon critical analysis, however, the situation is not as hopeless as it seems. Extreme optimism has no doubt brought

many radio parts manufacturers into their present predicament. As in many other lines, the plants have been expanded solely on the basis of production peaks rather than production valleys. Our factory burdens are largely based on an enormous capacity to meet the feverish orders of less than two months, with a more or less idle spell of ten months; whereas good business sense would dictate just the reverse situation, with factory burdens based on the average orders throughout the year, with the intensive working of equipment and personnel during the short rush season. Machinery and plant should be held down to an absolute minimum. During the rush, we should work every bit of equipment to the utmost, so that we may reap the fullest benefit from our capital investment. Quite conclusively, this points to three-shift operation during the rush of orders, so that overhead in machinery and floor space does not devour us during the rest of the year. This means that we must have but forty per cent of the equipment which would be required for just a daytime or one-shift plant. From an operating point of view, let us consider the advantages of night operation as against its disadvantages, always remembering that we contemplate using this system only during the comparatively short rush season.

We require 40 per cent and not 33 1/3 per cent if we work three shifts instead of the usual day shift, first, because we find there is generally the ten-hour day in effect throughout the industry, and secondly, there is a loss in night work over day work. However, where we find a ten-hour day we also find that with the addition of some sort of *fair* wage incentive system the actual cost of production in direct labor is lower for eight hours of work than it is for ten. Those industries which have gone on an eight-hour basis report that a man can do more work in eight hours than he can in ten,

Night Shifts

Night work can be more or less efficient depending on the management. There is a spirit about a night shift—a genuine feeling of fellowship—that is lacking in the usual daily work. For a short period of time this spirit can be used by the wide-awake management to very good effect. We are not advocating the three-shift idea for the full year, you will remember, but only for the duration of the feverish rush of orders that we find in radio and nowhere else. Rather than employ the same group of workers for a given shift during the rush period, it is best to change the shifts at weekly or bi-weekly intervals.

The plan of three 8-hour shifts is advocated instead of two 10-hour shifts with a 4-hour quiet period, because with night work the two extra hours are quite apt to be wasted. Also, it is the machinery and equipment which we desire to work to the utmost, rather than the labor. For our trained operators, we must be careful to maintain our regular staff at peak efficiency during the year. Men must be selected not only for their ability to perform a specific function during normal production times, but also for their ability to step into key positions for that short time of abnormal or peak production when the radio season is in full swing. The situation is not unlike some European armies in which the enlisted men and non-commissioned officers are fully trained to step into non-commissioned and commissioned officers' places in the event of war, with the ranks filled by the drafted citizenry.

Use of Plant

By utilizing our equipment to its limit during the peak of business, it would seem that we can reduce our excess equipment from 500 per cent to but 100 per cent of our normal requirements, in the case of most radio parts plants. This may also apply to many set manufacturers, although with more or less standardized products they can go ahead with a given production schedule based on their own ideas of probable sales, as contrasted with parts manufacturers who must make things to order.

With the peak load five times that of normal business, we can take care of the rush because of the three-shift operation of the plant, provided we have about *twice* the equipment that we would normally require. We have, therefore, even with the most efficient use of our plant during the peak period, twice as much machinery and twice as many trained men as we really require for the radio parts business. What are we to do with the excess during the slow production periods which go to make up four-fifths of the year?

Side Lines

The larger manufacturers have shown the way in principle if not by successful practice. More and more the larger radio manufacturers are going into side lines, such as electric refrigerators, electric clocks, automobile heaters, hair dryers, electrical appliances of all kinds, small arms ammunition, fractional horsepower motors, etc., etc., some with success and some with incipient failures. In many instances the thinkers have thought clearly enough but not far enough. A side line is the obvious solution, but a side line which necessitates the building of additional factories and calls for vast capital expenses is not a side line to take up the existing slack, but rather an additional business; and in many instances, because of an already overcrowded situation, simply an additional headache.

The idea of a side line is correct in principle if not in all its applications. The basic thought is sound. To take care of that additional machinery and trained man-power, the radio manufacturer needs additional non-radio production. There are two conditions that must be met by these projected side lines. First, they must be products that can be manufactured with existing equipment and without heavy capital expense in changing over from radio to side line. Secondly, the side line must be in a field not already overcrowded by manufacturers to whom it is a main line.

We have had enough examples of what it means to rush into non-radio fields that are already overcrowded. The electric refrigerator field, for instance, has been rushed by several radio manufacturers even after it already had a superabundance of its own manufacturers. Likewise with the fractional horsepower electric motor field. And also the same for the home movies field.

Of course, it is no easy matter to decide on new non-radio lines to fill in the valleys of a typical radio plant production curve. The writer has been asked dozens of times during the past six months regarding side lines. Not having as yet mastered the gentle art of pulling rabbits out of a silk hat, he has been unable to produce original ideas at the desired rate. One cannot walk down to the corner and find, without digging, a side line already developed but not too highly developed for the radio manufacturer to pick up and exploit. Most of the bets have already been well thumbed and considered by our radio competitors, as well as by a host of electrical manufacturers who are also seeking side lines. The finding of

ADDITIONAL NEW TUBES

IT is amusing at times to witness the left-handed ballyhoo launched through the daily press and in the pages of the less responsible, sensational technical journals purporting to announce revolutionary types of vacuum tubes for radio—tubes that are reported to sell for a few cents each and that will last forever.

Reputable manufacturers of tubes know that tubes must meet requirements of radio receiver design to be practical and useful. Engineers properly posted are aware that always there is need for betterment, but a good guide of sources of tube information is the manufacturer of radio receivers.

a suitable side line is a full sized job. In fact, about the only logical way we can suggest is to comb the patent art for old and new ideas that have manufacturing and merchandising potentialities, or, what seems an even better way, to maintain a research and development laboratory so that the search may be conducted in a virgin field.

Market For Ideas

The greatest need of our radio industry and for that matter most industries is a flow of ideas. While the business recession or depression may be laid at the door of many other causes, such as over-production and over-expansion of the past, unrestrained speculation, the aftermath of the World War, the foreign debts, instalment selling and so on without end, from the engineer's standpoint the one outstanding cause is a surprising lack of fresh ideas. What the sorely tried world at large needs right now is a fresh bag of tricks. We must have new ideas. We must have new industries. We must have new jobs. Having worn our old ideas and industries and jobs threadbare, we need some fresh ideas to get going once again.

Sooner or later, and preferably the former, we shall have business creators at work. They will come along with inventions, research, engineering, financing, production skill, merchandising ability, advertising and publicity. These creators of business will be the magicians of the business world. They will pull the rabbits out of the silk hat. They will wave the wand over dead plants, bringing them back to life. They will say the magic words that will restore sick companies to full health. That such individuals and organizations have not as yet appeared is one of the greatest mysteries of our present age.

Meanwhile, the individual radio manufacturer, particularly if he deals in parts, can do much to help himself in the matter of the abnormal peaks and valleys of present production. First, let him reduce his plant to the minimum. These are days of low-gear business. To remain in high gear is to lack pulling power during slack times. Many small manufacturers are cleaning up because they have small plants, small overhead, low prices and therefore a large clientele, to the bewilderment of their large, cumbersome competitors. Secondly, let the radio manufacturer work his plant to the utmost at all times, with two or three shifts during the rush season. Thirdly, let him take on non-radio side lines, wisely selected, so as to absorb whatever excessive production capacity he may have to spare during slack times. But let him be sure to take on side lines that are really side lines, so that there is not the danger of the tail wagging the dog in short order.

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Skin effect curves

By Gordon B. Robinson

SOME years ago, while studying the skin effect data presented in Circular 74 of the Bureau of Standards, a new and useful manner of presenting such data graphically was discovered. This relationship was not stated by the Bureau, nor has it been published to the general public, so far as is known.

Fig. 1 presents a group of skin effect curves using this new style of presentation. The fundamental data for these was obtained from the above circular; it is neither new nor original. The curves themselves are original. They are thought to be more readily usable for a variety of problems than any other form of curve for such information.

The unique form of this group of curves was made possible by the discovery that the skin effect ratio equation given by the Bureau of Standards could be rearranged to show that a given value of d-c. resistance per foot length of conductor gives a definite skin effect ratio *regardless of the diameter of the conductor.* This means, for example, that if a carbon rod say one inch in diameter has the same d-c. resistance per foot as a copper wire 0.002 inches in diameter, the skin effect ratio and the high-frequency resistance will be the same, for any frequency, in spite of their greatly different diameters. This does not apply to magnetic materials.

The skin effect ratios shown in Fig. 1 are for any round straight wire so long as it is not magnetic. Given the resistance per 1,000 feet of some conductor, to find the high-frequency resistance, follow the vertical line from this value on the lower scale up to the horizontal line from the desired wavelength on the left-hand scale. This locates a point. If the point happens to lie on one of the diagonal lines, the skin effect ratio is the value shown on that line. Of course, the high-frequency resistance is the d-c. resistance multiplied by this ratio. If the point located lies between diagonal lines the skin effect ratio will be estimated from the values on the adjacent lines. In the special case of copper wire of a known B. & S. gauge, the top scale may be used instead of the bottom scale.

If in use the wire is to be more or less coiled up, the high-frequency resistance will be higher than the values determined from these curves by an amount depending upon how tightly coiled it is to be. In such a case, these curves will still furnish a lower limit for the resistance of the conductor at the given wavelength or frequency.

