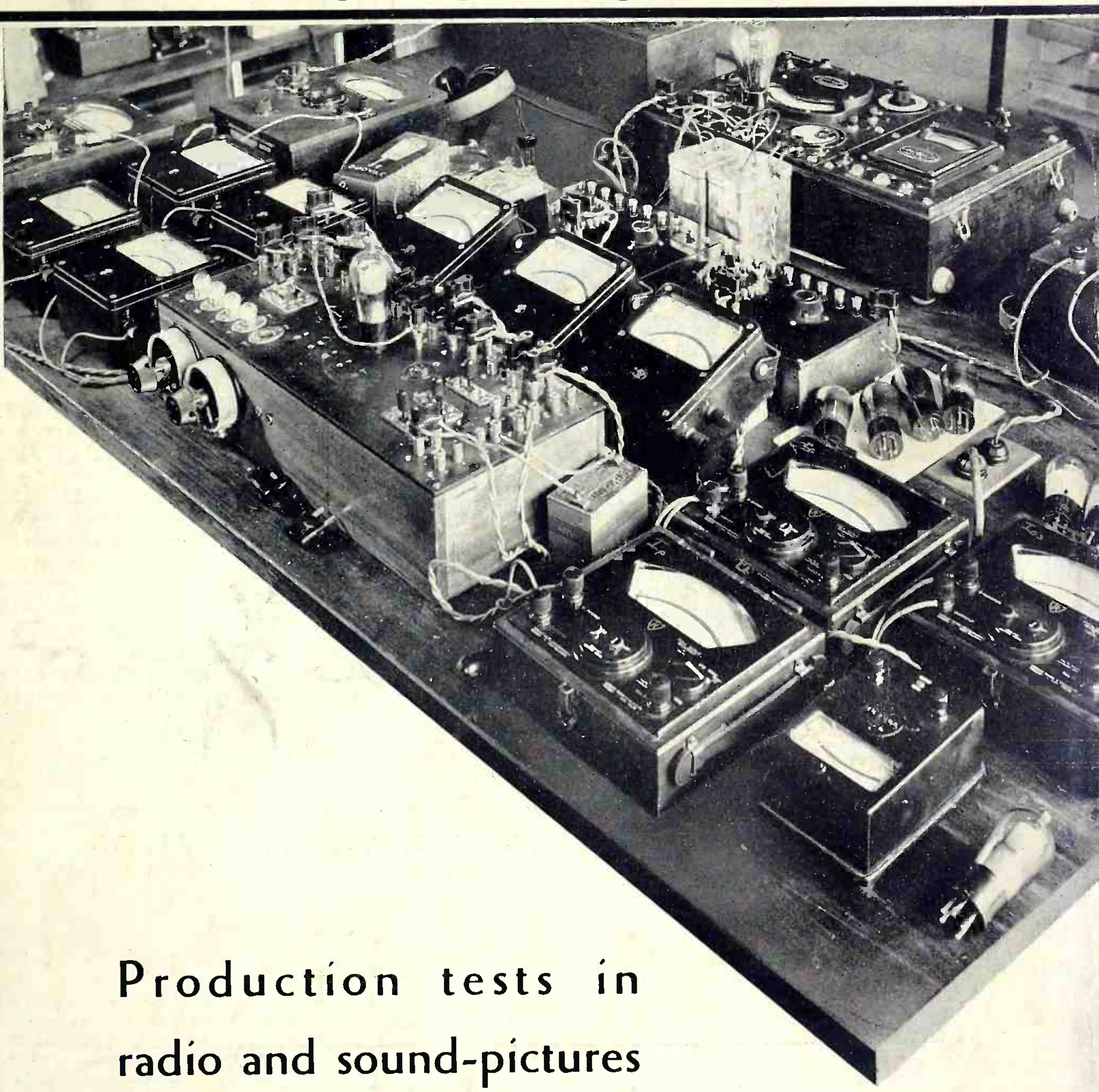
electronics

radio, sound, industrial applications of electron tubes + + + design, engineering, manufacture

radio
sound pictures
telephony
broadcasting
telegraphy
carrier systems
beam transmission
photo-electric cells
facsimile
amplifiers
phonographs
measurements
receivers
therapeutics
television
counting, grading
musical instruments
traffic control
metering
machine control
electric recording
analysis
aviation
metallurgy
beacons, compasses
automatic processing
crime detection
geophysics



Production tests in radio and sound-pictures
Photo-cell manufacture
Abuses in tube distribution

A McGRAW-HILL PUBLICATION

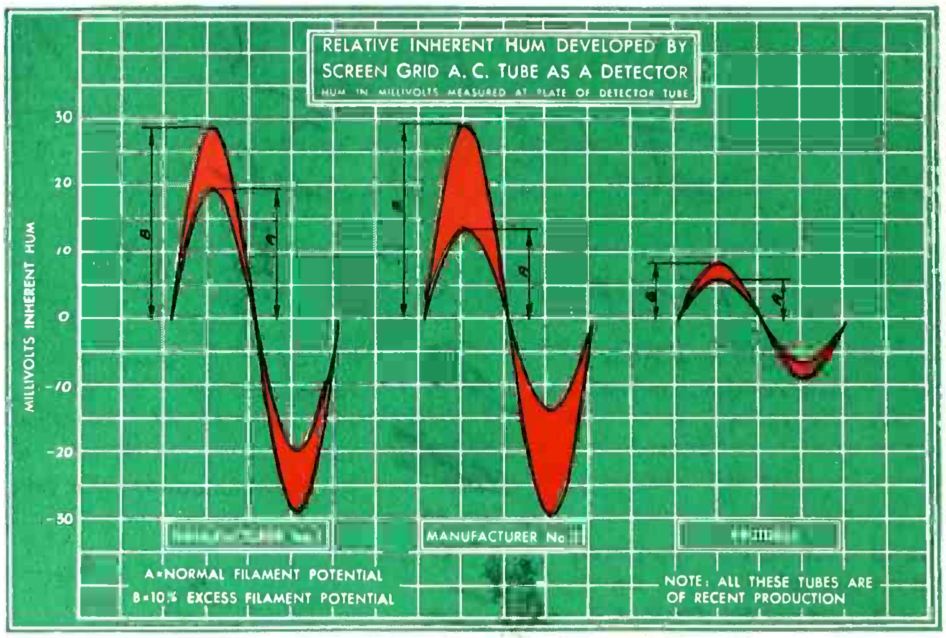
Price 35 Cents

FEBRUARY 1931

Laboratory Tests Prove

LOW HUM LEVEL

OF ARCTURUS SCREEN GRID TUBES



This diagram shows the comparative hum output of three different makes of screen grid tubes of recent manufacture when used:

(a) with normal filament potential
(b) with filament potential increased 10% above normal

The curves indicate the hum level at the plate of the tube when used as a detector. It will be noted that there is a considerable increase in hum with the tubes of manufacturers No. 1 and 2 when the filament potential is increased, while the curve for Arcturus Tubes remains at a minimum and practically constant under both these conditions.

A large number of different manufacturers' tubes were used in this test. Manufacturers No. 1 and 2 are among the largest in the Industry and the curves for those tubes shown in the diagram are representative of the majority of tubes in present use. The tubes of manufacturer No. 2 were found to have lower average hum than any other makes investigated with the exception of Arcturus.

To gain sensitivity, many modern radio sets use a screen grid tube as a detector. With this increased sensitivity, hum must necessarily be kept at a minimum since it becomes more apparent.

The new Arcturus Type 124 Screen Grid Tube, utilizing a unique filament insulation having a remarkably high resistance at high temperature, has been found to practically eliminate tube hum.

To definitely prove this, Arcturus' engineers conducted an interesting series of tests. The inherent hum of several leading makes of tubes of recent manufacture was measured and compared with the hum of the new Arcturus Screen Grid Tubes.

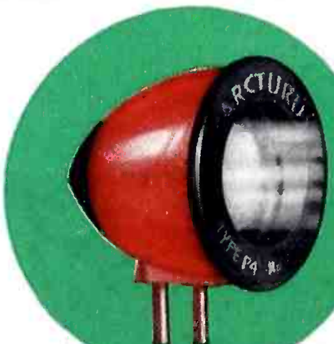
The results of these tests, shown in the chart above, conclusively prove that Arcturus Screen Grid Tubes have a markedly lower hum, not only under normal conditions but, equally important, when operated with over-voltage. Even when the filament potential is increased as much as 10%, the hum output of Arcturus Tubes is but slightly increased.

This freedom from objectionable hum, combined with quick heating, makes Arcturus Screen Grid Tubes unusually satisfactory as detectors. In Screen Grid detector receivers and in other circuits, Arcturus Blue Tubes have built a reputation for exceptionally satisfactory service.

ARCTURUS RADIO TUBE CO., NEWARK, N. J.

ARCTURUS

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



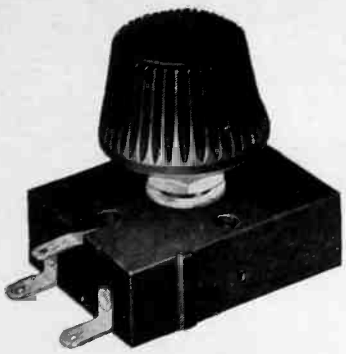
For Every PHOTO-ELECTRIC Device

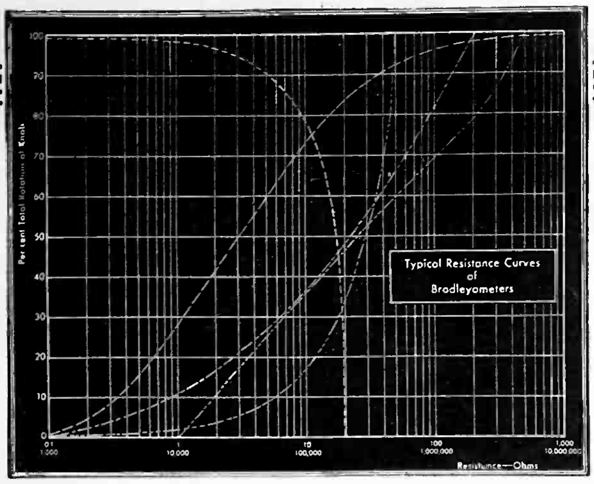
The Arcturus PHOTOLYTIC CELL

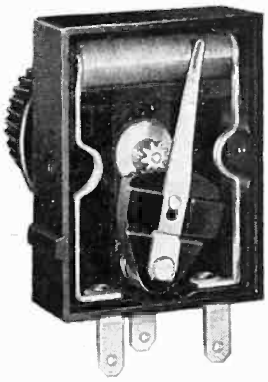
1—Absolutely no lag. 2—Uniform frequency response. 3—Low coupling impedance. 4—No background noises. 5—No excitation or adjustment required. 6—Shock-proof and non-microphonic. 7—Exceptional resistance to overloads. 8—Easily applied to any photo-electric circuit. 9—Unsurpassed for long life.

Write for Operating Data.

Electronics, February, 1931. Vol. 2, No. 2. Published monthly. McGraw-Hill Publishing Company, Inc., New York, N. Y. $3.00 per year, 35 cents a copy. Entered as second-class matter April 4, 1930, at the Post Office at New York, N. Y., under the Act of March 3, 1879.





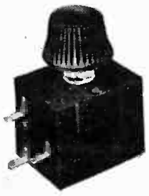


Only the Bradleyometer can achieve these results!

THE Bradleyometer is a distinctly new type of potentiometer, unusual in design and marvelous in performance. Approximately fifty solid resistance discs are interleaved between thin metal discs. A contact arm moves from one end of the resistance column to the other.

The resistance value of each disc is separately controlled and the total number of discs can be arranged in accordance with any resistance-rotation curve desired. No other type of resistor offers such flexibility in the variation of resistance so essential in modern electronic tube circuits.

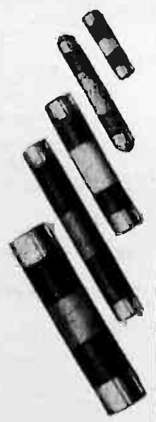
Type AA
Double
Bradleyameter



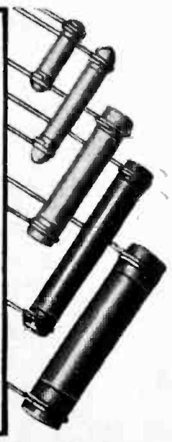
Type AAA
Triple
Bradleyometer

One or more Bradleyometers can be arranged to operate with one knob. Each Bradleyometer has its own resistance characteristic as shown in the diagram above. In this manner, mixer controls, T-pad and H-pad attenuators and other complex controls can be provided.

The extraordinary performance of the new Bradleyometer, its silent operation, and its unlimited adaptability can be appreciated only by installing a Bradleyometer in a test circuit. Samples will be gladly furnished to set manufacturers.



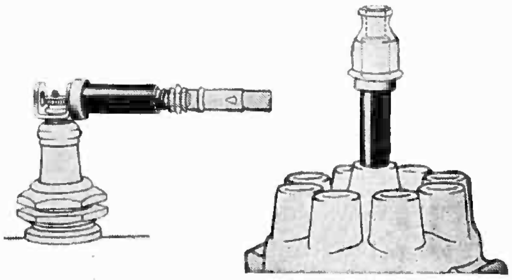
Bradleyunits are made in five sizes with or without tinned leads. All units are color-coded to meet set manufacturers' specifications.



BRADLEYUNIT RESISTORS

FOR ALL APPLICATIONS

Bradleyunits are solid molded resistors unaffected by temperature, moisture or age. Their accurate calibration, great mechanical strength and permanence make them ideal for providing correct C-bias, plate voltage, screen grid voltage and for use as gridleaks and as fixed resistors in resistance coupled circuits.



BRADLEY SUPPRESSORS

FOR RADIO-EQUIPPED CARS

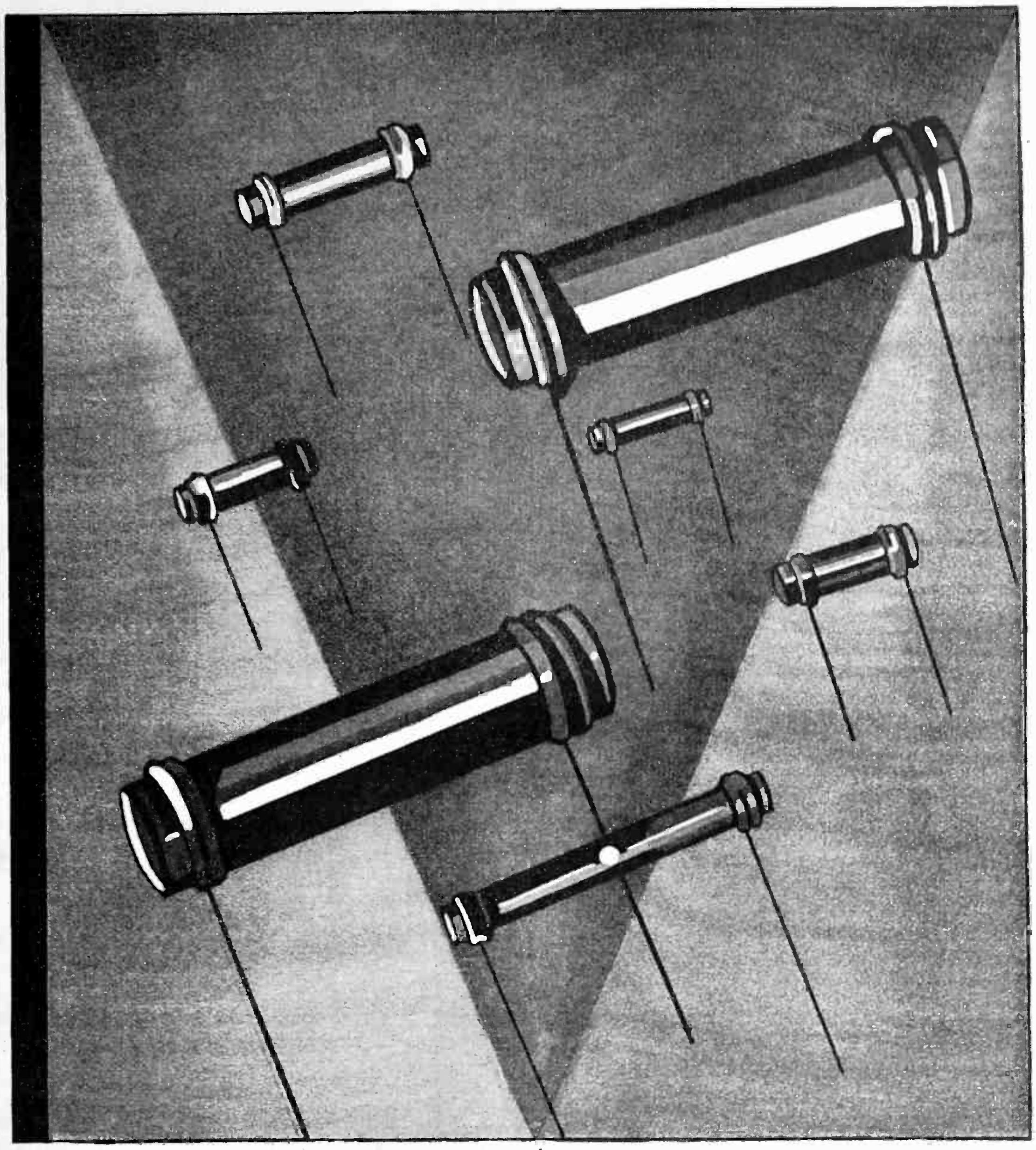
These special solid molded resistors are now used by prominent car manufacturers to provide individual resistors for each spark plug and for the common cable to the distributor on radio-equipped cars. They increase the resistance of the high tension ignition system and minimize the disturbing oscillations in the ignition circuit which interfere with the radio receiver in the car. When used with suitable by-pass condensers in other parts of the circuit, shielded ignition cables are unnecessary. They do not affect the operation of the motor.

For complete information on Allen-Bradley Resistors address

ALLEN-BRADLEY CO.
110 W. Greenfield Avenue **Milwaukee, Wisconsin**

ALLEN-BRADLEY RESISTORS

Produced by the makers of Allen-Bradley Control Apparatus



Found 99½% perfect by one of the world's largest radio manufacturers ERIE RESISTORS established a record heretofore deemed impossible in the industry. Less than 5 resistors in every thousand furnished (and there were millions of them) were found to be under standard.

Surely here is a most unusual showing—a tribute to our manufacturing and double inspection methods. We were told that a much larger percentage of rejections could be expected!

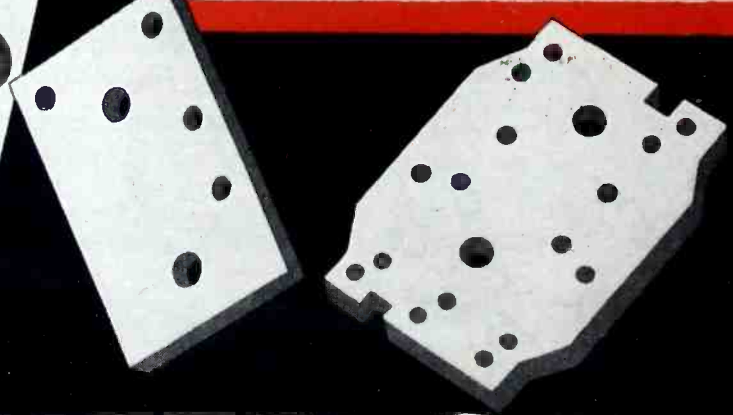
ERIE RESISTORS have a constant resistance value which is not affected by age or temperature. They are noiseless and will pass every test of your engineers.

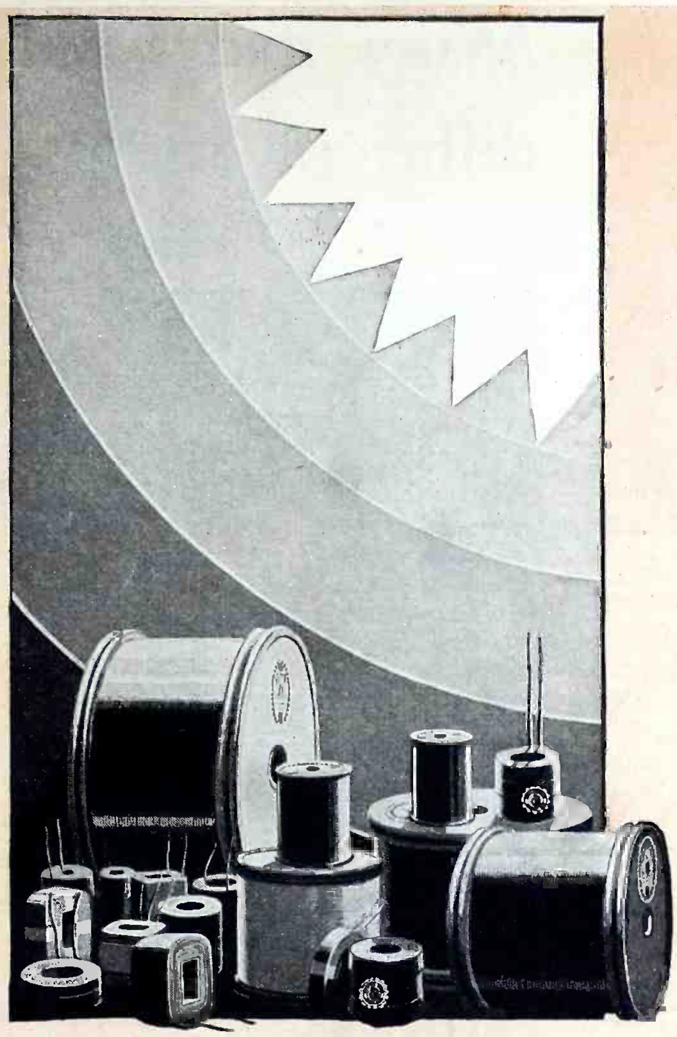
Samples, prices and other information on request.

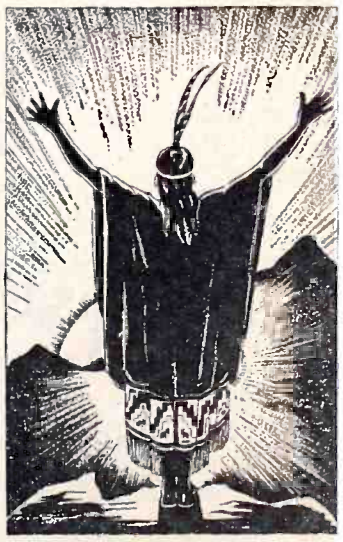
ERIE RESISTORS

Erie Resistor Corporation, Erie, Pa.

In the Center of the Radio Industry







electronics

O. H. CALDWELL
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Associate Editor
KEITH HENNEY
Associate Editor

A McGRAW-HILL PUBLICATION

New York, February, 1931

The march of the electronic arts

South Carolina radio tax unconstitutional

SOUTH CAROLINA'S proposed state tax on radio receiving sets has been declared unconstitutional by the state's own Supreme Court, thus ending the first effort in the short history of American broadcasting to levy fees on the listening public for the reception of radio programs. The Radio Manufacturers Association, and station WBT, Charlotte, N. C., fought the case through the courts.

As passed by the South Carolina legislature, the law placed a graduated tax of 50 cents to $2 on the use of all radio receivers costing $50 to $500, the proceeds to go to the state tuberculosis hospital. The tax was fought largely on the grounds that radio waves are interstate in character and that the proposed state tax would have been an interference with the federal government's authority over interstate commerce.

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NBC and CBS networks gross $26,667,391 in 1930

CHAIN BROADCASTING in America not only weathered the stormy financial seas of 1930 but came through the year with fiscal colors flying. Increasing its revenues from the sale of "time on the air" by 42 per cent over 1929, the National Broadcasting Company and the Columbia Broadcasting System together show a gross income from that source alone of $26,667,391 in 1930. This is exclusive of revenues from other sources, such as program talent—for today the networks are among the largest booking agencies in the show business.

Gross income to the NBC from time sold to advertisers during 1930 was $20,062,771, an average of about $1,671,148 per month. Columbia's gross income from time sold was $6,704,620, an average of about $558,718 per month. Though their choice broadcasting hours are now largely occupied by commercial sponsors, neither has sold all its available time and both continue to furnish far more sustaining, or non-commercial, programs than sponsored programs.

In 1929, the two chains sold time to the value of $18,729,571, forging 83 per cent ahead of 1928 when their combined income from time sold was $10,252,497. In 1927, when the NBC was alone in the field, network time brought in $3,760,010.

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MICROPHONE'S NEW DRESS

To prevent wind from whistling against the sensitive diaphragm, Paramount's studio engineers devised this microphone jacket for sound picture work

RMA Trade Show in four Chicago hotels

FOUR CHICAGO HOTELS, headed by the Stevens Hotel, the largest in the world, were engaged for the Fifth Annual Convention and Trade Show of the Radio Manufacturers Association next June by the RMA board of directors which met in Chicago, January 22. President Morris Metcalf of Springfield, Mass., presided, and the association directors took important action on many broadcasting, legislative and other policies and toward development of services for RMA members and the industry.

Contracts were signed with the Stevens Hotel and also with the Blackstone, Congress and Auditorium Hotels, all on Michigan Avenue, for the convention and trade show which will be held during the week of June 8th next. Between 25,000 and 30,000 radio industry visitors are expected to duplicate the past successes in 1928 and 1929 of the RMA conventions and trade shows in Chicago.

Nearly 30,000 square feet of exhibit space will be available in the Stevens hotel ball room and exhibition hall for the trade show.

✦

Motor bus radios

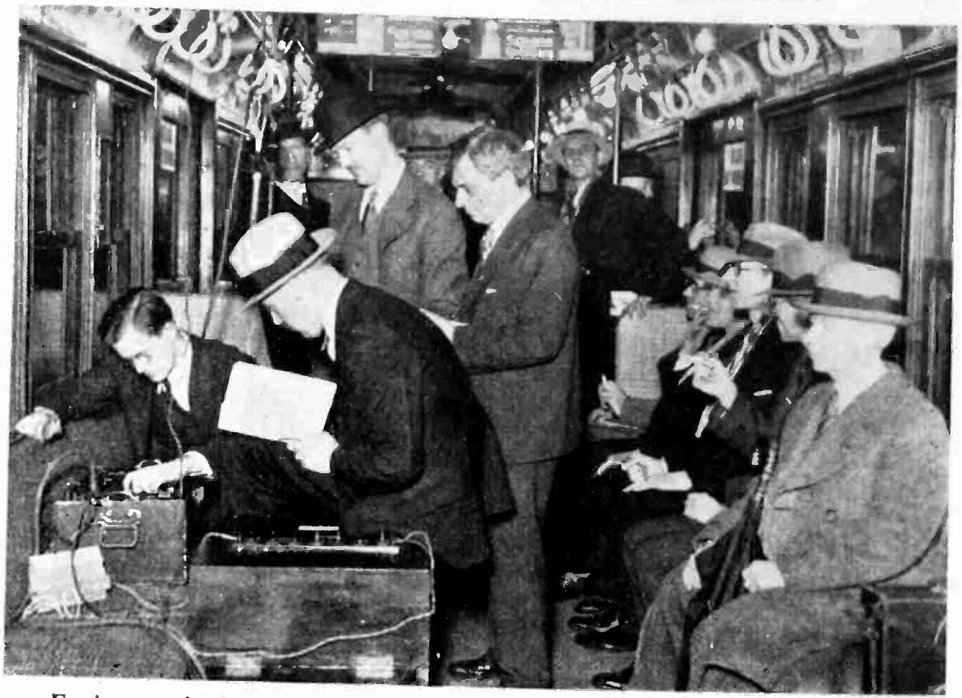
AS IN THE CASE of radio aboard trains, foreign countries are showing the way to the United States in adopting radios for the entertainment of omnibus passengers. A Czechoslovakian concern is equipping all of its busses with radios. Only a handful of the more enterprising bus lines in this country have equipped their coaches with radio to relieve the monotony of long journeys.

Ribbon microphone developed

To overcome many of the difficulties heretofore experienced in the recording of sound pictures, a new type of microphone has been developed by Dr. Harry F. Olson of RCA Photophone. This microphone claims certain directional sound pick-up characteristics which enables its use in reverberant sets in such a way as to pick up the voices of the actors and at the some time, considerably reduce the amount of reverberation picked up.

The principal on which the ribbon microphone operates is that of induction of electric current in an extremely thin and light corrugated aluminum ribbon, placed between the poles of an electro-magnet. This aluminum ribbon is only .0001 in. thick, 3/16 in. wide, and 2 in. long. The minute changes in air pressure occasioned by sound waves causes this ribbon to flutter or vibrate between the magnet poles, and electric currents are thereby set up in it. The microphone proper is contained in a perforated box. Its efficiency of pick-up is greatest in the direction normal to the face of the microphone, while its reception in the plane of the face of the microphone is zero.

LEARNING WHY SUBWAYS ARE NOISY



Engineers of Electrical Research Products, Inc., are now making acoustical measurements of noises on New York subways to aid in silencing subway trains

Ultra-violet rays used in food preservation

Radically new scientific developments in the use of light rays to increase the nutritive and health-giving properties of foods, which are expected to have far-reaching effects in food preservation, biology and medicine, were announced jointly, January 14, by the University of Cincinnati, and the General Foods Corporation. This development has been carried on under the direction of Prof. George Sperti of the Basic Science Research Laboratory of the University of Cincinnati.

This new process consists of filtering ultra-violet rays to definite wavelengths, and can be used to add Vitamin D in definitely controllable quantities to many articles of food and pharmaceutical products. It can also be used for sterilization in the prevention of food spoilage. Various germs of fermentation, yeast moulds and similar foes to preservation of foods, are claimed to yield to the university's light-treatment method. Its discoverers even see in it potentialities for the destruction of disease germs inside the human body, without injury to living tissues.

Prof. Sperti and his assistants, in attacking this problem, found that only a part of the total ultra-violet band of light waves was needed to produce Vitamin D. They also discovered a definite point on the ultra-violet scale at which Vitamin D was produced in quantities desired in foods or medicinal products. However, they found that at lower light frequencies in the ultra-violet band, they destroyed Vitamin D.

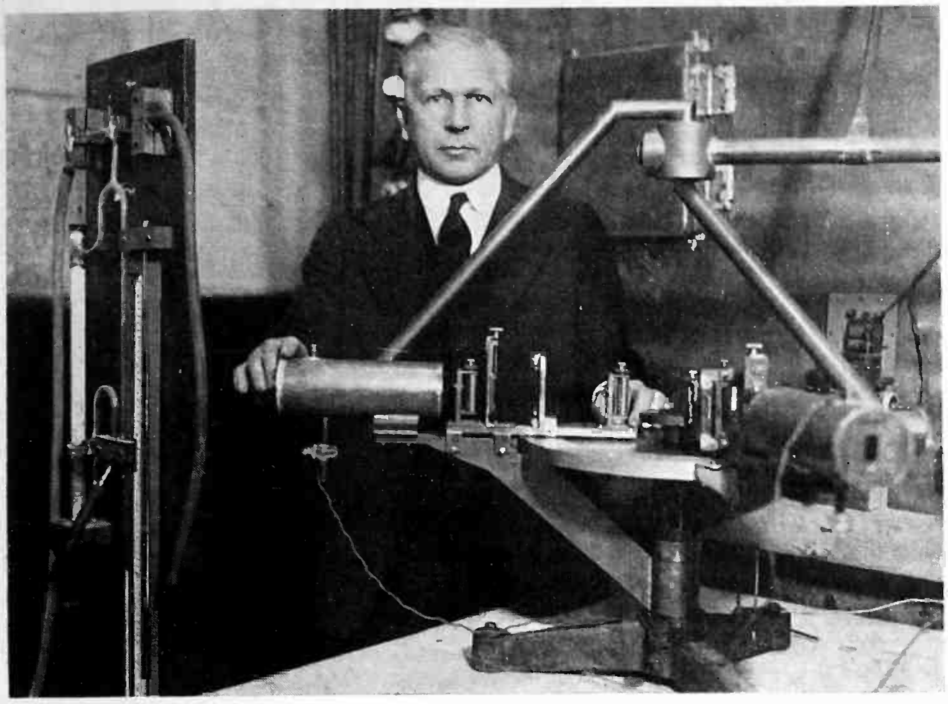
PASSENGER-PLANE PILOTS NOW TALK 200 MILES

Safety of airplane passenger service was improved during 1930 by this new station equipment on Boeing System's Chicago-San Francisco run, enabling pilots to communicate 200 miles. Plane equipment weight 100 lb.; station apparatus, 1,500 lb.

Columbia experimenting with synchronization

So far as the Columbia Broadcasting System is concerned, synchronization, or the broadcasting of chain programs by a multiplicity of stations on a single wavelength without mutual interference, is still in the laboratory stage. This, in substance, was reported to Columbia's board of directors by William S. Paley, president, who stated that "in a quiet way we have carried on some preliminary experiments, but we are far from the achievement of a definite synchronization plan."

MEASURES WAVELENGTH DIFFERENCES IN X-RAYS



Professor Ross, physics professor of Stanford University, with his double ionization chamber spectrometer used for measuring small wavelength differences in X-rays

✦ ✦ ✦

Hawaiian Islands to have short-wave telephone system

PLANS FOR THE ESTABLISHMENT of an elaborate system of inter-island communications in the Hawaiian Islands were disclosed by the announcement of the RCA Victor Company that shipment of the necessary radio equipment to the Mutual Telephone Company in Hawaii, would soon be made. The RCA contract with the Mutual Telephone Company involves the installation of eight complete short-wave transmitting and receiving stations of special design on the islands of Hawaii, Oahu, Maui and Kauai, for two-way communication in linking up the internal telephone systems on these islands with each other and with the United States. It will thus be possible in the near future to talk by telephone from anywhere in the United States, Europe or South America, to any of the small Hawaiian Islands. The Hawaiian radio stations will operate on wavelengths between 7 and 8 meters (between 43,000,000 and 37,500,000 cycles per second), the highest frequencies of any commercial station in the world.

✦

Sprague company to manufacture home talking movies

ACCORDING TO AN announcement of R. C. Sprague, president of the Sprague Specialties Company, this company plans to manufacture two models of home talking machines, for sale to distributors and dealers throughout the United States and Canada. Model A consists of a talking picture unit, to plug into a radio set, and Model B, a talking picture unit incorporating an amplifier and speaker to operate independently of the radio set.

Low voltage gas tubes for interior lighting

THE PRACTICAL APPLICATION of rare gas tubes, commonly known as neon tubes, to operate on standard 110/220-volt electric current, was announced January 30, by Leroy P. Sawyer, vice-president of Claude Neon Lights, Inc. These low voltage units have attained a luminosity as high as 2,000 lumens per ft. compared with 60 to 132 lumens per ft. for high voltage luminous tubes. The new tubes are applicable to commercial, industrial and special residential lighting. Special high powered units of greater intensity have been developed for industrial lighting. It is claimed the better quality and the more even distribution of the light with the lack of glare is of advantage for reading or close inspection work.

These tubes are available for white light or any color tone including daylight. The light is distributed evenly without the usual glare.

As the colors are derived directly from the source of the light (electrified rare gases), and not by filtering white light through colored glass or other filters, the efficiency of colored light or tinted light is comparatively very high. Less than one-fifth of the power is required to produce blue or green light, compared with filtered incandescent lamp lighting; about one-third of the power for red, and about one-half of the power for white light. These figures are based on the light which illuminates the objects in the room and not on the intensity at the source.

✦ ✦ ✦

AUTOMATIC RADIO COMPASS FOR AIRPLANES

View of an automatic radio compass for airplanes, designed by Gerhard Fisher and G. Kruesi for Western Air Express Company. Picture shows Dr. Deforest, holding course indicator, Gerhard Fisher and Miss Christiansen holding receiver unit

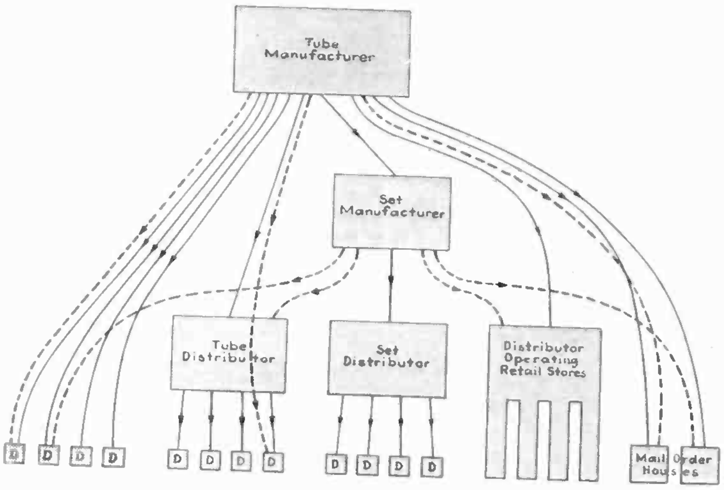
TUBE DISTRIBUTION

SOME fifty million radio tubes were sold in the United States last year. At least half of this number were handled as replacements across the counter, representing at retail over seventy-five million dollars in replacement business alone.

