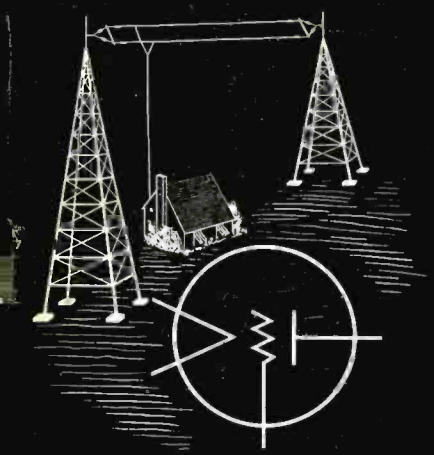
DECEMBER, 1931

Radio Engineering



IN THIS ISSUE

ELEVENTH YEAR OF SERVICE

The Journal of The Radio Industries

ESCAPE THIS ? *never!*

EVERY ARCTURUS TUBE *must pass* 137 TESTS *and* CHECKS

Reductions in prices or revisions in methods cannot . . . will not . . . interfere with Arcturus' rigid standards of giving each *blue* tube 137 tests and checks before it leaves the factory. The quality of Arcturus *Blue* tubes, recognized by critical engineers of leading set manufacturers, jobbers, dealers, consumers . . . *and even conceded by other tube manufacturers* . . . will not be sacrificed for any reason!

Not an Arcturus Tube escapes these 137 tests and checks. All raw materials, each operation, every part . . . each tube is interminably "third-degreed."

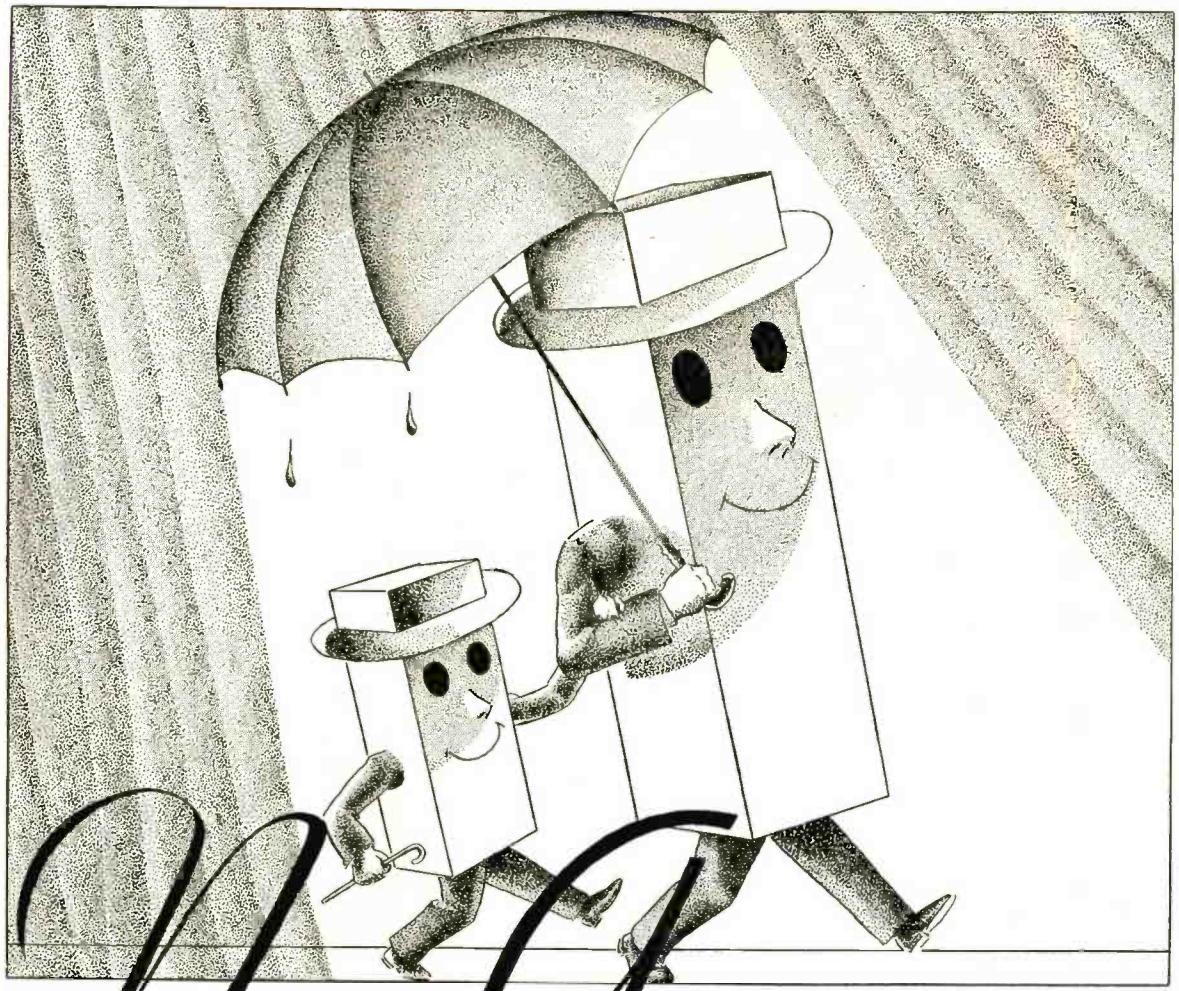
Each Arcturus Tube must meet the rigid Arcturus limits, closer than those of any other manufacturer; it must check for the highest degree of vacuum practically obtainable, precise characteristics, humless and undistorted reproduction in actual receivers, gruelling life tests, continuously checked and re-checked. Then, and only then, is the tube ready.

Certainly a painstaking operation to give you a well-engineered product to complement your well-engineered set. Technical data sheets on Arcturus *Blue* Tubes will be sent to engineers upon request.

ARCTURUS RADIO TUBE COMPANY
Newark, New Jersey

ARCTURUS

The BLUE TUBE *with the* LIFE-LIKE TONE



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THE Elkon Electrolytic condenser is dry—not a drop of free water* in it! Yet it has all the performance characteristics of the best electrolytic condenser—stable—compact—highest filtering efficiency. It costs less than any other good condenser. Furthermore Elkon has practically the same characteristics as paper condensers—but is lower in cost and much less bulky . . . and here's news—all of the above characteristics apply to our new By-pass condensers. 73 leading set manufacturers have standardized on Elkon. A request today will bring you your sample tomorrow. Complete information will be sent to all members of your technical staff. Just send their names.

*water of crystallization of course—but no *free* water.