It should be specially noticed that resistance material which is to have a skin effect ratio less than some value, such as 1001, is shown to be limited to a minimum resistance of a certain number of ohms per foot, regardless of what (non-magnetic) resistance material we may use.

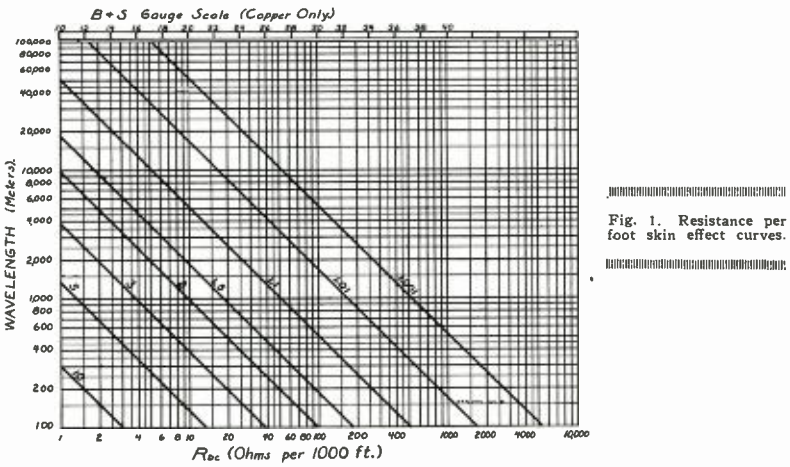


Fig. 1. Resistance per foot skin effect curves.

Piping system for power tube cooling water at radio station KDKA†

By E. M. Sollie*

In the design of a transmitting station of the size of KDKA there were many problems to be solved in the selection of apparatus. The transmitter was built with the intention of making the installation available for experimental purposes on high power, as well as for regular broadcasts on 50 kw. One of the many varied problems arising in the design was that of the selection of a water-cooling system for the power tubes.

A great deal of power must be dissipated by this system and great care was taken in the selection of the system. The filament power of each of the 100 kw. tubes is 10 kw., and for high power tests up to fourteen of these tubes are on at the same time, in addition to the smaller tubes in the intermediate amplifiers.

When operating as a 50 kw. transmitter, the water system must dissipate in the neighborhood of 125 kw., and when high power tests are conducted the water system must dissipate about 700 kw.

Two Water Systems

In the present layout of KDKA two water systems are used. One of these is used to furnish the cooling water for the power tubes and the second to cool the water flowing in the first system.

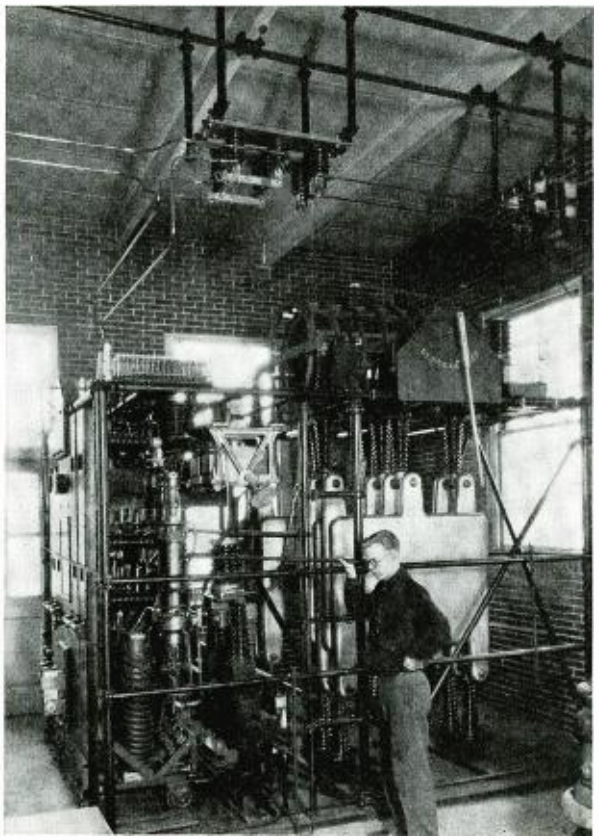
The tube water (as the first system is called), is stored in a sump located outside the station house. It is connected to the drains of the roof of the station house and thus utilizes rain water, which, because of its high resistivity, reduces electrolysis in the metal connections at the power tubes as much as possible. The water is obtained from this sump by means of either one or two centrifugal pumps which deliver the water to the distribution system at a pressure of 65 lb. The water is fed to tubes through a coil of hose of sufficient length to cut down the power loss and the electrolysis to a negligible amount. The water is removed from the tube in a similar way. After the water comes from the tubes, it flows by gravity through a heat interchanger back to the sump. This heat interchanger consists of a large number of small tubes mounted between two end plates (similar to steam boiler construction) and placed in a long iron pipe, or mounting, about 1½ ft. in diameter. The water from the tubes runs around these small pipes, and then flows back to the sump.

In order to obtain cooling water to be used in this heat interchanger, a large pond was constructed in front of the station house, approximately 150 ft. long, 75 ft. wide, and 8 ft. deep. It is supplied with water by seepage and surface drainage. One of the determining factors in the station's location was the ample supply of water available at all times.

Water is obtained from this pond by means of a second pump system which forces the pond water up the interchanger and through the tubes. The water then flows back to the pond. Cooling is obtained at the pond by means of surface evaporation. The heat interchangers are mounted, from the ceiling, in the basement of the station, and, therefore, no danger from freezing is encountered from this source. To provide a further guard against freezing, the pipes to and from both the pond and the sump are laid underground a sufficient amount.

In addition to providing cooling for the power tubes, water-cooling is also furnished for the rectifier systems and for the induction voltage regulators. These rectifier tubes are immersed in an oil bath, which, in turn, is cooled by means of the water system. This also applies to the induction voltage regulators which are in an oil bath with circulating water coils. The water for this system is obtained from the pond, and utilizes either the pressure drop across the heat interchangers or pressure obtained from a small auxiliary pump. Each of the 100 kw. tubes has 25 gallons of water passing through the water jacket surrounding the plate of the tube and in addition to this amount, 2 gallons is

(*Concluded on page* 35)



Broadcast power amplifier. Notice the four large amplifier tubes. Mr. Sollie, station engineer, makes hourly tests to be sure the water passing through the tubes is not boiling. This is accomplished by listening to the flow of the water through a hollow Micarta tube.

†*From Piping, Heating and Air Conditioning, October, 1931.*

**Radio Operations Department, Westinghouse Electric and Manufacturing Company, East Pitsburgh, Pa.*

Composition type resistors for radio receivers

By Leon Podolsky*

THE past few years have seen radical changes in radio receiver design, not least among which has been the change from voltage divider units to the use of individual resistors for each stage of the receiver. This change has been apparent not only in receiver design, but also in the many outgrowths of the radio industry employing vacuum tubes.

The demand for individual resistors for plate and bias voltages of each stage of the receiver, or other vacuum tube circuit, created a problem for the design engineers which was not easily met. The comparatively large wire-wound resistors available were too expensive to use in quantities without driving up the production costs of the device beyond reasonable limits.

Several companies throughout the country began the manufacture of individual resistor units which solved the problem completely. These resistors were small in size, low in cost and could be manufactured with reasonable engineering accuracy. This trio had instantaneous appeal to receiver designers.

Engineers term the type of resistor of which we speak a "composition type" resistor. This has been so because of the construction and method of manufacture of these units. There are at the present time approximately twelve companies in the United States and Canada manufacturing these resistors. Their individual engineering departments have spent several years in research and development of their several products and the data taken by these companies in their development work would fill many volumes. Each of the manufacturers has developed his own materials and processes and due to the highly competitive nature of the radio and associated industries these have been guarded jealously.

The materials which go into the making of composition resistors are, generally: conducting material, which is usually some form of carbon because of its high resistivity in finely divided form, some inert material which is used for filler and insulator between particles of conducting material, and some binding material such as gums or resins. These materials are treated in various ways to produce a uniform mechanical colloid, which is then extruded, or molded, in specially constructed machines, except in the filament type of resistor, where the material is coated on a glass filament. The processes of treatment of the raw materials and the steps in manufacture used by the several companies are so numerous and yet so closely guarded that it is impossible to go into detail here in regard to them.

There are many difficulties which may be caused by faulty resistors in a radio receiver or other vacuum tube circuit application, but these may be classed generally as follows:

1. The complete inoperation of the receiver or other device. (a) Due to complete failure of component resistors such as plate or grid units.

2. Falling off or faulty performance. (a) May be caused by resistors having changed appreciably in value. The following effects may be apparent:
   (1) Oscillation.
   (2) Overloading and distortion.
   (3) Weak output.
   (4) Noise.

Having outlined some few of the troubles which might be caused by defective or inferior resistors, let us consider the conditions which resistors must meet in the field in order to determine the qualifications of a satisfactory unit:

1. The device may operate continuously over a long period of time or may remain idle for a similar period.

2. Fluctuating currents in the circuits may cause considerably different voltage drops across the resistors at various periods of operation.

3. The device may be operated intermittently for short periods causing the resistors to heat and cool rapidly.

4. The receiver or other device may be operated at extreme climatic conditions as to temperature and humidity.

From the foregoing certain tests make themselves obvious to the technician who would perform them to determine the comparative merits of various resistors:

1. Shelf life tests and life tests at rated load for considerable periods of time.

2. Resistance measurements at several voltages (none to create wattage dissipation greater than rating) to determine changes in resistance with varying circuit conditions.