At the end of the tube distribution trail, as the final link with the purchasing public, stands the retail dealer. After some ten years of experience with retail distribution in all its forms, most tube manufacturers now accept the dealer as the necessary, widespread agency who finally puts the tube into the hands of the public.

Yet dealers are asking what merchandising policy the tube industry has yet adopted, generally, to insure that the retail tube dealer shall have price protection with which to conduct his business along sound lines, and to operate with at least an even chance to meet competition.

Today the ethical retailer who buys his tube merchandise in ethical channels, gets the usual discount, and attempts to sell at list prices —as dealers still do in smaller communities — is met with competition of prices cut 40 to 55 per cent "off list" by mail-order houses, chain stores, department stores, and others. As a result, the "regular" dealer is helpless, and must watch his trade drift away to other channels.



The channels through which radio tubes reach the public. Dotted lines show channels where discount abuses occur

Where do these low-priced tubes come from? Are the tube manufacturers to blame, or are there other parties along the line who contribute to this constant undercutting of the dealer who tries to run his business in a legitimate way, observing the suggested selling prices which his suppliers urge upon him?

Sources of cut-price tubes

Tubes which appear in the retail market cut 40 to 55 per cent below "list," are derived in devious ways from a variety of sources.

Sometimes distress stocks are sold in quantity by manufacturers to jobbers and dealers—the latter being usually chain organizations having centralized purchasing offices. Jobbers operating retail stores, and chain-store outfits also make purchases in bulk from manufacturers or from overloaded distributors.

Tube manufacturers make a practice of supplying tubes in quantities, without cartons, to receiving-set manufacturers, with which to equip the latter's receivers as they are shipped out. The discounts that are being regularly granted on such "bulk" sales, are extreme, running as high as 70 per cent or more, and thus open up channels for abuse, which may seriously affect dealers.

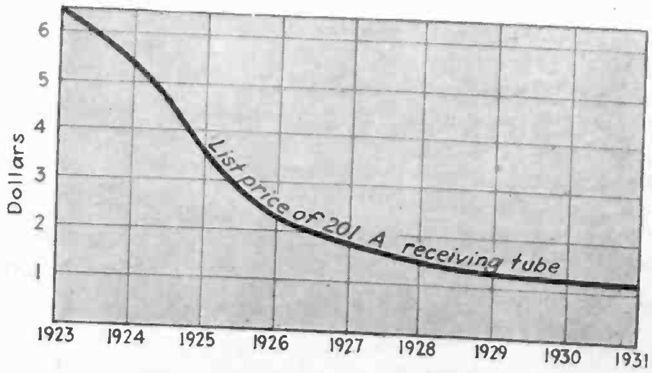
Set manufacturers who purchase this bulk "initial tube equipment" usually plan to ship such tubes with their sets. Sometimes the tubes are packed in kits, sent along with the sets. In certain types of sets the tubes can be enclosed (in loose packing) in the tube cans themselves. In other cases, experiments have been made with court plasters for sticking these tubes into the sockets. A "ring plaster" type of sticker seems to be most popular in this direction so far. Some of the court-plaster experiments have, however, been unsatisfactory, the plaster setting and holding so tight that sockets have been pulled loose and tubes have been broken in efforts to remove them.

But it can be imagined that tubes introduced into the merchandise distribution channels at a discount of 70 per cent or higher may later turn up in surprising places. Careless or avaricious set manufacturers may buy more than their own legitimate set requirements, even ordering from several different sources and pyramiding allotments, later to unload their bargains. Or they may be caught with an honest overstock and have to sell off some of their 70-per-cent-discount merchandise, which then further demoralizes an already demoralized market.

Retailers pose as jobbers, and demand wholesalers' discounts. Jobbers operate retail stores, and make large purchases as wholesalers, which they later resell as retailers, but at a sharp price concession. Chain stores, department stores and mail-order houses sometimes place their orders direct with manufacturers, and get wide discounts which they pass on to their public as cuts below list price.

In the face of such competition, the individual dealer stands helpless.

Tubes furnished to distributors and dealers in replace-



How tube list-prices have been reduced, as shown by one well-known number

EVILS—THE REMEDY

Six "sore spots" in present radio-tube distribution

1. **Tube makers sell tubes in bulk to set manufacturers for "initial installation" in sets, at 70 per cent or more off list. Many of these tubes later find their way into replacement channels.**
2. **Mail-order houses and chain stores buy direct from tube makers at discounts enabling them to retail at "40 per cent off."**
3. **Collection of "window-display dummy" cartons and sale of empty cartons of standard tubes, at two to three cents each, is now a regular business.**
4. **Service men on calls "replace" customers' tubes throughout, then pack the workable old tubes in discarded cartons and resell them at cut prices.**
5. **Replacement tubes supplied by manufacturers to replace faulty units are diverted into regular merchandise channels at cut-prices, demoralizing market.**
6. **List prices and discounts are now all too high, creating fictitious levels which result in price cuts undermining legitimate dealers' business.**

ment of faulty tubes, on claims, also often find their way back across the retail counter under price-cut conditions. This situation has been made especially acute by recent "trade-in" offers which have resulted in the collection of thousands of old, worn-out tubes of various makes. Some of these tubes are two to five years old, but many dealers have seemingly no scruples about sending them in to manufacturers and demanding new tubes in their places. Such new tubes, having cost nothing, then of course become candidates for price cuts.

Some dealers and service men are themselves responsible for another "racket," which is predicated upon the good advice contained in manufacturers' ads to the public, "Replace your tubes once a year." In these instances, when a service man is called into the customer's home to fix some minor set trouble, by casual questioning he learns how long the receiver has been in use, and before leaving "tests" the tubes, and invariably declares that *all must be replaced* with new ones. With the old tubes taken away and then repacked in the new cartons, another cut-price racket is soon started on its way.

Another adaptation of the same racket is the use of "window-display dummy" cartons supplied to the dealer for display purposes.

Present list prices fictitious

These are some of the present-day abuses which have fastened themselves on the distribution of radio tubes to the public.

But the principal troubles are those resulting from too wide discounts granted to agencies which compete unfairly with the legitimate dealer.

The best interest of radio and tube distribution depends upon a widespread distributing machine, which shall make a full line of tubes available everywhere, so that the public can buy easily and conveniently, as well as confidently. If this is the purpose to be accomplished, then other parallel links in the merchandising chain should be so adjusted as not to foul the independent dealer's operations.

If manufacturers can sell tubes at discounts of 70 to 80 per cent from their suggested list prices, one of two things is true—either (1) they are selling their merchandise at a loss, knowingly or ignorantly, or (2) the list price set is fictitious, and does not represent the true retail value of the article.

In turn, we are brought to the conclusion that list prices of tubes are now all too high; that the time is unmistakably here for another reduction in list prices, just as list prices have at intervals been revised with manufacturing improvements (see accompanying curve of list prices of a much-used tube).

A 25 per cent reduction in prices

To what extent should such revision go? How much change must be made in discount schedules, to accompany this reduction in list-prices? For, dealers as well as manufacturers have long ago learned, that it is not discounts and margins which count, but rate of turnover. A smaller margin frequently *repeated,* brings far more money into the cash register, than a wide margin on a list price that is seldom gotten.

If a new list price level were to be set up, based on recent revelations in the tube selling field, it would appear that present list prices would come down at least 25 to 30 per cent. Such a reduction would eliminate present fictitious price levels, and bring the "suggested selling price" more nearly into line with the figure at which the goods can be placed in the majority of retail outlets. In turn, of course, this would mean that 20 per cent would go to the jobber and distributor. And the retail dealer would merit 35 per cent to 40 per cent. But he would "really get it," and get it on *repeat* sales, instead of seeing his present higher margin cut from under him by ruthless competition.

In the meantime, with a 25 per cent lowering of list prices, the discounts at which initial tube equipment could properly be furnished to set manufacturers (in bulk, without cartons) would be around 40 per cent to 50 per cent. This cleaning up of the set manufacturer discount situation and a corresponding revision of discounts on direct bulk purchases by mail-order houses, chain stores, and other cut-price specialists, would have a profound effect on the whole tube distribution situation.

The solution of existing evils is a prompt revision of present figures with respect to list prices and discounts, to bring them closer into line with the operating facts of tube distribution from manufacturer to retail dealer.

TESTING—THE GUIDE TO

Products must be tested all along the line—from purchase as raw materials, throughout assembly, to the shipping platform

ACCURATE and sensitive measuring equipment of one sort or another controls the design, engineering and manufacture of every electronic product. From the research laboratory to the production test-bench each component part receives not only its share of individual tests but must be checked again and again as the assembly grows until the final product is ready for shipment—and then again it is tested.

Electronic products—vacuum-tubes and phototubes, radio receivers and transmitters, sound picture and public address amplifiers, are products of considerable complexity in construction and function. Faults in operation or even in construction are usually not visible; they must be discovered by test-operators who are frequently not conversant with the products under test or with the machinery by which that test is made. Rarely do these operators understand what is actually happening. Furthermore the components and completed units must be tested under the high pressure of quantity production; for many electronic products are built in a short season of highly concentrated activity.

Expenditures for instruments

Though the importance of physical research is penetrating every industry, electronics by its very birthplace, the physical laboratory, owes its existence and future to research of fundamental character. Realization of this fact may be one reason for the vast expenditures for costly, complicated, and extraordinarily sensitive testing and measuring equipment that annually finds its way into the laboratory and shops of electronic manufacturers.

The "flow sheet" of design and production tests, on the opposite page, may give some idea of the complex nature of the testing function. Raw materials must be examined for chemical, mechanical and electrical characteristics; components made from these raw materials must be tested to see if they fall within mechanical and electrical limits; these components are assembled into larger units and again testing must reject those whose parts do not fit together properly.

Some of these component parts must all be tested; others are sampled, many of them are tested and sorted. But somewhere along the production line of every unit is a test position which guards against defects which cause loss of time, equipment and money.

Equipment that formerly was sold to and used by only "high brow" scientists now finds its way in increasing quantities representing investments of hundreds of thousands of dollars into the factories of the electronics manufacturers. Standard laboratory apparatus—such as the Wheatstone bridge—is revamped for production testing; complicated instruments are simplified, made more rugged, and are dispersed widely, to become an industry within the electronics industry, that of safeguarding the design and manufacture of radio, audio and industrial applications of vacuum tubes and photocells.

INSTRUMENTS AND APPARATUS FOR TESTING

Antennae measuring equipment

Attenuators

Bridges
- Capacitance
- Conductivity
- Inductance
- Wheatstone
- Low-tension
- Limit bridges, etc.

Coil testers

Condensers
- Precision unit
- Single mica
- Air condensers
- Variable plate, etc.

Gain sets

Galvanometers
- Reflecting type
- Pointer type
- High frequency
- Thermo-ammeter, etc.

Harmonic analyzers

Insulation testers
- Meggers
- High voltage, etc.

Laboratory standards
- Resistance
- Capacity
- Inductance

Mechanical and optical
- Balances
- Gauges
- Micrometers
- Photometers
- Microscopes

Meters
- Acoustimeters
- Ammeters
- Standard voltmeters
- Vacuum tube voltmeters
- Ohmmeters
- Watt-meters
- Frequency meters
- Cross talk meters
- Circuit test
- Flux measuring

Oscillographs

Oscillators
- Tuning fork oscillators
- Fixed frequency oscillators
- Beat frequency oscillators
- Piezo electric oscillators
- Signal generator
- Service-testing

Potentiometers and rheostats

Power level indicators

Pyrometers

Radio set testers
- Portable (service)
- Special production equipment
- Set analyzer

Recorders

Relays

Resistance boxes

Shunts

Special electrical instruments

Stroboscopes

Testing machines (mechanical)

Thermocouples

Thermometers

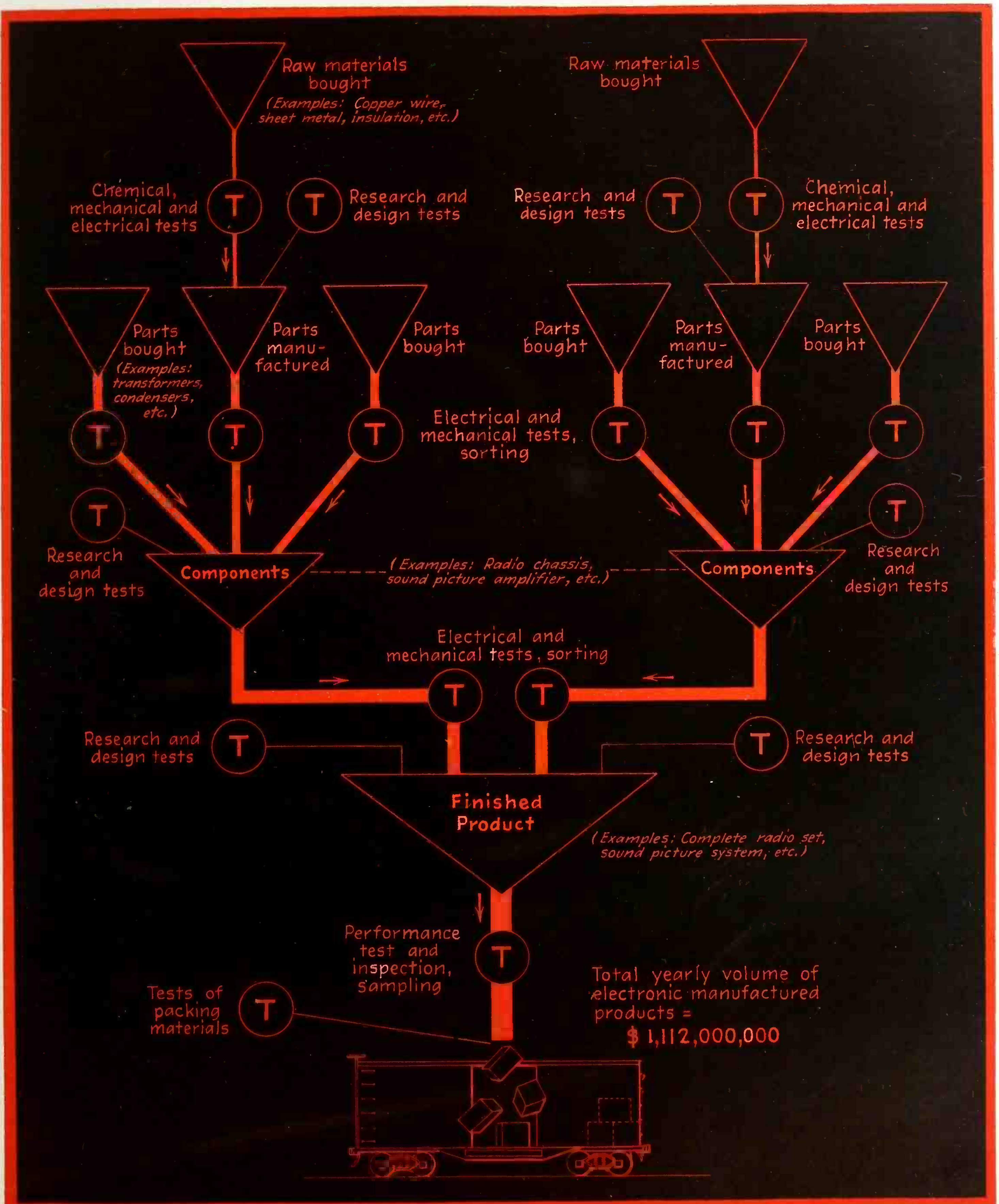
Transformer testers

Tube testers
- Portable (service)
- Special tube production test equipment

Tuning forks

Vacuum gauges

BETTER PRODUCTION



Flow sheet of production tests and design tests

in the electronic manufacturing industries

Production testing of

Present day radio receivers

By GEORGE G. THOMAS

Engineering Department,
RCA Victor Company, Inc.

RADIO receiver design has taken rapid strides during the past five years. Compared with the receiver of five years ago, the average present day receiver has performance characteristics that are unquestionably improved. It operates directly from the power supply line and without the presence of annoying hum. Its tuning operation consists of turning one single knob, or perhaps is accomplished from some point remote from the receiver by means of insignificant looking push-buttons. It is commonplace today that the levels of volume be automatically controlled and that means be provided for easy adjustment of the tone color. The average receiver of today represents quantity production, yet it is built to meet the requirements of critical users and to sell for a price that would have been astonishing five years ago.

Present day sales requirements demand that the performance of the receivers produced be uniform and up to fixed standards. Production methods ask that, in maintaining the quality of the product, as little as possible be sacrificed in production speed, that costs be kept low, and that no factors be allowed to interfere with the smooth rolling of the production line. This means that there is no place for "hay-wire" in the testing equipment. Reliability and accuracy are prime requisites, although speed and simplicity of operation must not be sacrificed. The test equipment cannot be too costly as compared with the cost of the goods being produced, and it must permit of easy maintenance. Elimination of the "human element" where this can be done, is essential. Sufficient tests must be had upon the product in its various stages to prevent defective parts or sets accumulating at any point in the production line, but care must be taken to include no unnecessary tests. These requirements must be and are met by present day testing methods and equipment. A visit to a modern radio factory will show that the testing of the receiver has really kept step with the receiver design.

A summary of the production tests made on a present day superheterodyne receiver would not give a complete picture of the tests involved in producing the receiver, for, raw materials and small miscellaneous parts which are purchased from outside manufacturers are given thorough mechanical inspections upon their entry into the plant. The quality of such materials and parts is further checked in laboratories having the up-to-date equipment needed to determine the conformity of the materials and parts to their specifications as regards chemical, physical and electrical properties.

Testing of component parts

In general, tests on component parts must be fast, accurate, and ruggedly simple. These points are borne in mind in the design of equipment to perform the tests which are outlined above for component parts.

The Wheatstone bridge circuit is easily adapted to production testing of resistances. In this application, sensitive galvanometers protected from overloads by quick acting relays indicate whether or not the resistance being measured is within limits.

Visual oscillographs lend themselves readily to the accurate and quick testing of chokes and small capacitors. The unit under test forms part of an oscillating circuit and the capacitance or inductance of the unit is suitably translated to the large screen of the visual oscillograph, the value of capacitance or inductance being indicated by the position of a line of light on the screen.

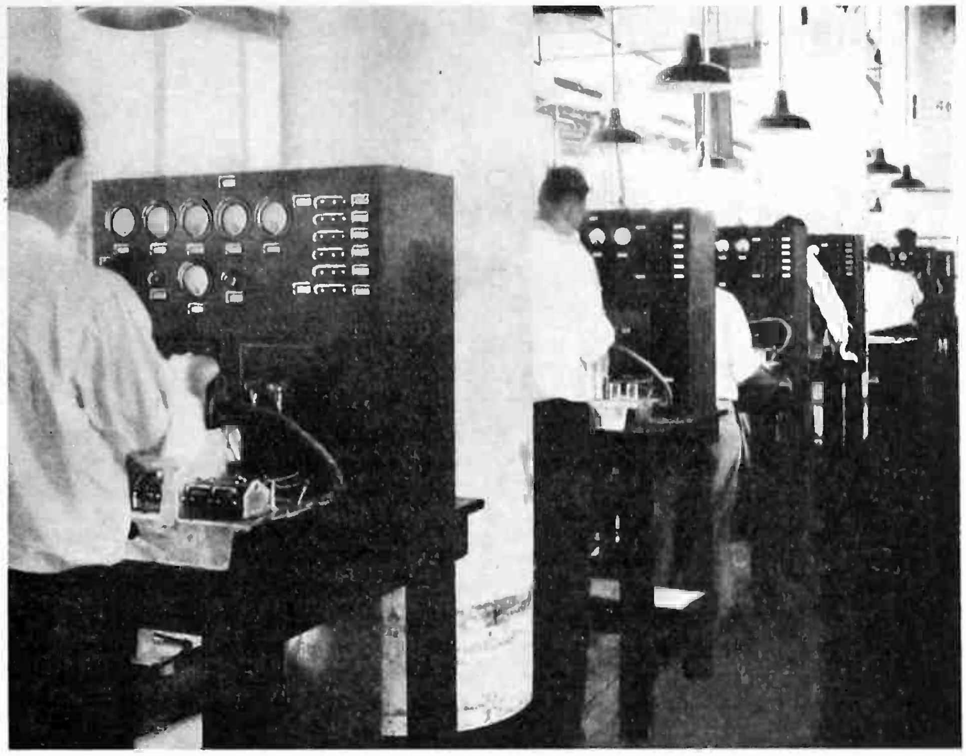
Visual oscillographs have also proved to be of unestimable value in the testing of intermediate frequency transformers. An input whose frequency varies for a short range on either side of the frequency, prescribed for the intermediate frequency amplifications, is fed to the transformer under test. The output of the transformer is reflected in the form of a visible resonance curve on the screen of the oscillograph. By this means, the primary and secondary circuits of the intermediate frequency transformer can be accurately adjusted to give a curve of the desired shape and amplitude.

The extreme accuracy required for the alignment of tuning capacitors and the adjustment of radio frequency transformer secondaries is best obtained by the beat frequency method. This system enables adjustment of capacitance or inductance to be made with an accuracy of 0.1 per cent or better. In this method of test, the coil or capacitor is inserted in the circuit of a radio frequency oscillator whose frequency is adjusted by means of a calibrated variable capacitor to "zero beat" a fixed frequency oscillator. The fixed frequency oscillator is controlled by a quartz crystal and indication of the "zero beat" is had either by aural or visual means.

Here radio frequency circuits are adjusted and sensitivity is measured

High voltage or "hipot" tests to determine the strength of dielectrics and insulating materials as used on different component parts are of great importance in order that no voltage breakdowns occur on the receiver during its normal life. Such tests are usually conducted with the part to be tested inserted in a jig which makes the necessary electrical connections and also protects the test operator from possible contact with points of high potential. The high voltage is automatically disconnected from the test fixture when the part is removed from the jig, but as an additional safeguard, it is standard practice that the high voltage only be applied when the test operator depresses two separated push-buttons, requiring the use of both the operator's hands.

Automatic tests have found application in the testing of some component parts. The more or less laborious tests required for power transformers are made on an equipment that automatically sorts out the defective units. Automatic "hipot," capacitance, and resistance tests on the less complicated component parts have been developed.



Test positions for determining continuity and resistance of circuits in receivers

When the receiver chassis has been completely assembled by the factory, it can be assumed that the parts making up the chassis have the correct electrical and mechanical constants. The testing work, however, is far from being complete, and with the receiver in chassis form, such tests as circuit continuity, check on the alignment of the intermediate frequency amplifier, adjustment of the radio frequency and oscillator circuits, sensitivity, and general performance, must be made.

Due to the extreme sensitivity of the present day superheterodyne, elaborately screened rooms are required for the tests on the intermediate frequency amplifier and overall tests on the receiver chassis. Such screened rooms are built using solid copper for the floors and for the lower part of the side walls with copper screening for the upper side walls and the ceiling to give needed light and ventilation. Power lines entering the screened room must include properly designed electrical filters to prevent radio frequency signals or disturbances from entering the room over such lines.

Continuity tests

Checking the continuity of the receiver has been simplified as far as possible. In conducting this test, it is necesesary for the operator to insert "dummy" tubes in the sockets of the chassis and make observations on certain meters when several different switches are depressed. The continuity of the circuits and the correctness of voltages at different points is indicated by single limit lines on the meters. Conveyor systems then carry the chassis into the shielded room for test on the intermediate frequency amplifier alignment and the overall test on the chassis. The intermediate frequency amplifier alignment is checked on a visual oscillograph in a manner similar to that described for the individual intermediate frequency transformer. It is necessary that the curve shown on the oscillograph screen be of prescribed shape and amplitude. Having passed the intermediate frequency alignment test, the receiver is carried by the belt conveyor to the chassis radio frequency test positions, where the trimmer condensers on the radio frequency stages and oscillator are adjusted so that maximum sensitivity is had from the receiver. The alignment of the trimmer condensers must also be such that the frequency calibration of the receiver is within specified limits. Tests for sensitivity and the frequency calibration are made using signals of known frequency and intensity supplied from master signal generators located in a shielded cage external to the screened room used for testing the receiver. Signals from this master signal generator are fed into the test room through well-shielded radio frequency transmission lines. The percentage modulation and radio frequency voltage input to the transmission lines are accurately maintained at the signal generator. Calibrated attenuators at each test position in the shielded room enable the test operator to select signals of the desired frequency and intensity. The output of the receiver is indicated either on a loudspeaker or an output meter calibrated in terms of a standard output power.

After satisfactorily passing the tests in the radio frequency test room, the chassis is sent on to a point where it is assembled in a cabinet with the socket power unit and loudspeaker. It is then given a final check in a shielded test room similar to that used on the chassis test. The final test includes the measurement of sensitivity, the hum voltage across the loudspeaker, a check on the dial calibration, and a listening test where a music modulated signal is picked up by the receiver.

The quality of the receiver as it is ready for shipment is further checked by taking a small percentage of each day's production into laboratories specially equipped for sample checking the performance and operation of receivers. In these laboratories, equipment is available for accurately and quickly measuring all the receiver characteristics, including sensitivity, selectivity and fidelity. Tests made on this basis give valuable engineering data and afford a valuable means for controlling the tests made on the production line.

Special instruments for

Radio receiver production testing

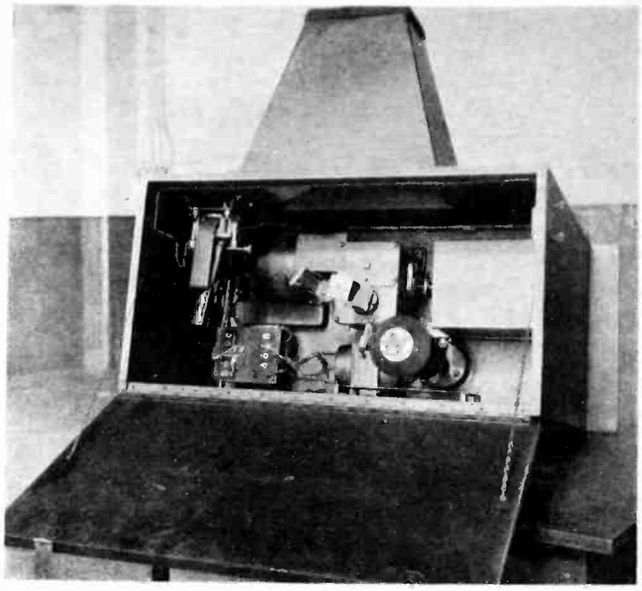
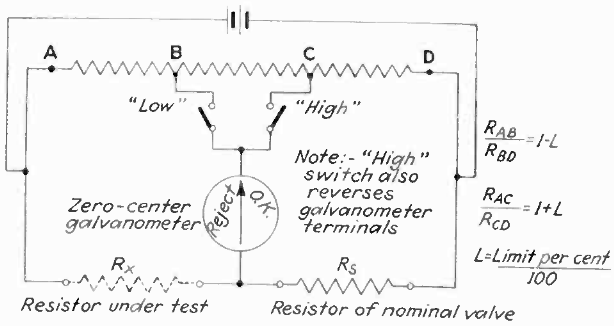


Fig. 2—Visual oscillograph for testing component parts showing the optical system

By RALPH P. GLOVER

THE era of mass production in radio receivers has brought with it many new problems for the test engineer. The better performance of receivers, which is the natural result of progress in the art and the demand for a finer product by the consumer, calls for a higher degree of manufacturing precision and more exhaustive test procedures than were required only a few years ago. In many cases it has become necessary to make tests in the factory which formerly were considered to be the special province of the laboratory. In addition, to fit in with modern production methods, apparatus must be sufficiently simple in operation to permit rapid handling by unskilled or semi-skilled employees.

These demands have been met by numerous special instruments, designed particularly for the process involved. Many of them are simply familiar pieces of laboratory equipment, redesigned and adapted for operation over a limited range with the minimum expenditure of time and energy by the operator; others involve new practices and have furnished the industry with new and important tools.



Magnitude of R_x	Galvanometer Deflection "High" (Reversed)	"Low"	
Less than lower limit $\frac{R_x}{R_s} < (1-L)$	OK	Reject	Reject
Equal to lower limit $\frac{R_x}{R_s} = (1-L)$	OK	Zero	Pass
Between limits $(1-L) < \frac{R_x}{R_s} < (1+L)$	OK	OK	Pass
Equal to upper limit $\frac{R_x}{R_s} = (1+L)$	Zero	OK	Pass
Greater than upper limit $\frac{R_x}{R_s} > (1+L)$	Reject	OK	Reject

Fig. 1—Diagram of a "limits" bridge—an adaptation of the Wheatstone bridge

Adaptation of the Wheatstone bridge

Bridge methods have been used for all sorts of precision laboratory measurements ever since Sir Charles Wheatstone conceived the principle early in the nineteenth century. However, in its usual general-purpose form, the bridge is ill suited for production use. More or less skill is required in operation and time-consuming adjustments are necessary to obtain a balance.

The *limit bridge* is a special application of a bridge network and is used extensively for production testing of resistors. It indicates whether or not the unit under test falls within the permissible variations from the nominal or specified value. Fig. 1 represents a basic limit bridge circuit. One side of the bridge is tapped to give "Low" and "High" ratios corresponding to the lower and upper limits as shown. A zero-center galvanometer is used as a detector. Switching from "Low" to "High" may be conveniently accomplished by the use of push-button switches placed side by side so that they may be operated in succession by adjacent fingers. The "High" switch also reverses the galvanometer terminals when it is depressed. This arrangement is not shown for sake of simplicity. A resistor of the nominal value is used as a standard. Inspection of the figure will show that all deflections of the galvanometer are in the same direction, say to the right, provided the resistors are within the specified limits. The right side of the scale can hence be marked "OK" and the left "REJECT." When the "High" button is depressed, the galvanometer deflects "OK" provided the unit is not above the upper limit. Similarly, the galvanometer points to "OK" when the low button is depressed if the unit is not below the lower limit. Bridge of this type have also been devised for measuring small condensers and are commercially available as well for tube measurements.

Condenser test equipment

The principle that the alternating current through a condenser is proportional to the capacity for constant impressed voltage and frequency, is made use of in the construction of direct-reading capacity meters or "microfaradmeters" as they are sometimes known. They are well suited for work which does not require extreme accuracy, a fact which qualifies them for use in testing filter, by-pass and other large condensers used in radio receivers. A particular advantage of this type of device is that it is readily combined with other panel-type instruments to form a complete unit for condenser testing. High voltage, capacity and leakage tests can thus be made at the same test position without expensive rehandling.

Visual test apparatus

An ingenious combination of laboratory methods of testing receivers and well-known principles of oscillography, has recently been developed by engineers of the RCA Victor Company. The particular apparatus referred to projects the selectivity curve of an intermediate amplifier of a superheterodyne receiver on a translucent screen before the operator and the results of the aligning process are at all times visible. This affords an entirely new degree of control over receiver characteristics as they pass through the factory. Formerly it was necessary to rely entirely on sensitivity observations for an indication of correct alignment; the new apparatus permits accurate inspection of the entire intermediate gain-frequency curve. Quite apart from the commercial aspects of the development, universities and other educational institutions will no doubt welcome the device for lecture-room demonstration purposes.

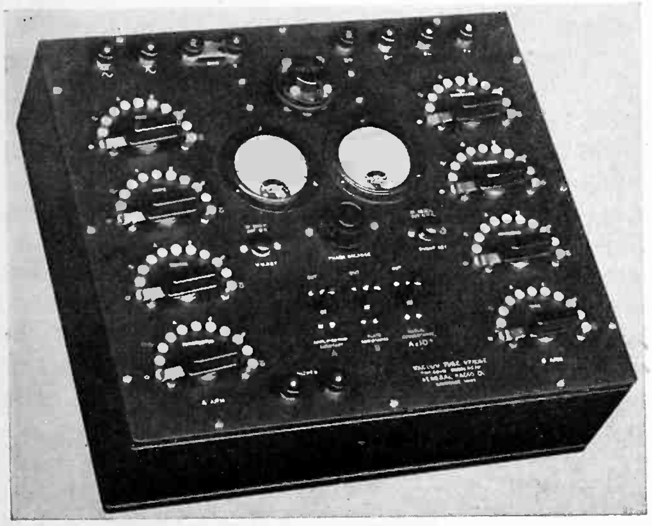


Fig. 4—Bridge circuit for vacuum tube measurements

Production testing of audio amplifiers

Manufacturers of radio receivers and audio amplifiers usually rely upon careful inspection of the individual audio components and aural tests in order to secure the desired characteristics. While in a majority of cases satisfactory results are obtained in this manner, a further check on the overall performance of the audio amplifier may be desired. Equipment which makes possible the rapid determination of the gain-frequency and overload characteristics of amplifiers at a number of points in the audio range, has been recently described.[1] The apparatus is basically that used for laboratory gain measurements, ingeniously adapted for high-speed inspection work. An electron-tube oscillator, operating at a number of discrete audio frequencies which are in turn selected by the operator, furnishes a constant voltage to the amplifier under test through calibrated attenuation networks. Comparison of input and output is readily obtained through the use of a simple a.c. operated electron-tube voltmeter. The gain is then given directly by the reading of a pointer on the shaft which controls the attenuator. Obviously no new principles are involved, but the assemblage of apparatus described is a noteworthy adaptation of precision laboratory apparatus for high-speed production service.

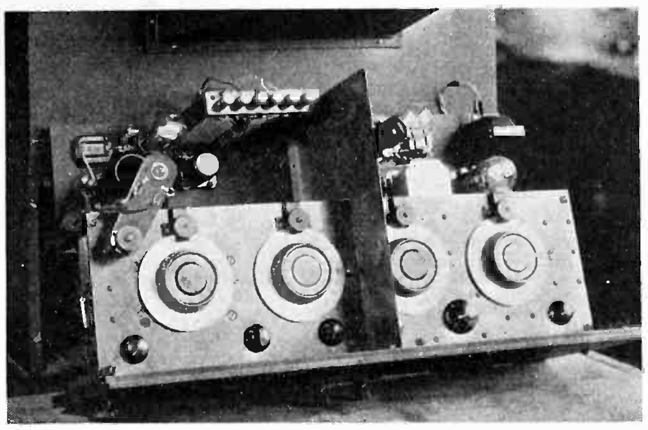


Fig. 3—Oscillator and detector of oscillograph for production testing

Loud speaker testing

For some time, development laboratories have employed more or less delicate apparatus for determinations of the sound pressure-frequency characteristics of loud speakers. Until recently, however, this has been a matter for the skilled acoustic technician. Much time and painstaking care were necessary to secure significant results. Several semi-automatic methods are now available for securing data on acoustic performance.[2] We are informed that at least one radio manufacturer[3] is developing such apparatus for use on the production line. The loudspeaker is driven by a variable-frequency oscillator and the output is picked up through a condenser microphone and amplifier. Several varieties of recorders are in use, ranging from a light beam to curve-tracing mechanisms geared to the oscillator frequency control and an attenuator in the pick up circuit. Further simplifications may be anticipated.

It is significant that in only a few instances have production testing facilities reached the fully automatic stage. The electron tube and photocell undoubtedly have an important part to play in future developments.

[1]Thiessen, The Accurate Testing of Audio Amplifiers in Production, *Proc. IRE.*, February, 1930; p. 231.

[2]For instance: Barnes, Measurement of the Performance of Loud Speakers, *Experimental Wireless*, June, 1930; p. 301.

[3]Graham & Olney, Engineering Control of Radio Receiver Production, *Proc. IRE.*, August, 1930; p. 1351.

Testing of sound-picture channels

By G. F. HUTCHINS

RCA Photophone, Inc., Hollywood, Calif.