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RADIO ENGINEERING

Reg. U. S. Patent Office

Member, Audit Bureau of Circulations

Western Editor ULMER G. TURNER

Editor DONALD McNICOL

Managing Editor F. WALEN

Vol. XI DECEMBER, 1931 Number 12

Contents

Departments

THOMAS A. EDISON'S WORKSHOP CHAIR

Edison Dead.'

Is the human voice dead?
Is song dead?
Has music vanished?
Are distant homes to know
No golden voices—
Hear no genius play?
Shall music no more leap
From a box of rosewood?

(Lines by H. T. Philips in the N. Y. Sun.)

BRYAN S. DAVIS *President*

JAS. A. WALKER *Secretary*

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Editorial

DECEMBER, 1931

FUTURE OF THE THERMIONIC TUBE

A YEAR or more ago much was made of the idea that by this time more thermionic tubes would be used in industries other than radio than in the radio art itself—tubes were reported to be on their way into the hands of others than radio engineers.

The developments of eighteen months indicate that by far the bulk of the tube product still finds service in radio receivers, transmitters and in associated sound systems in theatres and public-address.

True, power tubes, relay tubes and photocells have during the recent past been applied in various mechanical industries to simplify mechanical operations, and these applications will expand and increase as ingenuity provides the mechanism to meet new needs, but so far as is discernible now the market for tubes for twenty million radio receivers and three thousand transmitting stations, of all types, constitutes the major outlet for the immediate future.

A speaker at the Rochester Convention of the I.R.E. in November, stated the situation clearly when he reminded radio engineers that to them all industries look for information and for thermionic tube development. As the economic situation improves capital will no doubt become available for a broader exploitation of the tube in industry. The immediate opportunity for radio engineers is that of learning all of the uses and applications of tubes to the end that they may be prepared to meet the expansion as it develops.

The tube manufacturers appear now to realize that the furtherance of tube applications in industries other than radio is best served by acquainting radio engineers with tube advances as in the majority of cases when tubes find their way into factories, shops, operating services and into common use, radio engineers will play a major part in these applications.

▲

BROADCAST FREQUENCY ASSIGNMENTS

BEGINNING on June 22, 1932, Federal Radio Commission general order No. 116 requires that all radio broadcasting stations operating between 550 and 1500 kilocycles shall maintain the assigned frequency between the limits of 50 cycles per second above to 50 cycles per second below the assigned frequency. Further, stations are required to make provision for the checking of the frequency of the emitted wave by means independent of the frequency control of the transmitter, the independent means employed to be capable of measuring with the prescribed accuracy.

Monitor instruments which will indicate directly deviation from channel frequency as the familiar pointer type of meter will be in demand.

▲

FAN MAIL

IN DETERMINING broadcast station coverage fan mail still occupies an important position. A year or two ago it was predicted that in time fan mail would dwindle to inconsiderable volumes due to a lack of observable results of such letter writing. It appears now, however, that fan mail may still be stimulated and that when this evidence of coverage is desired by the broadcaster there are ways of largely increasing the daily receipt of letters from listeners-in.

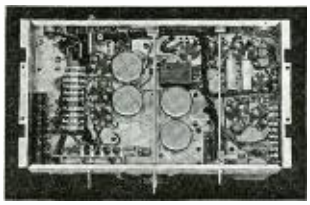
On November 18, last, approximately 35,000 letters and telegrams were received at the New York headquarters of the National Broadcasting Company. In addition to this large bulk of communications some 10,000 letters were opened and read at NBC division offices in Chicago and San Francisco. The grand total for the day was larger than the mail received by NBC in a month five years ago, and more than half the amount received during the entire year 1923, the first year of chain broadcasting through WEAF. For these communications not only is regular mail service used, but messenger boys, the telegraph, air mail and radiograms serve to bring in the avalanche of approval, disapproval, suggestion, razzing, appreciation and whatever it is of emotion that seeks expression from 35,000 individuals located here or there throughout the country.

Donald McNicol

Editor

Assembling without tapping

Stromberg-Carlson speeds production



When Stromberg-Carlson used machine screws to fasten parts to their radio receiver chassis, assembly work had to be halted while holes were being tapped. This delay in production was eliminated simply by changing to Self-tapping Screws—the modern means of making metallic fastenings. In addition to doing away with twenty-nine tapping operations on each receiver, Self-tapping Screws eliminated all of the expense and troubles that go with tapping. Stronger fastenings were gained, too.

Self-tapping Screws have made tapping an out-of-date, unnecessary operation in radio production. Practically all of the leading radio manufacturers, and scores of smaller concerns are now saving the time, labor and money once expended on tapping and the upkeep of tapping equipment. On their assemblies which were once made with rivets or bolts and nuts, Self-tapping Screws have eliminated unhandy operations that slow production and waste labor.

What will Self-tapping Screws save on your assemblies? It costs nothing to find out. Our Assembly Engineers will tell you, FREE, if you attach a description of one or more fastening jobs when you send the coupon for the informative booklets shown below.

Type "Z" Hardened Self-tapping Sheet Metal Screws

For joining and making fastenings to sheet metal up to six gauge; also aluminum, die castings, Bakelite, etc. Simply turn Screw into drilled, pierced or molded hole. It forms a thread in the material as it is turned in. Can be removed and replaced.

Type "U" Hardened Metallic Drive Screws

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

PARKER-KALON *Hardened* Self-tapping Screws

PAT. IN U. S. AND FOREIGN COUNTRIES

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

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

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

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

Address----------

Impressions and Expressions

By AUSTIN C. LESCARBOURA

CHEAPER TUBES

AS these lines are written the radio tube industry has slashed list prices once again, and the air is rife with rumors of still another drastic slash. To the uninitiated, it would seem that long ago the list prices had been reduced to profitless levels. Actually, however, the better equipped plants can still make money at the present list prices, and even at lower levels that may be established through further slashing.

During the past two years, remarkable tube production equipment has found its way into the larger plants. Whereas, until then the tube producers were contented to employ revised lamp-making equipment, the urge for lower production costs compelled the developments and introduction of equipment designed primarily for tube making. Recently the production speed, particularly on the sealing and exhausting units, has been further increased, in anticipation of lower list prices. Make no mistake about it, the large tube manufacturers are not yet selling at a loss, even with the startling low list prices.

The only question is whether tube list prices are not being reduced to ridiculously low levels. A study of recent sales figures indicates that price slashes do not increase sales materially, and even if they did, the volume in dollars would not match that before the slashes. The authors of these price slashes are not creating any additional demand. They are not making as much profit as before. They are not setting themselves apart from competitors, since their slashes are immediately met. And if they contemplate squeezing out the weaker manufacturers, they are certain to face a long and drastic struggle in which their own stockholders may prove unwilling to stand the gaff.