3. Cycle tests of short periods of operation at rated load and a cooling interval to determine the result of heating and cooling strains.

4. Resistance measurements at various reasonable temperatures to determine the temperature coefficient of the units.

5. Tests at high relative humidity to observe the effect of moisture on the resistance value.

6. Noise tests to determine the amount of microphonic noise created by the resistor while operating at rated load.

It is, of course, impossible to outline here an exact test procedure or state limits for these various tests as these are strictly the prerogative of the purchaser and must be adapted to his needs. It is strongly urged, however, that technicians bear in mind that this type of resistor is not intended to be a precision unit and that in order to meet the demand for a small, inexpensive resistor certain sacrifices in performance and compromises from the characteristics of wire-wound resistors have had to be made.

Standardization is necessary in this offspring of the radio industry. There are at present a multiplicity of wattage ratings such as 1/8, 1/4, 1/3, 1/2. 1, 2. 3, and 5 watts, all of which vary with the physical size of the various manufacturers' units. Some standard rating in terms of the physical dimensions of the units and their surface temperature rise under various conditions, such as enclosure, as is common practice in the wire-wound resistor industry, is still necessary. The major difficulty in standardization is much the same in this industry as it was in the earlier days of the radio industry generally, namely: The reluctance of the various manufacturers to cooperate due to the keen competition existent and the necessary secrecy of the workings of their various engineering departments.

All in all, however, considering the general requirements of radio receivers, amplifiers, etc., these composition resistors have met, and are meeting, the needs of the radio and associated industries most satisfactorily. It is sufficiently indicative that a good composition type resistor is satisfactory to engineering requirements when it is realized that one of the leading resistor manufacturers, supplying the largest radio producers in America, showed a rejection tally of only one-tenth of one per cent of the total units supplied for the period of a year.

*Engineering Department, Erie Resistor Co.

Probable future increase in available radio channels

By S. R. WINTERS

LIFTING the veil of radio in the future—5 years hence—Lieutenant-Commander T. A. M. Craven of the Radio Division of the Bureau of Engineering, United States Navy Department, foresees an addition of 1,682 channels for radio telegraph communication. This increase from the present available 2,240 frequencies to a total of 3,922, he anticipates, will be the fruition of advanced engineering practices —a permissible closer separation of the channels due to more precise frequency control methods and other advances in technical progress.

This increase in radio telegraph avenues of communication, according to the forecast of Lieutenant-Commander Craven, would be distributed over three bands of services, as follows: In the low and medium-frequency band, the number of available channels would increase from 502 to 649, a gain of 147 frequencies; in the continental high-frequency band, there would be an appreciable jump from 639 to 1,398 channels, a gain of 759 available frequencies; in the trans-oceanic high-frequency band there would be a correspondingly large growth—from 624 to 1,400 frequencies —a gain of 776 channels. Add to these increases the 475 radio telegraph avenues in the broadcast band and the number of usable frequencies for code communication has mounted to a total of 3,922, a gain of 1,682 channels.

This same degree of optimism, however, is not applied to the broadcast band. Any closer separation than 10 kilocycles for broadcasting would sacrifice the quality of music which is so desirable in this type of radio service. Furthermore, in an elaborate statistical array outlining the diversity of uses for radio channels the world over, this naval radio engineer notes that the cost of constructing a broadcasting station varies from $25,000 to $500,000. If, he indicates, the power factor ranges from 100 to 50,000 watts there is, of course, a corresponding wide variation in the coverage of a broadcasting station—from 50 to 1,000 miles. While the 10-kilocycle separation in broadcasting channels admits of only 96 avenues of communication for radio telephony—40 cleared, 43 regional, and 6 local channels—there are in the frequency band from 550 to 1,500 kilocycles, 475 radio telegraph channels, with only a 2-kilocycle separation.

The world-encompassing chart showing the distribution of radio channels to various services and the physical factors which make for their advantageous use, indicates that there is a progressive decline in the cost of radio stations as the channels employed vary from low to high frequencies. For instance, the cost of a station using the band of frequencies from 10 to 70 kilocycles—extremely long waves—ranges from $1,000,000 to $3,000,000 and the power necessary to give maximum service is computed to be 200,000 watts. This type of station is designed for communication over distances exceeding 2,000 miles. On the other hand, in the high-frequency band from 6,000 to 6,150 kilocycles the cost of a station varies from $250,000 to $1,000,000 and with variable power factors from 20,000 to 50,000 watts the coverage ranges from 500 to 8,000 miles.

In point-to-point radio communication is foreseen a possible advance in technical progress. This would take the form of a narrower allowable separation of the channels, thus increasing the available frequencies. However, at present, of the 162 channels in point-to-point service, 64 must not produce interference in other North American nations—13 are shared with Canada and 5 with Newfoundland, thus leaving 80 cleared channels for point-to-point communication.

Of the 90 channels assigned to government service, 32 are cleared avenues, 12 are shared with Newfoundland and 3 with Canada, 42 are in the mobile service, 37 of which are shielded from interference. In the allocation of radio frequencies to the various government services, it is recalled that another naval radio-man—Captain S. C. Hooper, director of the Naval Communication Service—has expressed the opinion that this particular administration of radio should be taken out of the jurisdiction of the Federal Radio Commission and restored to the Radio Division of the United States Department of Commerce.

It requires 53 different entries on a large, unwieldy chart for Lieutenant-Commander Craven to indicate the assignments of frequencies for various services throughout the world—these ranging from 10 to 23,000 kilocycles. The various services include fixed, mobile and mixed, coastal-fixed, non-commercial, mobile and point-to-point, radio beacons, air mobile, government mobile, broadcasting, amateurs, experimental visual broadcasting, general communication, and these are repeated time and again as several different bands of frequencies are assigned the same service. Seventeen parallel columns, each containing 53 different entries or a total of 901, are necessary to merely mention the services, and give figures as to coverage of stations, power required, cost of stations, width of channel, number of standard telephone channels in bands, and a survey of the channels as used in the United States. Withal, this is a complete and yet panoramic view showing the present general uses of radio frequencies, with respect to regional, general and international services.

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Japan to manufacture submarine telegraph cables

After considerable effort and study the production of submarine telegraphic cable will be started shortly by the Sumitomo Works. This project has been worked out with the assistance of the Department of Communications and its success will depend largely on substantial orders to be placed by this department for this type of cable. It is understood that the Minister of Communications signed a formal contract with the Sumitomo Cable Works on the 13th of August covering their requirements for deliveries during the next six months.

HOW TO USE THE RESISTOR CODE

THE various manufacturing members of the RMA will adopt this code on all new production so that on all future receivers the value of a resistor may be told at a glance.

The code identifies resistors by means of 3 colors, known as "body," "tip" and "dot" colors. The body color is the main color of the resistor and represents the first figure of the resistance value. The tip color is the color of the end of the resistor and represents the second figure of the resistance value. The dot color (sometimes a narrow band is used instead of a dot) indicates the number of ciphers following the first two figures.

Example: red body 2—green tip 5—orange dot or band 000—resistor value 25,000 ohms.

The figures represented by the various colors are given in the following table:

First Figure	Second Figure	Ciphers
0—Black	0—Black	None —Black
1—Brown	1—Brown	0 —Brown
2—Red	2—Red	00 —Red
3—Orange	3—Orange	000 —Orange
4—Yellow	4—Yellow	0000 —Yellow
5—Green	5—Green	00000 —Green
6—Blue	6—Blue	000000—Blue
7—Violet	7—Violet	
8—Gray	8—Gray	
9—White	9—White	

It should be borne in mind that this code applies only to the newer model receivers that are now appearing on the market. It will be a safe practice on all older model receivers to refer to the manufacturer's service notes for the color code on earlier model sets.

Using the new code, if a resistor is found which has a green body with a red tip and a yellow dot or band, it will be known that the value of that resistor is 520,000 ohms.

One of these handy code charts may be procured from the Erie Resistor Corpn., Erie, Penn.

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EUROPEAN RADIO CONCERNS COMBINE PATENT RIGHTS

EUROPE'S two largest radio manufacturing organizations will be united in the closest cooperation, especially in the spheres of patent rights and technical secrets, by means of the newly announced agreement between the German Telefunken Company and the Dutch N. V. Phillips concern. The agreement not only puts an end to the pending legal suits but divides the whole-world territory into spheres of influence between the two. Basic patents are controlled by both concerns, which will be shared according to the terms of the agreement. Rationalization of the respective plants is the second result—a decrease in the number of types of apparatus, use of standardized parts and simplified production methods all are foreseen.

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CHICAGO SECTION OF I. R. E. ELECTS 1932 OFFICERS

At the monthly meeting of the Chicago section of the Institute of Radio Engineers, held on December 4, the following officers for 1932 were elected: J. Barton Hoag, Ph.D, chairman; Robert M. Arnold, vice chairman; Donald H. Miller, secretary-treasurer.

E. W. Ritter, head of tube development work, for RCA-Radiotron Co., Inc., Harrison, N. J., delivered an interesting paper on "The Use of Suppressor Grids in Pentodes."