THE problems of maintenance and repair of sound equipment in motion picture studios are somewhat different than those encountered in allied fields. In the radio business, for instance, repairs and tests are quite often delayed until trouble is encountered, whereas with sound recording equipment, the cost of continuous check and maintenance is quite small when compared with the financial outlay on a sound production. In picture production repairs to sound equipment usually consists of replacements of complete units when trouble is encountered. The actual test and repair of the faulty unit is then much the same as in the case of radio equipment, and may be carried out at leisure, so to speak, while a spare equipment is used to carry on production. The problem unique to the studio is then to have at all times a complete knowledge of the conditions of each channel available, and an assurance of satisfactory performance by all channels in production, and others which are expected to insure continuous operation. In meeting this problem, routine tests are made on the equipment, usually daily, and sometimes oftener.

A sound recording channel, when the record is made on film, consists essentially of a microphone and its associated amplifier, a mixer and amplifier system which may be regarded as a unit for the purpose of this treatment, and the recording machine or "sound camera" which photographs the record of the speech circuit modulations. Maintenance on the latter is commonly placed in the hands of a group of specialists who confine their activities to the recorders alone. The nature of this work depends entirely upon the type of machine used, and to thoroughly discuss the details here would involve a separate treatment of each of the several types of recorder in use. The speech channels, on the other hand, are in general all quite similar, and the common practices in vogue for making measurements on them are applicable to all.

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SOME of the important tests and instruments necessary to maintain a recording channel in perfect condition are outlined in the accompanying article.

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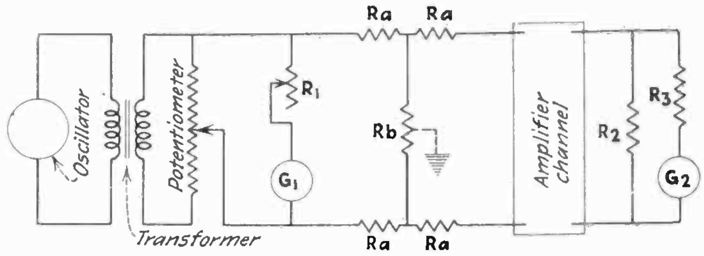

Fig. 1—Diagram of typical measuring circuit applicable to mixing and amplifying equipment found in modern studio installations

A commercial routine test on a sound channel should consist of a continuity test, a check of the condition and operation of each component part which might give trouble, frequency characteristics under all operating conditions, and a check of overall gain.

In checking and testing individual parts, a resistance bridge is indispensable. Trouble may be quickly located with a circuit continuity tester, many such devices being obtainable with approximate resistance readings on the scale, but an accurate wheatstone bridge is necessary for obtaining assurance of proper functioning of the various circuits in an amplifier used in this work. An extremely valuable device is one which allows each tube to be operated in a remote circuit containing complete metering equipment for the observation of all tube currents and voltages under actual operating conditions. Such "tube testers" are really more than the name implies, for they furnish an excellent check on the complete circuit as well as on the tube itself.

High quality instruments essential

Since the quality required in recording sound for motion pictures is of necessity much higher than in other branches of the sound industry, measuring apparatus employed in this work should be of very high quality. The use of mediocre or inferior measuring equipment on apparatus which is used in the making of productions costing many times the value of the equipment itself is obviously false economy.

Figure 1 shows a scheme of measurement applicable to most types of mixing and amplifying equipment found in modern studio installations. The section denoted as "amplifier channel" may consist of one amplifier, an amplifier and mixer, or almost any combination having an input impedance in the neighborhood of 500 ohms, and an output impedance of 500 ohms or less. This includes most mixer and amplifier combinations commonly in use. The oscillator should be chosen with the greatest care. Whether it be of the single oscillator or the beat frequency type, its harmonic content should be a minimum, and in no case greater than 4 per cent of the fundamental within the band of 50 to 10,000 cycles. Its voltage output need not be perfectly constant with changing frequency, but the required power should be avail-

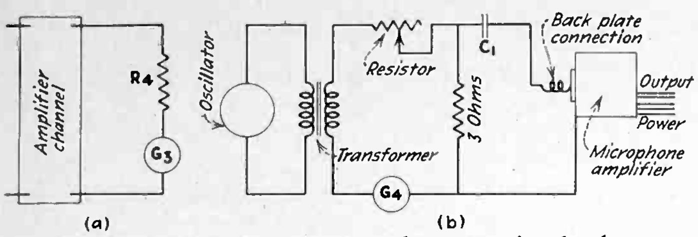

Fig. 2 (a)—Output circuit for measuring load of low impedance using thermo-coupled milliameter
(b)—Circuit for supplying constant input to microphone amplifier making it part of channel under measurement

able at all frequencies. From zero to plus ten decibels of power output are usually desirable with the scheme in question. Several oscillators are commercially available which meet these requirements. If the oscillator output impedance be too high for operation on the input line, a step-down transformer may be used to reduce the output impedance to something not exceeding the line value. In case the oscillator is not provided with a convenient volume control, or if further adjustment is desired, a potentiometer is introduced here to completely control the voltage input to the line. A slide wire or comparable type of potentiometer is satisfactory for this purpose, and may be in the order of 3,000 ohms for feeding a 500-ohm line.

From this point on the line is padded to exactly the impedance of the amplifier or mixer input circuit, and the input measurement should therefore be made at this point. The line voltage is measured with either a vacuum tube type of voltmeter, or a thermo-coupled device. The latter is usually preferable for frequency characteristic measurements. If a thermo-coupled milliammeter is used at G_1, as is good practice, a series resistor R_1 is used to raise the impedance of the meter circuit sufficiently to maintain good efficiency from the oscillator. The value of R_1 may be of such value as to make the total meter circuit resistance a round number to simplify calculation. In order to meter this circuit at low impedance, a fairly high signal level is required, and a pad attenuator must then be introduced in order to drop the line level exactly a known amount and at the same time maintain a constant line impedance. Such attenuators are available on the market, and are rapidly adjustable, usually in steps of one-half or one decibel. A total attenuation of about 60 decibels should be available. From the current and impedance relations existing, general expressions may be derived for obtaining the values of R_a and R_b at known attenuations with any given line impedance. These expressions are:

$$R_a = \frac{Z}{2}\left(\frac{K-1}{K+1}\right), \text{ and } R_b = 2Z\left(\frac{K}{K^2-1}\right)$$

where Z is the line impedance, and K = antilog $N/20$, N being the attenuation in decibels.

In case the input circuit of the amplifier is ungrounded, it is well to ground the center of R_b so as to stabilize the line, but if the amplifier input circuit is already grounded at any point no ground should be used on the attenuator, as this might cause the input circuit to carry part of the filament current to the amplifier, in case the filament circuit were also grounded, as it is usually. If the output impedance is of the order of 500 ohms, an output circuit consisting of R_2, R_3 and a thermo milliammeter G_2 form a good combination as shown in Fig. 1, for R_2 and R_3 may be so balanced as to make their parallel circuit, with the meter, equal to 500 ohms. In the case of most recorders, the load circuit is of very low impedance, usually about 2 to 10 ohms, and the output transformer may be designed to work directly into a load of this value. In such case the output circuit of Fig. 2(a) is sufficient with G_3 a thermo-coupled milliammeter of about one ampere capacity and a series resistor R_4 of the value of the load impedance minus the meter resistance.

Calculations for meter settings

As an example, suppose we have an amplifier and mixer with both input and output impedances of 500 ohms. If this channel is designed to operate a recording machine requiring a power level of +10 decibels, it will be desirable to hold the output level at this value while making characteristic and gain measurements, if the

[*Continued on page 526*]

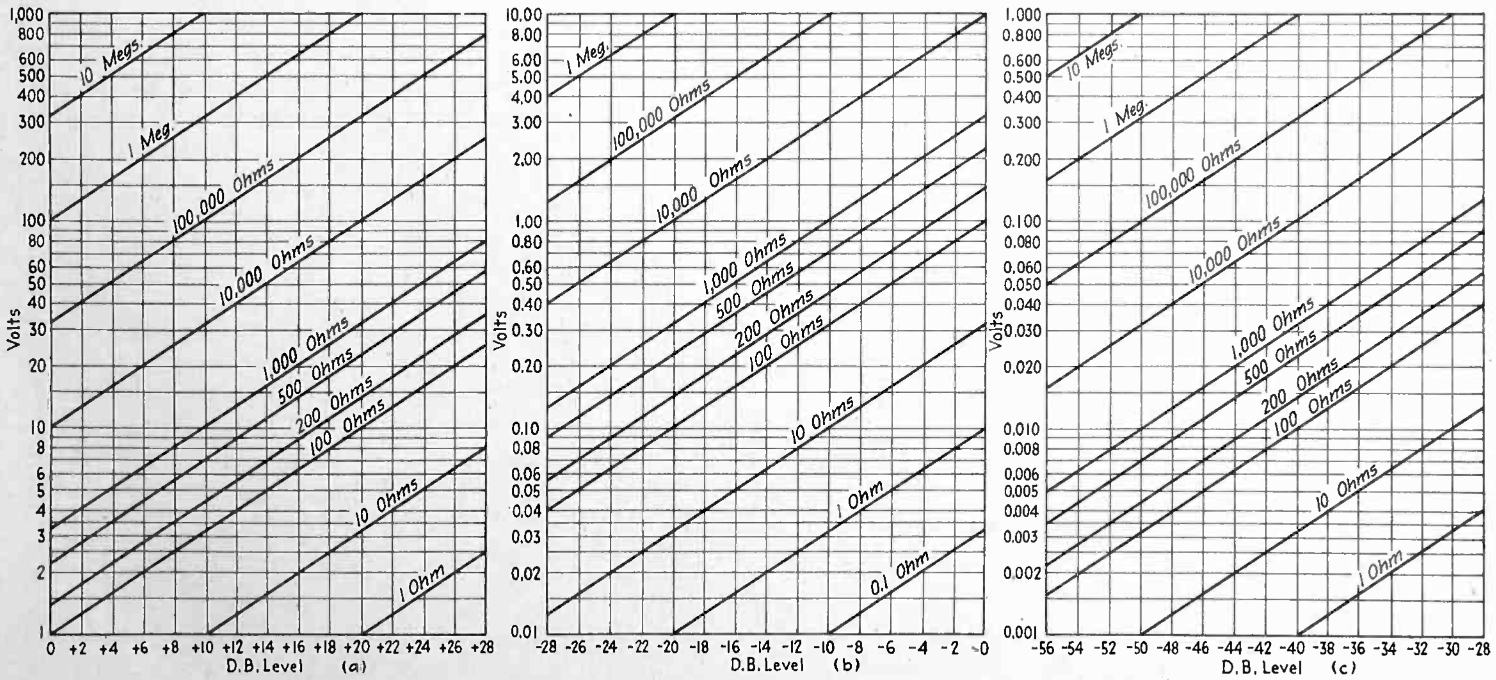

Fig. 3—These curves, representing various impedances, taking zero level at 10 milliwatts, show the correct line voltage to give desired level

By-pass condenser production test equipment

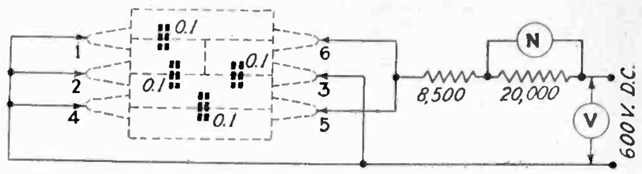

Fig. 1—Circuit for the high voltage test

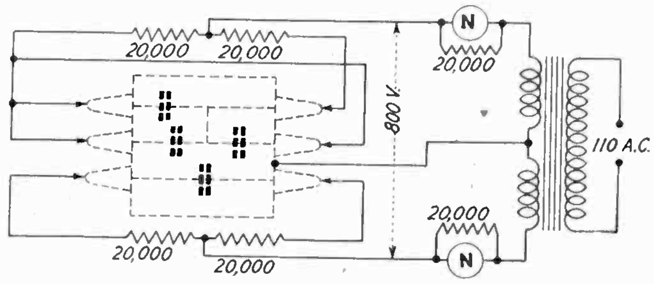

Fig. 2—Circuit for (a) discharging condensers, (b) testing at 400 volts for solder lugs poorly insulated from container, and (c) testing at 800 volts between individual lugs for insulation

By FRANK W. STELLWAGON

Test Engineer, A. H. Grebe & Co., Inc.

THE by-pass condenser test apparatus shown in the photograph is capable of completely testing over 500 by-pass condenser units per hour. The tests include a ten-second test at 200 per cent of rated d.c. voltage, discharging of the charged condensers, testing the insulation between the condenser terminals and the container, and checking the capacity of the four condenser sections.

The test apparatus consists essentially in three individual test circuits combined so as to permit making the above tests successively at one handling of the condenser unit.

A rotating wheel is used having on it six test mountings for holding the condenser units. Each test mounting is connected to a brush carriage holding seven brushes. Seven brushes are necessary to contact with the six solder lugs and the container of the condenser unit. The brushes rub on a seven-ring track, each ring being divided into six 60 degree segments which are insulated from one another.

Referring to the photograph, the track segment opposite position *A* is wired to the circuit of Fig. 1. Likewise the track segment of position *B* is wired to the circuit of Fig. 1. Both positions *A* and *B* apply a 600-volt d.c. test for about five seconds. The breakdown of a condenser is indicated by the glowing of either of the neon lamps *A* or *B*, depending on which position the breakdown occurs.

The track segment opposite position *C* connects to the circuit of Fig. 2. The condensers which were charged in position *B* are now discharged through resistors. Poor insulation between the container and the six solder lugs is detected by means of a 400-volt test; the insulation between the lugs 1, 2, 3, 6 to lugs 4, 5 is checked at 800 volts. The glowing of the neon lamp *C* indicate an insulation failure.

The capacity test

The track segment opposite the capacity position connects to the circuit of Fig. 3. In this test a constant voltage of 220 volts a.c. is held across the condensers and the capacitative current indicated on the four meters *C*-1, *C*-2, *C*-3 and *C*-4. The Hi-Lo switch connects in standard capacitances having the acceptable minimum and maximum capacitance values which can be switched in each of the four meter circuits in turn to obtain the

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AMONG a number of interesting and time-saving pieces of production testing equipment in use in the Grebe factory is an ingenious device for testing by-pass—or power condensers. By turning a handle each of several condenser units is successively brought into a new test position by the operator.

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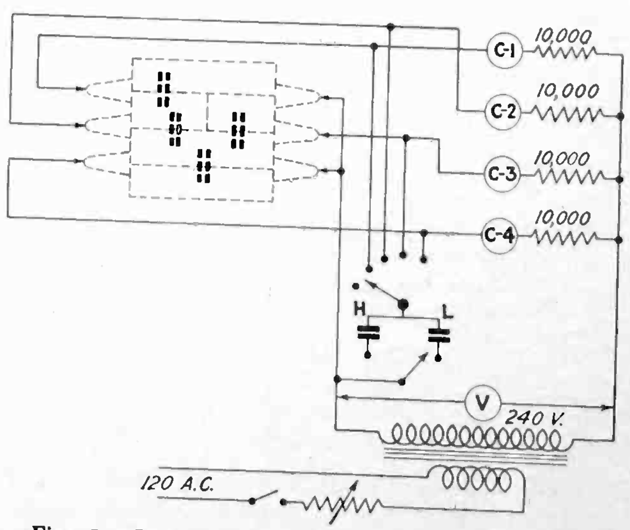


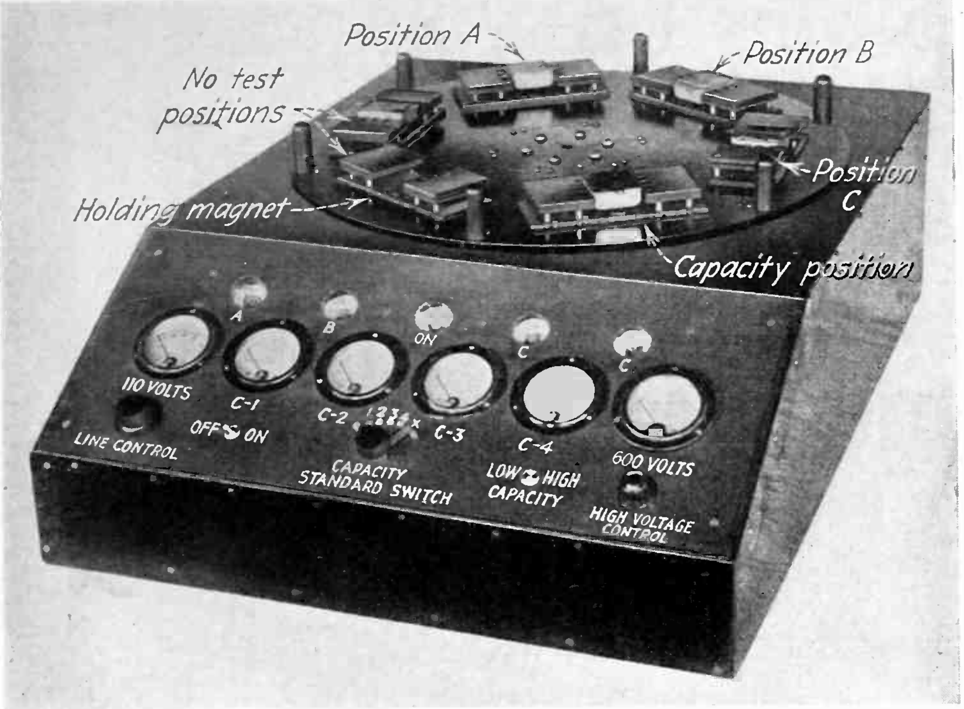
Fig. 3—Condensers in this circuit are tested for capacity

meter limits for acceptance of the condenser units.

The remaining 120 degrees on the test track is the no-test position where the brushes contact with no circuits. It is over this range that the operator removes tested condenser units and replaces them with untested ones.

Fig. 4 shows the wiring diagram of the seven-ring track to the three circuits discussed above. The power supply for the apparatus is shown in Fig. 5.

A feature of the apparatus is the holding magnets used on each test mounting. The iron containers of the condenser units are held firmly in position by the magnets assuring good contact between the test mounting contacts and the solder lugs of the condenser unit. The six holding magnets are connected in a series on the test wheel and power is supplied through a brush wiping on a ring connected to a 280 rectifier.



Photograph of the completed test apparatus. The operator pulls the condenser into new test positions by means of the handles

The power pack test apparatus embodies the same fundamental principles of operation applied to the by-pass condenser test apparatus discussed above. It tests completely a five-condenser section power pack at the rate of 500 packs per hour. The tests include a ten-second test at 200 per cent of rated d.c. voltage, discharging the charged condensers, testing the insulation between the condenser terminals and the container, and checking the five condenser sections for capacity.

The condenser packs are placed on the wheel with the

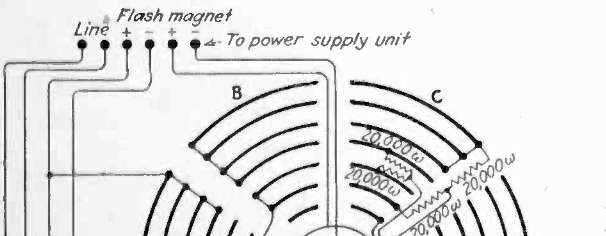


Fig. 4—Wiring diagram of the by-pass condenser test equipment

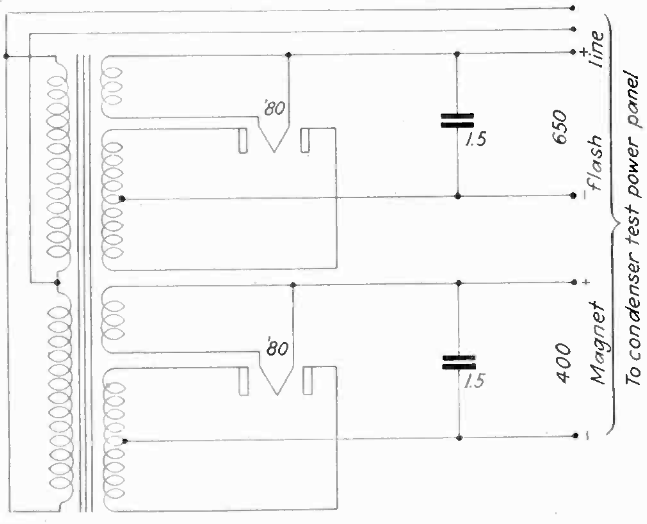


Fig. 5—Power supply circuit for the 0.1 mfd. by-pass condenser test

solder lugs projecting through the holes on the test wheel against contact springs. Magnets firmly hold the iron container of the power pack to the test board.

Glowing of neon lamps indicate that the condenser pack has one or more condenser sections which have failed on the 200 per cent rated voltage test, or that a solder lug is poorly insulated from the container. In the "Capacity" position, the meters indicate the capacity current of the respective condensers making up the condenser pack.

A standard capacity switch connects in the correct high and low values of capacity in the five respective meter circuits so that acceptance limits for each of the five condensers in the condenser pack may be easily determined at any time by the operator.

Notes on audio-frequency measurements

By JOHN K. HILLIARD

Research Engineer
United Artists Studio Corporation

THE importance of maintaining recording equipment of a studio in perfect condition is apparent to anyone having an appreciation of production schedules. To properly maintain such a system, it is very desirable to test the equipment on some definite schedule since experience has shown that such testing insures a uniform product without costly delays and inconvenience. The gain-frequency method of testing such equipment is very rapid, reliable and the apparatus used for making these tests can be assembled from standard units which are available.

In order to measure the gain of equipment at the various frequencies which pass through the system, an oscillator, gain set or attenuator, a volume indicator or power level device and the necessary switching keys are required. The amplifier and associated circuits to be measured are connected between the send and receive terminals of the gain-set. A tone of the desired frequency from the oscillator is applied to the attenuator input and the loss of the attenuator is set at the expected gain of the system. When the measuring device is transferred from the input of the attenuator to the output of the amplifier and the level is the same, the loss in the attenuator is equal to the gain of the amplifier provided the impedances of the amplifier are the same as that of the gain-set. When these impedances are not identical to those of the gain-set, repeating coils or transformers of the proper ratio are employed.

The equipment shown is the complete equipment necessary to make these tests. It is built in portable form so that it may be conveniently used to test field units and theater reproducing equipment. The lower panel consists of the input attenuators, keys, volume control and output termination for the equipment under test. The next panel above is a frequency oscillator. At the extreme top is a power amplifier which has a gain of 20 db. and a carrying capacity of plus 10 db. or 60 milliwatts. The volume control is placed between the oscillator output and amplifier input. Above the oscillator is a power level indicator. Above this is the impedance matching coils and the jacks. The connections to all pieces of equipment appear on individual jacks.

Portable equipment for making gain frequency measurements on studio field units and theater sound equipment

Power level indicator

In detail the attenuator unit consists of a General Radio type 552, 500-ohm H type, 30 db. network with 1.5 db. per step, one 40 db. fixed unit, and a 10 db. 500-200-ohm unit to be used when 200-ohm loads are measured. The attenuators are arranged on keys in such a manner that any combination of units can be used depending upon the impedance and loss required. The terminating resistance on the output is 500 ohms and the power level indicator is arranged on a double throw double pole switch to compare input and output.

It is customary to measure power level in voice transmission lines by observing the voltage across the line. This is an indication of the power when the impedance of the line is shown. A common impedance of such lines is 500 ohms. The power level is usually wanted in decibels from some standard reference level, such as six milliwatts. For these reasons the power level indicator is calibrated to read in decibe's above and below a six milliwatt reference level on a 500-ohm line. The sensitivity of the General Radio level indicator is such that it will read from a minus ten to a plus six decibel level. The scale of the meter is calibrated in 2 decibel steps through this range. A curve is supplied which gives the correction to be applied for lines of other impedances.

In order to increase the upper range of the instrument, a calibrated resistive multiplier is inserted between the input terminals and the rectifier and meter elements. The multiplier is so designed that the input impedance of the indicator is constant regardless of the multiplier setting. By means of the multiplier the upper range of the instru-

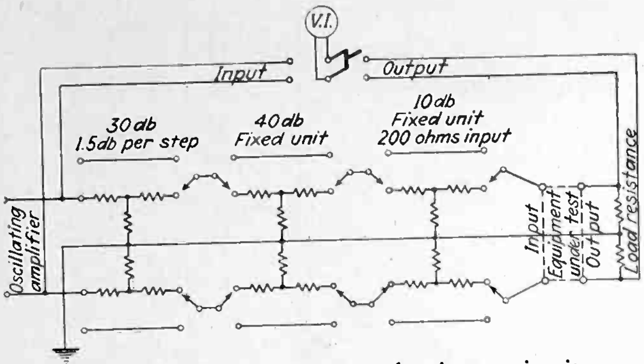


Fig. 1—Simplified diagram of gain set circuit to obtain power level in decibels

ment is increased to 36 decibels in 2 decibel steps.

The impedance of the unit is 5,000 ohms which is high enough so that it absorbs a negligible amount of the available power. When used on a 500 ohm line, the bridging loss is only 0.4 decibel. The sensitivity is independent of frequency from 20 to 10,000 cycles, and the error in this range is usually less than 0.2 decibel.

The volume indicator

The commercial volume indicator used to indicate relative sound volumes in public address, broadcasting, and recording, is based on a reference volume of six milliwatts across a 500-ohm circuit. This means that for an input of six milliwatts at its input terminals, the meter in its plate circuit gives a mid scale reading which is indicated as zero. A reading of more than this value is a measure of power greater than six milliwatts and is called a plus level. A reading less than mid scale is called a minus level. The meter generally has 30 divisions which means that the reference is taken at 30 divisions. It has been found convenient to calibrate the meter only 2 db. each side of reference. Since the meter is calibrated logarithmically, it is easy to estimate other values, since the scale reading is an indication of voltage. Hence, a reading of two times 30 or 60 gives a voltage ratio of 2 or an increase of 6 db., also a reading of 15 divisions indicates a decrease of 6 db. from reference. Other points may be obtained from the decibel-voltage table. Readings above 30 divisions are not reliable since at this point the tube begins to draw grid current. When a volume indicator is calibrated on steady tone, 6 milliwatts will give a deflection on the meter of approximately 23 divisions. The reason for indicating a reference at 30 divisions is because music and speech indicate a peak voltage while a steady tone approximates an average value.

Sometimes it is not convenient to have the meter and

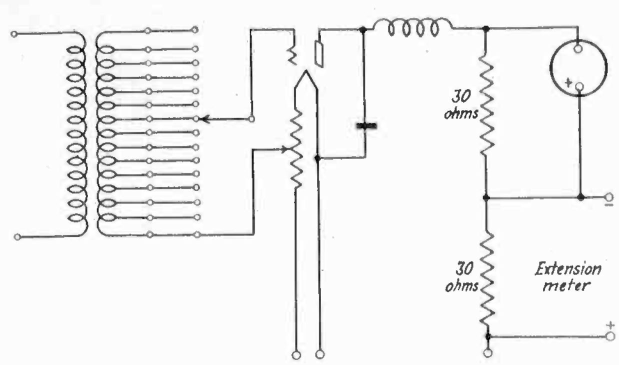


Fig. 2—Schematic diagram of volume indicator circuit showing connections for extension meter

the associated equipment of the volume indicator together. This can be remedied by extending the meter from the rest of the circuit as long as the loads have a small amount of resistance, not to exceed 2 ohms. In cases where it is desirable to have an extension meter as well as one with the equipment, an extension circuit can be provided, shown in Fig. 2.

In order to check the calibration of a volume indicator, the following method is used: With a single frequency sine wave from an oscillator, measure a definite volume into a 500-ohm circuit by means of a thermocouple, and obtain reference volume of 6 milliwatts. The 500-ohm load may be made up of a thermocouple with enough series resistance to make 500 ohms ($R_1 + R_2$) Fig. 3. The volume indicator bridged across this load with its dial set for reading reference volume, should then give a deflection on its meter of 23 divisions. To obtain reference volume a current of 3.46 milliamperes should flow through the 500-ohm load circuit. Since reference volume = .006 watts and $W = I^2R$

$$I = \sqrt{.006/600} = .00346 \text{ amperes}$$

If the voltage at reference volume across the 500-ohm load circuit = 500 × .00346 = 1.73 volts, the volume indicator bridged across a circuit in which there is an a.c. voltage across the volume indicator terminals of 1.73 volts (r.m.s.) and the volume indicator set for reading reference volume, its meter will give a reading of 23 divisions. Hence, either the voltage or current method may be used.

The principal error in volume indicators will be found to be the variation in characteristics of the tubes used in the circuit. Although the volume indicator is calibrated to read directly across a 500-ohm load, the instrument may be used across loads of other impedances by adding or subtracting the following correction term:

$$N = 10 \log_{10} 500/\text{load impedance}$$

A curve is plotted as shown in (Fig. 4) for various impedances.

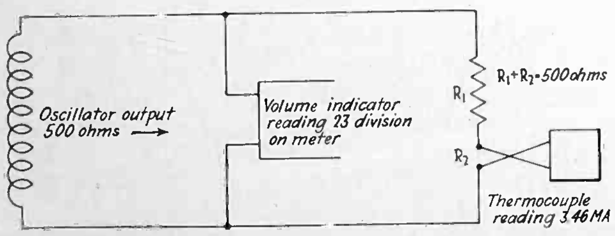


Fig. 3—Circuit used for calibrating volume indicator

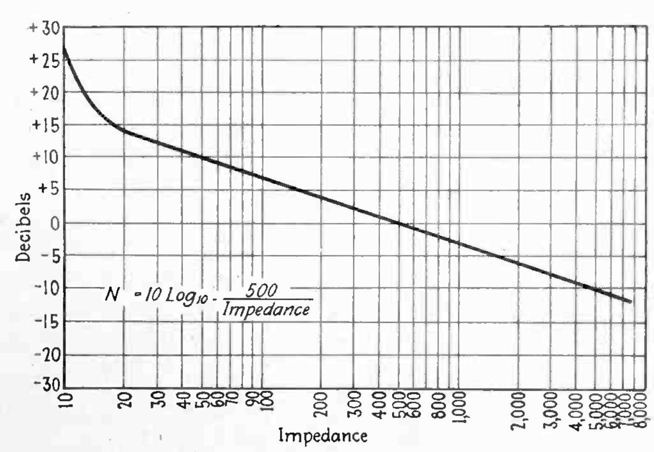


Fig. 4—Curve giving corrections in decibels to volume indicator readings when used across loads of other than 500 ohms impedance

The design of attenuation networks

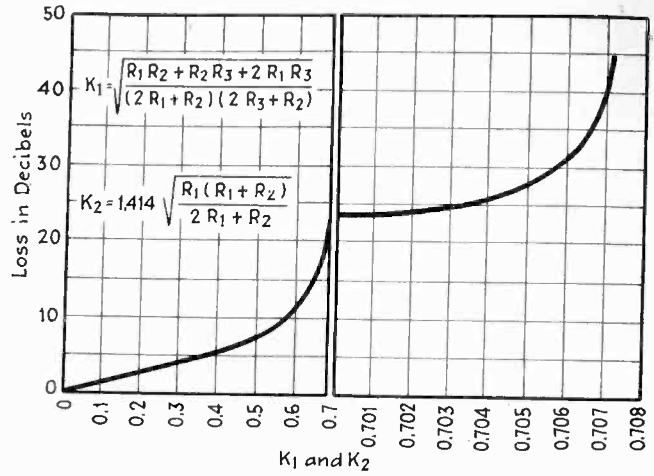


Fig. 2—Loss of either H or T type pads as a function of the resistances

By W. F. LANTERMAN

THE term "pad" as commonly employed in connection with audio frequency circuits, refers to an attenuation device used to reduce the power at a point in a circuit by some desired value. Pads are useful to the radio and sound engineer in innumerable ways. As accurately calibrated constant impedance attenuators, they are valuable in testing and measurement work. Fixed pads are used for terminating apparatus or transmission lines to provide loads of definite impedance; variable pads are often used as volume controls, and for this purpose are superior to most other devices. The following work is an attempt to put pad design formulas into simplified forms most useful in practical applications.

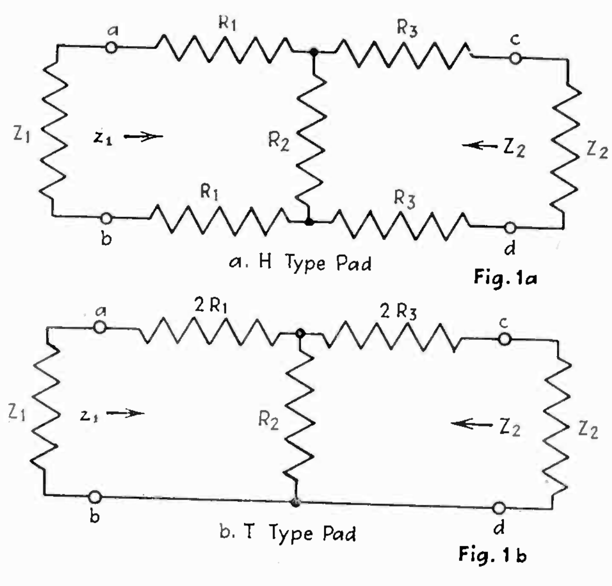


Fig. 1—Pads of the H and T types

Regarded as an electric circuit, a pad consists of a one-section artificial line whose elements are pure resistances. It is designed so that its input and output impedances are, respectively, the image impedances of the apparatus from which and into which it works: i.e., the impedances at the junction points of the pad and the other parts of the circuit are "matched." Such a condition exists if the impedance at the terminals (*a, b*) of the network (Fig. 1) equals the impedance Z_1 of the preceding apparatus, when the network is terminated at (*c, d*) by an impedance equal to Z_2. The power loss caused by the insertion of a pad is measured in decibels. When the values of the input and output impedances and the loss in *db* are designated, a pad is completely specified, and the amount of resistance required for each leg may be computed. Conversely, if all of the resistances of an existent pad are known, its input and output impedances, and its loss in *db* can be determined.

H or T types of network

The resistances forming the pad are arranged in an H or T network. The T pad is simpler and easier to construct than the H type, and in general may be used with the same results; the H type is necessary only where each side of the line is required to contain the same series impedances to preserve the electrical balance of the system. For example, a transformer circuit with center taps grounded would require pads of the H type, whereas a circuit with one side of the line grounded might use T pads. The expressions to be developed here apply to both types if the resistances have the values shown in Fig. 1.

From fundamental circuit theory we obtain

$$Z_1 = 1.414\sqrt{\frac{(2R_1 + R_2)\ (R_1R_2 + R_2R_3 + 2R_1R_3)}{(2R_3 + R_2)}} \quad (1)$$

$$Z_2 = 1.414\sqrt{\frac{(2R_3 + R_2)\ (R_1R_2 + R_2R_3 + 2R_1R_3)}{(2R_1 + R_2)}} \quad (2)$$

The loss in decibels is

$$L_{db} = 8.686 \tanh^{-1}\left[1.414\sqrt{\frac{R_1R_2 + R_2R_3 + 2R_1R_3}{(2R_1 + R_2)\ (2R_3 + R_2)}}\right] \quad (3)$$

$$= 8.686 \tanh^{-1}(1.414\ K_1) \quad (3a)$$

where $K_1 = \sqrt{\frac{R_1R_2 + R_2R_3 + 2R_1R_3}{(2R_1 + R_2)\ (2R_3 + R_2)}}$

A plot of (3a) for various values of the quantity K_1 is shown in Fig. 2.

Equations (1), (2) and (3) are the general expressions for finding the input and output impedances and the loss of a pad having known resistances. In the special case where $R_1 = R_3$, (1) and (2) reduce to the identity (4) and the impedances are equal:

$$Z_1 = Z_2 = 2\sqrt{R_1(R_1 + R_2)} \quad (4)$$

[1]The reader who is interested in the mathematical development of these expressions will find a complete treatment of the subject in K. S. Johnson's "Transmission Circuits for Telephone Communication."

Also, (3) becomes

$$L_{db} = 8.686 \tanh^{-1} \left[\frac{2\sqrt{R_1(R_1 + R_2)}}{2R_1 + R_2}\right] \qquad (5)$$

$$= 8.686 \tanh^{-1} (1.414\ K_2) \qquad (5a)$$

where

$$K_2 = 1.414 \frac{\sqrt{R_1(R_1 + R_2)}}{2R_1 + R_2}$$

the values of L_{db} in (5a) corresponding to various values of K_2 can be read from the curve, Fig. 2.