▲

BETTER NETWORKS

THE critical radio listener has doubtless noticed a marked improvement in the tone quality of programs originating in remote studios and brought to the local broadcasting station via long wire lines. Quite obviously, the telephone lines have been improved upon, for there is a noticeable extension of the frequency range. No longer does the network program suffer by contrast with the local program.

Upon investigation, we find that the telephone organization has been installing a new type of cable for the handling of broadcast programs. The cable is now in use, linking the various stations between New York and Chicago, and an extension of the installation is planned in the near future, so as to link up with stations in other areas. The new cable has been developed in anticipation of better microphones, better broadcast transmitters, and better radio receivers. Rather than handicap radio developments with limited wire lines, the telephone engineers began research work some time ago on improved long lines service.

The new cable enables the handling of a wider frequency band than has heretofore been possible over wire lines. It permits a frequency range of from 30 to 8,000 cycles, instead of the ordinary telephone line range of 150 to 5,000 cycles. In practical terms, this means that there is no longer a marked discrepancy between the network program and the local program. The entire country will soon be joined together into a truly local audience.

▲

COSTLY ENGINEERING

THERE is nothing more costly in the radio industry today than cheap engineering. A study of manufacturing failures discloses poor engineering as a common contributory cause. And just so long as the industry believes that real engineers can be hired for $25 to $40 per week, just so long are we going to have an epidemic of failures seemingly due to mysterious causes.

Resting on a highly intricate technique, the radio industry is mainly dependent on competent and thorough engineering. While stockholders of manufacturing companies may be contented with the appointment of a new high-powered sales manager, the fact remains that any company is made or broken by the intrinsic worth of its products. Unless the engineering is sound, the product cannot be sound. Sales success starts in the research and engineering department, and any number of prima donnas in the merchandising end cannot undo a false start.

In traveling about the industry, the writer is frankly appalled to find mere boys, paid a salary of $25 to $40 per week, entrusted with production schedules that run into the hundreds of thousands of dollars. How anything else but failure can come out of such rank gambles is difficult to comprehend.

▲

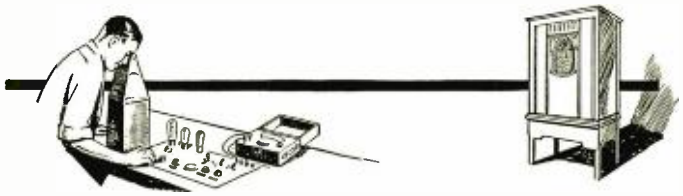
TELEVISION LITIGATION

THE first shots have been fired in what promises to be a lively television patent battle. With television workers here and there laying their hands on real money through actual effort rather than the sale of promises to stockholders, the television patent situation is looming up as a bright picture for some and a dark one for others.

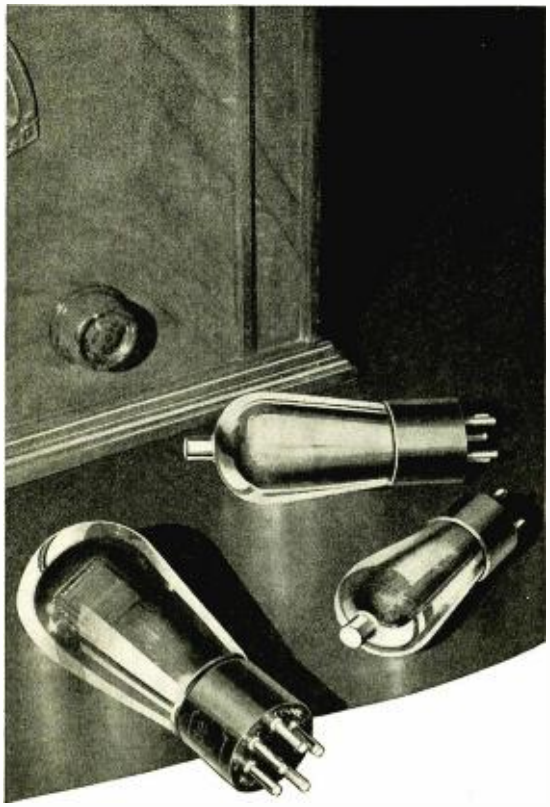
While it is true that the basic principles of television are very old, dating back several decades to the German inventor, Nipkow, the fact remains that many patents have already been granted on television details and refinements. Such features as lens, scanning discs and signal synchronizing means are covered by presumably sound patents, although one would never think so, judging by the general use of such features by various television workers.

Television organizations that have pioneered in evolving a workable system out of the many experiments of the past, covering their efforts with many patents, may now have an opportunity of testing their property rights, especially at a time when opportunities are rushing into the field for the purpose of quick and easy profits. It remains largely for the courts to decide to whom belongs the fruits of pioneering efforts.

PRODUCTION FACILITIES



IN LINE WITH THE SET MANUFACTURER'S NEEDS:



HYGRADE SYLVANIA HAS PRODUCTION FACILITIES IN LINE WITH THE SET MANUFACTURER'S NEEDS

As evidence of its unusual ability to serve set manufacturers who must have a dependable source of supply of radio tubes —

Hygrade Sylvania presents these qualifications:

Experience

Not only has Hygrade Sylvania made a comprehensive study of the needs of set manufacturers, it has already had a wide experience filling them.

Production Facilities

Capable of taking on stiff production schedules and meeting them.

Financial Strength

Financial strength, the result of sound and successful methods has made Hygrade Sylvania one of the outstanding companies in its field.