1932

IMPORTANT indications of a swing upward in the volume of manufactured products and sales in 1932 are the National Government's plans, now maturing, for large construction expenditures, centering particularly on projects that involve large payments for labor and for manufactured materials. Also, the business of large political conventions and a presidential election hold for radio, particularly, real promise of increased expenditures for receivers, tubes and accessories.

Probable numerous extensions of public-address installations in all parts of the country will create a demand for the latest and best in microphones, amplifiers, loudspeakers, condensers, resistors, vacuum tubes, transformers, pickups, coils, name plates, sockets, wire and all of the other hundred and one raw materials that go into the making of these devices.

CONTINUOUS, INSTANTANEOUS SIGNALING SYSTEM FOR POLICE CARS

(*Concluded from page* 12)

ping on police signals on long or short waves may be prevented. At the present time criminals can tune in on messages sent to police cars. In Michigan, for example, in the effort to circumvent this, short-wave receivers cannot be installed legally in any but police autos. Two years ago short-wave sets were not used by criminals, and now it becomes necessary to use the "scrambler" device such as resorted to in transoceanic phone conversations in order that messages will be unintelligible to the merely inquisitive short-wave listener.

The "scrambler" converts the spoken word into meaningless syllables through a means of interchanging frequencies, but can be "unscrambled" by proper receiving equipment. The use of code is at present time most valuable.

Recent statements on the subject have been issued by William D. Terrell, Director of Radio of the Department of Commerce, and the Federal Radio Commission. The view is held that police departments using radio systems must keep ahead of the ordinary development and use of short-wave radio. They must make such improvements and changes from time to time in their apparatus to keep "several jumps" ahead of the organized crime rackets they are combating.

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RCA DIVIDENDS

At the meeting of the Board of Directors of the Radio Corporation of America, held on December 3, 1931, the following dividends were declared:

A quarterly dividend of one and three-quarters per cent. (1¾%), (87½c. per share) on the "A" preferred stock for the fourth quarter of the year 1931, payable January 1, 1932 to holders of "A" preferred stock of record December 14th, 1931.

An annual dividend of seven per cent. (7%) (35c. per share), for the year 1931 on the original preferred stock, payable January 1, 1932 to holders of original preferred stock of record December 14, 1931.

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THE DESIGN AND ACOUSTICS OF BROADCAST STUDIOS

(*Concluded from page* 16)

standard accepted materials when properly used will produce excellent results.

Another consideration in the interior design of the modern studio is that of decoration. This may not seem important, but it is a known fact that the mood and performance of the artist is greatly influenced by his surroundings. Where pictures and designs are to be painted on the acoustic material itself, care should be taken that the pores of the material are not closed with the paint. If painting the material stiffens the membranes, the absorption efficiency is reduced. The effect of spraying paint is not as serious as that of applying it with a brush. It has been found that acoustic plasters may be sprayed with special paint without serious effect, also that materials with high porosity and large openings in the surface may be sprayed without noticeable change in absorption power. It is certain that the interior of the modern studio is anything but depressing, and the artist need only overcome the natural feeling of strangeness in the studio to feel quite comfortable.

BOOK REVIEW

RADIO PHYSICS COURSE. By Alfred A. Ghirardi. 990 pages, over 500 illustrations. Published by Radio Technical Publishing Co., 22 West 21st St., New York City. Price, $3.50.

A new, complete non-mathematical course in sound and electricity. Free use is made of the modern electron theory without going beyond the grasp of the student.

The chapter on sound gives the student a clear understanding of the production of sound waves by the various musical instruments and the human voice. Their characteristics are studied with the definite object of enabling the reader to understand just what the radio transmitting and receiving equipment must accomplish for satisfactory broadcasting of music and speech.

The chapters on vacuum tubes, superheterodynes, electric receivers, short waves, television and the talkies have been brought right up to the minute with complete descriptions of all the new developments brought out during the past year. A complete course on servicing of receiving equipment has been included.

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ELECTRIC EYE TO SORT MAIL IN RAILROAD TERMINALS

THE photoelectric relay is the unerring eye of a robot railway mail sorter, in the functioning of a new type of equipment developed by the Cleveland Electric Tramrail Division of the Cleveland Crane & Engineering Company in collaboration with General Electric engineers. This equipment, designed to be of great help in railroad terminals. will automatically route sacks of mail to the proper railroad cars.

Each sack is loaded with mail for one city. When the sack is full, it is placed in a tray container which travels on an automatic conveyor system of the overhead monorail type. The containers are made up into "trains" pulled along at about five miles an hour by a motor-driven carrier, as many as 50 containers making up a train. The little mail train has for its destination a number of railway mail cars, each going to a different city. As the train goes by, the mail sacks are automatically sorted and dropped on the loading platform near the proper railway cars.

An ingenious arrangement of photoelectric relays is the basis of this sorting. On each mail bag tray conveyor are a photoelectric relay and solenoid mechanism which travel along the conveyor with the tray. The photoelectric tube, when actuated by a beam of light; causes the relay to release the mail sacks by means of the solenoid mechanism.

In a demonstration arrangement in Cincinnati there were 34 possible destinations for the mail trays. The light source (which actuates the photoelectric relay) at each railway mail car was arranged to shine its beam on a different plane from all the others, and at one or the other of two angles. In order to cause delivery of any given sack of mail at a particular destination, it is merely necessary to set the photoelectric tube on a suitable plane and at the proper angle to intercept a particular light beam and no other. Thus only those mail sacks whose photoelectric tubes are correctly set are delivered; if the tubes are set correctly, the mail is automatically delivered.

The setting of the photoelectric equipment takes place at the dispatching platform, immediately after loading. The dispatcher, as the mail passes him on the conveyor, inspects the destination tag on each sack and sets the relay equipment accordingly. In order to allow the operators plenty of time for loading and dispatching, an automatic arrangement of control slows down the conveyor at that point, speeding it up again after leaving.

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A FORM OF BRIBERY

Mose was asked how he voted.

"Well, suh," said the old darky, "de day befoh de election de Republicans gib me five dollahs, and on election day de Democrats gib me three, so I voted foh de Democrats. I figured dey was less corrupt."

Mose might have been arrested for selling his vote. But sales of deciding votes in the selection of equipment, by public officials and purchasing agents, go on every day, disguised as entertainment. Dinners and drinks have come to be accepted as legitimate ways of obtaining business, reported as a matter of course—though sometimes the actual items appear to be transubstantiated—on expense accounts. Agents, both public and private, receive these perquisites, this lagniappe; they would be horrified to have them called tips. Men, too, who would never think of taking a cash payment.

All other things being equal, one will nearly always purchase from a friend.

Competition for friendship has led to lavish expenditures, all part of the cost of selling and added to the price of the goods.

As long as competitors entertain. few companies will do away with such petty bribery, and prospects feel that they might as well have their share of largess. Often it is equally boring to the man with goods to sell and the one with purchasing power. Though they wouldn't admit it, most middle-aged prospects would rather be home in bed than frolicking in a cabaret, and salesmen with sensibilities are ashamed of that way of angling for business.

Abolition of such a system would be welcome, doubtless, by harassed executives, as well as by the representatives, both selling and buying, who are supposed to benefit personally.

"My company," said a traveling representative, "has discharged most of its draftsmen, and cut the time and rate of those remaining. Yet, even in depression, my expense accounts for night clubs and liquors are passed without question."

Entertainment as a way of putting money in circulation admits of very feeble defense, because such expenditures are not turned into legitimate business channels.

It is a sorry state of affairs, indeed, when companies feel compelled, in an effort to sell their goods, to patronize bootleggers, though they have to let the draftsmen go. Put into better quality or given to the buyer in the form of lower prices, this item of expense might have a real effect in stimulating business.—*Engineering Experiment Station News, Ohio State University.*

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PIPING SYSTEM FOR POWER TUBE COOLING WATER AT RADIO STATION KDKA

(*Concluded from page* 31)

passed through the center of the tube to cool the grid structure, thus making a total of 27 gallons per tube per minute. The smaller 20 kw. tubes are about 8 to 10 gallons of cooling water.

Incoming water from the sump has a temperature range from 30 C to 50 C and the water temperature after passing through the tubes ranges from 100 to 140 F. The cooling water from the pond ranges from 12 to 32 C. The above temperature ranges correspond to the winter and summer operating conditions respectively. The temperature of the voltage regulators is kept at or below 40 C, while the temperature of the rectifier tanks is kept at or below 32 C.

The water system has been installed in duplicate, two pumps being placed in each system and two heat interchangers provided. Valves are inserted in the system to enable cutting off any part so that work may be done on it without shutting down the whole system. This is important because shutdowns in a broadcasting station are serious, entailing a loss of time on the air.

New tubes

AMONG the new vacuum tubes recently announced are the following: Cable Radio and Tube Corporation announces the Speed Triple Twin developed to function as a detector or audio-frequency tube. It is stated that the Triple-Twin will function more efficiently than three or more other type tubes, affording economy in chassis construction, greater sensitivity in operation, with triple the output of the 245, and double the output of the 247, without increase in plate voltages.

A New Super-Control R-F. Amplifier Pentode

RCA-Radiotron Company, Inc., and E. T. Cunningham, Inc., have announced a new tube called the super-control radio-frequency amplifier pentode. The type designation is Radiotron RCA-239 and Cunningham C-239.

This new tube is an addition to the automobile tube series and incorporates a number of new design features which make it particularly suitable for use in new designs of automobile receivers and radio sets intended for use on 110 volt direct current lines.