To design a pad

In practice, the conditions are usually the reverse of those just considered—the engineer is most often concerned with designing a pad to have given input and output impedances and to produce a given loss. The equations for this purpose are developed from (1), (2) and (3) by a somewhat involved mathematical process.[1] The results are the general equations for a transmission network:

$$R_1 = \tfrac{1}{2}\left[\frac{Z_1}{\tanh\theta} - \frac{\sqrt{Z_1Z_2}}{\sinh\theta}\right] \qquad (6)$$

$$R_3 = \tfrac{1}{2}\left[\frac{Z_2}{\tanh\theta} - \frac{\sqrt{Z_1Z_2}}{\sinh\theta}\right] \qquad (7)$$

$$R_2 = \frac{\sqrt{Z_1Z_2}}{\sinh\theta} \qquad (8)$$

in which

$$\theta = \tfrac{1}{2}\log_e \frac{\text{volt-amperes at } (a, b)}{\text{volt-amperes at } (c, d)} \qquad (9)$$

For resistance networks, (9) may be written

$$\theta = \frac{\text{loss in } db}{8.686}$$

For practical purposes, we may rewrite equations (6), (7) and (8) as follows:

$$R_1 = K_3Z_1 - K_4\sqrt{Z_1Z_2} \qquad (10)$$

$$R_3 = K_3Z_2 - K_4\sqrt{Z_1Z_2} \qquad (11)$$

$$R_2 = 2K_4\sqrt{Z_1Z_2} \qquad (12)$$

where K_3 and K_4 depend on the loss in *db* as shown in Table I. These are the relations most useful in the practical design of pads.

From (10) and (11) we see that if $K_4\sqrt{Z_1Z_2}$ is larger than K_3Z_1 or K_3Z_2, R_1 or R_3 will be negative. Since this is not possible practically, there is a limit to the ratio of $\frac{Z_1}{Z_2}$ or $\frac{Z_2}{Z_1}$ consistent with any given loss in *db*. This limit is reached when R_1 or R_3 becomes zero; it is found from (10) and (11) to be

$$\frac{Z_1}{Z_2} \text{ or } \frac{Z_2}{Z_1} \leq \frac{K_3^2}{K_4^2} = K_5\ (= \cosh^2\theta) \qquad (13)$$

where Z_1 and Z_2 are taken in the order which makes the ratio $\frac{Z_1}{Z_2}$ or $\frac{Z_2}{Z_1}$ equal to or larger than unity. In other words, the ratio of the larger terminal impedance of the pad to the smaller impedance cannot be greater than a quantity (K_5 in equation (13)) which depends upon the loss. Values of K_5 for various values of the loss in *db* are given in Table I. The limiting values of the ratios are plotted in Fig. 3.

From equations (10), (11) and (12) together with (13) and Table I, we can determine the resistance values for any pad of given loss and input impedances. To illustrate the method of applying them to a practical design problem, assume that we wish to build a pad to work between a circuit whose terminal impedance is 400 ohms and another whose input impedance is 600 ohms,

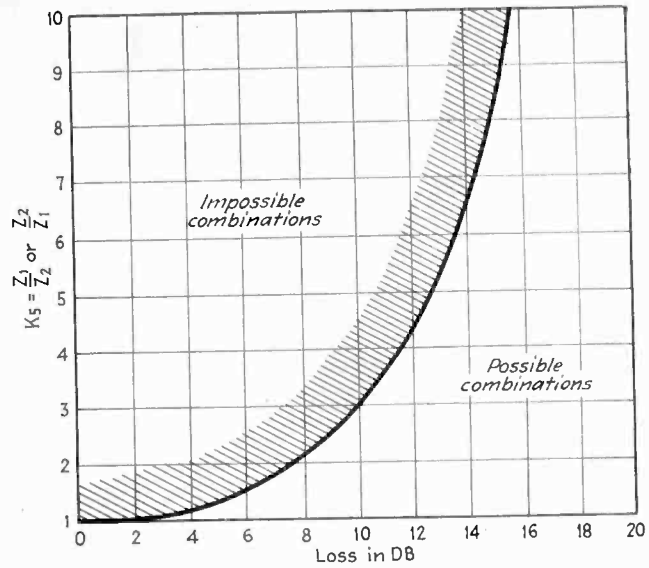


Fig. 3—Loss as a function of the terminal impedances

and that the pad so designed is to have a loss of 10 *db*.

First, referring to Fig. 3 or Table I, we find it is possible to construct a pad having this loss and an impedance ratio of $\frac{600}{400}$ or 1.5 (3.03 being the maximum impedance ratio possible). Then by Table I we see that for a loss of 10 *db*,

TABLE I

Loss in db	K_3	K_4	K_5
1	4.34	4.34	1.013
2	2.21	2.15	1.05
3	1.51	1.43	1.12
4	1.16	1.05	1.23
5	.965	.820	1.37
6	.835	.670	1.56
7	.725	.525	1.79
8	.690	.476	2.10
9	.645	.406	2.50
10	.610	.352	3.03
12	.565	.269	4.45
14	.540	.208	6.76
15	.532	.184	8.35
16	.525	.163	10.43
18	.515	.128	16.74
20	.510	.101	25.40
25	.502	.056	79.80
30	.500	.0318	247.00
35	.500	.0178	784.00
40	.500	.0100	2401.00
45	.500	.00565	7921.00
50	.500	.00320	24964.00

$$K_3 = 0.610$$
$$K_4 = 0.352.$$

Substituting these and the given values of Z_1 and Z_2 in (10), (11) and (12) gives

$$R_1 = (.61 \times 400) - (.352 \times 490) = 71.5 \text{ ohms.}$$
$$R_2 = 2 \times .352 \times 490 = 345 \text{ ohms.}$$
$$R_3 = (.61 \times 600) - (.352 \times 490) = 193.5 \text{ ohms.}$$

In practice we would make $R_1 = 70$ ohms, $R_2 = 350$ ohms, and $R_3 = 200$ ohms.

Thus far only fixed pads have been dealt with. In many applications, of which the "gain" or volume control is the best example, a pad having a variable loss is needed. A pad might also be designed to have variable input and output impedances, but there is little practical application for such an arrangement in ordinary audio frequency circuits.

To vary the amount of loss in a pad and at the same

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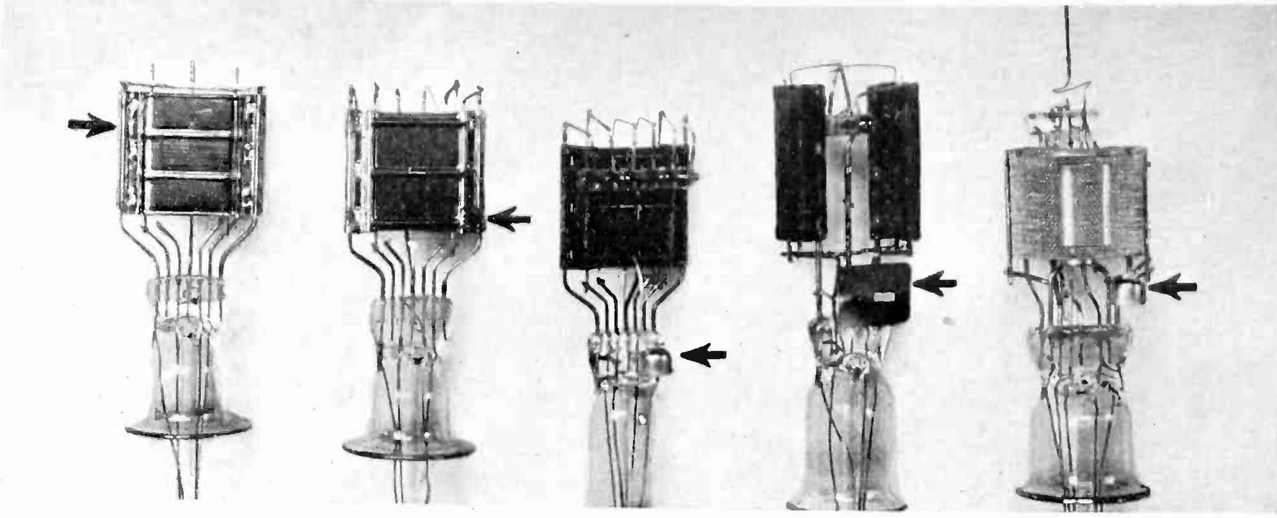

Fig. 1—Mounts of several types of tubes. The arrow indicates the position of the getter. Left to right, the mounts are of the following types—201A, 171A, 245, 280, 224

Some comments on the use of "getters"

By GEORGE D. O'NEILL

Engineering Department,
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AFTER the soft audion evolved into the hard vacuum tube, the question of satisfactory getters arose and is still a topic always open for discussion among tube engineers. In the manufacture of incandescent lamps getters had been fairly well developed. Means of removing traces of water vapor and oxygen were known, as were methods of preventing the volatilized particles of tungsten from forming a continuous film on the inner wall of the bulb.

One of the materials used as a getter in lamps is red phosphorus which is applied to the filament by running it through a suspension of dried, ground red phosphorus in alcohol. As a result of lamp experience, red phosphorus was early in use as a getter for high-vacuum tubes having tungsten filaments. In coated filament tubes, lime painted on the stem press was used as a getter for the purpose of absorbing water and carbon dioxide. Both phosphorus and lime are still in use, to a limited extent, in conjunction with the magnesium. Phosphorus would be more popular but for its erratic action on the grid contact potential, while the use of lime is often of little or no value and is entirely discredited by some engineers.

In the majority of tubes made to date, magnesium has been used as a getter material, which appears in the finished tube as a silvery, mirror-like deposit on the inside of the bulb. Magnesium is inexpensive, keeps well, and is easily applied to the tube. It came into general use about the time tubes began to be produced on a large scale, and while its position is being strongly challenged by other materials, is still the most generally used of all tube getters.

Use of phosphorus and magnesium

For a time, phosphorus was used in combination with magnesium in some tubes such as the 201-A, 199 and 120. The magnesium, either in the form of a short length of wire about one fortieth inch in diameter and a quarter inch or less in length, or in the form of ribbon, was spot-welded directly to the plate of the tube and red phosphorus in alcohol was applied with a brush to the side of the plate. An alternative method was to mix the phosphorus with magnesium and aluminum powder in a binder composed of nitrocellulose in a solvent, and to place one or more drops of the mixture on the plates before sealing on the bulb. The aluminum has no action as a getter in this case, but serves, because of its small size and light weight, to keep the magnesium in suspension while the getter is being applied.

After the phosphorus and magnesium were applied, the bulb was sealed to the mount (which comprises the stem with the electrodes mounted thereon) and the tube exhausted. Just before the tube was removed from the exhaust machine by the tipping off torch, the plates were heated by high-frequency induction, which caused the phosphorus and magnesium to vaporize and condense on the bulbs.

Applying getters to the above three types of tubes is still accomplished the same way, although the use of phosphorus has been more or less abandoned, principally because of the high-grid currents resulting from its use. The magnesium alone is either welded to the plate or applied as a powder with aluminum powder and a binder.

Other methods of applying magnesium getter to the mount of a radio tube have been developed, several of which are in use at present. The method of attaching the getter to the mount is not a matter of whim or of one method being better than another; it is indicated by the type of tube in question, by the type of machine to be used for exhausting, by the time in the exhaust cycle at which the getter is to be vaporized or "flashed" and by the location on the bulb where the getter is to be deposited. Simplicity and economy in mounting expense naturally influence the choice.

During the exhausting of a tube it is necessary to heat the plate to a high temperature in order to free it of gas and, in some cases, to aid in the break-down of the coating material on the filament or cathode. If the amount of heating required is not great the magnesium may be welded directly to the plate as in the 201-A. Where somewhat longer or greater heating is required, as in the 171-A or 226, the flashing of the getter must be delayed until after the plate has had a thorough heating and the vacuum pumps have had a chance to remove most of the gas. In order to delay the flash until the proper moment the magnesium wire is crimped in a thin nickel tab which is welded, on the edge away from the magnesium, to the plate.

When it is necessary to use a considerable amount of power in heating, as when a carbonized plate is used, it is essential that the getter be so mounted that it will not flash even under the most intense heating of the plate. In the 245, for example, this is accomplished by welding the getter into a small nickel cup which is located well below the plate so that only the last heating coil, which is made especially long, will heat the cup to a temperature high enough to flash the getter. In the 280, 281 and 250 types the getter is welded to a flat tab of sheet nickel at some distance from the plate and may only be flashed by a special coil in which the axis is directed perpendicular to the getter tab.

Special adaptation for 224 tube

The 224 tube presents a special case necessitated by its design for securing low inter-electrode capacitance. As the grid lead is brought out through the top of the bulb it is of importance that the upper part of the bulb be kept free from magnesium, as its presence acts as a coupling medium between grid and plate leads. In order to do this, a getter cup like that used in the 245 is placed below the outer screen in such a manner that all of the magnesium which leaves the cup condenses on the lower part of the bulb.

It is of considerable importance that in any of the larger tubes, such as the 245, 280 and 250, a considerable portion of the bulb be not entirely covered by getter so that the heat radiated from the plates will have a chance to get out of the bulb without heating it up to too high a temperature. When this feature is overlooked loose bases or short life are apt to become evident.

The getters already described are not by any means the only ones known or used. Aluminum has been successfully used in high-power tubes. It has not come into common use for receiving tubes as it presents little or no advantage and is difficult to flash. One process of flashing aluminum is to vaporize it by heating a molybdenum-aluminum alloy, which breaks down only at a very high temperature, the aluminum then being in an extremely active condition. The process, which is very effective, is not readily applicable to receiving tubes.

Misch metal, a mixture composed of several rare metals of the cerium group, is a satisfactory getter although its greatest field appears to be in gas filled tubes.

Probably the most effective and widely used getter which has come into use since magnesium became standard is barium. The value of this material as a getter has been recognized for some time, although its use did not become general until within the past two years.

Barium an effective getter

While barium is considerably more expensive than magnesium the cost is often offset by lower factory shrinkage or improved life, especially when high exhaust machine speeds are used or where the speed of the vacuum pumps is low.

The writer conducted tests about five years ago in which barium was used to obtain a good vacuum in the 201-A tube on a machine running at very high speed, the barium being obtained within the tube by heating a pellet of barium salt and misch metal. This process seemed advantageous for a time but eventually was abandoned in favor of magnesium, the latter proving more satisfactory after the pumping, bulb heating, and bombarding had been properly developed.

Other workers at this time were obtaining excellent results from a standpoint of getter action with barium obtained by decomposing barium azide in the tube. As this process had an undesirable effect on the grid poten-

[*Continued on page 528*]

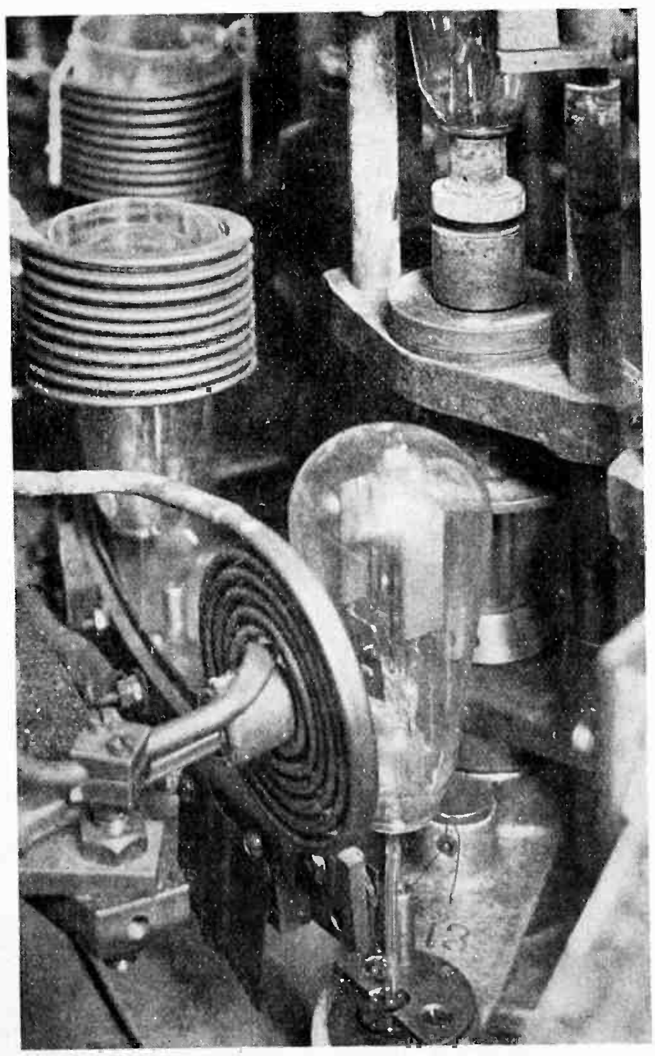


Fig. 2—Flashing the getter in the 280. The getter tab is seen behind the edge of the pancake coil, which heats the tab by high-frequency induction. The two helical coils are for heating the plates

Frequency characteristics of optical slits

By J. P. LIVADARY

Technical Sound Director, Columbia Pictures Corporation

MR. LIVADARY in the accompanying article treats of the relative efficiency of different optical slits and their frequency characteristics in connection with sound recording and reproduction. This discussion covers sound recording by means of a glow lamp and sound reproduction of "variable area" and "variable density" sound tracks.

THE art of sound recording deals with the problem of registering sound upon a convenient medium in a manner that will permit distortionless reproduction. The sound engineer is confronted with problems of diversified nature, most of which are intimately related to all branches of modern science.

Ordinarily, sound originates on a stage or out-doors and the proper method of "pick-up" with a microphone involves a study of the acoustics of the surrounding medium; this in turn, yields valuable information as to proper materials to be used in the construction of sets, methods of soundproofing, correct microphone placement and general stage technique. From this point on, the feeble voice energy picked up by the microphone must be sufficiently amplified to make possible its registration upon the recording medium. This requires proper design and reliable operation of practically distortionless amplifiers and associated indicating and monitoring systems.

The recording medium itself may be film, wax, magnetic wire or any other suitable material. The proper method of registration largely determines the quality of the recorded sound. In this article a study will be made of the relative efficiency of various methods used in registering sound on film at the present time, together with a discussion of the frequency characteristic of sound reproduced from film as affected by the optical system of the sound projector.

The material under study is divided in two parts only one of which is covered in this issue. This part deals with sound recording by means of a glow lamp and sound reproduction of variable density and variable area sound tracks.

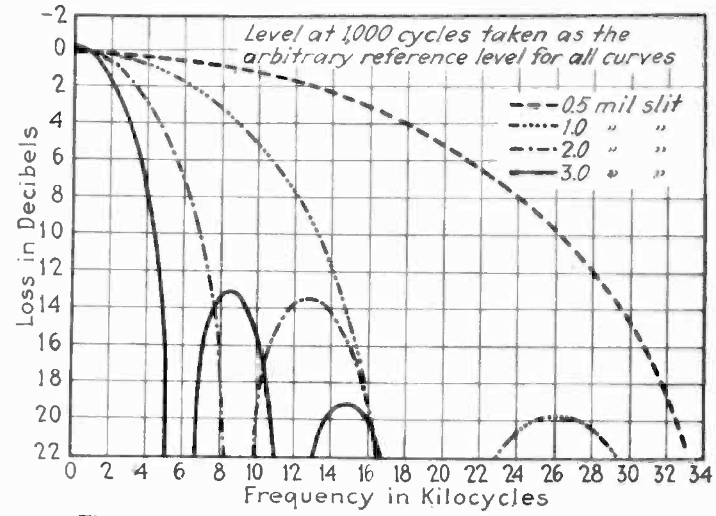


Fig. 1—Fixed optical slit frequency characteristics for variable density and variable area sound track projection and variable density sound recording

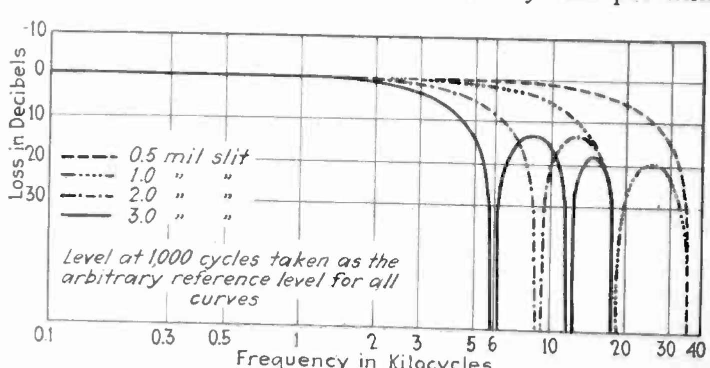


Fig. 2—Frequency characteristics as in Fig. 1 with the frequency axis plotted on log scale to show voice frequency range in detail

From the very inception of the art of recording the speed of the film has been taken as ninety feet per minute; this we will designate by v. We will assume that a glow lamp is used to expose film through an optical slit of fixed dimensions and that the voice currents are superimposed upon the normal excitation of this lamp, causing its instantaneous light intensity to vary in direct proportion to the current through the lamp.

The following symbols will be used:

I_0 = unmodulated glow lamp intensity.
$i = I_0 (1 + m \cos \omega t)$ = instantaneous intensity of glow lamp.
m = per cent of modulation of the lamp.
f = frequency to be recorded.
$\omega = 2\pi f$.
t = time.
S_0 = width of optical slit in the direction of motion of the film.

As the film moves with velocity v, any given point of it remains in the field of light of the optical slit for a time $\frac{S_o}{v}$. During this time the exposure varies in proportion to the change in intensity of the glow lamp. If we consider an infinitesimal element as it passes before the slit, we may write its exposure as follows:

$$E = \int_{t_1}^{t_2} I_o \, (1 + m \cos \omega t) \, dt \qquad (1)$$

t_1 = time film element enters light field.

t_2 = time film element leaves light field $= t_1 + \frac{S_o}{v}$

This integral reduces to the following expression:

$$E = \frac{S_o I_o}{v} \left\{ 1 + m \sqrt{\left(\frac{\sin \frac{\omega S_o}{v}}{\frac{\omega S_o}{v}} \right)^2 + \left(\frac{\cos \frac{\omega S_o}{v} - 1}{\frac{\omega S_o}{v}} \right)^2} \; . \cos \left(\omega t_1 + \frac{\omega S_o}{2v} \right) . \right\} \qquad (2)$$

The exposure of the film is shown to be made up of two parts: a fixed exposure $\frac{S_o I_o}{v}$ and a variable exposure

$$m \cdot \frac{S_o I_o}{v} \sqrt{\left(\frac{\sin \frac{\omega S_o}{v}}{\frac{\omega S_o}{v}} \right)^2 + \left(\frac{\cos \frac{\omega S_o}{v} - 1}{\frac{\omega S_o}{v}} \right)^2} . \cos \left(\omega t_1 + \frac{\omega S_o}{2v} \right) \qquad (3)$$

This variable part has a coefficient which varies with frequency and a phase shift which is linear with respect to frequency.

A study of this expression leads to the conclusion that film exposed by this method registers the original sound with increasing attenuation to higher frequencies and without phase distortion, as shown by the linearity of the phase displacement coefficient.

The frequency characteristic obtained depends upon the frequency, the velocity of the film and the width of the slit. The last quantity is the only factor that we may reasonably control, since it is undesirable to discriminate in the range of frequencies to be recorded or to change the velocity of the film.

The accompanying table shows the attenuation loss in decibels for frequencies from 35 to 33,000 cycles, computed for optical slits from half a mil to three mils in width. It also shows the phase shift for the same frequency range.

Figures 1 and 2 show the results of the table in graphical form. The graphs on figure 2 are plotted on log paper in order to spread out the voice frequency range. Fig. 3 shows the phase shift.

It is evident from these curves that with very narrow slits high quality recording is possible, without need for equalization on account of the drooping characteristics at the high frequency end.

It may be of interest to note that there is always a definite frequency whose wave length on the film equals the width of the recording slit. As this frequency is approached the attenuation of the film sound record rises rapidly, becoming infinite when the wave length on the film is equal to the slit width. On account of this phenomenon we have the peculiar result that a 2 mil slit, for example, which has a better overall frequency characteristic than a 3 mil slit, cannot possibly record, or reproduce, as we will show later, 9,000 cycles per second, whereas the 3 mil slit is capable of doing it with an attenuation of only 13.5 decibels.

It so happens that in the analysis of sound reproduction from film the mathematical expressions for the value of the photoelectric currents in the cell of the sound projector are of the same form as (1). In the case of the variable density sound track the photoelectric current is given by the integral

$$kT_o \int_{S_1}^{S_2} \left(1 + m \cos \frac{\omega s}{v} \right) ds \qquad (4)$$

while for the case of the variable area track the cell current is given by

$$\frac{kb}{2} \int_{S_1}^{S_2} \left(1 + m \cos \frac{\omega s}{v} \right) ds \qquad (5)$$

where

k = photoelectric constant,
T_o = unmodulated transmission of sound track,
S_1 = point of the sound track entering field of optical slit,
S_2 = point of sound track leaving field of optical slit,
b = width of the variable area sound track.

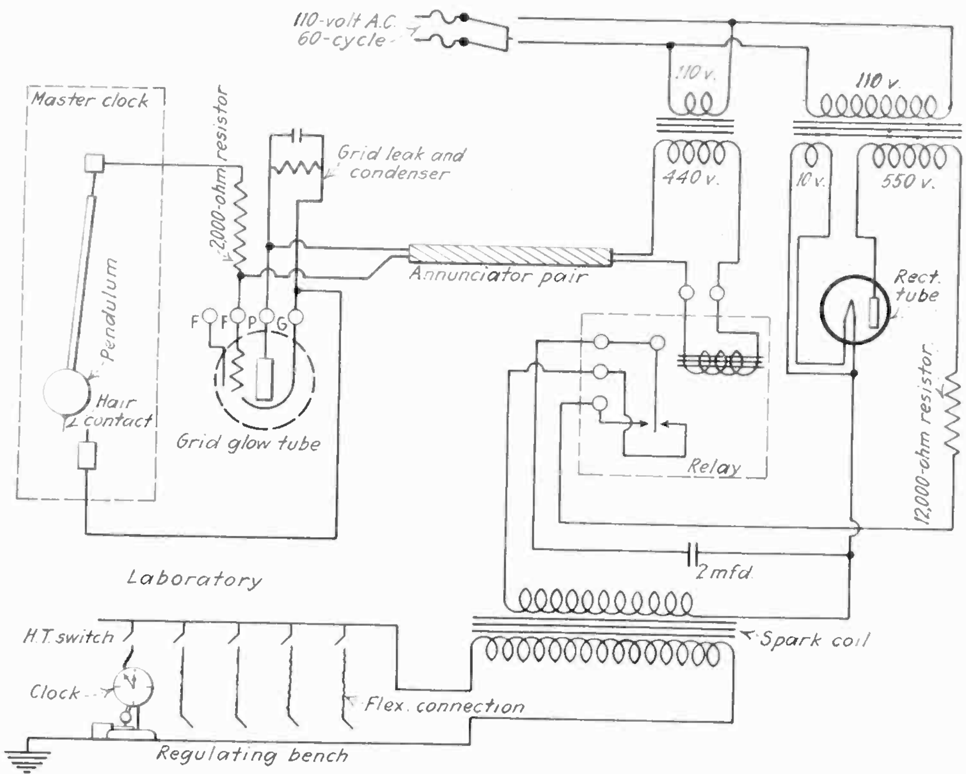
[*continued on page 530*]

Attenuation losses for different optical slits

Frequency Cycles per Sec.	Slit Width-0.5 mil		Slit Width-1.0 mil		Slit Width-2.0 mils		Slit Width-3.0 mils	
	Loss-DB	Phase Shift Degrees	Loss-DB	Phase Shift Degrees	Loss-DB	Phase Shift Degrees	Loss-DB	Phase Shift Degrees
35	0.00	— 4.82	— 0.04	— 9.65	— 0.17	—19.3	— 0.38	—28.95
60	0.00	— 4.7	— 0.04	— 9.4	— 0.17	—18.8	— 0.38	—28.2
100	0.00	— 4.5	— 0.04	— 9.0	— 0.17	—18.0	— 0.38	—27.0
200	0.00	— 4.0	— 0.04	— 8.0	— 0.17	—16.0	— 0.38	—24.0
500	0.00	— 2.5	— 0.04	— 5.0	— 0.17	—10.0	— 0.26	—15.0
1000	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
2000	0.05	5.0	0.16	10.0	0.54	20.0	1.30	30.0
3000	0.12	10.0	0.40	20.0	1.50	40.0	3.74	60.0
4000	0.17	15.0	0.73	30.0	2.88	60.0	7.32	90.0
5000	0.26	20.0	1.06	40.0	4.76	80.0	14.0	120.0
6000	0.36	25.0	1.60	50.0	7.50	100.0	∝	—30.0
7000	0.58	30.0	2.24	60.0	11.46	120.0	16.9	0.0
8000	0.71	35.0	2.98	70.0	18.10	140.0	13.3	30.0
9000	0.92	40.0	3.88	80.0	∝	—20.0	13.1	60.0
10000	1.12	45.0	4.92	90.0	20.0	0.0	15.3	90.0
11000	.....	.....	.....	.....	.....	.....	21.20	120.0
12000	.....	.....	7.64	110.0	13.70	40.0	.....	.....
13000	.....	.....	.....	.....	.....	.....	22.72	0.0
13500	.....	.....	.....	.....	13.50	70.0	.....	.....
14000	.....	.....	11.60	130.0	.....	.....	18.56	30.0
15000	2.64	70.0	.....	.....	15.70	100.0	.....	.....
16000	.....	.....	18.24	150.0	.....	.....	19.74	90.0
17000	.....	.....	24.64	160.0	24.90	140.0	.....	.....
20000	5.00	95.0	.....	.....	.....	.....	.....	.....
25000	8.52	120.0	.....	.....	.....	.....	.....	.....
30000	14.38	145.0	.....	.....	.....	.....	.....	.....
33000	21.0	160.0	.....	.....	.....	.....	.....	.....

Reference Frequency—1000 cycles per second.
This table gives tabulated data for figures 1, 2 and 3.

HIGH LIGHTS ON ELECTRONIC



Simplifies adjusting clocks

The Poole Manufacturing Company, Ithaca, N. Y., employs a vacuum-tube circuit application in its factory as a method of regulating pendulum clocks.

A master clock closes an electric circuit at each vibration of the pendulum. This trips a grid-glow tube which allows current to pass and charge a condenser which is subsequently discharged through the low side of an induction coil. The clocks under test are fixed so that the one terminal of the high-tension coil can be readily connected to the pendulum and the other terminal to a plate which is temporarily placed underneath the pendulum. Consequently, at every beat of the master clock a spark jumps from the pendulum to the plate, thereby giving an indication of the instantaneous position of the pendulum. As the spark moves in one direction or another it indicates whether the clock under test is gaining or losing.

"By means of this method," explains Arthur F. Poole, vice-president and manager, "we can regulate one of our clocks to an accuracy of ten or fifteen seconds a day, in a period of about five minutes."

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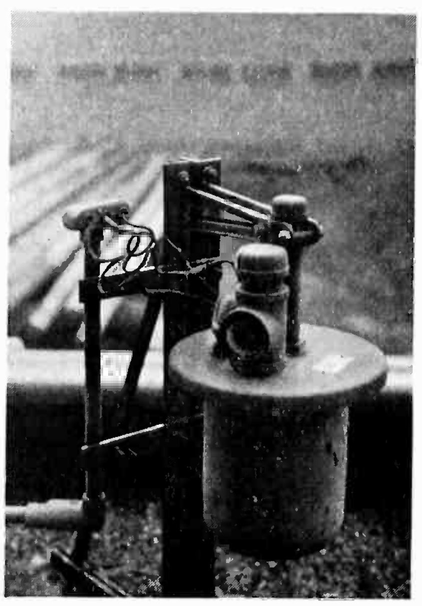
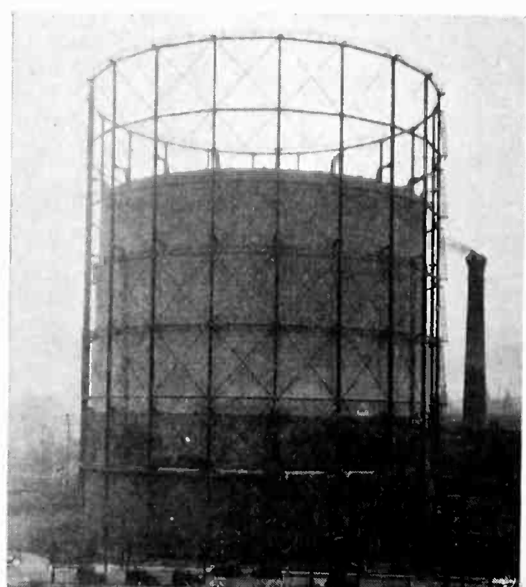
TUBE CONTROLS AVIATION OBSTRUCTION LIGHTS





Approximately 50 aviation obstruction lights located on this large storage gas holder in Syracuse, N. Y., are controlled by the G.E. photo-electric tube unit shown

✦

Amplifier music above factory din quiets workers' nerves

[By Martin Codel]

Music's charm to sooth the frayed nerves of routine factory workers is being enlisted more and more by plant executives. Not only does radio and phonograph music help relieve the monotony of routine tasks, but there is evidence that it stimulates efficiency and production.

As if to set an example for other industrial plants, the factories of the RCA-Victor Company at Camden, N. J., the RCA-Radiotron Company at Harrison, N. J., the Philco Company at Philadelphia and the CeCo Company at Providence, R. I., have been equipped with loud speakers to bring radio programs to the workers on their jobs throughout the day.

From Camden comes the report that radio is effective and popular even where the machinery is noisy; in fact, it is said that radio provides a better nervous anodyne when heard by workers above the roar of machinery they are attending than on the quieter jobs. Of course, the radio companies are quite enthusiastic about factory radios, for proof of its effectiveness will soon open up big new markets for receiving apparatus.

The first experiment in factory radio on record was tried some two years ago by the Chair City Upholstery Co., of Garden City, Mass., whose workers demanded the installation of loud speakers when asked to work overtime. They wanted to hear the presidential campaign speeches. A trial soon convinced the factory heads; they reported that production increased 17.5 per cent over a given period due to the radio.

"We find," reported Nathan G. Erwandter, president of the company, "that the best type of music to speed up work is jazz. Speeches tend to slow-up workers when they try to catch every word. Some of the employees, however, say they can work better when listening to classical selections. There is no doubt in my mind that the use of broadcast music to increase production

DEVICES IN INDUSTRY ✦ ✦

in industry is worth a thorough investigation."

Many cigar factories which formerly employed readers to keep the minds of the workers off their dull routine are now turning to radio. Some executives in factories and offices are finding radios valuable for tuning in stock market quotations.

✦

Ultra-violet and infra-red identify paintings

Scientific methods of art criticism developed by laboratories attached to the great Parisian art museum, the Louvre, and which promise to relegate professional art critics to obscurity in favor of violet-ray machines and infra-red devices, were described before a recent meeting in Paris of the French Association of Electrical Engineers. Every great artist of the past was in the habit, art critics long have known, of using definite pigments mixed in definite ways. These pigments, methods of mixing, methods of application and the like usually differed from one artist to another. Knowledge of such differences, based on experience in the study of the works of different artists, has long been the stock-in-trade of the experts able to distinguish the work of one artist from that of others or to detect copies and forgeries. The physicists of the Louvre laboratories now have reduced this general knowledge to a strictly scientific basis so that it can be applied by anyone, even by persons with little or no knowledge of art. One method is to photograph a painting successively with several different colors of monochromatic light, including the "invisible colors" of the ultra-violet rays and infra-red rays. These photographs have different appearances depending upon the exact pigments which the artist used and upon how these pigments reflect the various kinds of rays. Another method is to examine the color reflection characteristics of sports of individual pigment on a painting. For example, the red pigment ordinarily used by Rembrandt yields to the photo-electric reflection meter a curve characteristically different from similar curves for red pigments used by other masters.