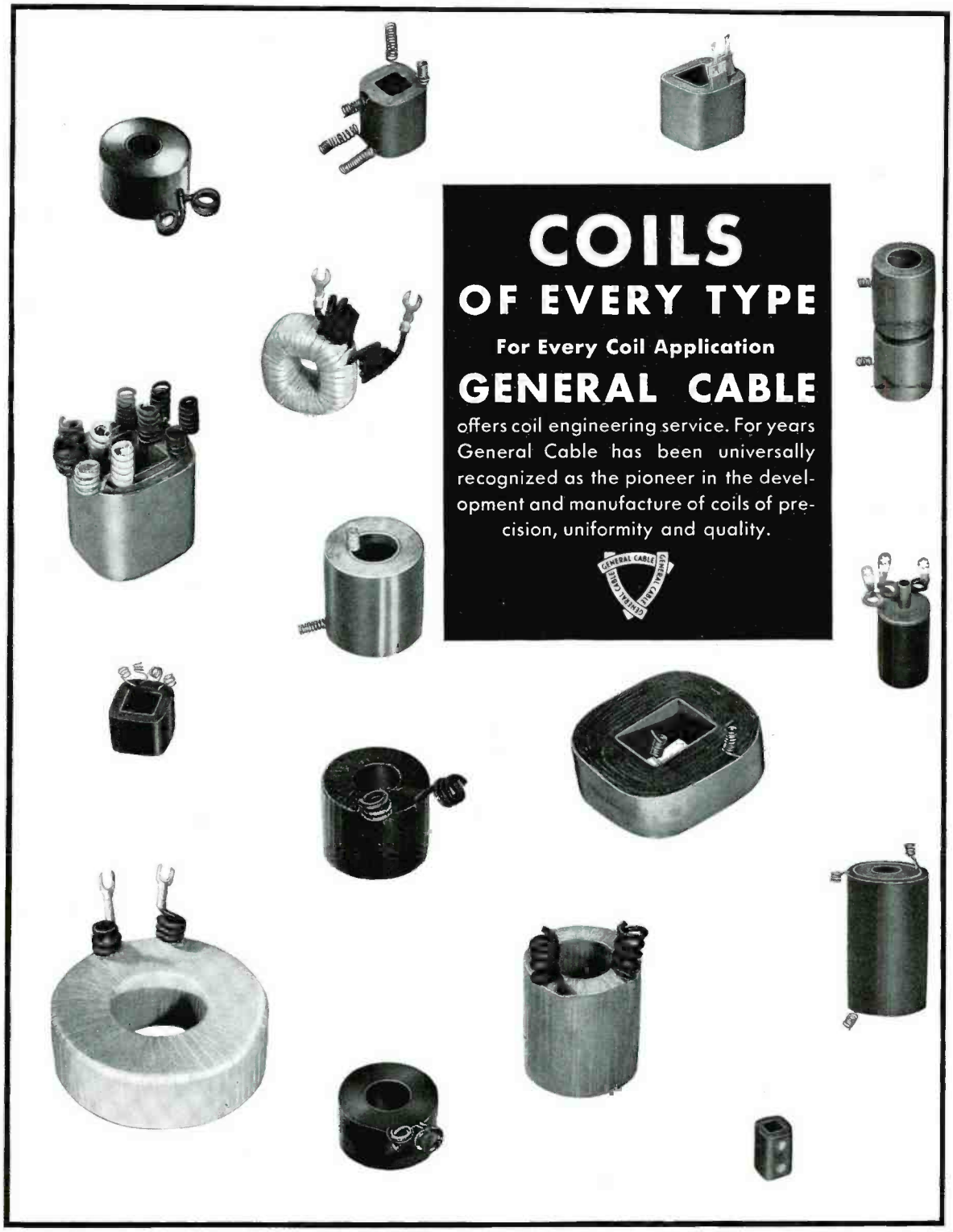
Engineering Skill

This same financial strength makes it possible to maintain at all times an engineering department representative of a high degree of skill.

HYGRADE SYLVANIA CORPORATION

HYGRADE LAMP DIVISION
SALEM, MASS.

SYLVANIA DIVISION
EMPORIUM, PA.



COILS
OF EVERY TYPE

For Every Coil Application

GENERAL CABLE

offers coil engineering service. For years General Cable has been universally recognized as the pioneer in the development and manufacture of coils of precision, uniformity and quality.

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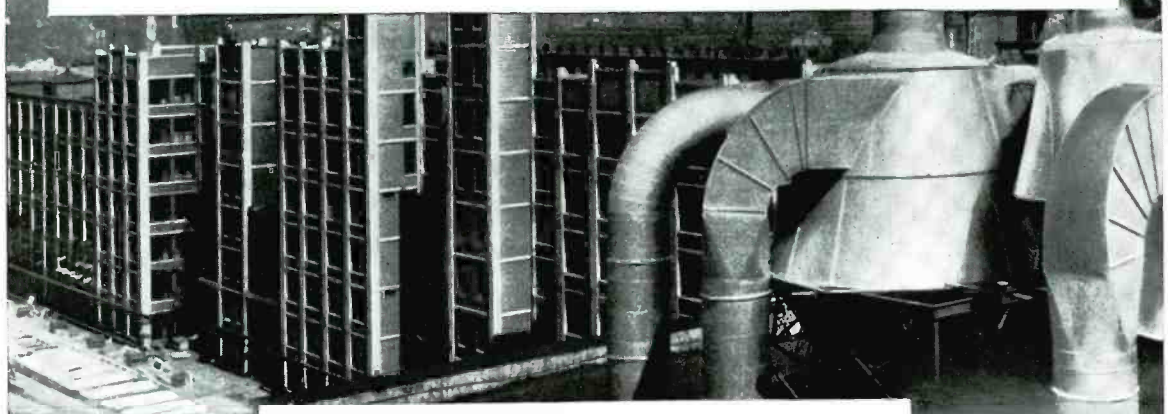
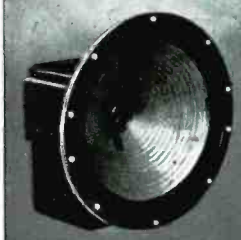
FROM "RADIO HEADQUARTERS"



Dependable loudspeakers for every purpose



Type RL-2
De Luxe Electro-dynamic Loudspeaker

Type RL-43 Permanent
Magnet Loudspeaker
for automobile receivers

Type RL-35
De Luxe Permanent
Magnet Loudspeaker

Type RL-36
Midget Electro-dynamic Loudspeaker

There is now available to radio manufacturers an RCA Victor speaker for every purpose. The latest development from the RCA Victor laboratories is the type *RL-43 Permanent Magnet Dynamic Speaker* for use with automobile or battery operated receivers. This speaker combines high quality reproduction with low cost and eliminates the objectionable drain on the "A" battery required for field excitation of an electro-dynamic speaker.

Write us today for information on a speaker to meet your particular requirements.