The '39 is recommended for use as a radio-frequency amplifier, intermediate-frequency amplifier, and superheterodyne first detector. It is very effective in reducing cross modulation and modulation distortion over the usual range of received signals. Its design, like that of the '35, is such as to permit easy control of a large range of signal voltages without the use of special local-distance controls. This super-control characteristic makes the tube uniquely suitable for use in receivers designed for automatic volume control.

This new tube is a five-electrode design, hence the name, pentode. In addition to the usual cathode, grid, screen, and plate elements, a fifth element called the suppressor is placed between the screen and the plate. This suppressor is connected within the tube to the cathode and effectively eliminates the secondary emission effects which otherwise limit the voltage swing permissible in screen-grid tubes if operated with a low plate voltage, that is, at a plate voltage approximately equal to the screen voltage. The suppressor in this new radio-frequency pentode therefore makes possible the operation of this new type of tube with excellent results where the plate voltage available is limited, as for example in sets designed for operation on 110-volt direct current.

The use of the suppressor makes possible further advantages tending toward better set performances, since the fifth element permits of greater flexibility in securing a high mutual conductance and a high plate resistance, even though the tube may be operated at a low supply voltage.

The '39 utilizes a coated cathode of the heater type designed for direct current operation. Owing to the special cathode construction, the heater voltage may vary during the charge and discharge cycles of the automobile storage battery, without affecting seriously the performance or serviceableness of this tube. No resistor in the heater circuit is required for operation from a six-volt battery.

For operation in receivers designed for direct-current power lines, the heaters of two or more of these tubes may be connected in series. Since the current rating of this tube is the same as the '36, '37, and '38, that is 0.3 amperes, any heater combination of these tubes in series is practical, provided the current is adjusted to the proper value.

This new tube is not interchangeable with any other type of Radiotron or Cunningham vacuum tube.

The preliminary rating and characteristics of the RCA-239 and the C-239 are as follows:

TENTATIVE RATING AND CHARACTERISTICS

Heater voltage			6.3 volts d-c.
Heater current			0.3 amperes
Plate voltage..	90*	135	180 volts max.
Screen voltage, maximum....	90*	90	90 volts
Grid voltage, variable.....	—3*	—3	—3 volts min.
Plate current.	4.4	4.4	4.5 milliamp.
Screen current	1.3	1.2	1.2 milliamp.
Plate resistance.....	375,000	540,000	750,000 ohms.
Amplification factor.....	360	530	750
Mutual conductance.....	960	980	1,000 micromhos
Mutual conductance at —30 volts bias	10	10	10 micromhos
—40 volts bias	very small, but not zero		

Interelectrode capacitances—

Effective grid-plate capacitance	0.007 $\mu\mu$f. maximum
Input capacitance.....	4 $\mu\mu$f.
Output capacitance.....	10 $\mu\mu$f.
Overall dimensions—	
Length	4 3/16"—4 11/16"
Diameter	1 9/16"
Cap	0.346"—0.369"
Bulb	S-12
Base	Small 5 Prong

*Recommended values for use in receivers designed for 110-volt d-c. operation.

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Arcturus Develops New Construction for Automobile Tubes

With automobile sets coming into wider use, it became evident that there was considerable room for improvement in types '36, '37 and '38 automobile receiving tubes. Longer and more dependable life was highly desirable; it was also advisable to eliminate fluctuations in current draw caused by the jarring of the coiled filament against the insulator which resulted in noisy and defective reception.

To overcome the deficiencies characterized in this series of tubes and in bringing about the much desired improvements, Arcturus ultilized a new "M" filament which added to the life and was confined in such a way as to eliminate fluctuation in current as well as noisy reception. The chief advantages of this new filament and construction are:

1. An "M" filament is used instead of a coiled filament providing a more rugged and dependable element. This is the *first* time an "M" filament has been used in indirectly heated cathode receiving tubes as a heater.

2. The Arcturus "M" filament is non-inductive and reduces hum to a negligible factor. Because of this, these types, besides being used with d-c. sources of filament voltages, can be used with a-c.—a factor of considerable importance to set manufacturers.

3. Many of the failures in similar types of other makes were due to the breaking down of the insulator because of the extremely high temperature of portions of the coiled filaments. The insulator used in these Arcturus tubes will withstand higher temperatures than 2600° centigrade, although the maximum operating temperature of the 136A, 137A and 138A is less than 1700° centigrade—providing a generous safety factor.

4. While the filament current is apt to vary appreciably where coiled filaments are used and even fluctuates if the tubes are jarred (because of variable contact between the insulator and the filament) this is obviated with the "M" filament tubes. This filament is held securely in position throughout its length by a rugged insulator, which prevents shorts and leakages and insures uniform filament current that will not fluctuate even though the tubes are jarred. This is of particular importance when the tubes are connected in series, as for 110 volt d-c. operation.

5. The variable contact between the insulator and the coiled filament was responsible for noises in reception due to scraping. These noises are entirely eliminated with the new Arcturus construction.

6. Because of the uniform filament temperature insured by the "M" filament (elimination of "hot spots"), the life of this filament is appreciably longer than the coiled filament which is used in other tubes.

7. The 136A, 137A and 138A are interchangeable with the corresponding '36, '37 and '38 types and like all Arcturus tubes these three types are quick-acting.

Because of the broader use for these tubes including the a-c. field, they have been designated as types 136A, 137A and 138A. The rugged design and compact size of these types meet the specifications for a universal receiver to operate on either a-c. or d-c.

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Sylvania 239

The Sylvania Division of the Hygrade Sylvania Corporation announces a new tube. the SY-239. This tube is an r-f. pentode, having super-control characteristics. This tube belongs to the automobile series, which already includes the SY-236, SY-237 and SY-238.

The SY-239 is a super-control pentode for use as a radio-frequency and intermediate-frequency amplifier in automobile receivers or any receiver operating from 110-volt power line. The term "super-control" is used to indicate that the tube is similar in characteristics to the "variable" or "multi" mu tubes, Types SY-235 and SY-551.

The SY-239 is designed with a "suppressor" grid between the screen and plate. The suppressor grid is connected to the cathode, thus operating at a much lower potential than the elements between which it is placed, and retarding the interchange of secondary electrons between these elements. It is this effect in the normal screen grid tube which makes it necessary to operate the plate at voltages well above the screen-grid potential in order to secure high plate resistance. With the addition of the suppressor it is possible to operate the plate at the same, or even lower, voltages than that applied to the screen without serious loss in gain.

The SY-239 is effective in reducing modulation distortion and cross-talk. In the average automobile installation the advantages of this tube will not be as readily apparent. because of the relatively small antenna pickup obtained due to the short antenna. The advantages of this tube will be more fully realized with d-c. line operated receivers which employ a longer antenna. and hence are subjected to considerably higher input signals.

The cathode structure is similar to that employed in the SY-236. It is designed to insure adequate performance over the normal voltage variations of an automobile battery during the charge and discharge. This feature, together with that general freedom from microphonic and battery circuit disturbances of the heater cathode type, makes this new tube especially suited for use in automobile receivers.

NEWS OF THE INDUSTRY

DEJUR AMSCO IN CANADA

Opening of a new factory in Toronto, Canada, that will be completely equipped for the manufacture of DeJur-Amsco radio products is announced by Harry DeJur, president of the DeJur Amsco Corporation.

The Canadian factory, which will represent an investment of nearly a million dollars, will be in operation early in the new year.

"Consistent increase in our business with set manufacturers in Canada and other parts of the British Empire made it necessary for us to join the group of American corporations who have found it profitable to meet the barriers presented by the fast rising tariff walls against products of American manufacture," Mr. DeJur says. "The demand for our variable condensers and other radio parts has steadily increased throughout this year and the tariff on radios and radio products from this country has presented an ever increasing burden. The Canadian factory in Toronto will be entirely equipped with Canadian machinery and also will be entirely manned by Canadian workmen."

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MALLORY PURCHASES YAXLEY

On October 15, 1931, P. R. Mallory & Co., Inc., Indianapolis, pioneers in the development of dry electrolytic condensers sold under the trade name "Elkon," purchased the Yaxley Manufacturing Company of Chicago. The "Yaxley" name has been for twenty-five years identified with a line of quality electrical parts known throughout the world. The Yaxley company will receive full benefit of the Mallory company's engineering, chemical and metallurgical facilities.

Ray F. Sparrow will remain in his executive capacity as sales manager, in full charge of service in all its aspects to the many Yaxley customers.

▲

C. C. HENRY NOW CHIEF ENGINEER OF LEAR DEVELOPMENTS

Wm. P. Lear announces the appointment of C. C. Henry as chief engineer of Lear Developments, Inc., Chicago, Illinois. Mr. Henry has long been identified with the radio and electrical industry. From 1924 to 1927 he served as assistant general manager of Federal Telephone and Telegraph Company, later he was engineer for Sonora Phonograph Company. More recently he was associated with Grigsby-Grunow Company, where for over three years he was chief executive of quality control of radio and refrigerator products. Mr. Henry has specialized in research, merchandising and material control phases of radio and electrical specialty manufacturing, bringing to the Lear organization a wealth of experience and knowledge. He is an alumnus of the Massachusetts Institute of Technology; and a war-time instructor in the Harvard Naval Radio School.