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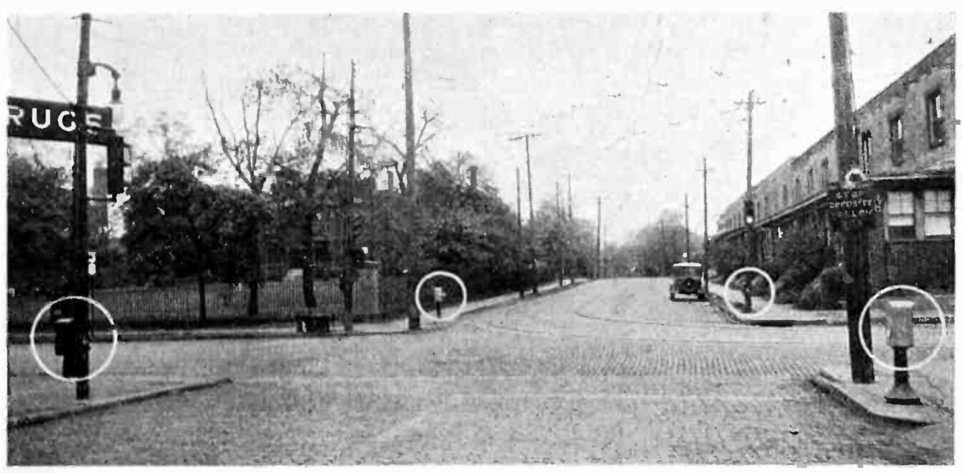
Traffic controlled by light beams*

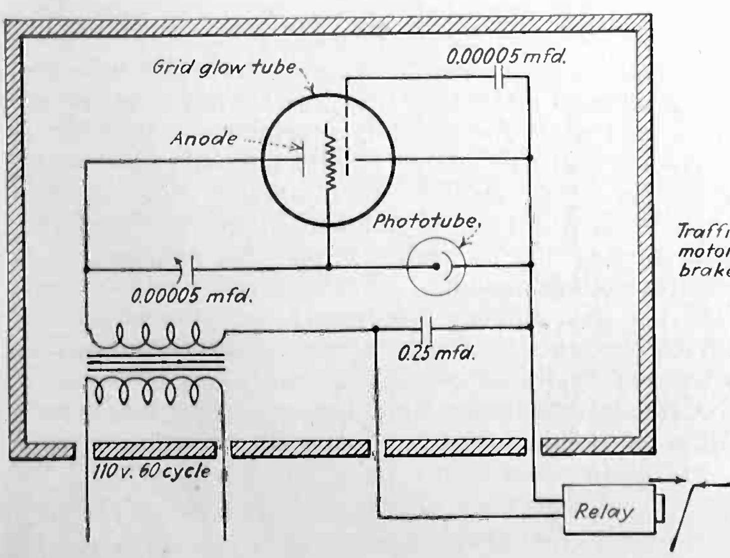
The installations shown were developed by the research laboratories of the Westinghouse Electric and Manufacturing Company to obtain working information on traffic control systems, and field experience on phototubes illuminated at a distance from light sources. They are experimental and the equipment is not yet available in commercial form.

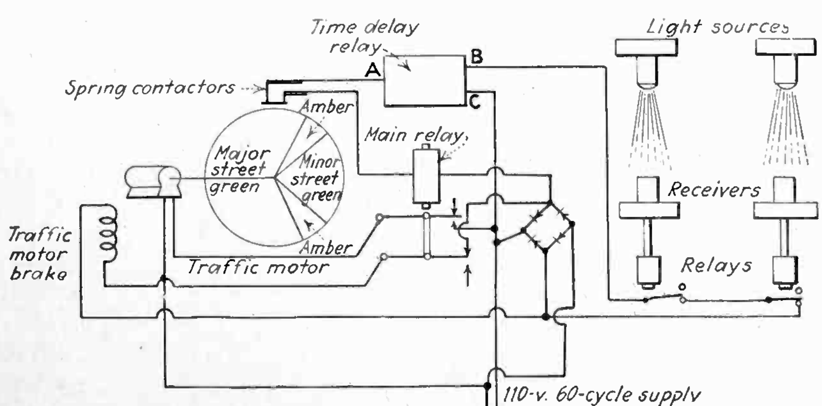
When traveling on a major highway, it is annoying, as well as wasteful of time, to stop at a red traffic signal, when there is no car waiting to use the green light which has been flashed on the minor highway. To keep the light green all the time on the major, and give the right-of-way to the minor street only when necessary, a light beam can be focussed on a phototube across the minor street, so that when a car intercepts the beam the traffic light would be flashed green on the minor street.

The first installation was in East Liberty, Pennsylvania, at the corner of Stanton and Highland Avenues. The second installation was at the corner of Coal Street and South Avenue, the latter being parallel to the William Penn and Lincoln Highways, in Wilkinsburg, Pennsylvania. South Avenue carries a fraction of the heavy main highway traffic.

*By R. C. Hitchcock, Research Engineer, Westinghouse Electric and Manufacturing Company.







Circuits and arrangement of photo-cell relays in traffic-control system

Special tubes for automobile radio sets

By ROGER M. WISE

Chief Engineer,
Sylvania Products Company

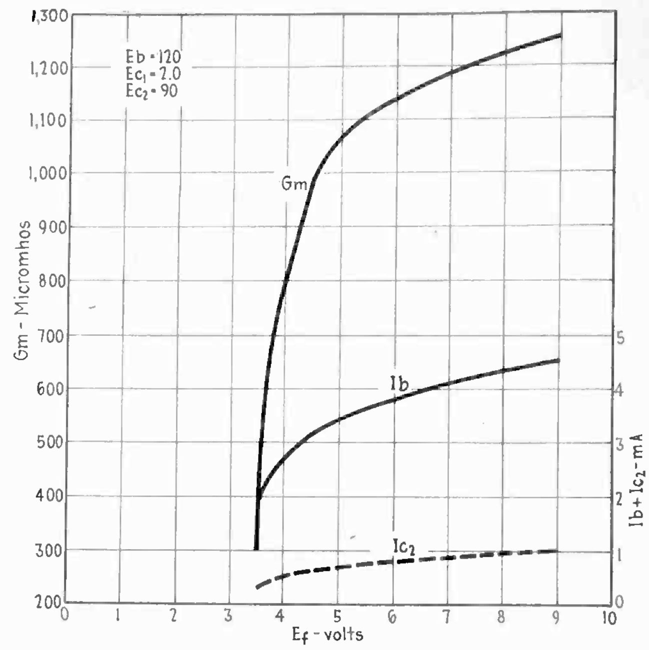


Fig. 2—Characteristics of the screen-grid tube

FOR reasons unforeseen at the time the heater-type vacuum tubes were developed they adapt themselves to many services unthought of at the time. The fact that the heater or filament is electrically insulated from the cathode is of enormous importance; but there are some services where this tube would be very useful, provided present types did not possess other disadvantages, such as large space requirements, unfortunate choice of heater current and voltage, etc.

In automobile, aircraft and direct-current receivers particularly present tubes are not entirely satisfactory, and while it is in the interest of standardization not to increase the number of tube types in existence, in the interest of better products a new series of tubes would be valuable. For this reason Sylvania engineers undertook the development of three tubes, a screen-grid type, a general purpose type and a power tube, especially adaptable to this general group of receivers. They were to be smaller in size if possible, and to have heater power requirements more easily met in special services.

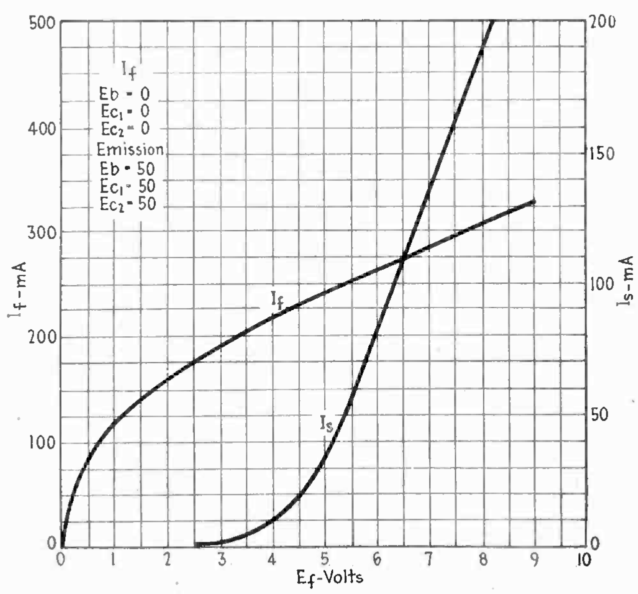


Fig. 1—Filament characteristics of the 6.5 volt, .25 ampere tubes

In automobile service the separate cathode has the following advantages, either side of the storage battery may be grounded, condensers in the receiver to avoid short circuits are unnecessary, and series connection can be employed without the usual difficulties with unequal plate currents and grid biases.

In automobile receivers some economy is obtained by operating two or three tubes in series, the nominal rating for two in series being 5.0 volts, 1.75 amperes, and for three, 7.5 volts, 1.75 amperes. Neither of these ratings is fully satisfactory, since the ordinary range of battery voltages with the generator charging and not charging, and with varying stages of charge and discharge of the battery is from 5.5 volts to 8 volts or slightly above. The 5.0 volt rating entails the loss of some power in a rheostat or ballast resistor or rheostat and the 7.5 volt involves the danger of operating at too low a temperature when the battery voltage is low (particularly in view of the usual drop in the battery cable with the above mentioned value of heater current).

Another disadvantage of present tubes is that of space limitations, space being at a premium in the automobile and aircraft receivers in particular. The 199 and 230 tubes are far more satisfactory from this standpoint than the 227, but the corresponding screen-grid tubes (222 and 232) are identical in size with the 224, and their characteristics make their use less attractive to the set designer than is the 224-227 combination.

Another problem is that of obtaining adequate output from the power amplifier when voltages of 135 or less must be used (in d.c. or automobile sets) the performance of 224 and 227 tubes being quite satisfactory as regards voltage amplification at moderately low voltages. The use of a cathode type power output tube for this service becomes especially attractive when the various operating conditions are considered.

Cathode type tubes are inherently more satisfactory from the standpoint of freedom from microphonic noise particularly when care is taken to rigidly support the cathode at each end of the structure and to prevent vibration of the grid.

To meet all the above requirements, three new tubes have been developed (referred to in this article as 224-C; 227-C, and 171-C). The tubes are quite similar—all being placed in the T-9 bulb ($1\frac{1}{8}$ in. in maximum diameter), and provided with a new base, identical, however, in pin size and spacing with the present five-prong base, and differing from it only in having a small shell. The base fits the present five-prong socket and is identical in diameter with the new four-prong base used on the 230 and 231 tubes.

Cathode construction

The same cathode is used in all three types and is made of seamless nickel tubing, much smaller in diameter than the standard 224 and 227 cathodes. The diameter of the cathode in the tubes illustrated is 0.035 in.—or approximately one-half that of the 224 cathode. Special precautions have been taken to insure uniform cathode temperature in order that the tube may operate over as wide a range of filament voltages as possible without excessive change in mutual conductances. The tungsten filament is rated at 6.5 volts, 0.25 ampere. Filament characteristics are shown in Fig. 2, from which it is evident that considerable ballasting action is obtained.

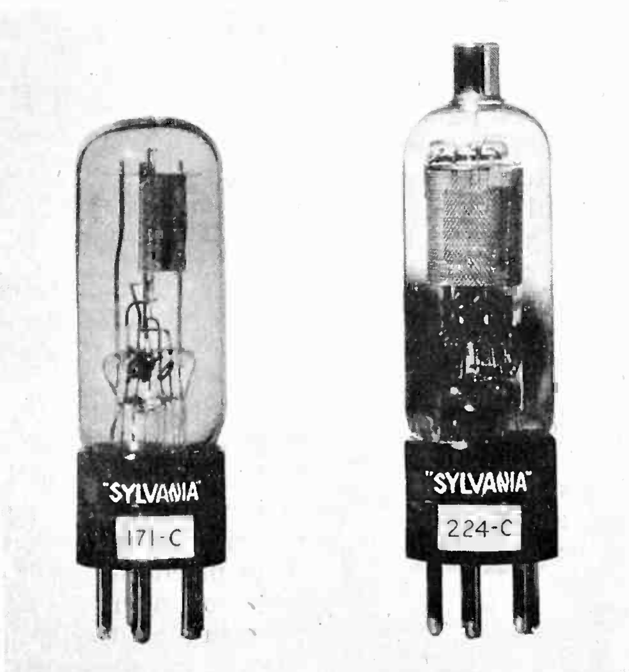


Fig. 3—Photograph showing construction of the new tubes

Since the filament must operate over the wide range of voltages noted above, life-tests were made at the following heater voltages: 5.5, 6.5, 7.5 and 8.5 volts. The first difficulty experienced was that of burnout of the filament due to the selection of too small a filament, resulting in a high operating temperature, which together with a small trace of impurities in the ceramic material used for insulation between heater wire and cathode sleeve caused etching of the filament, the development of hot spots and final melting of the wire. The operating temperature was lowered without changing the rating or cathode temperature by using a greater length of heater wire larger in diameter than the first wire tested. The ceramic material has been greatly improved by the development of a new material more suitable for this service than magnesia. This development is a result of the work of Dr. Henry Miller, director of the Sylvania Research Laboratory, who has been active in this particular field during the past five years. The new material is inert at temperatures several hundred degrees higher than that permissible with the best grades of magnesia available on the market.

Emission characteristics are shown in Fig. 1. It is evident that ample emission for all normal requirements is obtained from the small cathode provided in these models.

Data on the effect of the variation in heater voltages upon operating characteristics is given in Fig. 2. Note that at a voltage as low as 4.0 volts, the mutual conductance is 800, at 4.5 it is 1.000, at 5.5, 1,120; then increasing very gradually until at 9.0 volts it reaches 1,260.

When the tube is operated continuously at 5.5 volts there is some tendency for the emission to gradually decrease due to the fact that fresh barium is not formed from the oxide at as rapid a rate as it evaporates from the surface, hence the amount of active material on the oxide surface decreases. However in automobile service where the voltage will drop that low it will also rise above normal, where the above conditions will be reversed. This condition results in a correction of the above mentioned condition, as has been determined by operating cathodes on such intermittent cycles, results being more satisfactory than steady operation at 5.5 volts and comparing favorably with operation at rated voltage.

Preliminary design data indicated that interelectrode spacings would have to be greatly reduced in order to secure characteristics approaching those of the 224, 227, and 171-A. The difficulties encountered with small clearances are those involved in maintaining uniformity of characteristics, in the increased possibility of short circuits between elements, and, in the case of cathode types of tubes such as these, in providing proper precautions to keep all portions of the grid cool enough to prevent primary emission from this element, with resultant grid current.

The same physical dimensions are adhered to in the grids for all three tubes, the pitch only being varied to secure the desired value of amplification factor. The use of the double side rod is advantageous in preventing the fine cross wires from becoming overheated, thus eliminating the danger of primary emission from the grid. So effective is this construction in this respect that it has been possible to reduce the size of the cross wire from the usual value of 0.005 in. to 0.004 in. or 0.003 in. with resultant improvement in mutual conductance, and at the same time retain sufficient strength (using molybdenum wire) to permit fairly rough handling of the grid without change of physical dimensions.

The interelectrode capacity of the 224-C is somewhat lower than that of the 224, except plate-grid capacity.

In respect to the latter value the 224-C is within the maximum limit of 0.01 mmf., but not as low as the present average of Sylvania 224's which is 0.006 mmf.

The 227-C does not differ appreciably in characteristics from the 227 as far as amplification factor, mutual conductance and plate current are concerned, but has a lower value of interelectrode capacity.

In developing the tubes described above the assistance of Mr. Carl Miller of the Sylvania Engineering Department has been very helpful, particularly in making up the sample tubes tested and in developing the details of mounting and of exhaust and ageing. Mr. Walter R. Jones assisted in measurements on the tubes.

Sensitizing the photocell

By DR. RICHARD FLEISCHER

Technical Assistant, Physical Institute, Saxony Technical High School, Dresden, Germany

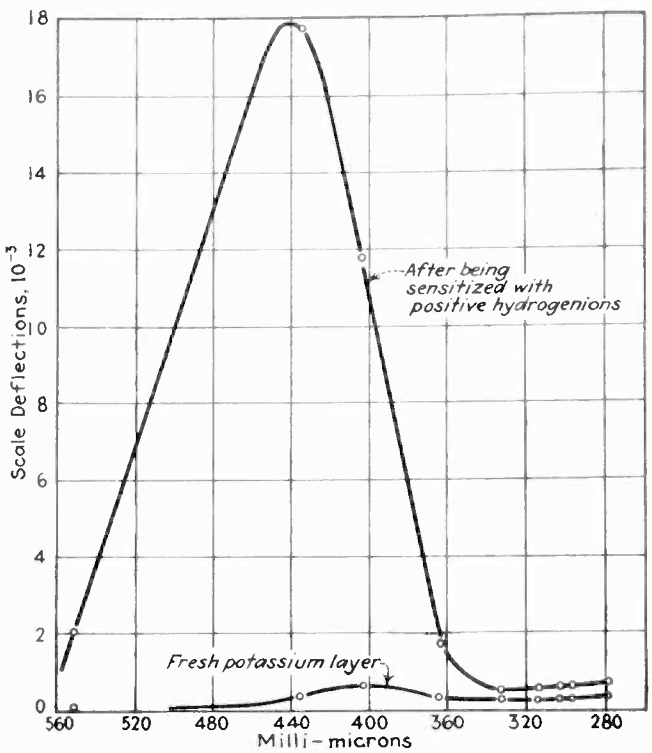


Fig. 2—Sensitization of fresh potassium layer after being loaded with positive ions. The increase in sensitivity is apparent

THE photo-electric effect was discovered shortly before 1890 by the director of the Physical Institute of the Dresden Technical High School, Wilhelm Hallwachs, who died in 1922. However, neither the discoverer himself nor the interested scientists had any idea that research, technical, and applied physics least of all industry as a whole had through this discovery been given the foundation for a device of almost numberless applications.

It has been determined that every material is sensitive to light regardless of the state of the material, whether it be a gas, a liquid, or a solid. It may be an electrical conductor or an insulator. It is only necessary to know which wavelength the light must have in order to release the electrons. Gaseous substances emit when subjected to X-rays. Fluids must be exposed to the

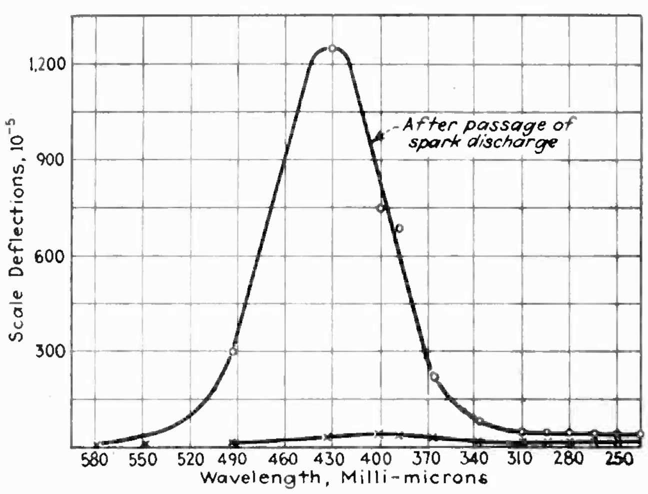


Fig. 1—Sensitivity changes of compact potassium surface

very short wavelengths of ultra-violet light with a maximum wavelength of 180 milli-microns in order that electrons are released. Solids, especially metals, will emit under the influence of ordinary ultra-violet light. The upper limit of wavelength at which solids are still light-sensitive is about 300 milli-microns. In only a few cases is this upper limit exceeded so as to include the visible and infra-red spectrum. To these exceptions belong the alkali metals: sodium, potassium, rubidium, caesium, and lithium. These alkali metals can be extremely sensitive in the visible spectrum. Besides, their upper limit of sensitivity sometimes reaches far into the infra-red.

As practically applied the photo-electric effect represents nothing more than a variable resistance in the space between the cathode and the anode.

By merely placing a "collector" plate opposite the light-sensitive plate we have the simplest form of photo-electric apparatus. Since the effect is largely dependent upon the nature and pressure of the surrounding gas and the density of the adsorbed and absorbed gas, the light-sensitive system is incorporated in a vacuum tube. The characteristics of the gas may thus be controlled and the troublesome effects of these three factors may be greatly minimized.

Photo-electric cell properties

Two of the natural properties of the photo-electric effect are most important in determining its applications.

First is the practically instantaneous flow of electrons when light strikes the metal surface. The electronic current reaches maximum as soon as light strikes the cathode; the electronic current ceases to flow when the light is cut off. The speed with which the cell acts is limited by the time required by the electrons to pass through the space between the cathode and the anode.

The second important property is the simple relation between the applied light intensity and the resulting electronic current. The latter increases in proportion to the intensity of the applied light.

This linear dependence signifies particularly the ease with which the photo-electric effect may be applied to photometry. The following are given as examples:

Translated from the German by C. W. Loeber.

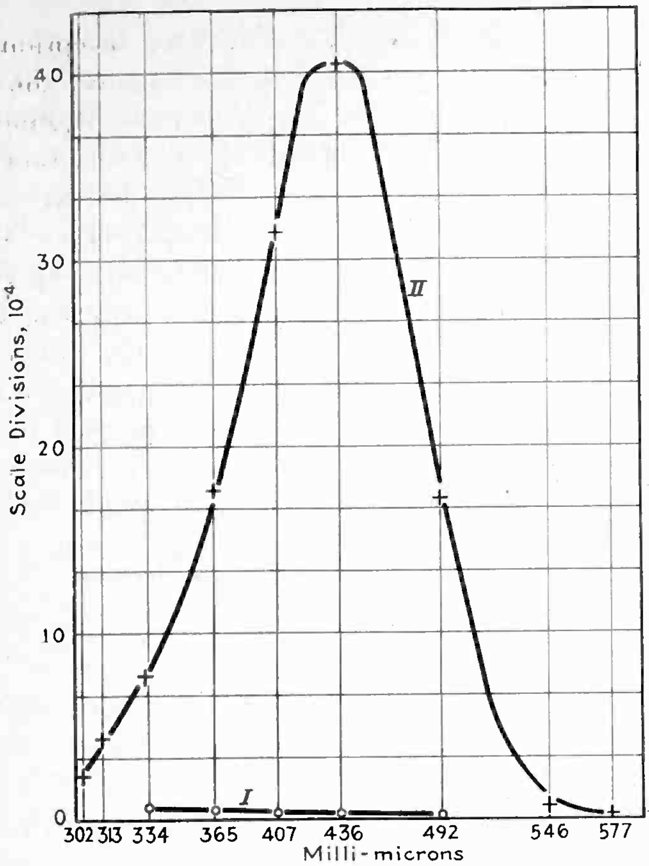


Fig. 3—Lower curve—potassium surface supersaturated with hydrogen. Upper curve—same surface after vaporization with fresh potassium layer

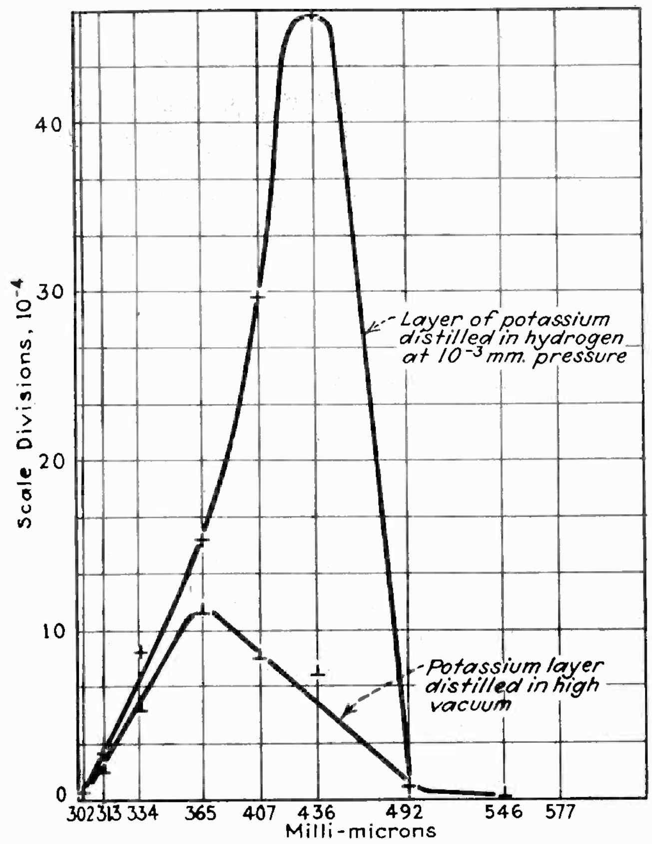


Fig. 4—Effect of sensitizing potassium layer in an atmosphere of hydrogen under a pressure of 10^{-3} mm. of mercury

measurement of the light intensity of stars, measurement of the light intensity of the heavens by day and by night, solar measurements, measurements of absorption, etc.

This sensitivity is important where for the various applications different values of sensitivity are required. The sensitivity of a cell used for solar measurements need not be as great as that of a cell used to make measurements of the heavens at night.

Aside from these two characteristics of the photo-electric effect two more demands are made upon the photocell in order that it may be a useful aid to research and technical science. These are the sensitivity of the cell in the visible spectrum of light and the constancy of the cell.

Sensitivity and constancy

Concerning the first requirements, nature has aided greatly by providing the alkali metals. These are sufficiently sensitive for short wavelength red, the visible spectrum, and long wavelength ultra-violet. The normal sensitivity of an alkali cell is generally sufficiently great for measurements in pure research when sensitive instruments are used (quadrant electrometer, reflecting galvanometer) or less sensitive instruments with one or more vacuum tube amplifiers.

The constancy of the cell depends mainly upon the condition of equilibrium between the gas and the photo-electrically sensitive metal, since it is recognized that the sensitivity is strongly dependent upon the nature and the pressure of the residual gas in the cell and the density of the gas which is adsorbed and absorbed by the metal. In addition, the constancy is also affected greatly by its insulation and by the formation of charges on the walls of the cell which give rise to field distortion. However, insulation difficulties and stray charges may be avoided by proper construction of the cell.

The four requirements mentioned above—instantaneous response, the linear relation between light intensity, sensitivity in the visible spectrum, and constancy—are of equal importance in the application of the photo-electric cell for research and technical purposes.

If a greater degree of sensitivity is required, it is necessary to employ a sensitizing process.

The process of sensitizing which is generally employed is that described by Elster and Geitel in 1910 (Phys. Z. 11,257, 1910). A spark discharge is produced in an alkali cell which is filled with hydrogen or some inert gas under low pressure. An increase in sensitivity is produced, as shown in Fig. 1. (Suhrmann and Theissing. Z. f. Phys., 52,453, 1928.)

The surface of the alkali cathode becomes discolored during the discharge. Hallwachs called this discolored, light-sensitive gas-metal surface colloidal alkali metal. It is seen from this designation that neither the condition of this more or less loose combination between the alkali metal and the gas nor the combination itself was clearly described.

It was Suhrmann who undertook this last problem again—the combination between the alkali metal and the gas. He established the fact that the great photo-electric sensitivity of potassium and especially the selective maximum at 436.8 milli-microns is caused by the presence of positive hydrogen ions. Figure 2 shows, according to Suhrmann, (Phys. Z. 29,811, 1928), the increase in photo-electric sensitivity of a potassium layer covered with hydrogen ions.

It is to be noted that when sensitizing by means of a

[*continued on page 530*]

electronics

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O. H. CALDWELL. *Editor*

Volume II — FEBRUARY, 1931 — Number 2

Flattening the radio production peak

NO MORE vital administrative responsibility faces radio executives today than that of ironing out the excessive production peaks which now usually occur during a few weeks or months each year.

Great radio assembly lines are started up, employees are taken on and trained, and production gets started. And then a month or two later, just as the huge assembly machine is running smoothly, usually there comes the order to "slow down" and finally to shut down! Employees are let out, their training is lost, and for months the vast investment stands idle. Then the wasteful cycle is repeated.

Economic necessity demands that production once started should continue at least a major part of the year. To accomplish such result will require close coordination of management, sales, engineering and manufacturing departments, and perhaps a new outlook on the part of each, facing this central problem.

The Navy's part in radio

THE present development of the radio art owes much to the interest, cooperation and financial aid rendered by the Navy in promoting the commercial progress of the industry. The fact that radio offered the ideal and only means of communication between ships at sea was seized upon by naval officers at the very inception of radio. The Navy was first to recognize the importance of a domestic source of radio equipment and the importance of strictly American-owned radio stations, in the United States, and its outlying possessions. The high standard set by Navy specifications has resulted in manufacturing companies improving their products to the end that there has been a steady advance in the radio art. By being the first to create the demand for new equipment and also assuming a large part of the development charges of the pioneer radio companies, the Navy provided the incentive for and practically supported this growing industry.

Electron currents in incandescent lamps

MANY radio engineers observing the electron streams flowing in vacuum tubes, have wondered to what extent similar currents occur between the filament ends of commercial incandescent lamps, forming a "by-pass," as the negative electrons boiled off the negative end, are attracted to the positive end.

In 115-volt incandescent lamps, in sizes between 15 watts and 100 watts, the electron current flowing between ends of the filament is of the order of one milliampere, being slightly greater in the gas filled lamps.

This current is limited by the space-charge effect as the actual electron emission from the filament is much greater.

This "by-pass' current, as it might be termed is not taken into account in measurements of lamp rating or efficiency as it is smaller than other experimental errors. It is not believed to be a factor in the life of the lamp because recent studies of the location of filament burn-outs would indicate that such burn-outs are not more common at the filament ends.

No real loss of power or light is involved because this electron bombardment heats the portion of the filament that it strikes.

This matter is of interest historically, W. C. White of Schenectady, N. Y., points out, because it was the trail that Dr. Langmuir followed in arriving at his space-charge discoveries. A study of Richardson's emission data indicated that sufficient emission would cause very appreciable currents to flow between portions of the lamp filament and Dr. Langmuir knew that actually such currents did not flow.

He was led to investigate the matter because existing physical laws could not explain why these currents would not flow.

State radio-set tax unconstitutional

THE U. S. District Court at Charleston, S. C., has declared the recent tax on radio receiving sets imposed by the South Carolina legislature to be a restraint on interstate commerce and therefore voided.

This decision by Judges Parker, Cochran and Glenn, declaring the South Carolina radio tax unconstitutional on fundamental grounds, thus forever puts an end to efforts on the part of other state legislatures to obtain convenient revenues for miscellaneous purposes, at the expense of the radio listeners. The case is stated in clear language by the opinion.

"The tax in question cannot be sustained under those cases which hold that the state has a right to impose an *ordinary* property tax upon property having a situs within its territory and employed in interstate commerce; for here the tax is not a general property tax, but a license tax for the privilege of using an instrument of interstate commerce . . . The Act of the Legislature imposing it is therefore in conflict with the constitution of the United States, and null and void."

Electronics finds the missing Arizona meteor

A NOVEL use of electronic geophysics is that just reported from the great Canon Diabolo meteor crater in Arizona where, it has long been believed, a vast body of meteoric iron must lie embedded beneath the flat layers of the country rock, below the mile-wide crater-like opening.

For the past four months a geophysical survey has been made by J. J. Jakosky of International Geophysics, Inc., Los Angeles, Calif. His results now definitely show a highly conductive zone (meteoric iron) of considerable dimensions, located in the southwest quadrant within the crater.

Thus, after years of unsuccessful exploration at the cost of hundreds of thousands of dollars for drilling, the search was finally turned over to electronic specialists working inexpensively on the surface, and quickly the meteoric mass was found.

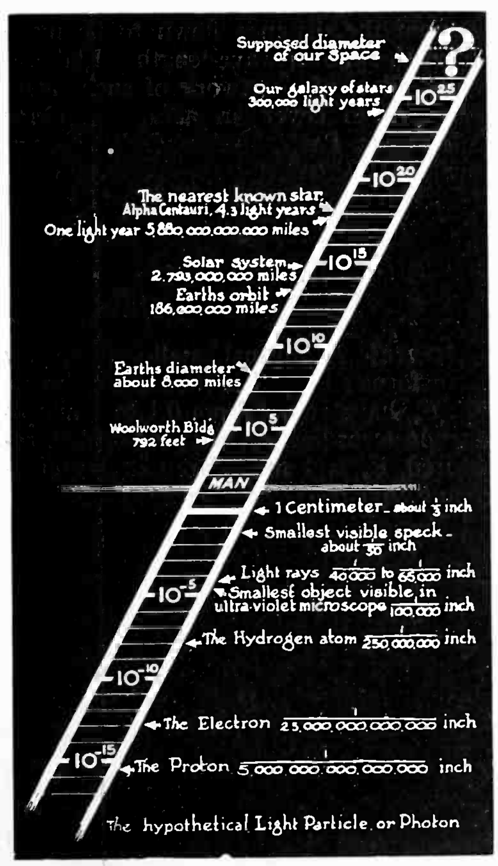
It's a wise father—

RADIO has always suffered from rackets. A consulting radio engineer recently was approached to develop a midget chassis that would cost next to nothing and would fit into the cabinet of a midget made by a large eastern manufacturer. It seems that dealers take the present chassis out of the midget cabinet, install it in a fancy cabinet and resell at a high price, thereby netting from $30 to $50. This stunt, however, leaves them with the midget cabinet on their hands. The next move is to get a very cheap midget chassis made from miscellaneous parts, install it in the well known cabinet and sell the combination for the original midget price (or below). Again the dealer makes a nice profit.

It's a wise radio manufacturer who can recognize his own product these days of radio rackets.

The electron's place in Nature

Compiled by New York University



REVIEW OF ELECTRONIC LITERATURE

HERE AND ABROAD

Effect of temperature on photoelectric currents

[Dimitier Ramadnoff] One of the main difficulties which has confronted various investigators in studying the variation of photoelectric currents with temperature has been to separate the thermionic from the photoelectric current. By using a perforated disk to interrupt the light the photoelectric current is made pulsating and may be transmitted through a resistance-capacitance coupled amplifier whereas the thermionic current being direct, will not pass through. A paper containing data obtained with this apparatus will soon be submitted to the *Physical Review* for publication. The method has also been used by L. R. Koller to measure the emission from thin films of caseium. —*Review of Scientific Instruments, December, 1930.*

✦

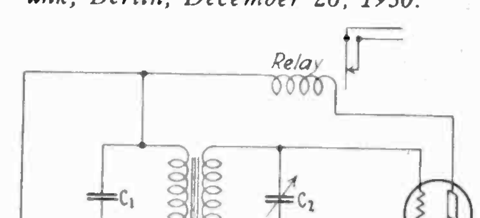
A system of airplane guiding

[Biot] A system of interferences is created along the line of flight by two synchronous emissions at the two ends, and an automatic device attached to the receiver of the plane counts the number of successive maxima and minima encountered, thus enabling a calculation of the distance flown to be made from the known wave-length. Elaborations allow of a network of such interferences to cover an aera. — *L'Onde Electrique, Paris, "November" (December 26), 1930.*

✦

Tube-"bug" (telegraph key)

[Evertz] A normal audio-frequency transformer is used in the circuit shown. C_1, C_2, have values from 0.1 to 2 microfarads according to the speed of dots required, C_3 is 1 microfarad or larger.—*Funk, Berlin, December 26, 1930.*



Measurements on receivers

[Clausing] Among points discussed are the relationship of the necessary loud-speaker power to the size of the room, with curves showing that the increase in power is not directly proportional to the volume of the room but rises more slowly; the use of the "Klirrfaktor" (proportion of false overtones to fundamental), and its reduction by the choice of the optimum radio-frequency voltage on the detector grid and by shallow modulation. — *Radio B.Ff.A., Stuttgart, January, 1931.*

✦

Louis de Broglie who has contributed important theories to modern views on the nature of the electron

✦

Amplifier method of measuring velocity of flow past aerofoils

[E. Tyler.] For an object of aerofoil section inclined at a given angle of incidence to the direction of flow of a stream of fluid there is a critical velocity at which eddying motion is produced in its wake, and beyond this velocity vortices are produced which pass down the stream at a definite frequency, the rate of which increases as the angle of inclination decreases for a constant fluid speed. As a consequence of such vortex motion periodic forces acting at right angles to the direction of flow of the fluid are produced, and in a practical case of a stream line aeroplane strut, if the dimensions and tensions are such that one of its natural frequencies coincides with that of these forces there will be a possibility of resonant vibration being set up, with resultant fracture. If these vortices are caused to act on a hot wire, they produce periodic changes in its resistance, and hence current flow through it, which changes are caused to actuate a five-stage amplifier working into a telephone. The frequency of the output was of course the same as the frequency of formation of the vortices. —*Journal of Scientific Instruments, November, 1930.*

Radio method for synchronizing recording apparatus

February number of the Bureau of Standards *Journal of Research* describes a simple radio method for synchronizing radio fading recorders. One of the recorders was mounted in a laboratory automobile so that it could be moved to any desired distance from the fixed recorder at the control station. It was necessary that the recording tapes at the two different points run at exactly the same speed, since the changes to be studied were quite rapid and it was desired to superpose the records for comparison.