Type RL-31
Console Electro-dynamic Loudspeaker

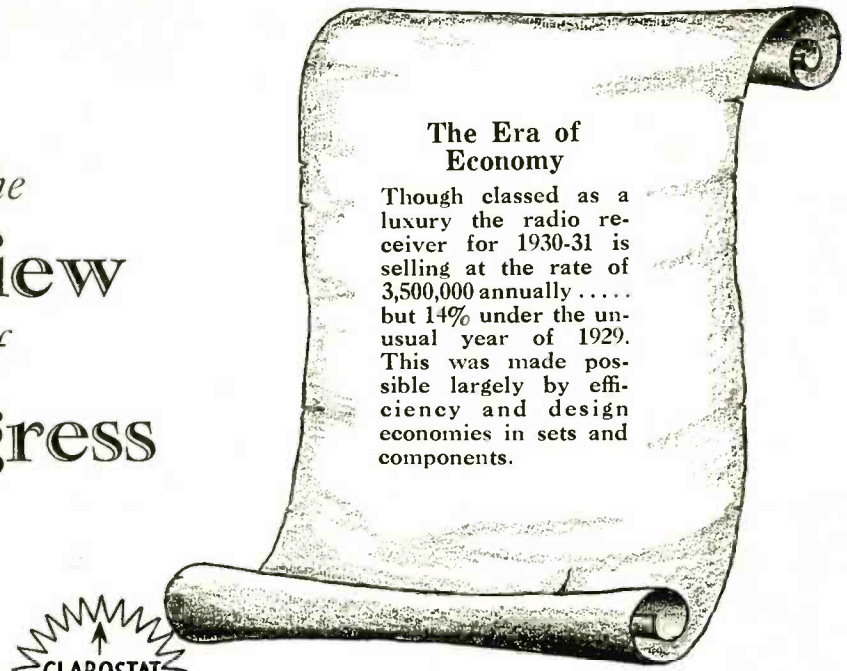
RCA

RCA Victor Company, Inc.

INDUSTRIAL PRODUCTS DIVISION

CAMDEN, N. J.

The
Review
of
Progress



CLAROSTAT

EVERY step in electronic development has been anticipated by Clarostat engineers in their art of control design . . . They now offer a 60% saving in the "C"-bias limiting resistor.

This year engineering problems in set design were largely matters of lowering cost. Many methods of cost reduction were attempted . . . . . some were seriously menacing factors of safety.

The "C"-bias limiting resistance was subjected to various forms of design economy. In some cases it was attached like an appendix to one of the volume control terminals. In most cases these efforts resulted in lack of mechanical and electrical protection and a high percentage of assembly troubles.

Clarostat engineers, backed by a decade of control and resistor experience are now offering a simple solution. The "C"-bias limiting resistor is made an integral part of the volume control resistance winding. The contact arm is accurately stopped when it reaches the bias winding, resulting in an exact fixed value of desired "C"-bias permanently set at the Clarostat factory. Thus the "C"-bias limiting resistance is protected within the volume control housing, resulting in a simpler trouble-proof design. More important, a 60% saving is effected in the cost of the "C"-bias limiting resistance, with actual increase in mechanical and electrical factors of safety.

Clarostat can provide this design to meet any special requirements.

Clarostat service to the electronic arts includes volume controls, voltage regulators, rheostats and resistors.

Clarostat Manufacturing Co., Inc.

285 North 6th Street, Brooklyn, N. Y.

RMA directors consider problems

SALES promotion plans, television, the patent problem, the proposed sales tax on radio and many other important industry problems were considered by the RMA Board of Directors at their meeting November 19, at the Hotel Cleveland in Cleveland, Ohio. Preliminary plans for the 8th annual RMA convention and trade show at Chicago, beginning May 23, 1932, the only official industry show, also were approved. J. Clarke Coit of Chicago, president of the RMA, presided at the directors' meeting. Officers and directors of the National Federation of Radio Associations and the Radio Wholesalers Association also met at luncheon with the managing committee of the RMA for a conference on sales promotion projects and improved radio merchandising practices.

Probability of treasury recommendations to Congress of a manufacturers' sales tax on radio products was presented to the RMA board by Frank D. Scott, the association's Washington legislative counsel. Action in the sales tax matter was deferred by the board, to await developments in Washington. It is planned to take any necessary and appropriate action with due regard to the Government's revenue needs and conditions of the radio industry, in cooperation with other radio and industry organizations. The RMA legislative committee, of which H. B. Richmond, former RMA president, is chairman, is in charge of the matter.

President Coit and other chairmen reported progress on the patent problem, in which negotiations and conferences have not been completed.

Deploring many false reports regarding television and "blue sky" television stock promotions, the RMA board took steps to advise the industry and the public regarding the true progress at present of television. A special statement on the actual status of television will be prepared and issued by the RMA. The board of directors ordered preparation of such a statement by the association's engineering division of which Dr. C. E. Brigham of Newark, N. J., is chairman.

Cooperation with Broadcasters

Closer cooperation on mutual problems has been effected between radio manufacturing and broadcasting interests, through the RMA and the National Association of Broadcasters. Legislative, advertising and many other broadcasting problems are being studied and assisted by the RMA. At the annual convention at Detroit on October 27th of the National Association of Broadcasters, Bond Geddes, executive vice-president of the RMA, was a guest speaker representing President Coit and the Association.

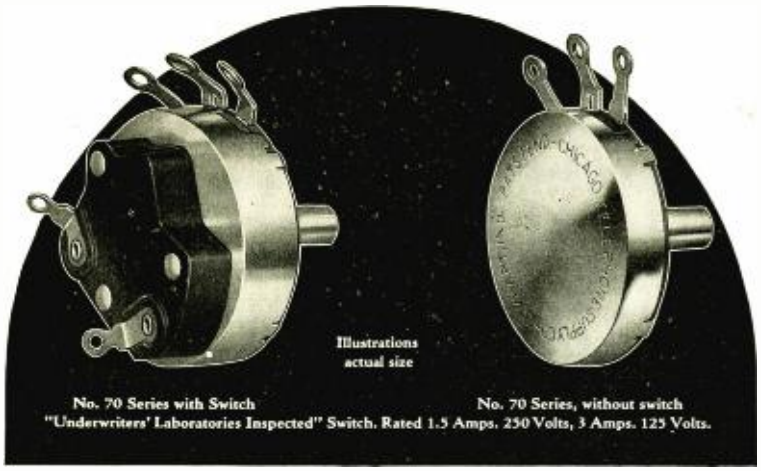
LESLIE F. MUTER, Treasurer, RMA.