ARNOLD APPOINTED SENTINEL CHIEF ENGINEER

Announcement has been made by John T. Beatty, president of the United Air Cleaner Corp., Chicago, manufacturer of Sentinel radio receiving sets, of the appointment of Robert M. Arnold as chief engineer and a vice-president of the company. He returns to the Sentinel organization after six months as chief engineer of the radio division of the Grigsby-Grunow Co.

Mr. Arnold is one of the foremost radio engineers in the country and has made many notable contributions to the science. He received his technical education at the Massachusetts Institute of Technology. In 1922 he became a test engineer for the Commonwealth Edison Co., engaging in the development of carrier-frequency communication equipment. In 1924 he was chief engineer of the Krasco Manufacturing Co., makers of Monarch radios, following which he was consulting engineer for the Vesta Battery Corp. and the Mellotrone Tube Corp., and also did consultation work in connection with the design, equipment and construction of radio stations. In 1928 he became associated with the Development and Research Department of the American Telephone & Telegraph Co., leaving in 1930 to become chief engineer of the United Air Cleaner Corp., to which company he now returns.

ROBERT M. ARNOLD
Vice-President and Chief Engineer, United Air Cleaner Corp.

Mr. Arnold is an associate member of the Institute of Radio Engineers, the American Institute of Electrical Engineers, and the Western Society of Engineers; a member of the Radio Club of America, and a junior member of the American Society of Mechanical Engineers. He is a past president of the Radio Engineers' Club of Chicago, and for 1932 is vice-chairman of the Chicago Section of the Institute of Radio Engineers.

▲

COMMERCIAL RADIO LABORATORY

The United Radio Laboratories, 27 Howard St., Arlington, Mass., Richard F. Shea, president and general manager, offer to radio manufacturers an up-to-date consulting service, based on many years of experience in the radio industry.

▲

FRED WILLIAMS JOINS MALLORY

Fred D. Williams has been elected vice-president and general manager of P. R. Mallory & Company of New York and Indianapolis, it was announced on Dec. 11. Mr. Williams has severed his connection with the National Carbon Company, for which organization he has been manager of Eveready Raytheon tube division and, prior to that, vice-president of the Raytheon Manufacturing Company, which was taken over by National Carbon.

In his new work, Mr. Williams will be concerned with P. R. Mallory & Company, and its subsidiaries, Elkon, Inc., Knapp Electric Company, and Yaxley Manufacturing Company. One of the principal Elkon products is Elkonite, a copper tungsten alloy having wide application, particularly in the welding industry. Also, the Mallory company is the largest supplier of contacts for ignition and relay applications, besides being a pioneer in dry electrolytic condensers, which it markets under the trade name Elkon.

▲

WIRE, COILS, ALLOYS AND RIBBONS

Herbert S. Glasby, associated with the Acme Wire Company of New Haven, Conn., for the past few years, has opened a sales office at 123 South Broad Street, Philadelphia, Pa. In addition to handling the line of magnet wire, coils, varnished insulations, and Parvolt condensers made by Acme, he will represent the National Harris Wire Company of Newark, N. J., manufacturers of high resistance alloy wires and ribbons for electrical and mechanical purposes; the Macallen Company of Boston, Mass., producers of mica sheet tapes and molded articles, and the Waterbury Button Company of Waterbury, Conn., makers of bakelite, dureg, and other high dielectric molded products, and metal goods for the electrical trade.

▲

FOSTER D. SNELL, INC.

Harry J. Hosking has resigned his position in the research laboratory of the Roessler and Hasslacher Chemical Co. at Niagara Falls, N. Y., to take up similar work with Foster D. Snell, Inc., consulting chemists and engineers, 130 Clinton St., Brooklyn, N. Y.

W. C. Pinkerton has taken a position as industrial representative with Foster D. Snell, Inc. He was previously with the International Exposition Co.

RADIO SERVICE ORGANIZATION

Group action is essential to the success of any enterprise, and radio servicing is no exception. The Institute of Radio Service Men, 720 South Dearborn St., Chicago, was formed in order that there might be a medium through which the radio servicemen might accomplish those things which individually servicemen can not do.

The fallacy of the plan by which the servicemen stumbled blindly along without any particular aim, and without anyone to sponsor their cause has been demonstrated. Henceforth, the service branch of the industry, a highly important one, will assume a ranking position in the radio field, through the Institute, which takes the responsibility for placing radio servicemen in their proper status.

The organization must have prestige in order to be effective. It must be conversant with the problems with which it is coping. It must be familiar with the industry. The Institute of Radio Service Men was started by a group of men who are fully cognizant of service problems from the standpoint of the servicemen and from the standpoint of the radio listeners. The managing directorate consists of three men who have been engaged in radio since its earliest days. Marcus Hinson, executive vice-president, is a retailer and operates a radio service station. He holds the office of vice-president of the Midwest Radio Trades Association, the dealers' organization in Chicago, having charge of the activities of the servicemen in the Chicago area for that group. K. A. Hathaway, executive secretary of the Institute of Radio Service Men, held the position of radio technical advisor on the staff of one of the Chicago newspapers for six years.

▲

ARCTURUS REDUCES PRICE OF SCREEN GRID TUBE

Effective December 14, the Arcturus Radio Tube Company, Newark, N. J., announced that it reduced the list price of the Type 112 d-c. screen-grid tube to $3.00.

▲

CORES FOR COILS

The Meyer Company, 1636 S. Homan Avenue, Chicago, Ill., announce that they have recently installed new and modern wood turning machinery for the production of wood bushings and wood cores for coil winding. This firm has been doing wood turning for the radio and furniture industry for many years and with the additional facilities is now in a position to quote reduced prices on this type of work.

Henry Meyer, general manager, informs us that readers of RADIO ENGINEERING may send blue prints from which samples will be turned.

▲

COLLEGE COURSE IN RADIO

There has been a long felt want in the radio field for a school of recognized standing, to give a complete, comprehensive well balanced course in radio communication, to be complete in itself and capable of being finished within a reasonable time. Realizing this need the University of Wisconsin. extension division in Milwaukee, is giving such a course to fit students for advanced places in radio activities. This is a new type of college training of a semi-professional nature, with the object of training young men for positions in a field between the skilled craftsman and the trained professional engineer.

All trades and professions are now demanding that the men participating in them shall be thoroughly trained in the theory and fundamentals of the trade or profession in question. The ever expanding science of radio is possibly more exacting than any other because of the technical nature of the subject and of the responsibilities upon the shoulders of an operator. A few years ago a man could be a fairly good operator or technician without any particular training, but today, if a man expects to succeed in this field he must be thoroughly grounded in the theory and practical applications of the fundamental principles of radio communication. The question has been to the serious-minded person, "Where can I secure such an education without taking a regular degree in engineering?"

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OUTPUT METER

The output meter No. 501, manufactured by Wireless Egert Engineering, Inc., 179 Varick St., New York City, is used for measuring output levels of receiving sets. The meter employs a tube rectifier which is energized by two dry cells. This instrument can be calibrated to give direct readings. The input impedance of the No. 501 output meter is 4,000 ohms. There is also a variable control of this instrument which provides for 30, 60 and 150-volt ranges. The instrument is encased in a black crystallized box with an aluminum panel.

▲

HOW PHILCO DOES IT

While sales in the radio industry in 1930 were only about 70 per cent of 1929, Philco's business went 100 per cent ahead of that year.

Sales for the present year are well ahead of the 1930-31 season, which was the best in the company's history.

According to vice-president Sayre M. Ramsdell, "Consistent advertising and sales promotion helped us rise from far down the line to a place among the leaders. Then came 1930, when conservative estimates for radio sales placed prospective volume at about 50 to 60 per cent of 1929 figures."

The fact that total Philco sales in 1930 were 100 per cent over 1929 is due largely to the introduction of the Baby Grand Philco. Other factors were:

1. Consistent national and local advertising.
2. Unusual sales promotion.
3. A plan of production control which placed Philco and its dealers in such good condition that a general dumping of radios on the market in no way affected the company's sets other than to emphasize their good position—*Ink*. December, 1931.

▲

CONTINENTAL CARBON, INC.

Continental Carbon, Inc., 13900 Lorain Avenue, Cleveland, Ohio (in Canada, Continental Carbon of Canada, Ltd., 89 Jarvis Street, Toronto) was the first to introduce the now popular wire terminaled, color lacquered, radio resistor unit, with terminals soldered to the copper plated resistor ends. They have been manufacturing the much used and well known line of Continental resistors since 1923.

This concern occupies a modern factory, equipped with latest automatic machinery to produce a uniform product of the highest quality. Strict factory and laboratory control and inspection are maintained to insure the production of a unit of the first grade. A research and development department is constantly on the alert to improve resistor characteristics and meet the customers' ever changing specifications and requirements.

Continental suppressors, used on radio equipped automobiles, have enjoyed in the past year a widespread and increased popularity, particularly the screw terminaled type, which the company introduced about twelve months ago. The resistor element in these units is enclosed and sealed in a ceramic tube chosen for both its mechanical and electrical properties.

▲

PHILLIPPI JOINS MALLORY

A. K. Phillippi, who has been associated with the Westinghouse Electric & Manufacturing Company in various engineering and manufacturing capacities for the past fourteen years, has resigned to accept the position of works manager, in charge of engineering and production, for the Yaxley Manufacturing Company of Chicago, a division of the P. R. Mallory & Co., Inc.