Each recorder was driven by a synchronous motor of the type used for clocks. The motor at the control station was connected directly to the 60-cycle power line. To this same source of power was connected a simple radio transmitter of the half-wave self-rectifying type giving a signal modulated at 60 cycles. This 60-cycle transmission was received at the portable station and amplified sufficiently to drive the synchronous motor which propelled the recorder there. It was found possible to control the portable recorder at a distance of 10 miles with lower power output from the transmitter.

✦

Neon musical oscillator

[R. Raven Hart] This article propounds a new theory which may be stated as follows: The "quality" of the majority of musical instruments is due to the presence of one or more "toneformers" which are heard simultaneously with the fundamental. These are damped oscillations of a definite frequency, which frequency is always higher than the fundamental, and is not necessarily a multiple of it; in fact for a considerable range of variation of the fundamental that of the "toneformer" remains unaltered. They are produced by momentary variations of volume occurring at least once in each period of the fundamental oscillation and they die out before the end of each fundamental period or are wiped out by the beginning of the following one.

The article describes circuits which may be used for the demonstration of this theory. A description of various interesting experiments performed with this apparatus is included.—*Wireless World, December 10, 1930.*

Automatic maintenance of solid-liquid equilibrium

[PAUL ANDERSON] The specific resistance of a molten metal at the melting point is approximately twice that of the solid metal at the same temperature while the volume change attending fusion is only about 5 to 10 per cent. If a constant direct current is passed through a mass of metal contained in a furnace-thermostat the potential drop across contacts immersed in the metal will increase with the proportion that has liquified and this change may be utilized to control the heating current in the furnace. Tungsten current contacts from a two-volt storage battery and tungsten potential contacts leading to a Moll galvanometer are immersed in the bath. The galvanometer has a voltage sensitivity of approximately 5×10^{-6}. A beam of light from a lamp is reflected from the galvanometer mirror and enters through a slot a photoelectric cell, with its long dimension, about 4 cm. parallel to the travel of the galvanometer spot. The heating current from the 110 volt a.c. line enters the furnace through two resistances connected in parallel. R_1 and R_2— The resistance R_1 is adjusted with R_2 cut out, so that the heating current is just sufficient to hold the furnace slightly below the melting temperature of the metal. Then R_2, a mercury arc tube (thyratron) with grid in series with a variable resistance is adjusted to bring the temperature slightly above the melting point. The grid is controlled by the photoelectric current flowing from the cell across a fixed resistance and a source of d.c. potential through the space filament grid.

In the experiments made with zinc, the resistance of the zinc bath was of the order of 1×10^{-5} ohms in the solid state. With a current from the battery of 20 amperes the change in IR drop during fusion was about 2×10^{-4} volts and the corresponding change in galvanometer deflection was 40 mm. A change in deflection of 2 mm. was sufficient to operate the photocell.—*The Review of Scientific Instruments, December, 1930.*

✦

Improving urban reception

[SCHWANDT] Summary of von Ardenne's proposals and of the somewhat animated discussion which followed their presentation at the Heinrich Herz Institute. The proposals, which received undue previous journalistic attention and exaggerated praise in the non-technical press, are to receive the whole wave-band from 200 to 600 meters outside the city area, to amplify the whole band aperiodically, and to pass the resultant (always at radio frequency) over cable or by short waves (e.g. of 4 meters) to the center of the city, and here to retransmit the whole wave-band. Alternatively, it is of course possible to receive some portion of this band only, or some selected stations only. The attacks were chiefly directed on the probable interference effects between the wave directly received from the distant sender and that re-broadcasted locally, and on the alleged unduly premature publication without sufficiently full experimental and detail work.—*Radio B.F.f.A., Stuttgart, December, 1930.*

✦

Selenium rectifier

[UNSIGNED] Brief description of a rectifier of this type, resembling the copper-oxide rectifier but in which a thin layer of crystalline selenium replaces the copper oxide. It is stated that the reversed current is less than one per cent of the useful current, and that mechanical vibrations or temperatures up to 100 C. have practically no effect on the action.—*La Nature, Paris, December 1, 1930.*

✦

Phase modulation

[LOEST] A discussion of the theory of this system, with special reference to the existence of side-bands as in other forms of modulation.—*Z.f.Hf.T., Berlin, November, 1930.*

Paris radio show of 1930

[UNSIGNED] Points emphasized are the electrification of receivers (now 42 per cent of the total exhibited), the reduction to one audio-frequency stage 7 per cent, the decrease in superheterodynes in favor of straight radio-frequency amplification, especially in the newer sets, and a decrease in single dial control receivers. A very interesting table of tubes is given, with a diagram on which these are shown as points on a logarithmic network with internal resistance and μ as ordinates. Eighty such points are shown, but it is estimated that 200 *different* types of tubes were exposed. (Note. This is one of the very few unbiased reports of the show, the majority being inspired by the manufacturers). — *L'Onde Electrique, Paris, "November" (December 26), 1930.*

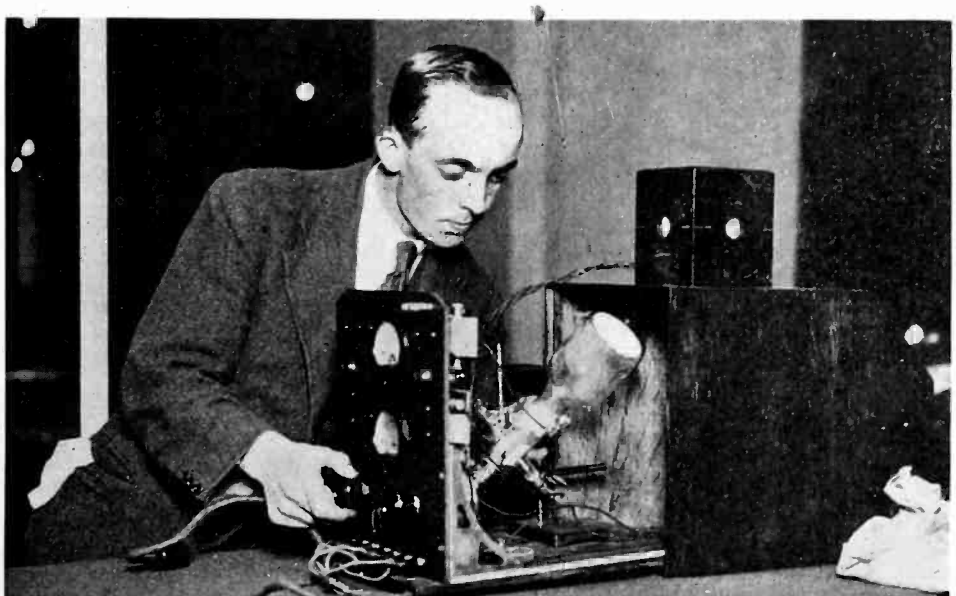
✦

Inertia-free sources of light for television

[WINCKEL] Discussion of the "Superfrequency lamp" of Mihaly (glow lamp with iron alloy electrodes in place of the normal aluminum); of the use of the Braun tube (glow lamp exhausted to 0.02 to 0.001 millimeters pressure) by Zworykin and Skaupy; of Mihaly's use of the Wolfram arc lamp (two Wolfram spheres in an inert gas, between which an invisible arc is formed which heats the spheres to a white glow); and other possible solutions.—*Radio B. F. f. A., Leipzig, November, 1930.*

✦ ✦ ✦

NAVIGATION AID, WESTMINISTER, ENGLAND



Cathode-ray tube used to detect approach of ships in fog, displayed at International Exhibition of Inventions, Westminster, by inventor H. Barns

+ NEW PRODUCTS

THE MANUFACTURERS OFFER

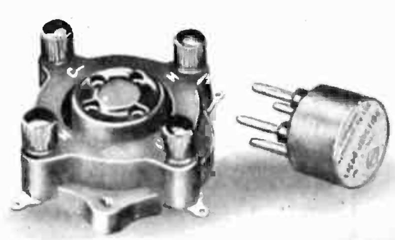
Insulation tester

As a practical, usable instrument, the "Meg" or "Super-Meg" with its 500-volt generator and 100-megohm range as manufactured by James G. Biddle Company, 1211 Arch St., Philadelphia, Pa., has many advantages for testing insulation. Both types of testers are enclosed in an aluminum case. These units are direct reading; the pointer indicates ohms or megohms directly on the scale. They are provided with convenient handles, are portable and will stand hard service. The "Meg" weighs 6¾ lbs. and "Super-Meg" 7¼ lbs. The "Meg" has a variable-pressure generator and the "Super-Meg" a constant-pressure generator.—*Electronics, February, 1931.*

✦

Vacuo-junctions

Vacuo-junctions of various sensitivities are manufactured by the Cambridge Instrument Company, Grand Central Terminal Building, New York City. The type shown consists essentially of a thermo-junction and a heater enclosed in a highly exhausted glass bulb, which



eliminates the effect of air currents and improves the sensitivity. The glass bulb is mounted in a compact moulded case which is provided with connections for insertion in a standard valve holder. The design ensures correct connection and polarity and enables the vacuo-junction to be easily replaced or interchanged for one of different sensitivity. —*Electronics, February, 1931.*

✦

Phenolic tubing

Designed particularly for radio use, the Spaulding bakelite tubing, manufactured by the Spaulding Fibre Company, Inc., Tonawanda, N. Y., has many useful features. It threads easily and can be punched without fracturing. It has low moisture absorption, is tough, and as manufactured is concentric with uniform wall thickness.—*Electronics, February, 1931.*

New test oscillator

A portable test oscillator has been added to the line of radio servicing equipment manufactured by the Jewell Electrical Instrument Company, 1642-0 Walnut Street, Chicago, Ill. Some of the frequent jobs for which the test oscillator is used are as follows: Aligning gang condensers, locating shorted r.f. coils, "peaking" or "flat topping"

intermediate frequency stages, adjusting oscillator stage of super-hetrodyne receivers, and making comparative gain tests with a standard set. Selection of either intermediate or broadcast frequency band is made with a single switch. The intermediate band, 125 to 185 kc. provides for the adjustment of all super-hetrodyne sets, including the 130 and 175 kc. types. The model 560 portable test oscillator, complete with tubes, batteries and triple range output meter; list price $97.00; without output meter, $82.00.—*Electronics, February, 1931.*

✦

Parts for automobile radio

For supplying necessary parts for automobile radio, the National Company, Malden, Mass., has announced a complete set of units including junction box, battery box, speaker and receiver frame and cover. The National Company has designed this series of parts to meet the specialized requirements of automobile installation. The receiver is designed so that it may be readily removed when desired by means of a convenient cable and plug system. All parts are extremely compact for automobile use. *Electronics, February, 1931.*

Standard potentiometers

Type-K potentiometer manufactured by Leeds and Northrup Company, 4901 Stenton Avenue, Philadelphia, Pa., supplies the need of a standardized instrument for measuring electromotive force with high precision. It is designed to combine accuracy and high sensitivity with facility of manipulation for all classes of work. There are no contact resistances in the potentiometer circuit proper. The last one-tenth volt is covered by a slide wire which makes it a simple matter to follow a fluctuating voltage with ease and accuracy not possible where several switches have to be manipulated. The double scale makes it possible to read accurately lower electromotive forces than can be read with the older forms of potentiometers.— —*Electronics, February, 1931.*

✦

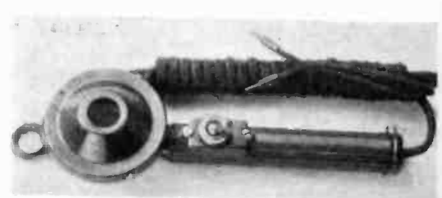
A.C. synchronous motor

A new type of a.c. synchronous commutator motor, operating with high efficiency and power factor and low starting current, has recently been developed by the Electric Specialty Company, Stamford, Conn. The motors are made in sizes of from ⅛ to 3 hp. They are being used by many manufacturers of talking picture projection apparatus and for many other types of equipment requiring synchronous motors.—*Electronics, February, 1931.*

✦

One-button hand microphone

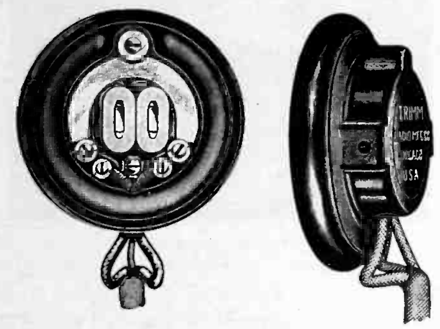
Where a hand microphone of single button construction is desired, the one-button hand microphone announced by the Universal Microphone Company, Ltd., Inglewood, Calif., known under the trade name of the "Handi-Mike" is available. It is finished in bronze or gunmetal, equipped with an "off" and "on" toggle switch, 15 ft. cord, and



provided with an eye at extreme top for hanging while in or out of use. This unit is scientifically constructed with gold plated button and mounted in sound damping resilient felt. Price, $10.00.—*Electronics, February, 1931.*

Feather-weight headphone

A FEATHER-WEIGHT HEADPHONE has recently been developed by the Trimm Radio Manufacturing Company, 847 West Harrison St., Chicago, Ill. This device will probably find its widest application in aiding the hard-of-hearing, not



only permitting them full enjoyment of radio programs, but also bring them sound movies, lectures, church services, improved audition in the theater, etc. Because of its small dimensions, feather weight and extreme sensitivity it is particularly appropriate for airplane service as it fits readily into the pilot's helmet. Its dimensions are: $1\frac{3}{16}$ in. outside diameter, $\frac{3}{4}$ in. thick and weighs $1\frac{1}{2}$ ounces. The receiver is wound in any desired impedance and is equipped with a thin steel head band and light weight cord, 3. 6 or 12 ft. long.—*Electronics, February, 1931.*

✦

Stepdown auto-transformers

THE KENYON TRANSFORMER CORPORATION, 122 Cypress Ave., New York City, announces a line of stepdown auto-transformers 220 to 110 volts for use with radio receivers, amplifiers, and similar equipment. These transformers are suited to adapt standard 110-volt equipment to the existing 220-volt lines frequently found here and in the export field. The transformers are furnished in 50, 100, and 150 watt capacities for use on 50 to 60 cycle lines. Kenyon transformers of this type are designed to carry more than 50 per cent overload before reaching the A.I.E.E. standard for transformer temperature rise. List prices of 50, 100, and 150-watt transformers respectively are $4.50, $5.50, and $6,50.—*Electronics, February, 1931.*

✦

Super-sensitive mercury relay

A RELAY WHICH WILL OPERATE on only four milliamperes at 3 volts, and will relay up to 1,000 watts, has been designed by the American Instrument Company, 774 Girard St., N.W., Washington, D. C. This relay acts as a trigger to relay a larger amount of current used for operating motors, heaters, solenoid valves, etc. It will also operate in a vacuum tube circuit, and therefore may be used in experiments where a photo-electric cell controls a circuit by varying degrees of light which fall upon it. A diagram of this hook-up will be furnished to those interested, upon request. This relay uses either a.c. or d.c., by the use of suitable rectifying transformers or resistors which can be furnished; the relay will operate on any standard 110- or 220-volt light circuit.—List price $20.—*Electronics, February, 1931.*

✦

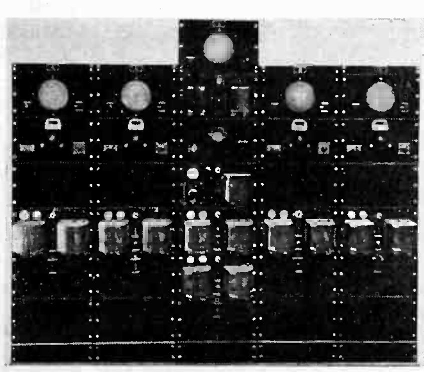
Indoor light source for photo-electric cells

TWO NEW LIGHT SOURCES, CR-7500-A-1 and B-1 (for indoor and outdoor use) respectively designed for use in connection with standard relay units, has been announced by the General Electric Company, Schenectady, N. Y. This unit provides a light beam up to a distance of 25 feet in applications where the control is to function as a result of the interruption of that light. The indoor type, suitable for either a.c. or d.c. is small in size; is equipped with a high intensity lamp, operating on 6 volts, and has a lens arranged to provide a beam with approximately parallel rays. A standard transformer is also provided for supplying the necessary filament voltage to the lamp. The new photo-electric relay units are also available for operation on either a.c. or d.c. supply.—*Electronics, February, 1931.*

✦

Centralized-radio installation

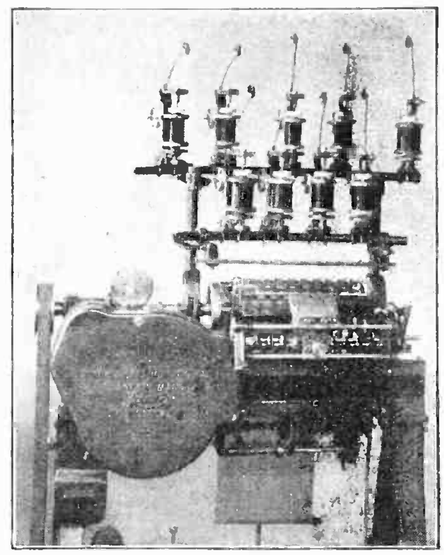
AN AMPLIFIER INSTALLATION designed to be used where a selection of four channels of radio and one additional channel for all around work, is incorporated in the centralized radio unit announced by Operadio Manufacturing Company, St. Charles, Ill. The entire



equipment may be automatically controlled by a time clock. It has a level indicator panel so that the volume of each channel may be adjusted to the proper level. The equipment is so designed that it is possible to break in on any speaker, regardless of whether it is turned on at the speaker or not.—*Electronics, February, 1931.*

Automatic winding machine

THE UNIVERSAL WINDING COMPANY, Providence, R. I. has developed an automatic winding machine for paper-section coils known as Type 104. Fully adjustable, it can readily be set to handle different types of coils, using any size of wire from No. 20 to No. 40 (B&S gauge), and by means of a variable traverse cam, will produce any required length of wire layer from $\frac{1}{4}$ in. to 5 in. One of the interesting features of this machine is the manner in which the insulating paper is handled. This ele-



ment is injected between the wire layers at high speed, without interruption to the normal winding rate, and each successive insert is automatically lengthened to take care of the constantly increasing coil diameter, thus insuring a uniform amount of overlap throughout the coil. Other features include: coil-slitting attachment for separating the coils before removal from the winding arbor, winding speeds of 3,000 to 3,300 r.p.m., slow start and rapid acceleration of the winding spindle by means of a variable speed motor and semi-automatic counter which meters individual wire turns up to 25,000 and stops machine mechanically.—*Electronics, February, 1931.*

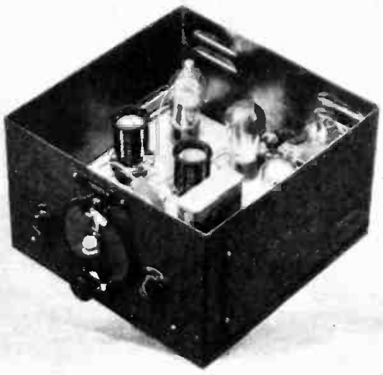
✦

Manual on condensers and resistors

THE AEROVOX 1931 condenser and resistor manual, containing detailed specifications of the condensers and resistors manufactured by the Aerovox Wireless Corporation, 70 Washington St., Brooklyn, N. Y., for radio and industrial applications has just been announced by this company. In addition to the usual detailed specifications, it contains much technical data, formulas and other information of value to engineers, purchasing agents, servicemen and experimenters. Copies may be obtained free of charge by writing to the company direct.—*Electronics, February, 1931.*

Short wave superheterodyne adapter

Owners of tuned radio frequency broadcast receivers can now have short-wave reception, with the new superheterodyne adapter brought out by C.



R. Leutz, Inc., Altoona, Pa. This device can be quickly connected or disconnected from the receiver. To operate, the antenna and ground are disconnected from the broadcast set and connected to the adapter. Two leads are then run from the adapter to the regular set. This adapter has its own built-in power pack. The first 224 tube is the screen-grid detector, the 227 the heterodyne oscillator, and the 226 is used as a small rectifier in the built-in power pack. Four sets of interchangeable coils (8 coils) covering approximately 16 to 200 meters are included. For 110-volt 60-cycle operation, list price $70; for 25-cycle operation $75.—*Electronics,* February, 1931.

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Sound-absorbing material

After a long period of scientific development, the Celotex Company, 919 North Michigan Ave., Chicago, Ill. has brought out a sound-absorbing material, known as Acoustic-Celotex, for correcting acoustics and quieting noise in all kinds of buildings. It is made of tough cane fibres called bagasse, and its ability to absorb sound is due to minute interstices between the fibres in which sound is dissipated by friction. It is manufactured in the form of convenient-sized tiles, the faces of which are perforated and the perforations act as channels through which sound energy has ready access to the fibrous interior. This establishes a fixed coefficient of sound absorption. — *Electronics, February, 1931.*

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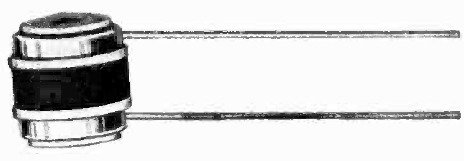
Wire wound resistor

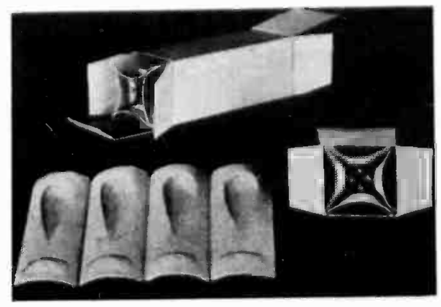
Below is a photograph of a new type wire wound resistor manufactured by the International Resistance Company, 2006 Chestnut St., Phila., Pa. It is designed particularly for use in photo electric cell applications or wherever an accurate resistor is required. This resistor is constructed with a moulded



end cap in place of the spot soldered contact usually found in wire wound resistors. This method of making contact automatically eliminates the trouble of open contact. This type of resistor is made in ranges of from 200 ohms up to 100,000 ohms. Data sheets containing complete information in regard to the products manufactured by the International Resistance Company may be obtained by writing direct to the Service Department of this company. — *Electronics, February, 1931.*

Radio tube wrapper

A practical application of the simple principle of "suspension packing" is seen in the tube wrapper, manufactured



by the Holed-Tite Packing Corporation, 100 East 42 St., New York City. This company also manufactures a radio tube packing pad for packing 50-tube cartons and tube kits. As shown in the illustration, the depressions on the sides of this light weight moulded pulp wrapper grip the tube like an encircling hand and hold it firmly in place at the base. This wrapper is made in sizes to fit all standard tubes.—*Electronics, February, 1931.*

✦

Direct-current volt-ohmmeter

The Roller-Smith Company, 233 Broadway, New York City, announces a new instrument, the type PD direct-current volt-ohmmeter. This instrument may be used for continuity testing, as a direct reading ohmmeter or for reading voltages up to 600 volts, direct-current. It is designed particularly for radio testing. The voltage ranges have a resistance of 1,000 ohms per volt. The Type PD volt-ohmmeter, has ranges of 0-3, 0-30, 0-300 and 0-600 volts; 0-10,000 and 0-100,000 ohms. Complete with insulated test prods, $61.50. — *Electronics, February, 1931.*

Testing of sound picture channels

[*Continued from page 503*]

results are to represent operating conditions. In making calculations for meter settings, a set of parameters as in Figs. 3(a), (b) and (c), are of great aid. These curves are calculated taking zero level at 10 milliwatts, and show the correct line voltage to give a desired level, the several curves representing several line impedances as indicated. To obtain at 500 ohms a level of +10 decibels then, it is seen from Fig. 3(a) that 7 volts are required across the line. If we have a 10 m.a. thermo-coupled meter at G_2 with a resistance of 150 ohms, we may add 850 ohms at R_3 and 1,000 ohms at R_2 to give an output impedance of 500 ohms. To hold 7 volts, then, we merely set the meter at 7 milliamperes. In the input circuit we may again make the meter circuit equal to 1,000 ohms, and if the meter is of about 2 m.a. capacity, a scale reading of 0.5 m.a. will be convenient, and will give a voltage of 0.5 volt and hence — 13 decibels (Fig. 3(b). The attenuator should be adjusted to its maximum attenuation, and the potentiometer set at zero while the oscillator is adjusted to the desired frequency. The potentiometer is then brought up until 0.5 m.a. is had at G_1. Now the attenuation is decreased until the output meter G_2 reads 7 m.a., and the amplifier overall gain is then equal to the reading of the attenuator plus 23 decibels (13 + 10). If this is repeated at each frequency, a characteristic curve may be drawn to indicate the actual gain over the entire operating range.

Quite often it is desirable to supply constant input to the microphone amplifier, making it a part of the channel under measurement. This input circuit is of high impedance if the amplifier is designed to operate with a condenser type microphone, and an arrangement such as that of Fig. 2(b) is necessary to secure constant input at something resembling operating conditions. With equipment such as is in use generally in picture studios at present, a capacity C_1 of about 0.0002 mf. is satisfactory with a constant input at G_4 of about 1 m.a. To hold pickup in this circuit at a minimum, the leads may be shielded, and the shield grounded. Variations in the circuit are made for special conditions.

PATENTS

IN THE FIELD OF ELECTRONICS

A list of patents (up to Feb. 4) granted by the United States Patent Office, chosen by the editors of *Electronics* for their interest to workers in the fields of the radio, visio, audio and industrial applications of the vacuum tube

Electronic Applications

Aerial navigation. Two equal antennas carried in bilaterally equivalent positions on airplanes and connected to a differential relay to tube amplifiers, indicate and control the position of plane. O. G. McIlvaine, assigned to the Radio Television Co., Cleveland, O. No. 1,787,992.

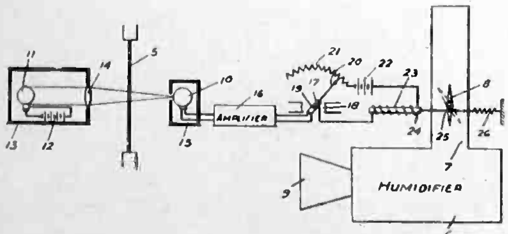
High-frequency surgical cutting device. Oscillating circuit in which is produced and maintained a frequency of the order of 10,000,000 cycles. An electrode is connected to a live point on the inductance coil, and is insulated from the ground. The operator is at ground potential, because of the high frequency involved, and has no connection with the oscillator which is attached to the material to be cut, except through the material itself. F. C. Wappler. No. 1,787,709.

Determining gravity variation. A number of mutually-calibrated simple pendulums, located at different points, are simultaneously started into oscillation. At a single point, the number of oscillations of each pendulum is recorded, apparently by means of a light source, a photo-cell and a radio transmitter. H. D. Hayes, Washington, D. C. No. 1,787,536.

Frequency change indicator. An arrangement of capacity and inductance which indicates the frequency change in a generator. Hans Schuchman, assigned to Siemens & Halske, Berlin, Germany. No. 1,787,997.

Electrostatic measuring, indicating apparatus. Producing an electrostatic field and measuring the cooling effect of this field upon a conductor. W. M. Thornton, Newcastle-Upon-Tyne, England. No. 1,787,879.

Humidity-control device. A method of using a light beam, photo-cell and amplifier for controlling humidity. S. M. Anderson, assigned to B. F. Sturtevant Co., Boston, Mass. No. 1,789,268.



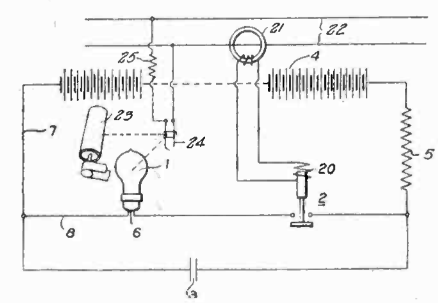
Railway control apparatus. Methods of controlling railway traffic by means of vacuum tubes. No. 1,789,898, granted to Lars Grondahl, assigned to Union Switch & Signal Co., and No. 1,789,465 granted to J. S. Holliday, New York, N. Y.

Gas change indicator. Piezo-electric crystals in a gas, spaced from a surface equal to one-half the wave-length of sound having a frequency corresponding to the natural mechanical period of the crystals, operates a vacuum tube. A. Meissner, Berlin, Germany. No. 1,789,369.

Static minimizer. The use of a double-wave rectifier tube, one plate connected to the antenna and the other plate to the radio receiving set. C. W. Woodruff, Columbus, Ohio. No. 1,789,208.

Dynamo controller. A vacuum tube method of controlling a characteristic of a dynamo. E. R. Morton, assigned to B. T. L., Inc. No. 1,788,733. Similar patents, No. 1,788,734, also to E. R. Morton, and No. 1,789,145 to A. V. Livingston, assigned to the Safety Car Heating & Lighting Co., involving the use of two-element vacuum tubes for controlling a generator. Similar patent No. 1,789,146, also to A. V. Livingston.

Oscillograph timer. Method of charging condenser and connecting periodically across lamp terminals of an oscillograph. J. W. Legg, assigned to Westinghouse E. & M. Co. No. 1,790,158.



Generation, Detection, Etc.

Generator. Operating an oscillator so that the control element has its potential varied at the oscillation frequency, about a value so far negative with respect to the cathode that the anode current is interrupted for a large portion of each period by making the external impedance very low, and near zero for multiple frequencies of the oscillations, and very high for all frequencies lower than the oscillation frequency. H. S. Black, assigned to B. T. L., Inc. No. 1,788,560.

Oscillation generator. Two sources of energy having different natural frequencies are forced to oscillate at a common frequency. The relative intensity of the energy supplied by each source is varied to vary the common frequency. C. W. Hansell, assigned to RCA. No. 1,787,979.

Oscillation generator. Polyphase generator of adjustable frequency, consisting of a polyphase circuit supplied with polyphase current of constant frequency and a single phase current of adjustable frequency. C. J. Young, assigned to G. E. Co. No. 1,788,362.

Rectifier and filter. Eliminating hum from a rectifier filter system. B. F. Miessner, assigned to RCA. No. 1,788,342.

Wave meter. A piezo crystal-controlled wave meter so arranged that it can oscillate at either the fundamental or any of the crystal harmonics. E. L. White, assigned to Federal Telegraph Co. No. 1,788,219.

Frequency control system. Impulses derived from one of two waves of a duration different from the half period of the wave are used to control frequency. W. A. Marrison, assigned to B. T. L., Inc. No. 1,788,533.

Radio frequency amplifier. An interstage coupling transformer having a low resistance with respect to the output circuit of two tubes coupled together. Lester L. Jones, Oradell, N. J. No. 1,788,197.

Photo-electric amplifier. A photo-electric surface in a vacuum tube furnishes the electrons. A. A. Thomas, New York, N. Y. No. 1,788,553.

Oscillation control. A rectifier whose resistance is variable with the variation in the voltage across its terminals, is put across the input of an oscillation circuit. J. R. Meagher, assigned to Carborundum Co., Niagara Falls, N. Y. No. 1,788,401.

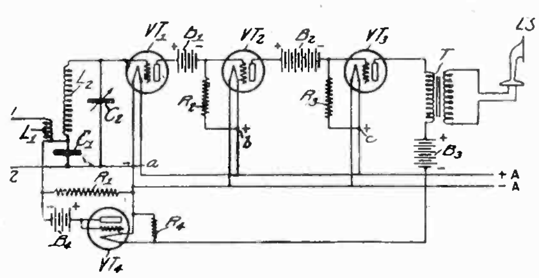
Uniform amplification. Mutual inductance of iron core transformers is utilized to get uniform amplification. E. Grinley, assigned to B. T. L., Inc. No. 1,788,714.

Feed-back control. A typical feed-back control circuit. J. M. Miller, assigned to Atwater-Kent Mfg. Co. No. 1,788,732.

Combining and eliminating frequencies. A method of reducing radio frequency harmonics to make possible use of more carrier frequencies in a given frequency spectrum. C. W. Hansell, assigned to RCA. No. 1,789,364.

Neutralized amplifier. A method of balancing the vacuum tube inter-electrode impedances. R. K. Potter, assigned to A. T. & T. Co. No. 1,789,416.

Direct-coupled amplifier. The cathode-plate impedance of each preceding tube is of the same order as the impedance input of the next succeeding tube. F. Y. White, assigned to E. H. Loftin. No. 1,789,664.



A.C. operated receiver. A method of radio receiver entirely from alternating current, including a crystal detector and a means of getting the radio frequency signals from the a.c. line. B. F. Miessner, assigned to RCA. No. 1,789,950.

Polyphase oscillator. Several generators less in number than the number of phases to be generated have inter-coupled frequency-determining circuits. A. E. Jensen, assigned to B. T. L., Inc. No. 1,788,720.

Signaling system. Determining the direction of sound vibration by intercepting the sound at several points, converting the vibration into electrical waves, combining the waves with carrier waves of higher frequency and passing the combined waves through some phase-shifting device. J. W. Horton, assigned to W. E. Co., Inc., No. 1,788,522.

Short-wave receiver. A screen-grid receiver in which the tubes project from one compartment into another, for increasing the shielding effect. R. A. Heising, assigned to B. T. L., Inc. No. 1,788,521.

Picture Transmission, Television, Etc.

Electro-optical system. A source of polarized light, a source of variable electromotive source for doubly refracting light from this source, so as to cause the amplitude of the light wave to vary in direct proportion to the variation in electromotive force. Harry Nyquist, assigned to A. T. & T. Co. No. 1,788,470.

Television system. A system utilizing Piezo crystals at both transmitter and receiver. F. Feingold, Brooklyn, N. Y. No. 1,789,521.

Light valve apparatus. A vibratible single conductor into which received current flows, and a method of setting up a field of force which reacts with the current in the conductor. A light aperture in line with the conductive source of light is lined up with respect to the conductor by means of a wheatstone bridge circuit. F. W. Reynolds, assigned to A. T. & T. Co. No. 1,788,472.

Picture transmission. A general method of transmitting a picture, consisting of illumination, unit transmission, light-sensitive cells, etc. E. F. W. Alexanderson and R. H. Ranger, assigned to RCA. No. 1,787,851.

Picture transmitter. An oscillating method of scanning a surface into a series of points of light. Philip Chalfin and Benjamin Chalfin, Philadelphia, Pa. No. 1,790,038.

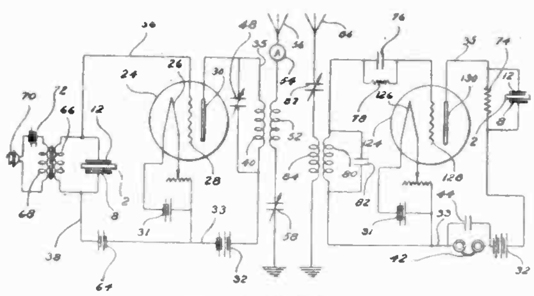
Radio receiver. A vacuum tube with a.c. on its plate; oscillations in the apparatus are quenched during the negative half-cycle independently of the grid potentials. The grid is biased insufficiently to maintain oscillation during period of non-reception. W. K. Brown and C. R. Burch, assigned to Associated Electrical Industries, Ltd. No. 1,790,197.

Super-regenerative receiver. In a super-regenerative receiver producing from an incoming signal a frequency higher than the carrier wave, and coupling means between the super-regenerative system and the frequency raiser. J. R. Balsley, assigned to Westinghouse E. & M. Co. No. 1,788,078.

Reaction control. A compensating method of preventing or controlling reaction between successive stages in the radio frequency amplifier. J. M. Miller, assigned to Atwater Kent Mfg. Co. No. 1,787,950.