Engineering Service

Expansion of engineering service to RMA members is being effected by its engineering division. Dr. C. E. Brigham of Newark, N. J., chief of the Association's engineering division, has completed organization of the division. He has appointed the following: general standards committee, Virgil M. Graham. Rochester, N. Y., chairman; vacuum tube committee, R. M. Wise, Emporium, Pa., chairman; interference committee, Tobe Deutschmann, Canton, Mass., chairman; television committee, D. E. Replogle, Newark, N. J., chairman; cabinet committee, E. V. Hughes, Peru, Ind., chairman; service section, E. M. Hartley, Camden, N. J., chairman; safety section, L. C. Curtis, Springfield, Mass., chairman; acoustic devices committee, Peter L. Jensen, Chicago, chairman; committee on receivers and power supply, Lincoln Walsh, Buffalo, chairman.

In addition, Director Brigham plans to organize a committee on component parts for standardization work.

Chairman Wise of the vacuum tube committee held a meeting in New York on October 28th to develop further standards for new tubes.



Dominant among Volume and Tone Controls

LEADERSHIP in any industry usually is founded upon several factors, not the least of which are that the product itself must be of superior quality and of unquestioned value.

Our Volume and Tone Controls have won their position of dominance in the radio industry through sheer merit plus an easily recognized value.

Striking examples of this are to be found in our recently announced "70" Series Composition Element Volume and Tone Controls, and in our No. 20 Series Wire-Wound Units, both of which are outstanding achievements in their respective fields.

Our new "70" Series Controls offer surprising value and high quality in a low-priced unit of the composition element type. Similarly, our No. 20 Series, with its specially designed contact member, provided the first really practical solution of the problem of noise in wire-wound Volume and Tone Controls.

We shall be glad to send full details of the seasoned principles involved in the construction of these controls, and invite inquiries from interested engineers. If you will send us exact specifications, we will, without obligation, submit samples free of charge.

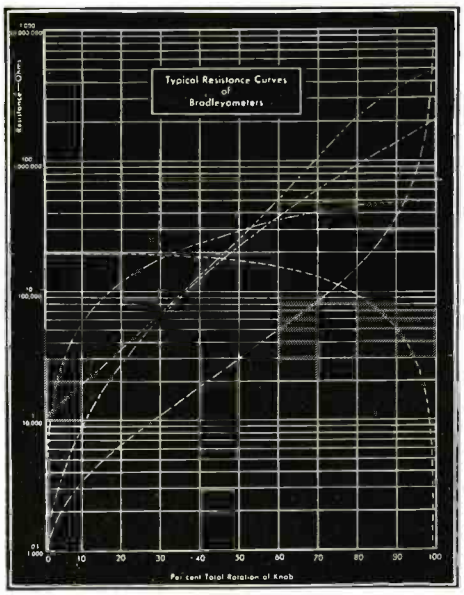
CHICAGO TELEPHONE SUPPLY CO.

HERBERT H. FROST, Inc.

SALES DIVISION

General Offices ELKHART, INDIANA *and Plant*

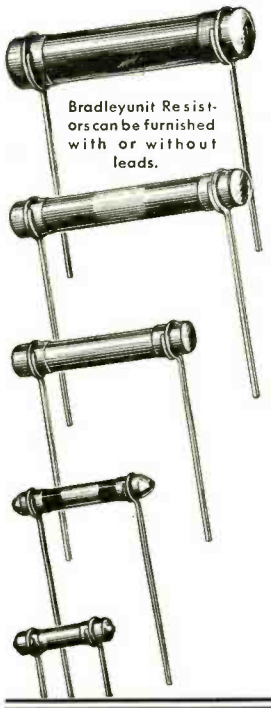
In the Bradleyometer approximately 50 solid resistance disks are interleaved between metal disks, forming a resistance column that will produce any form of resistance-rotation curve, as shown to the right.



The Bradleyometer is a "stepped" potentiometer for volume level control and tone control. Can be furnished with one to six units operated by one knob. Ideal for sound recording, telephone lines, etc.

Every Radio Engineer

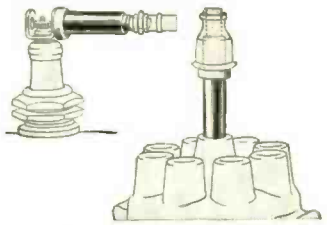
should have the latest data on these remarkable resistors



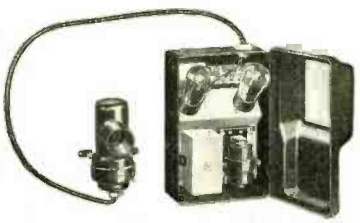
Bradleyunit Resistors can be furnished with or without leads.

Bradleyunit Resistors are made in five sizes, with or without leads. All Bradleyunits are color-coded to meet set manufacturers' specifications. These solid molded resistors are accurately calibrated and have great mechanical strength. They are used by the world's largest radio manufacturers for providing correct C-bias, plate voltage, screen grid voltage, and for use as grid leaks. Get an Allen-Bradley quotation on your next order.

Bradley Suppressors are special solid molded resistors which minimize the disturbing oscillations in the ignition circuit of cars equipped with radio resistors. They resist the destructive effects of heat, moisture, and age. They are the last word for motor car radio. Send for complete data.



Bradley Suppressors installed on spark plugs and distributor of radio-equipped car.



Allen-Bradley Bulletin 880 Photo-electric Relay used with Allen-Bradley Bulletin 875 Light Source. Can be furnished in water-tight enclosures for outdoor service. Send for Bulletins 875 and 880 today.

Allen-Bradley Co.

126 W. Greenfield Ave. Milwaukee, Wisconsin

ALLEN-BRADLEY RESISTORS

Produced by the makers of Allen-Bradley Control Apparatus

RADIO ENGINEERING

Production, Administration, Engineering, Servicing

DECEMBER, 1931

Choosing a screen-grid tube

By RINALDO DE COLA

An experimental inquiry with reference to characteristics of the 235, 551 and 224 type radio tubes.

SINCE the first inception of the high vacuum thermionic device, the most important single factor for judging the merits of such devices has been transconductance. This was and still is an excellent merit factor, since it represents a relationship between the more important tube constants, i.e., amplification factor and alternating plate circuit resistance. However, the application of such a figure of merit for tubes does not apply equally well in all cases. For illustration, in radio receivers, it was found that substitution of screen-grid tubes with a high value of transconductance did not yield a higher value of amplification as expected, when compared with tubes with a smaller value of transconductance. In some cases a considerable decrease in gain (voltage amplification) was realized with the higher Sm tube. The effect mentioned above has led to some doubt as to the importance of Sm as a factor of merit for tubes when used as voltage amplifiers.