From 1921 to 1924 he was a member of the radio engineering department of the Westinghouse Electric & Manufacturing Company located at East Pittsburgh, Pennsylvania, and was then transferred to the Springfield, Massachusetts plant as resident radio engineer, in charge of design.

Mr. Phillippi brings to his new connection a thorough understanding of the requirements and problems confronting the uses of parts utilized in the fabrication of radio and electrical devices.

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KILOVOLTMETER MULTIPLIER

Kilovoltmeter multipliers are furnished for measurements of d-c. and a-c. up to 20,000 volts, such as encountered in broadcasting stations, intermediate voltage power transmission, dust precipitators, neon signs, X-ray crystalography, electron tube development and manufacturing, miscellaneous chemical plants, various industrial applications and educational institution laboratories.

The instruments are assembled in a cast aluminum box 5½ inches wide by 9 inches long, having a bakelite panel on which are mounted specially designed high voltage binding posts and low voltage binding posts for ground and meter connections. The high voltage binding posts are made of a ceramic which has a negligible surface and volume leakage. The dielectric strength of this ceramic is 25,000 volts for 1-16 inch thickness. The interior assembly is so mounted to the panel as to provide ample space between all high potential parts and the grounded box. These multipliers are not designed for use with potentials higher than 20 kilovolts.

These are manufactured by The Shallcross Mfg. Co., Collingdale, Penna.

▲

AN A-C. VOLTMETER FROM D-C. MILLIAMMETER

Now a miniature low-priced dry rectifier is made available by means of which a d-c. milliammeter may be employed as an a-c. voltmeter. Advantages are: Accuracy, low current drain, and uniform scale readings.

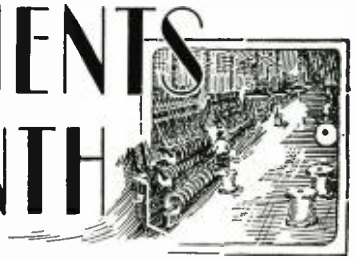
This useful device is manufactured by Leo Taussig, 1326 Gates Ave., Brooklyn, N. Y.

▲

FOREIGN IMPORTER WANTS RECEIVERS

Ulens, Gembloux, Belgium, desires exclusive representation of American manufacturers of radio receivers, tubes, loudspeakers and other radio products. The above address is either cable or post.

NEW DEVELOPMENTS OF THE MONTH



PRECISION METERS

With the improvements made in electrical measuring instruments in recent years it would seem that further betterment would be practically out of the question. But now the Sensitive Instrument Corporation, 4545 Bronx Boulevard, New York, issue their catalog No. 32, which describes and illustrates an advanced line of electrical precision meters.

The Model C Polyranger has 13 ranges in current and voltage. The accuracy is

to ¼ of 1 per cent. and the scale is 6½ inches.

The line includes ammeters, milliammeters, voltmeters, microammeters, etc., all of direct use in radio manufacture, laboratories, broadcast stations and in testing.

▲

FREQUENCY MONITORING EQUIPMENT FOR BROADCASTING STATIONS

To enable broadcasters to meet the rigid requirements of General Order No. 116, the General Radio Company has developed a new frequency monitor which indicates directly the deviation from channel frequency on a large pointer-type meter in the operating room. This equipment is simple and is easily installed and maintained by the station operating personnel. Its guaranteed accuracy, although set at a conservative figure, is well in excess of that demanded by the Commission, and with careful operation an even better accuracy can be obtained.

The essential element in the new monitor is a highly stable piezoelectric frequency standard which operates at a frequency differing from the assigned channel by exactly 1000 cycles per second (usually on the high-frequency side). Voltages from this standard and from the unmodulated master oscillator of the transmitter are supplied to a new type of audio-frequency meter which indicates directly and continuously the deviation of the resulting audio-frequency beat tone from 1000 cycles per second.

For example, if the transmitter is off-channel by 40 cycles per second on the high side, the beat-tone frequency is 960 cycles per second; if off-channel 40 cycles per second on the low side, the beat-tone frequency is 1040 cycles per second. Actually, the large meter dial is marked in cycles per second so that it reads "40 cycles high" or "40 cycles low," as the case may be. No calculations are required; the device is direct reading.

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UNIVERSAL A-C.—D-C. PORTABLE

For those whose profession or business necessitates traveling from one place to another the Ansley Universal A-C.-D-C. portable radio is available. This set operates on both alternating and direct current. The black or brown leatherette case measures only 9½ x 10½ x 16 inches—the weight complete is 23 pounds. The set uses the new six-volt heater type tubes, three 336, one 337, one 338 pentode and a 280 rectifier—six tubes in all.

This receiver is a development of the Ansley Radio Laboratory, 147 West 23d Street, New York City.

▲

CONDENSER MICROPHONES

Three new models of condenser microphones for every requirement of broadcasting, recording and public-address operation are announced by the Gates Radio and Supply Co., Quincy, Illinois. Bulletin No. 6 describes these new units.

▲

MICROPHONE STANDS

A new line of microphone stands is announced by the Eastern Mike-Stand Company, 168 Center St., New York City.

These stands, besides being properly made from a mechanical standpoint, are equipped with extra heavy bases to prevent the possibility of tipping.

A feature of the line is a double banquet

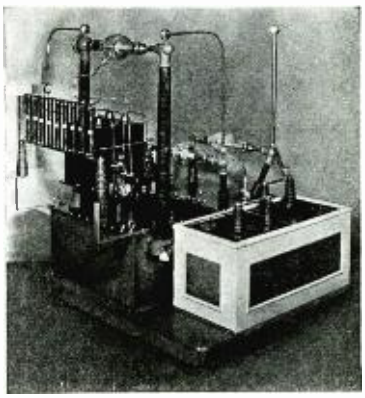
stand, especially designed to allow the after dinner speaker to sway from side to side without diminishing the voice pickup.

A circular describing the complete line of stands is available by writing to the Company.

X-RAY PICTURE IN 1/1000th OF A SECOND

A new Westinghouse three element X-ray tube and machine makes possible the taking of an X-ray snapshot in less than 1/1000th of a second. This enables physicians to see clearly, for positive diagnosis, the inside of a human body; up to this time blurred or hidden in X-days by the motion of the patient's muscles. This new instrument was shown for the first time at the Convention of the Radiological Society of North America at St. Louis. This newest aid to science is the invention of Montford Morrison, Westinghouse X-ray Company, and Dr. C. T. Ulrey of the Westinghouse Lamp Company.

An interesting feature of this new apparatus is that it can be operated from an ordinary house lighting circuit and in ap-



pearance resembles a large size radio tube. The method of operation is similar to water collecting behind a dam. When the accumulated electricity behind the dam is sufficient, the dam is opened, which sends the power suddenly, like a bolt of lightning, through the tube and the fast picture is produced.

▲

NEW ALLOYS FOR CONTACTS

Pitting of electrical contacts is said to be practically eliminated with the new contact alloys developed by P. R. Mallory & Company, Indianapolis, Indiana. These newly developed contact alloys possess marked advantages over ordinary contact materials. The particular applications of these various alloys are as follows: The alloy known as 20S, is suitable for arcing tips of very high current density. Another one, G 11, is used for arcing tips of low current density and also for make-and-break contacts where current density is high and non-welding necessary. G 13 is used for make-and-break contacts where current density is high and welding of contacts is not encountered.

LIGHT CONTROLLED EQUIPMENT

Electrotec Engineering Corporation, 180 Madison Ave., New York, has developed a phototube light control unit that is universal in its application and may be set up and operated by any one with no previous experience. This unit has been designed so that it will meet any possible

light control requirements, it has an external adjustment that may be set to operate on a change of one-tenth of one foot-candle in illumination, from absolute dark to daylight or for impulse operation from light source. The Electrotec phototube relay is manufactured in three models that may be purchased from jobbers and dealers, a-c., d-c., and battery, with cord and plug, and terminals for open and closed-circuit operation. All three models housed in same size case which measures 3½ inches diameter and 7 inches long. Electrotec Engineering Corporation also manufacture a complete line of phototube light measuring, color and density matching equipment and invite inquiries on any application.

▲

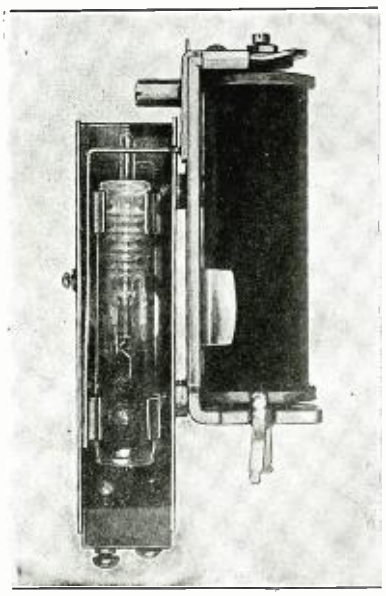
VACUUM CONTACT IN CONJUNCTION WITH TELEPHONE RELAY

By attaching a vacuum contact, a telephone type relay may be converted into an inexpensive power relay. This contact combines high sensitivity with the ability to handle loads as large as 1,350 watts with ease, with a motivating force of only 6 to 10 ounces and a movement of only .02 inch. Thus, by means of the vacuum contact a minute amount of energy can handle and control thousands of times as much energy. Moreover, the device is quite simple and eliminates the need for much of the cumbersome apparatus heretofore required in association with power **relays.**

The vacuum contact, which is manufactured by the Burgess Battery Company, 202 East 44th Street, New York, is based on the principle of a bellows made of a peculiarly elastic glass according to a special design. This glass bellows supports a glass rod actuating a contact in vacuum. The slightest pressure (6 ounce) on the protruding glass rod separates the contact members, which, because they operate in a vacuum, break the circuit when separated by so small a space as .02 inch. It may either be made or broken with the application of such pressure. Another advantage of the vacuum is that it prevents oxidation and corrosion of the contact members and practically eliminates arcing. Oscillograph records show an instantaneous make and break. The contact may be operated in any position, an advantage over the mercury switch in certain applications. There is no movement on the leads. It can be operated very rapidly and its long life, due to its functioning in a vacuum, is attested by tests in which the device has been operated 10 times per second 124,000,000 times without a breakdown.