Electron relays. Receiving system including a vacuum tube circuit whose input and output circuits are reactive, but in opposite directions with respect to a given frequency of operation. F. A. Kolster, and G. E. Kruesi, assigned to Federal Telegraph Co. No. 1,787,582.

Piezo oscillators. A combination of oscillator and receiver, both controlled by piezo-electric crystals. G. W. Pierce, Cambridge, Mass. No. 1,789,496.



Communication

Reducing reaction. A method of reducing or elimiating the effect of potentials in one circuit on the input circuit of this or another circuit. J. M. Miller, assigned to Atwater Kent Mfg. Co. No. 1,790,165.

Magnetic radio receiver. A method of rectifying modulated r.f. current and using rectified current to modulate the saturation of an inductance. J. Slepian, assigned to Westinghouse E. & M. Co. No. 1,790,171.

Directional receiving antenna. A combination of several loop-antennas, selective in some direction, and a vertical non-selective antenna. John Stone, assigned to A. T. & T. Co. No. 1,789,419.

Frequency modulation. A receiver for receiving signals sent out by frequency modulation methods. H. O. Peterson, assigned to RCA. No. 1,789,371.

Interference eliminating circuit. A receiving circuit for eliminating atmospherics, in which the grids of successive tubes are connected together by a tuned anti-resonant circuit. Ettore Bellini, Paris, France. No. 1,789,650.

Frequency changing receiver. A method of changing modulated low-frequency energy to modulated high-frequency energy. Henri Chireix, Paris, France. No. 1,789,303.

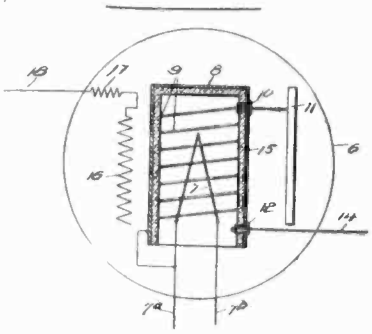
Volume control circuit. Adjustable attenuating network having for each adjustment a characteristic complementary in form to the curve of minimum audibility of the ear. E. A. Stevenson, assigned to B. T. L., Inc. No. 1,788,025.

Vacuum Tubes, X-Ray Tubes.

Rectifier. A gaseous discharge device with two anodes and a conductor near each anode for suppressing the discharge in one direction. E. A. Lederer, Westinghouse Lamp Co. No. 1,787,690.

Electron emission material. A cathode comprised of a refractory metal case containing approximately 1% of vanadium. J. W. Marden and H. C. Rentschler, assigned to Westinghouse Lamp Co. No. 1,787,694.

Indirect heater tube. In this tube a winding inside the cathode repels electrons from the heater to an insulating member. A. L. Levin, assigned to Lestein Corp. No. 1,790,313.



Some comments on the use of "getters"

[*Continued from page 511*]

this process had an undesirable effect on the grid potential and plate current of the tubes it was reluctantly abandoned.

More recently, barium in metallic form became available for use in tubes, being supplied in a closed copper sheath to protect it from being spoiled by air or moisture. In this form barium came into considerable use, although it was expensive and difficult to flash. With the development of the present magnesium-barium and aluminum-barium alloy getters supplied in pellet form, the copper clad barium passed out of use. The barium alloy pellets are easy to handle and produce the desired gettering effect.

Other getters which have been used are calcium, both pure and in alloy form, lithium, active charcoal, and cerium. Some especially good results have been obtained with the calcium alloys. Like barium, the calcium alloys are most effective in tubes which operate with the bulb at a temperature high enough to keep the getter in an active condition. Caesium, potassium, and sodium also have a gettering action, although when used in tubes their primary function is not that of a getter.

While getters are of vital importance in tube manufacturing, too much reliance should not be placed upon them. Most tube engineers admit that there is no substitute for thorough firing or "degassing," proper baking or bulb heating, and bombarding. They do not agree however, as to *what* constitutes proper firing, exhausting, etc. It is often difficult to draw conclusions from comparative tests, as the sum total of the degree of thoroughness is largely what counts. Just how thoroughly these processes should be carried out without unnecessary expense is largely a matter of judgment and experience. It is the writer's contention that the above processes should at least be carried to the point where the question of getter is no longer of primary importance, and that if there is any question as to the effectiveness of magnesium getter in a receiving tube, the proper procedure does not lie in the direction of a substitute getter but is along the line of improving one or all of the vital processes in the manufacture of the tube.

Frequency characteristics of optical slits

[*continued from page 513*]

The similarity of the integrals (4) and (5) with that of (1) is due to the fact that in reproducing sound a constant intensity light is used which is focused upon an optical slit. This slit is, in turn, focused upon the sound track which is moving at a velocity v. As the light passes through the film it becomes modulated by the variable density or area track and then proceeds to excite the photocell which is located on the other side of the film. It is evident that the solutions of (4) and (5) must be of the same form as (2).

Naturally, perfect film development is assumed and the dimensions of the slit upon the moving sound track are used rather than the dimensions of the slit itself, in figuring the frequency characteristic of the reproduction. Therefore, curves 1, 2 and 3 illustrate also the frequency characteristic of the sound projector.

It is important to note that a very strong tendency exists among sound recording studios to release entirely with re-recorded sound. Re-recording is the process of reproducing sound through a special sound projector and recording it as though it had originated on a sound stage. This is often necessary because it renders easier and more economical the addition of effects and music to the original sound, it simplifies operation in the film laboratory and further lends itself to better sound perspective and reality.

The importance of a very sharp focus in the optical system of the re-recording apparatus is very evident. One mil is the standard focus used at present. Two years ago, when talking pictures were in their infancy, 3 mil focus in the sound projectors was a very common occurrence. This coupled with a similar condition in the optical system of the film recording machines and lack of adequate knowledge of proper film development, account sufficiently for the poor quality of the early talkies and the natural tendency of certain producers to release on discs instead of film. In studios which release on both discs and film, disc releases have dropped from a commanding position to about 30 per cent and the tendency is that they will eventually disappear.

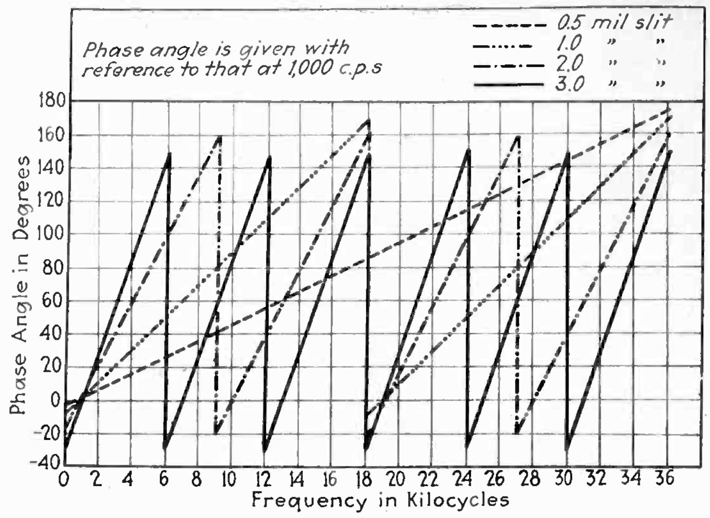


Fig. 3—Phase shift curves for fixed optical slits used in sound recording and projection

The frequency characteristics of variable area sound recording through a fixed dimension slit and variable density recording through a slit of *variable* dimensions will be discussed in a subsequent issue of *Electronics*.

Sensitizing the photocell

[*continued from page 519*]

spark discharge, first, the potassium is atomized, and secondly, the success of the process is dependent upon the gas pressure in the cell. The first observation indicates that during the sensitizing process potassium is present in the form of a vapor. The dependence upon gas pressure varies in the following manner: the simultaneous increase in sensitivity with the spark discharge occurs only when the pressure is approximately 0.1 mm. of mercury. If the gas pressure is about ten times less or still lower there will be no increase in sensitivity caused by the spark discharge. On the contrary, the sensitivity may be reduced. Only when a small drop of potassium is vaporized in any part of the cell will an increase in sensitivity take place. Several examples of this are given in the following table (R. Fleischer, Phys. Z. 30,320, 1929).

PHOTO-ELECTRIC CURRENT

Cell	Before Sparking	After Sparking	After Redistillation	Pressure
C	103 Div.	96 Div.	129 Div.	0.01
D	21 Div.	4 Div.	70 Div.	0.01
G	30 Div.	1 Div.	170 Div.	0.01

These examples indicate that in order to increase the sensitivity, the potassium, in the form of potassium vapor, must be brought into intimate contact with the hydrogen or inert gas which is present.

There still remains to determine, whether the hydrogen or the gas which is present produces highly sensitive potassium layers as an ion or as a neutral gas combined with the potassium vapor.

In this connection two investigations were undertaken at the Dresden Physical Institute. First, fresh potassium, which had been degassed as far as possible by distillation in a high vacuum, was vaporized and deposited under very low pressure upon a potassium layer which had been super-saturated with hydrogen.

Secondly, potassium, similarly prepared, was distilled upon platinum foil, which had been degassed by heating to incandescence, this distillation taking place in a high vacuum and also in an atmosphere of hydrogen under a pressure of 10^{-3} mm. of mercury.

Figures 3 and 4 show clearly the increase in sensitivity obtained in both cases. (R. Fleischer and H. Teichman, Z. f. Phys., 61,222, 1930.)

In the first case, the potassium vapor comes into contact with hydrogen which is adsorbed and absorbed by another potassium surface. In the second case, the potassium vapor has the opportunity to combine with the neutral hydrogen which is present in the cell.

Both investigations show that in order to obtain an increase in sensitivity of a potassium layer, the potassium, in vapor form, must be brought into contact with the gas which is present. This conception is not in disagreement with the sensitizing methods of Elster and Geitel and of Suhrmann, since in both cases potassium is vaporized by ionic bombardment.

The design of attenuation networks

[*continued from page 509*]

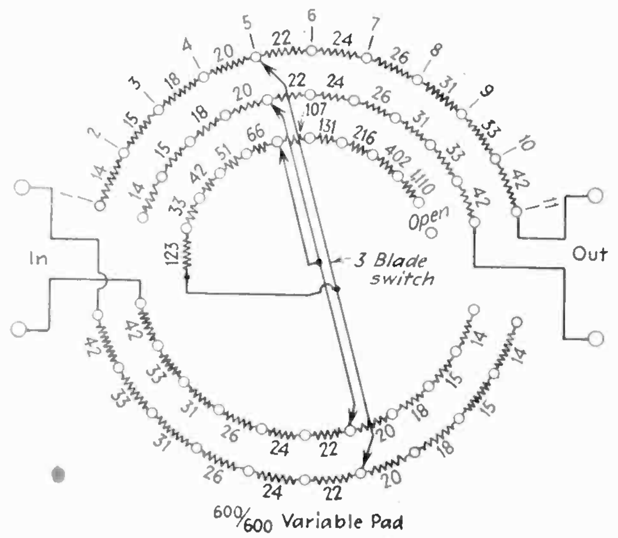


Fig. 6—Circuit and switching arrangement for variable pad

time maintain constant input and output impedances, means that all of the component resistances must be made variable. They may be either continuously so, as for instance, the graphite- element sliding contact type, or may be fixed resistances with taps. The latter method is preferable from the standpoint of permanence of calibration and mechanical construction. It has the disadvantage that the pad is adjustable only by steps instead of continuously; but if these steps are made small enough (say one or two *db* each) the change in volume per step will be scarcely noticeable at the loud speaker.

The labor in the design of a variable pad is greatly reduced by plotting curves for the expressions (10), (11) and (12). In the majority of practical cases, Z_1 equals Z_2, so that (10) and (11) become identities and but two curves are required. Such curves are shown in Figs. 4 and 5. From them the ratios of $\frac{R_1}{Z_1}, \frac{R_3}{Z_1}$ and $\frac{R_2}{Z_1}$ for any loss in *db* can be read directly, and the values of

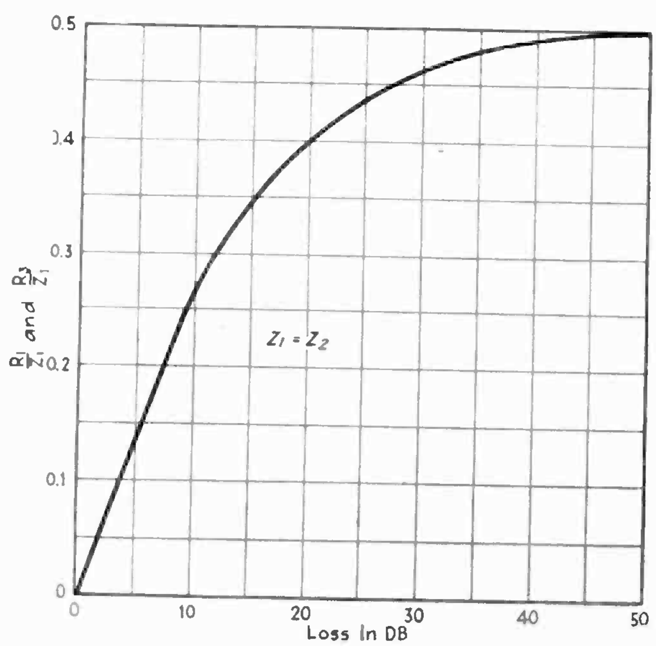


Fig. 4—Loss as a function of ratio between shunt resistance

R_1, R_3 and R_2 subsequently obtained by multiplying these ratios by Z_1. Designing a variable pad actually consists of designing a series of fixed pads. Taps and switch contacts are arranged so that on any step each resistance is increased or decreased from its value on the preceding step by the required amount.

Let us design, as an example, a pad with input and

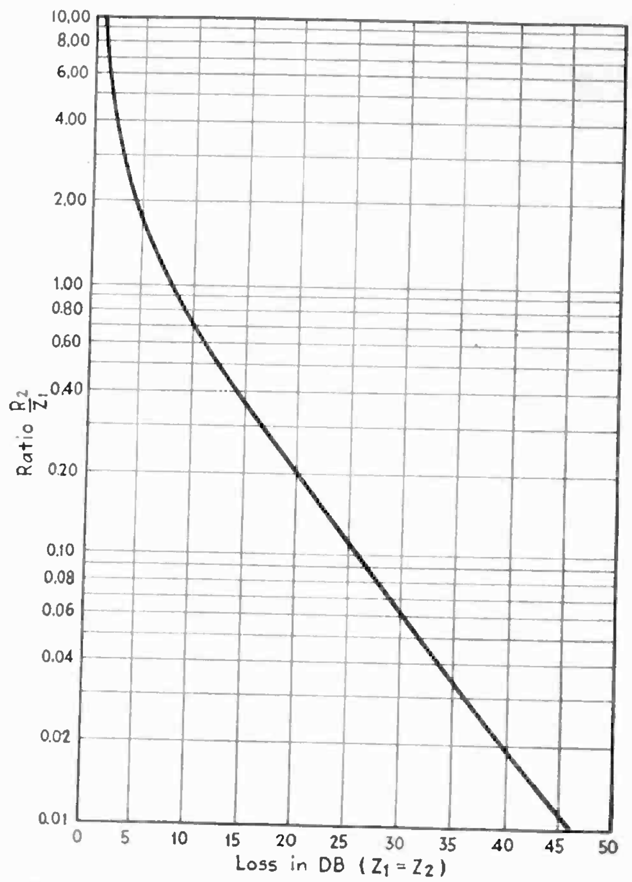


Fig 5—Loss as a function of the shunt resistance

output impedances of 600 ohms and a loss range of from 20 to 0 *db* in eleven steps of 2 *db* each. The first step will correspond to minimum volume or the maximum loss of 20 *db*. From Figs. 4 and 5, we find for 20 *db*, $\frac{R_1}{Z_1} = 0.408$ and $\frac{R_2}{Z_1} = 0.205$. Since Z_1 and Z_2 are 600 ohms, R_1 and R_3 are each 245 ohms, and R_2 is 123 ohms. Likewise, for the second step, which has 18 *db* loss, $R_1 = 231$ and $R_2 = 156$, and so on for each step, giving the results for the complete pad shown in Table II. The last step has a zero loss and R_1 and R_3 will be zero, while R_2 will be infinite or open circuited.

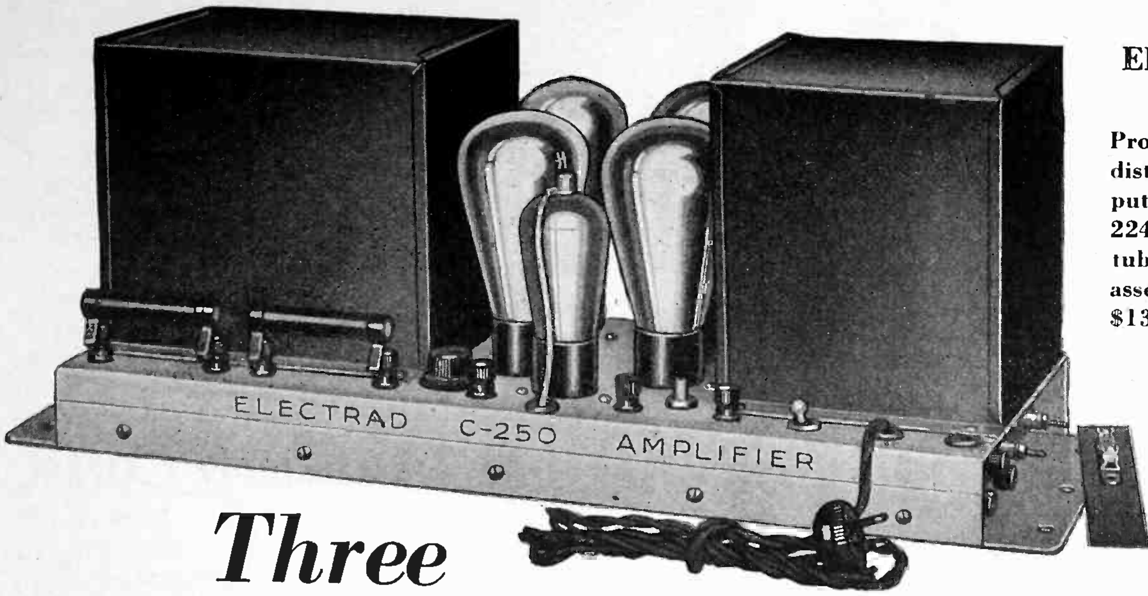
TABLE II

Design of variable pad having 11 steps of 2 db each, from 0 to 20, and output and input impedances of 600 ohms.

Step	Loss db	$\frac{R_1}{Z_1}$	R_1 and R_3	ΔR_1 and ΔR_3	$\frac{R_2}{Z_1}$	R_2	ΔR_2
1	20	.408	245	....	.205	123	....
2	18	.386	231	—14	.260	156	33
3	16	.360	216	—15	.330	198	42
4	14	.330	198	—18	.415	249	51
5	12	.296	178	—20	.525	315	66
6	10	.258	155	—22	.702	421	107
7	8	.220	132	—24	.920	552	131
8	6	.176	106	—26	1.280	768	216
9	4	.125	75	—31	1.950	1170	402
10	2	.070	42	—33	3.80	2280	1110
11	0	.000	0	—42	Open circuit		

ELECTRAD C-250 AMPLIFIER

Provides 10.35 watts undistorted output with input volts .3. Utilizes one 224, two 250 and two 281 tubes. Sold completely assembled only. List Price, $135.00, less tubes.



Three EXCEPTIONAL Amplifiers

ELECTRAD-BUILT

Using the Famous

LOFTIN-WHITE

Direct-Coupled System

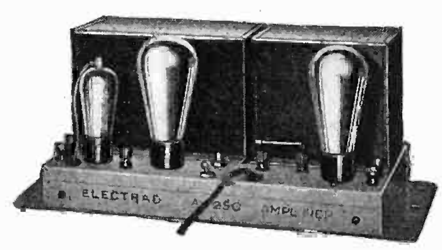
ENGINEERS will welcome these perfected amplifiers embodying the principles of the famous Loftin-White *direct-coupled* system.

Three notable models that supply all modern requirements of high quality output, stability, low initial cost and economical operation.

Electrad designed and built, these amplifiers typify the high standards of workmanship that have won world-wide recognition for all Electrad radio and power-supply products.

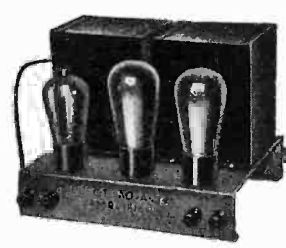
They are readily adaptable to all forms of sound amplification from microphones, phonograph pick-ups and radio tuners.

Our engineering department will be glad to show you how these Amplifiers can be used to your advantage. Write for data.



ELECTRAD A-250 AMPLIFIER

Provides 4.6 watts undistorted output. Utilizes one 224, one 250 and one 281 tube. Sold completely assembled only. List Price, $87.50, less tubes.



ELECTRAD A-245 AMPLIFIER

Provides 1.6 watts undistorted output with one 224, one 245 and one 280 tube. Completely assembled or in kit form. List Prices: Assembled, $40.00, less tubes. Kit, $35.00, less tubes.

Mail Coupon for New Complete Catalog

ELECTRAD, INC., *Dept. E-2;*
175 Varick St., New York, N. Y.

Please send me copy of new, complete ELECTRAD CATALOG, containing valuable technical data. Enclosed 10 cents (stamps or coin) for mailing cost.

Name ....

Address ....

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

175 Varick St., New York, N.Y.

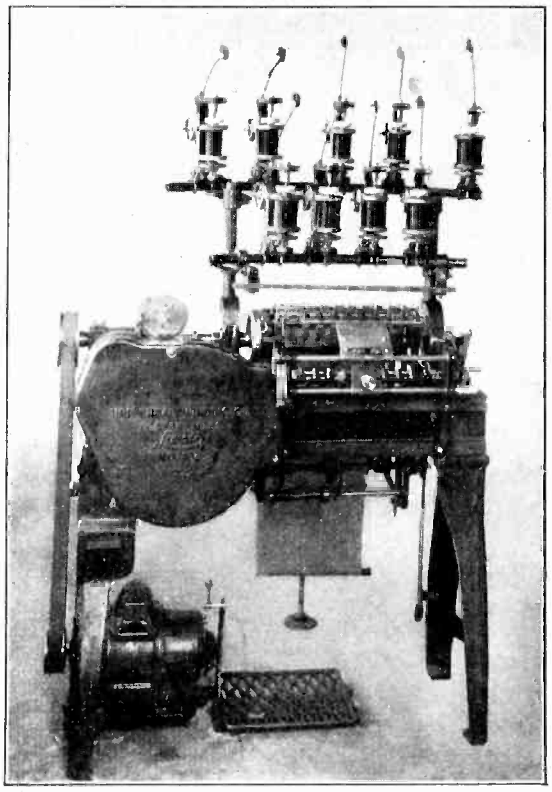
ELECTRAD INC.

ELECTRAD AMPLIFIERS are licensed under Loftin-White and R.C.A. Patents

Announcing ~

The New No. 104 Universal Winding Machine

for Multiple Production of Paper Insulated Coils



Entirely Automatic
Fully Adjustable
Reasonable in Price
Extraordinary in Performance

INSULATING paper mechanically inserted and automatically increased in length throughout the coil; Traverse Cam adjustable for coils up to 5″ in length; Automatic Counter meters individual wire turns, stops machine and resets in fraction of a second; Supply Attachment permits quick changing of wire spools; Machine performs efficiently at 3300 r. p. m., variable speed motor insuring gradual start and rapid acceleration of winding arbor; Slitting Attachment separates coils before removal from machine.

LEESONA
REG. U.S.A. AND OTHER PRINCIPAL COUNTRIES

Truly a remarkable piece of equipment, and now available to manufacturers interested in higher quality and lower cost of coils.

UNIVERSAL WINDING COMPANY
BOSTON

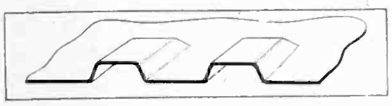
Manufacturers of coil winding equipment covering practically every phase of the electrical industry

" Every noteworthy advance in industry comes from thinking in the right material"

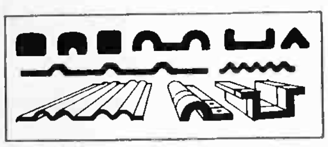
ENGINEERS!

INDUSTRY, in the year 1931, is going to need (and get) a lot of constructive thinking. Old methods will be scrapped. New ideas will be welcomed, and money will be made by those who originate economies.

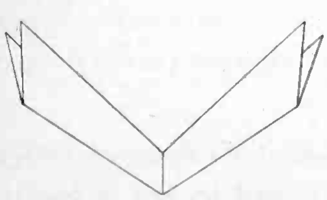
If *your* thinking is along the lines of reduced overhead, lower manufacturing costs, better appearance, value or performance, check your theories aga nst the versatile properties and uses of NVF products.



The basic forms of Vulcanized Fibre—sheets, rods, and tubes are capable of an almost unlimited number of forming and shaping processes. Does the diagram above suggest a way of reducing an operation or facilitating assembly in your product?



Phenolite (laminated bakelite) has great tensile and dielectric strength as well as complete resistance to oil, water, alcohol, dilute acids and other solvents (Above shapes are laminated molded Phenolite). Can you see it replacing a material that isn't *exactly right* for your product or work?



And then there's Peerless Insulation --a very thin, tough and very flexible fibre of high dielectric strength. Maybe it will fit into some ideas you have for improvement.

All NVF products—their uses, properties and workabilities are fully detailed in "Fact-Sheets of Industry." May we send you a copy?

N V F

"Our costs are as low as I can get them—

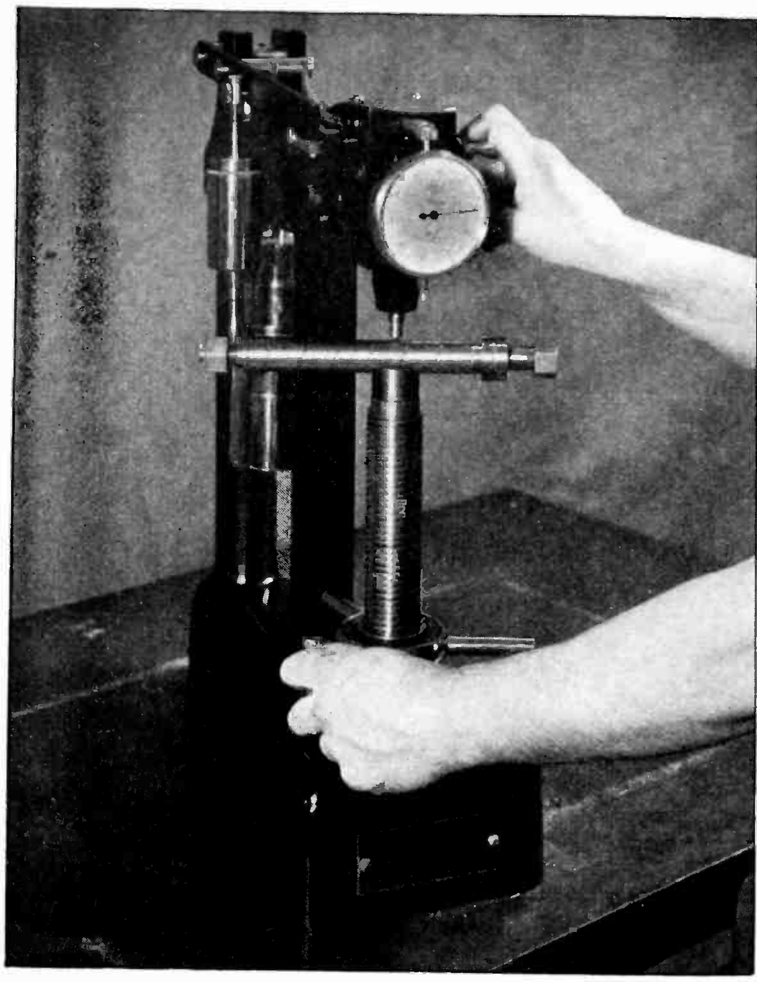
"I've checked every piece of material and every operation from the receiving department to the shipping platform, and there's not another cent we can lop off our costs without cutting down on the quality . . . If you want to turn out a cheaper product just say the word. I know how to do that too. But if we're going to keep on with this model, why not pass the buck to the sales department?"

ENGINEERS fighting to keep the quality up. Sales force battling to get the price down. Too often it ends with a compromise on value, when *thinking in the right material* would have solved the problem.

More than one manufacturer has overcome just such difficulties by comparing the requirements of the job in question with those versatile NVF materials—Vulcanized Fibre, Phenolite (laminated bakelite) and Peerless Insulation. What they can do towards reducing manufacturing costs while maintaining the product's full value has proved a revelation to many. It's the job of our Engineering Staff to discover the ways and means of applying "the materials of a million uses" to your problem. Put it up to us now—our services on development are gratis.

NATIONAL VULCANIZED FIBRE CO.
Wilmington, Delaware *Offices in principal cities*

PRECISION



THE MANUFACTURE of RCA Radiotrons necessitates the use of machinery that is accurate, dependable, and infallible. It accepts no substitute for—PRECISION!

This demands the maintenance of an extensive Development Equipment Laboratory, operated by a corps of highly specialized mechanical engineers. Here are designed and built super-accurate machines incorporating the very latest developments resulting from the constant research and experimentation of RCA Radiotron engineers.

This machinery is built with a watch-maker's accuracy, meeting the most rigid specifications and subjected to the severest of tests and inspections.

RCA RADIOTRON COMPANY, INC. — HARRISON, N. J.

A RADIO CORPORATION OF AMERICA SUBSIDIARY

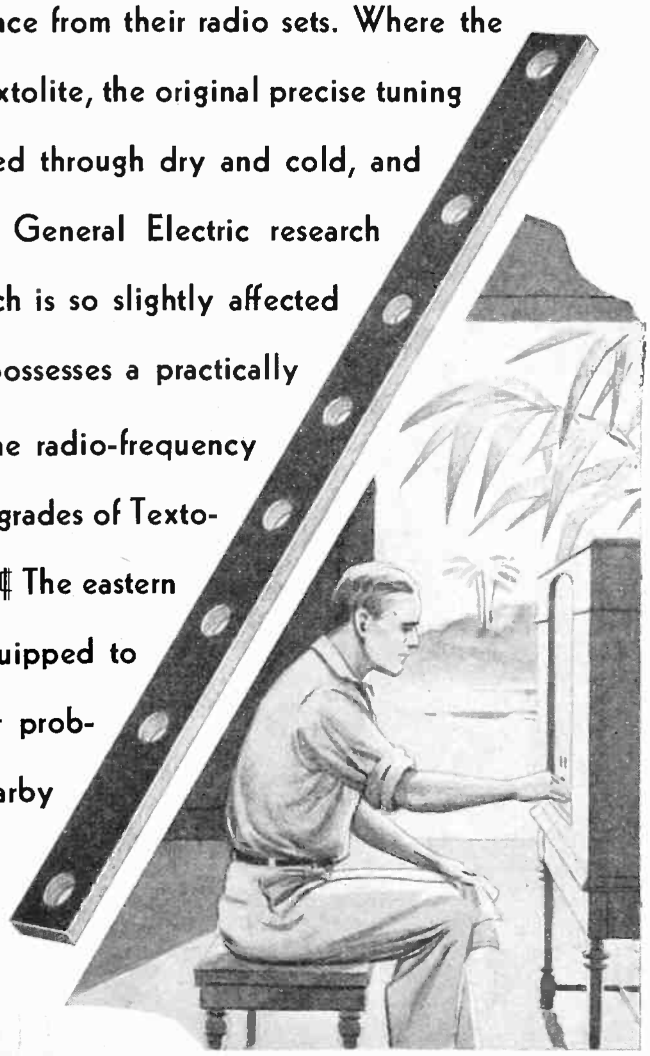
RCA RADIOTRONS

« « THE HEART OF YOUR RADIO » »

TEXTOLITE LAMINATED

Preserves the original tuning regardless of the weather

RIGHT on the premises of Uncle Sam, the whims of weather vary between seasons (and between localities) from arctic frigidity to tropical humidity. ¶ In every season and atmosphere, radio listeners expect uniform performance from their radio sets. Where the insulation used is Textolite, the original precise tuning of radio sets is preserved through dry and cold, and hot and humid weather. General Electric research developed this material, which is so slightly affected by changes in humidity that it possesses a practically constant power-factor. ¶ Besides the radio-frequency grade, there are available many other grades of Textolite for the needs of radio manufacturers. ¶ The eastern and western fabricators of Textolite are equipped to furnish advice or specifications regarding your problems. There is also a Textolite specialist in your nearby G-E sales office.



General Fabricating Co.
37 East 18th St.
New York City

Electrical Insulation Corp.
308 W. Washington St.
Chicago, Ill.

Join us in the General Electric program, broadcast every Saturday evening on a nation-wide N.B.C. network

885-47

GENERAL ELECTRIC

SALES AND ENGINEERING SERVICE IN PRINCIPAL CITIES

Standard of Excellence

A phrase synonymous with dependability—a phrase that has come to be applied to all Amertran equipment.

High grade engineering skill—unusual technical experience—precision methods of manufacture—the finest of materials—have produced a range of modern products to fill every radio requirement.

Your attention is called to the following equipment in particular.

Audio Transformers

Complete Amplifiers

Sound Systems

High Voltage Testing Sets

Choke Coils

Power Supply Units

Special Transformers

Electric Spot Welders

Radio Power Transformers

Bulletins describing all these products are available. Your request for information will receive prompt and courteous reply.

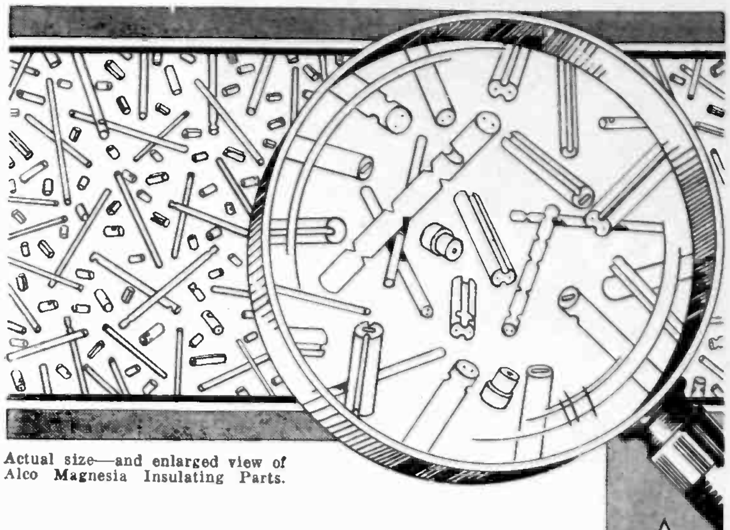
AMERICAN TRANSFORMER COMPANY

176 Emmet Street, Newark, N. J.

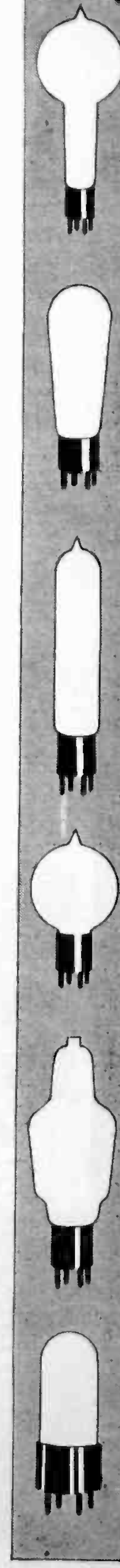
Representatives in the following cities

Atlanta . Boston . Chicago . Knoxville . Minneapolis
Montreal . Philadelphia . San Francisco . St. Louis

AMERTRAN



Actual size—and enlarged view of Alco Magnesia Insulating Parts.



MAGNESIA CERAMICS

For Tube Insulators

Only the purest of Magnesia should be considered.

Such insulators perfectly formed represent the highest achievements in tube insulation.

Our equipment is available for your particular designs.