To make more clear what is to follow it will be stated here, that for voltage amplifiers, the term, $\mu\ (R'/R'+R_p)$, is more significant as a figure of merit than the transconductance factor. In this term, μ, represents the voltage amplification factor of the tube, R', the d-c. internal plate circuit resistance and R_p, the a-c. resistance. Also, the d-c. resistance of a tube has a very material effect upon the circuit into which it is connected. In fact, this value of resistance can be considered as connected directly across the plate circuit load. Consequently, tubes with low values of d-c. resistance may very materially affect such circuits, especially those of high impedance, due to the high damping introduced.

In the early stages of the introduction of the variable-mu or exponential tube, and the various debates hinged upon the original 235 versus the 551, the affects mentioned above were particularly noticeable, due to the considerable decrease in d-c. resistance of these tubes, and also to the reduction of the factor, $\mu\ (R'/R'+R_p)$.

However, this reduction was greater in the 235 than the 551, and less in the case of the 224 than in either of the two other tubes. This was to some extent responsible for many manufacturers, who were not primarily interested in other virtues possessed by the variable-mu tube, in retaining the 224. This consideration was undoubtedly of some weight in the final choice of characteristics for the present 235.

Table I shows the average readings of various characteristics of several makes of 224 tubes. The readings represent an average of 12 tubes of each make. In the subsequent considerations the average readings shown in this table will be used rather than the individual reading of the particular tube used. In all cases, however, the particular tubes used conformed quite closely to the average characteristics indicated.

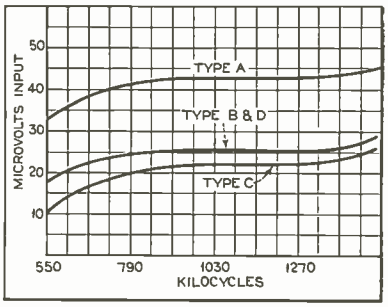


Fig. 1. Sensitivity of superheterodyne receiver.

Fig. 1, shows a sensitivity curve of a superheterodyne receiver. Different curves represent the sensitivity for the particular make of tube used, and are so indicated. This particular receiver employed the following tubes: 224—first r-f. 227—osc., 227—first detector, 224—first i-f., 224—second i-f. and a 227 second detector. This detector fed directly into a single pentode. Both plate and grid circuits of the i-f. amplifiers were tuned. The input signal was modulated at the customary 400 cycles and

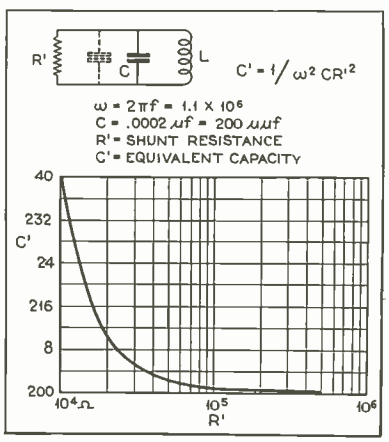


Fig. 2 A.

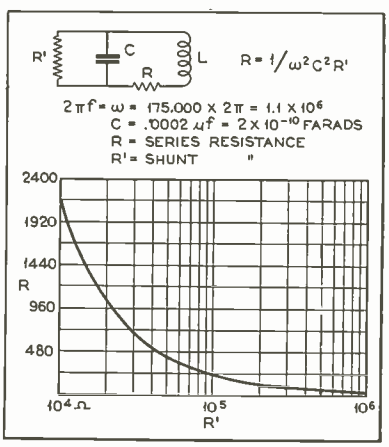


Fig. 2 B.

Influence of shunt resistance.

the output taken at fifty milliwatts. In each case only the 224 type tubes were replaced.

It will be noticed that these curves do not give any conclusive indication of which set of tubes had the highest value of transconductance. In fact tube type C, with a much lower value of transconductance, gave an average value of gain greater than that of tube type D, which had the highest value of transconductance. A study of these curves shows quite clearly that a relationship of gain to transconductance is not very evident, but the term $\mu\ (R'/R'+R_p)$, gives a very good indication of which is the most desirable tube.

In most cases substitution of different tubes, required a retuning of circuits. This retuning was necessary mostly in the plate circuits.

However, a measurement of the various interelectrode capacities for individual tubes showed very close conformity, between the various makes. Consequently, the change in capacity upon substitution of various tubes could not be accounted for by the small differences in interelectrode capacities. In fact, the variations in capacity of different tubes did not bear any relationship whatever to the change apparent when inserted in the set. In most cases the substitution of a tube having a slightly greater capacity necessitated an increase in capacity rather than the predicted decrease. However, the change in capacity mentioned can be accounted for by reference to Fig. 2-A. This shows the influence of the shunt resistance R′, on the effective capacity in the tuned circuit. For resistances in the vicinity of 45,000 ohms, which is average for the 224 type tube, a certain per cent change in resistance is not as effective in changing C′, as is an equal percentage change, say to 30,000 ohms, which is the d-c. resistance of the average 235.

Fig. 2-B shows the influence of different values of shunt resistance R′, upon the equivalent series resistance introduced into the tuned circuit LC. This value of series resistance was calculated from the relation,

$$R = 1/\omega^2 C^2 R'$$

where ω is $2\pi f$, and R, R′, C have the same meaning as indicated in this figure. It will be noticed that even resistances as high as 500,000 ohms have an appreciable equivalent series resistance, which in this case is 40 ohms. A 20,000 ohm resistance introduces over 2,000 ohms series resistance into the circuit. The values of resistance shown in this figure do not include the resistance which exists within the condenser and inductance. In this figure both of these factors are considered perfect electrically.

To show more clearly the effect of the resistance R and its effect upon the gain, the curve shown as Fig. 3 is illustrated. This gain was calculated from the relation, $K = \omega L/R$. The symbols have the meanings and values indicated on the figure. This relation expresses a voltage gain obtainable in such a circuit, and is most accurate for small values of R. Since this gain is just as intrinsic as gain obtainable through vacuum devices its importance cannot be overlooked. In fact a well designed circuit of this nature may be more effective in increasing the gain of an r-f. system than the addition of another stage of amplification.

The Theory

Let us consider a single stage of r-f. amplification and from it attempt to obtain some simple but effective methods of predicting its gain. Such a circuit is shown in Fig. 4-A. For r-f. voltages the by-pass condensers illustrated can be considered as effective in connecting each point at which they are connected directly to ground. Since the space current due to R′, exists between the cathode and plate, the cathode end of R′ is at zero r-f. potential.