The Burgess vacuum contact is conservatively rated to handle 6 amperes continuously at 220 volts, or 8 amperes intermittently. Measured in mechanical terms, the contact is able to handle about 2 horsepower. The device may be held in its mounting by means of a pair of fused clips or suitable bands. The manufacturers of the contact now supply a standard contact mounting which may be applied to most associated equipment.

The vacuum contact, developed and



manufactured in Germany, is being introduced in America and sold by the Burgess Battery Company. Its easy adaptation to the telephone type power relay presages its wide use in place of switches in this field.

▲

AKRA-OHM RESISTORS

Resistance units, wire wound, inductive or non-inductive, for operating circuits and for laboratory uses. These units are finding increasing usage in radio applications, in public address and in communication. Resistance range of Type 100, 101, 102, 103 from 1 ohm to 2,000,000 ohms with a maximum load of 1 watt. They are recommended for: Electrical instruments, television amplifiers, telephone equipment, burglar alarm equipment, resistance amplifiers, talking picture equipment, broadcasting station equipment, fire alarm equipment, voltmeter multipliers, attenuators and fading controls, electronic tube amplifiers, bridges for measuring resistance, capacity and inductance, television equipment, and other high-grade apparatus.

The 900 series megohm decade resistance boxes are designed for the specific requirements of the physicist, research engineer, and others engaged in scientific investigations.

The wide range of high resistances available in these resistance boxes now provide comparison standards for high resistance measurements, insulation measurements and other uses in many fields of research and engineering such as: physical, electrical, radio, geo-physical, electronic tube, physical chemistry, X-ray, sound recording and industrial laboratories.

These megohm decade boxes are of great value in connection with photoelectric cell and amplifier circuits in radio and television, frequency response correction networks, potential dividers, voltmeter multipliers with milliammeters and microammeters. When used in conjunction with a sensitive galvanometer the proper decade box will provide a voltmeter of 10 megohms per volt.

Akra-ohm resistors and megohm decade boxes are manufactured by the Shallcross Mfg. Co., Collingdale, Penna.

▲

CONDUCTANCE METERS

A direct-reading mutual conductance measuring meter, model GM, which gives direct values of plate impedance of type 224 and similar thermionic tubes, is announced by the Sensitive Instruments Corporation, 4545 Bronx Boulevard, New York. Every radio manufacturer, radio

laboratory, tube works and design engineer should procure a copy of this company's catalog No. 32.

Annual Design Number Radio Engineering

February, 1932

The radio industries are now working on new and improved devices for 1932-33. New receivers, amplifiers, home talkies, television apparatus, police and automobile radio, communication equipment and accessories are being designed. Components and materials are being compared and selected.

Note: The A.B.C. paid circulation of Radio Engineering is 50% greater than the paid circulation of any other electronic or radio industrial publication.

The February Design Number of *Radio Engineering* will be largely used to announce available components and materials.

(Advertising Forms Close January 28th)

INDEX OF ADVERTISERS

Make Your 1932 DOLLAR *Go* FARTHER

by using CRC's 500 SERIES SOCKETS

● The unique design of this new series permits the elimination of costly materials which are non-essential in most applications. They are designed to provide the proper kind and amount of contact for all uses. This new design is the result of a careful study of the problem of cost reduction without sacrificing features or materials which are inherently a part of well designed and efficient sockets. . . . Variations available are practically endless so far as size, arrangement and terminals are concerned.

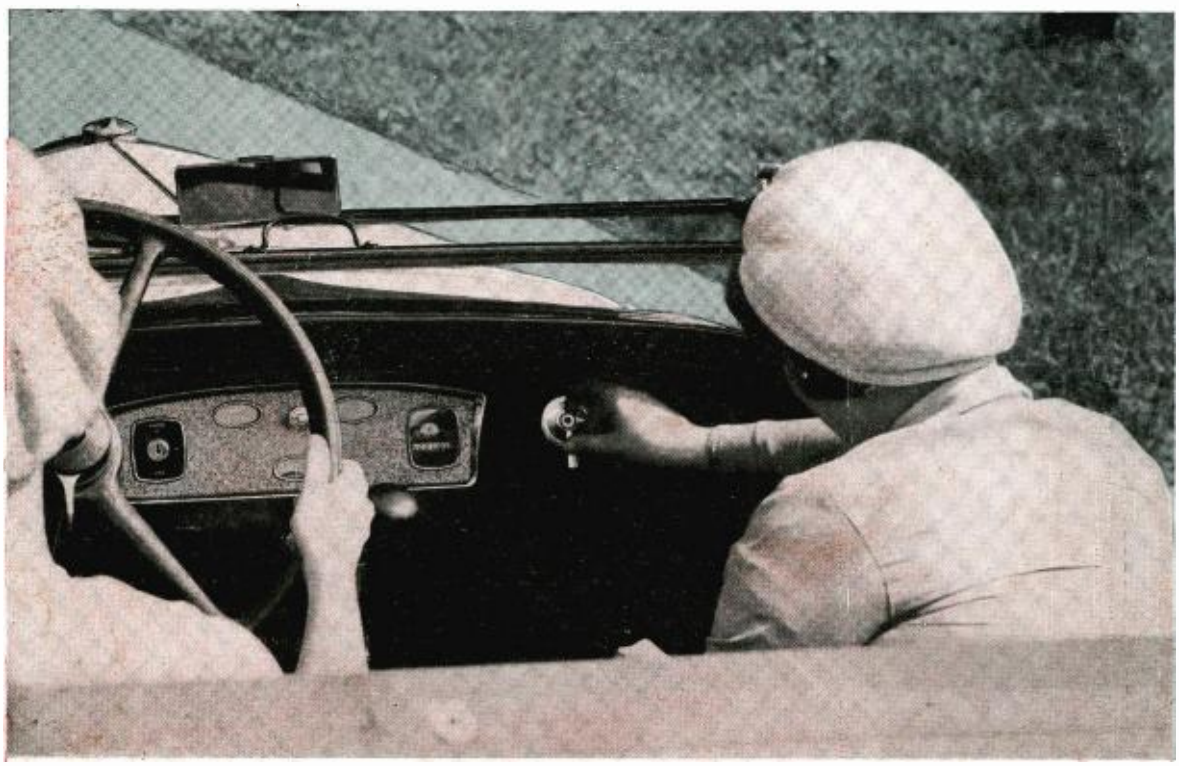
500 MODEL
$1\frac{27}{32}$" mounting centers
(actual size)

500 MODEL
1½" mounting centers
(actual size)

Send for the 1932 folder entitled "NINE REASONS WHY"

CRC

CENTRAL RADIO CORP.
BELOIT, WISCONSIN



When radio goes joy riding

sturdy insulations are required

Several popular-priced automobiles, to be introduced at the 1932 Automobile Shows, will be wired and otherwise equipped for radio. The handicap of wiring having been eliminated, makers of small auto radios should receive a welcome increase in sales. Since these sets are subjected to unusual vibration, sudden shocks and wide variations of temperature and moisture conditions, insulating materials must be chosen with care.

Bakelite Materials, both Molded and Laminated are ideal for this service. They possess high insulating efficiency and mechanical strength and they are unaffected by temperature changes, oil, moisture or gasoline. Because of their high dielectric and mechanical strength they may be made into small yet efficient insulators, helping to make the set trim and compact.

Bakelite Materials have long been the choice of manufacturers of radio devices of all kinds. In addition to their excellent insulating properties, they have effected many real production savings. Bakelite Molded, through the use of multiple cavity molds, lends itself admirably to quantity production methods without sacrifice of accuracy or efficiency. Bakelite Laminated is readily sawed, punched, drilled or otherwise machined.

Write for our illustrated booklets 12M, "Bakelite Molded" and 12L, "Bakelite Laminated". These booklets contain valuable information concerning the properties and uses of Bakelite Materials. There are also many special materials developed to solve particular insulating problems. Do not hesitate to call upon us for information about any of these materials.

BAKELITE CORPORATION, 247 Park Ave., New York ... 635 W. 22nd St., Chicago

BAKELITE CORPORATION OF CANADA, LIMITED, 163 Dufferin Street, Toronto, Ontario

BAKELITE

REGISTERED U. S. PAT. OFF.

The registered trade marks shown above distinguish materials manufactured by Bakelite Corporation. Under the capital "B" is the numerical sign for infinity, or unlimited quantity. It symbolizes the infinite number of present and future uses of Bakelite Corporation's products.

THE MATERIAL OF A THOUSAND USES