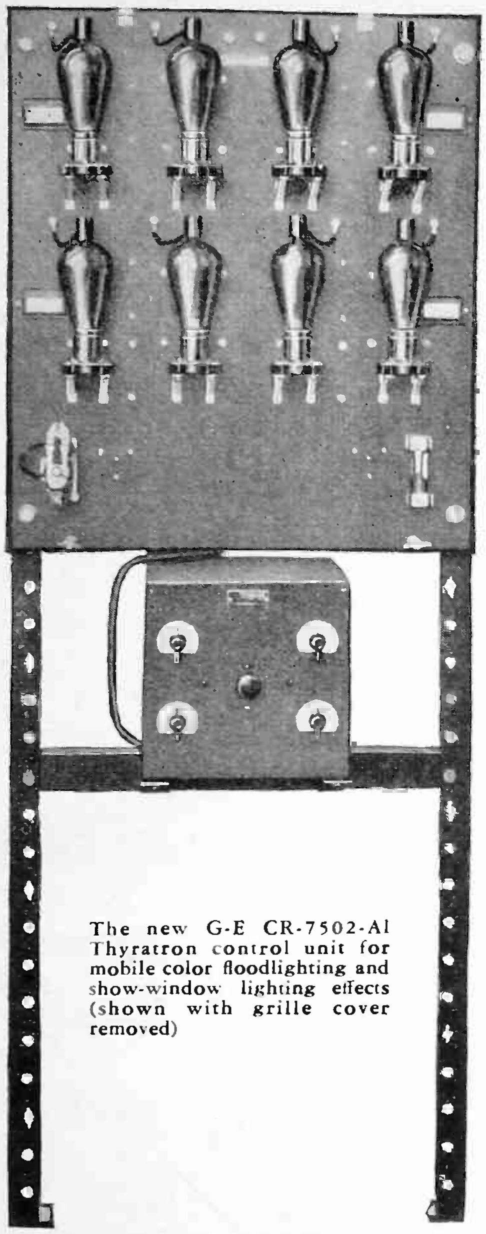
▼

Inquiries Invited

AMERICAN LAVA CORPORATION

CHATTANOOGA, TENNESSEE

This New G-E Thyratron Control Unit

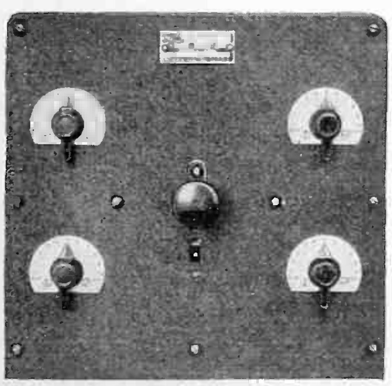


The new G-E CR-7502-A1 Thyratron control unit for mobile color floodlighting and show-window lighting effects (shown with grille cover removed)

brings greater beauty, flexibility, and *simplicity* to MOBILE COLOR LIGHTING

THIS new G-E control unit utilizing the Thyratron tube, an exclusive product of General Electric research, sets the stage for greater color harmonies in mobile color floodlighting and polychromatic color effects for modern show windows.

Maximum flexibility and simplicity have been attained in this lighting control by eliminating all cumbersome and inefficient dimming resistors and allied apparatus. Centralized control of all color effects is provided by regulators driven by a small synchronous motor, this part of the complete equipment being enclosed in a neat, portable case. Variation in time cycles may be obtained by a simple adjusting screw, bringing an ever-changing sequence of artistic color combinations.



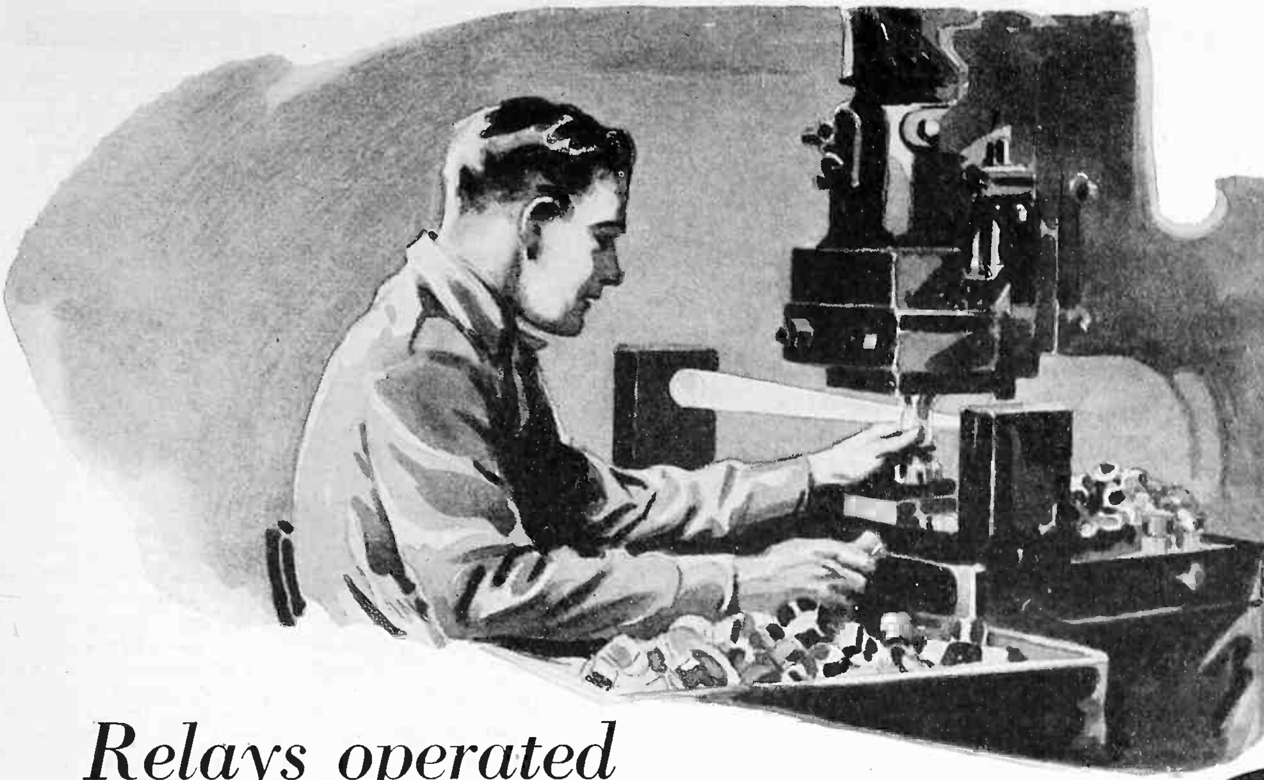
Close-up, attractive cabinet housing color-cycle control equipment. May be placed in show-window as a secondary "attention-getter", since pointers move in synchronism with light changes

JOIN US IN THE GENERAL ELECTRIC PROGRAM, BROADCAST EVERY SATURDAY EVENING ON A NATION-WIDE N.B.C. NETWORK

301-67

GENERAL ELECTRIC

SALES AND ENGINEERING SERVICE IN PRINCIPAL CITIES



Relays operated directly from photo-cells

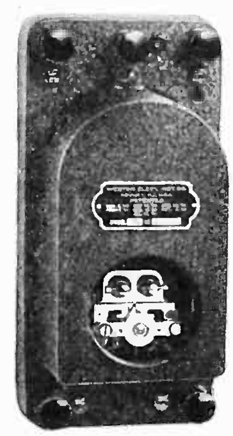
Model 534 Flush Type

PHOTO-CELLS no longer require amplification to operate relays — Weston Relays are so sensitive they can be operated directly by the minute electrical impulses of the liquid (photo-voltaic) and selenium (photo conductive) type light sensitive cells.

The elimination of amplification in operating relays is a big development in the electronic arts—a great aid to industrial and scientific applications—simplification is obtained where needed.

Weston D. C. Relays have been used for the past thirty years with outstanding success for automatically controlling voltages and currents. The advent of the Photo Cell gave Weston Relays new prominence because of their exceptional sensitivity and reliability of operation. These two outstanding features make them ideally suited for many Photo Cell applications.

The Weston laboratories will gladly advise and cooperate with those seeking the solution to problems arising from applications of Photo Cells and Relays.

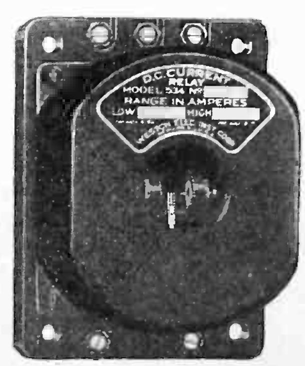


Model 30

RELAY MODEL 30 — Highly sensitive, precision type. Operates on very low values of current. For switchboard or surface mounting or portable use.

RELAY MODEL 534—Recommended for higher values of current and where compactness, light weight and lower cost are important and where great accuracy is not required. Made in flush or surface types. Flush type may be made indicating if desired.

Both models may be operated as Galvanometers (zero center). Constant Current or Low and High Current Relays.

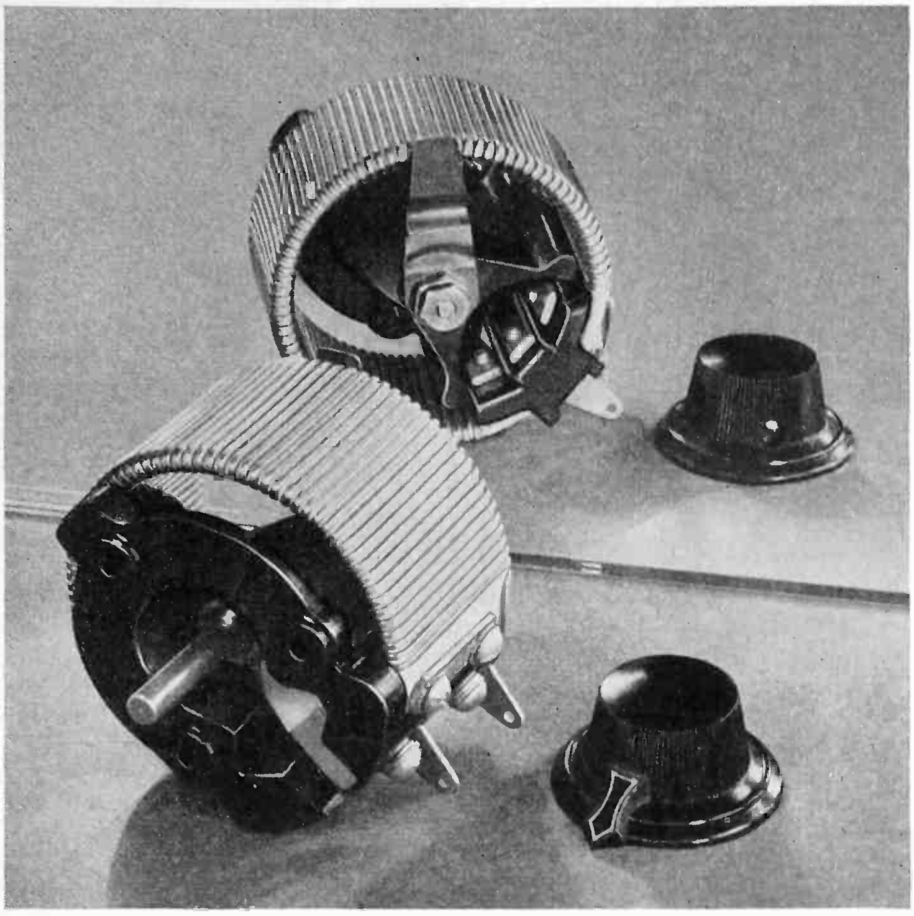


Surface Type Model 534

WESTON

ELECTRICAL INSTRUMENT CORPORATION

618 Frelinghuysen Avenue . . . Newark, N. J.



When low dielectric losses are essential *use Bakelite Molded X. M. 262*

Occasionally, molded parts are required for radio, television or other purposes, where low dielectric losses are essential to satisfactory performance. To meet this need a new Bakelite Molded (X.M.262) has been developed and is in successful use. It is made in natural brown and in black.

Whenever molded parts of unusual properties are needed to meet exceptional conditions, as was the case with the DeJur-Amsco heavy duty rheostats, some one of the various forms of Bakelite Molded is almost certain to fulfill the specified requirements.

Our research engineers and laboratories are always glad to cooperate with radio and other manufacturers in selecting the material best suited for any particular job. Write for a copy of Booklet 68M, "Bakelite Molded," and for full particulars about X. M. 262, and other new Bakelite Molding Materials.

BAKELITE CORPORATION, 247 Park Avenue, New York. CHICAGO OFFICE, 635 West 22nd Street

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.

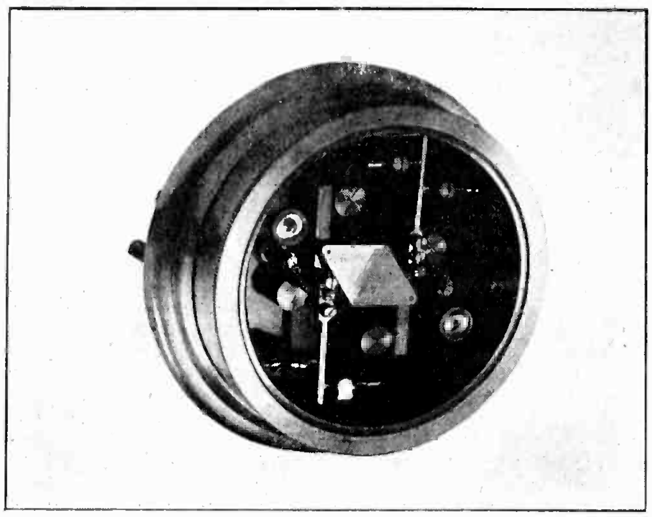
THE MATERIAL OF A THOUSAND USES

QUALITY QUANTITY PRODUCTION

of High Grade Instruments

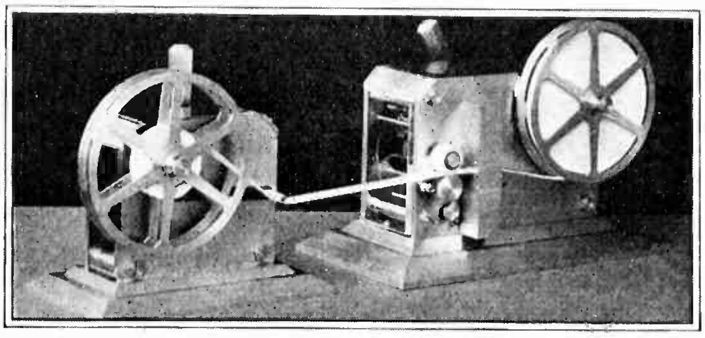
and

Specialists in Model Work



SPECIAL FIRE ALARM RELAY

The above double circuit relay is used in fire alarm central offices on the supervisory circuits. Can be adjusted to operate on a direct current margin of five per cent.



TYPE B PUNCH REGISTER AND TAKE UP REEL

The Fire Department of the City of Philadelphia have just expressed their approval of our type B Punching register and take up reel by placing a contract for 95 sets of these instruments. This new register is the result of many years of experimenting and manufacturing of both inking and perforating registers for recording electrical impulses.

FOOTE PIERSON & CO., Inc.

75 Hudson Street, Newark, N. J.

For thirty-five years manufacturers of electrical and mechanical devices and instruments of precision.

IMPROVED MULTIMETER

FOR DIRECT CURRENT

14 RANGES

Supplied in three separate combinations

Just 3 Binding Posts and 1 Selector Switch

1 microampere to 1 ampere (1,000,000 mics) 20 microvolts to 1000 volts

Specially suitable for covering both minimum and maximum readings on separate mounted thermo couples in vacuo For High Frequency Work, also with photo cells.

RAWSON ELECTRICAL INSTRUMENT CO.

INCORPORATED 1918

CAMBRIDGE, MASS.

Branch Office: 91 Seventh Avenue, New York City

Mid-Western Representative:

EARL N. WEBBER, Daily News Bldg., Chicago, Ill.

Specialists in High Sensitivity Meters

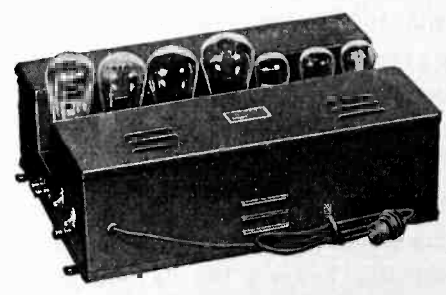
AMPLIFIERS FOR ALL PURPOSES

Photo Cell, Microphone, Public Address, etc.

This Company specializes in the design and manufacture of Audio Frequency Amplifiers. Your problems are solicited.

NEW LOW PRICES ON STOCK MODELS

Model GA 20



NET PRICE $75.00

SPECIFICATIONS

Number of stages—3
Maximum undistorted output—10 watts
Tubes required—1—'27, 2—'26,—2—'50,—2—'81.
Input signal for maximum output—0.2 volts.
Gain at 1000 cycles—68 db.
Power consumption—160 watts.
Supply voltage 105-120 volts, 50-60 cycles A.C.

Descriptive literature will be sent on request.

GENERAL AMPLIFIER COMPANY

27 Commercial Ave. Cambridge, Mass.

THE MAKIN'S MAKE THE TUBE

•

THE TUBE MAKES THE RADIO

•

...we make the finest pure nickel seamless tubing

•

Just specify

SUMMERILL TUBING

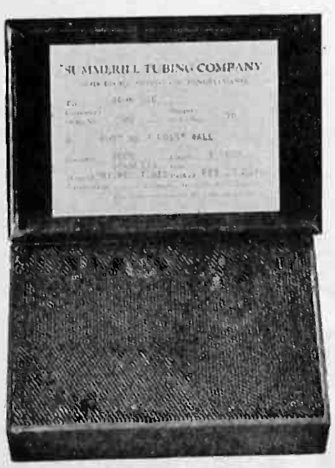
•

THE SUMMERILL TUBING COMPANY

FOUNDED 1899

BRIDGEPORT, PENNA.

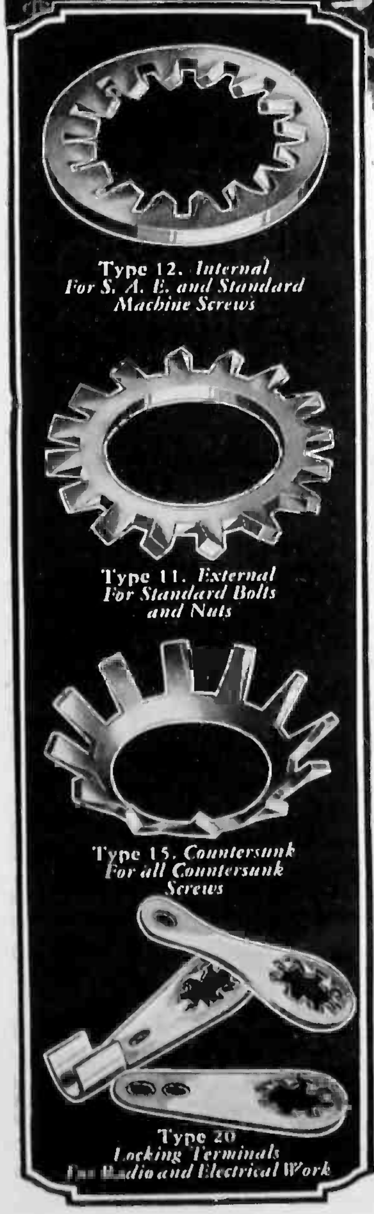
(Philadelphia District)



PROMPT DELIVERIES
—anywhere—any time
—any quantity

The scientific care used in making Summerill Seamless Nickel Tubing is carried through until it reaches you. It is packed in a sturdy box carefully made to insure the contents against all shocks in transport. It assures perfect condition of the tubing when it reaches you.

Spreadproof *Too*!



Even under an *Air Wrench*

ON mass production lines—where speed and efficiency count—Shakeproof Lock Washers have definitely demonstrated their outstanding superiority. Being made in one continuous circle, they are tangleproof and spreadproof too! This means easier and quicker handling and also prevents lost time and delays in backing off a nut because a washer has spread.

In scores of industries today, Shakeproof Lock Washers are saving manufacturers thousands of dollars on their assembly costs. And, at the same time, this positive locking method is making thousands of products perform better and last longer. That's why it will pay you to test Shakeproof on your own production line and see for yourself how they cut down overhead and reduce customer complaints.

Send at once for free samples—we will gladly furnish a supply of any type or size desired—write for yours today!

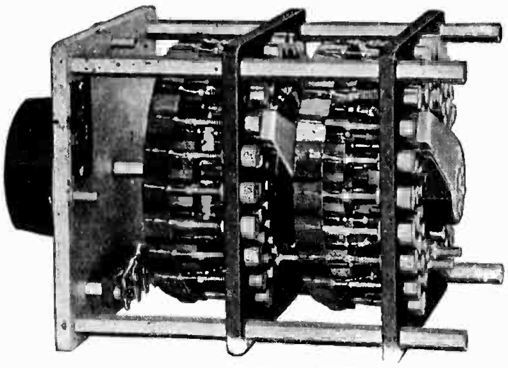
U. S. Patents
1,419,564
1,604,122
1,697,954
1,782,387
Other patents pending.
Foreign patents.

SHAKEPROOF
Lock Washer Company
(Division of Illinois Tool Works)
2539 North Keeler Avenue, Chicago, Illinois

"It's the Twisted Teeth that LOCK"

VOLUME CONTROLS FOR QUALITY SOUND SYSTEMS

In sound transmission systems where a premium is placed on reliability and freedom from noise and distortion, the Type 552 Volume Controls supply a great need.



They are of excellent electrical and mechanical design. Individual resistors are held to close tolerances, the attenuation being "as branded" to within 1 db at 20 kc. A dust cover of nickel-plated brass gives protection against stray electric fields. The illustration shows a balanced-H section.

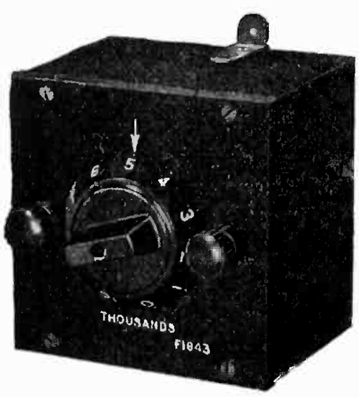
Type	*Attenuation*	*Section*	*Impedance*	*Price*
552-LA	30 db in steps of 1.5 db	L	50 ohms	$28.00
552-LB	30 db in steps of 1.5 db	L	200 "	28.00
552-LC	30 db in steps of 1.5 db	L	500 "	28.00
552-TB	30 db in steps of 1.5 db	T	200 "	34.00
552-TC	30 db in steps of 1.5 db	T	500 "	34.00
552-HB	30 db in steps of 1.5 db	Balanced-H	200 "	48.00
552-HC	30 db in steps of 1.5 db	Balanced-H	500 "	48.00

Further details are given in Catalog F-E4

GENERAL RADIO COMPANY
OFFICES LABORATORIES FACTORY
CAMBRIDGE A, MASSACHUSETTS

COMPLETE MANUFACTURING SERVICE

Engineering
Development and
Experimental Models
SMALL LOT AND QUANTITY PRODUCTION



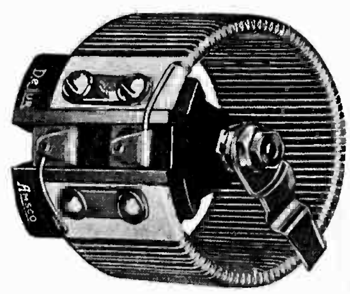
Relays
Polar Relays
Keys
Resistance Boxes
Panels
Siphon
Recorders
Etc.

Bunnell Resistance Boxes—Built for Precision Work are Reliable—Contain 10 Steps and Zero. Standard Resistances 1/100, 1/10, 1, 10, 100, 1,000 and 10,000 Ohms.

J. H. BUNNELL & CO.

215 FULTON STREET
NEW YORK CITY

DeJur-Amsco



RHEOSTATS AND POTENTIOMETERS

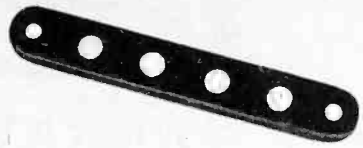
For Delicate Power Control

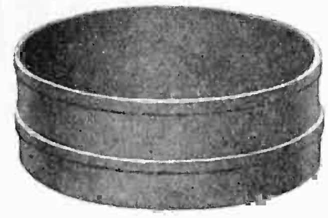
DeJur-Amsco power rheostats and potentiometers are engineered mechanically and electrically to provide a consistent and unvarying current control and to give an added degree of perfection in the power control of circuits and systems to which the wire wound variable resistor is adapted.

Engineers will immediately recognize in these DeJur-Amsco variable resistors the solution of many problems in Power Circuits, Mixing Panels, Spot Welding, Motors and in the Photo-Electric field.

Write us your requirements. Our engineers are ready to assist you in the development of special apparatus to fit your particular needs. Literature on request.

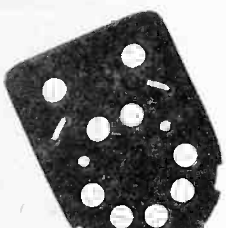
DEJUR-AMSCO CORPORATION
95 Morton Street, New York City

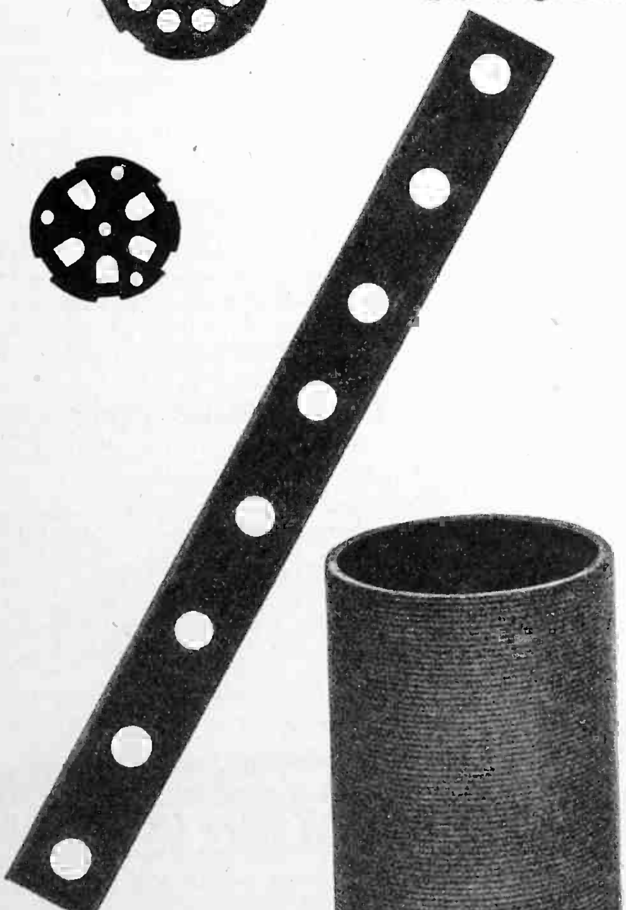




EVERY RESOURCE

for Quality and Uniformity!





THE Formica organization is well equipped to give the electrical and radio industries prompt service on high quality insulating material.

It has the largest equipment for producing and fabricating materials of this kind in the country. It has a well equipped and competently manned laboratory for the control of production and the development of new and better formulas.

For 18 years it has specialized on just one product. During most of that time it has served some of the leading American technical organizations.

FORMICA

THE FORMICA INSULATION COMPANY
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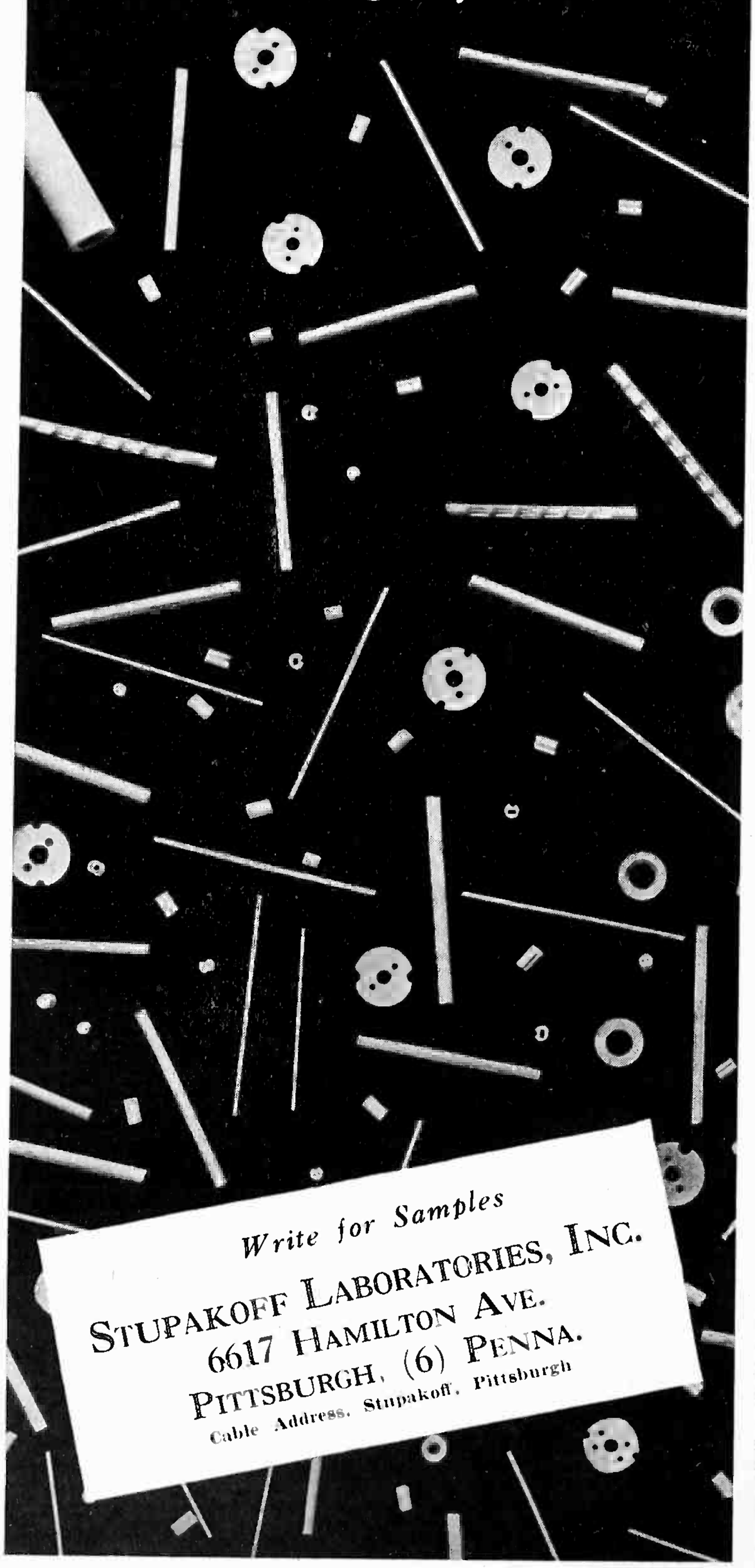
CINCINNATI, OHIO



electronics

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Contents for FEBRUARY, 1931

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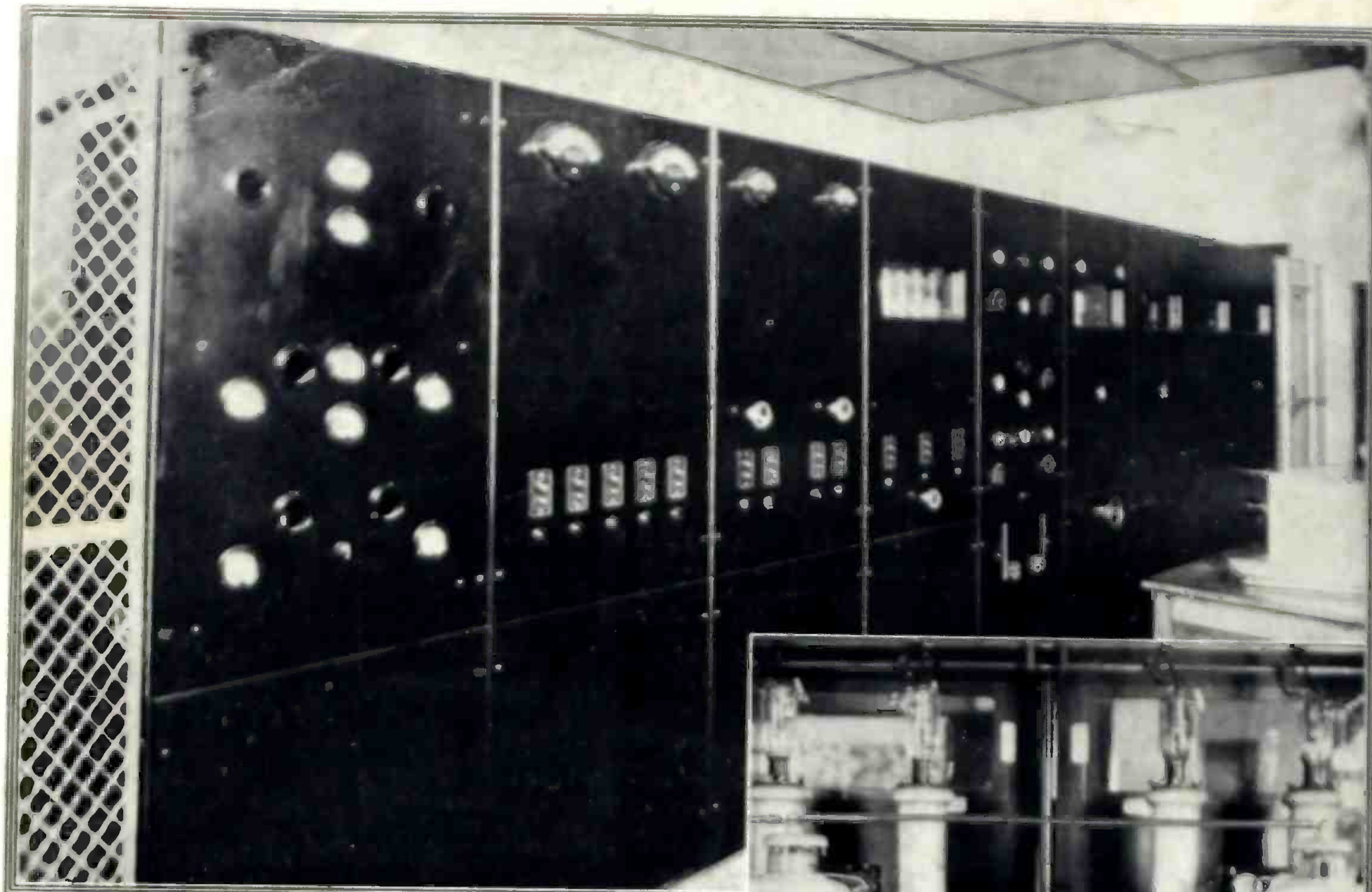

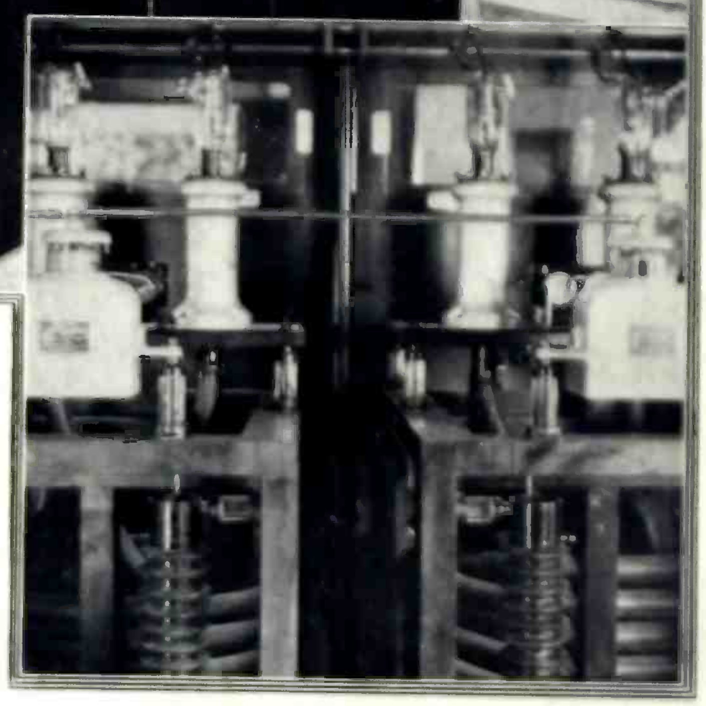

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