We can picture the circuit by an equivalent form shown as Fig. 4-B. This shows the d-c. resistance R′ as

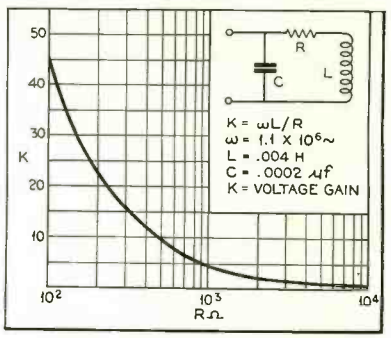


Fig. 3. Effect of resistance on gain.

connected directly across the tuned LC circuit. The LC circuit is assumed to be ideal, i.e., resistanceless. A study of Fig. 4-B will show that it can be represented in its equivalent, simpler form, as shown in Fig. 4-C. And the voltage across R′ expressed by

$$E_{R'} = \mu \left(\frac{R'}{R' + R_p}\right) E_g \qquad (1)$$

This relation is obvious. If we consider E_g as a unit voltage we obtain,

$$E_{R'} = \mu \left(\frac{R'}{R' + R_p}\right) \qquad (2)$$

As previously illustrated R′ can be reduced to its series equivalent, in circuit LC, from which we can obtain an expression for optimum voltage gain. This can be written as,

$$\frac{E_L}{E_g} = \mu \left(\frac{R'}{R' + R_p}\right) \omega\ L/R \qquad (3)$$

Where E_L is the voltage developed across the inductance L. It will be noticed that the transconductance factor of the device plays no direct part in the determination of voltage gain obtainable, which is quite in keeping with the experimental results mentioned previously.

For conditions of plate load other than the ideal circuit considered above, it must be remembered that due to the reduction in impedance or reactance, depending on which type of load is used, the circuit will have a shunt effect upon the resistance R′ reducing the voltage drop across it. Thus it can be seen that for small plate loads such as used in many radio-frequency systems, this value of voltage developed across the output circuit will be smaller, becoming zero for short circuit conditions.

To obtain some idea of what voltage may be expected across the load, in such cases, we can picture Fig. 4-A, with a small load, instead of the ideal circuit shown. This is shown in equivalent

(*Concluded on page 32*)

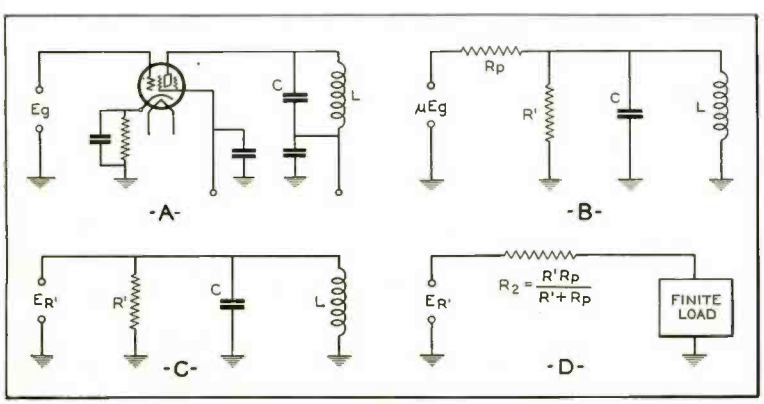


Fig. 4. Analysis of gain in a single stage of r-f

Photo-electric relays

By Lynn H. Matthias*

PHOTOELECTRIC relays consist essentially of a light sensitive cell and means of amplifying the minute variations in current through the photocell to sufficient magnitude to operate a relay or other electrical device. A variation in the intensity of light falling on the photocell causes variation in the photocell current. This current greatly amplified, operates a relay or other electrical device.

The photoelectric relay may be used as a pilot control for any operation which may be initiated by the interruption of a beam of light. Since the interruption of a beam of light does not require appreciable mechanical forces. the photoelectric relay may be used for a great number of applications where mechanical devices are not suitable. It thus opens up an entirely new field of automatic control.

Photoelectric relays may be used as counting relays. limit switches, alignment controls. sorting devices, automatic smoke detectors. for signs, airplane beacons and warning lights, offices, etc., illumination controls, position indicators, safety devices, automatic inspection devices. etc. Perhaps the widest field of application is in automatic equipment, although the use of the devices in other fields is widespread.

Operation

A beam of light is allowed to fall on the photoelectric cell. Any interruption of this beam of light varies the current through the photoelectric cell. The current through the photoelectric cell controls the operation of the two discharge tubes which act as a discontinuous amplifier, i. e., for certain impressed potentials, they conduct current. They either conduct maximum current or are entirely off, there are no intermediate points at which the current through the discharge tubes is slowly increasing.

The schematic diagram of this device is shown in Fig. 1, the tubes D, are 2-element gaseous discharge tubes. The current voltage characteristics of this type of tube are shown in Fig. 2. It is seen that the potential across the tube must be increased to A before an appreciable current flows through the tube. Once the discharge is started. the potential across the tube must be reduced to B before it stops conducting current. This characteristic of the discharge tube, i. e.. the fact that it requires a much higher potential to get the tube in a conducting state, than it does to render the tube non-conducting, is made use of in the photoelectric relay.

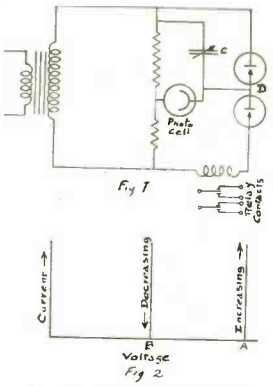
In operation, the photocell alters the potential distribution across two discharge tubes in series. When the potential across one tube becomes greater than A (Fig. 2), that tube becomes a comparatively good conductor and the voltage drop across it, falls to B. This increases the potential difference across the remaining discharge tube, since the transformer voltage is practically constant, and, hence it also breaks down. Since the two tubes are in series across the supply and both in a conducting state, a comparatively large current flows through the relay transformer, etc.

The condenser C is adjustable and varies the potential applied across the tubes at the nominal illumination, i. e., it is varied to adjust the operating point for different light intensities.

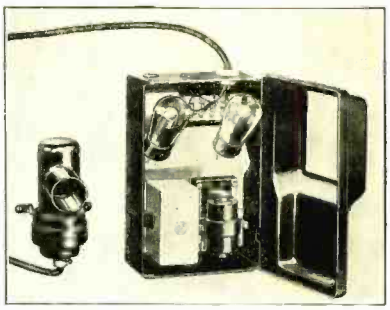
The photoelectric relays may be operated in any position. Provision must be made for access to the light intensity adjustment and also for removal or opening of the cover.

Relay

The relay is a sensitive type, requiring only 0.15 watts to close with d-c.. and is operated directly from the small currents through the discharge tubes. Since the current through the tubes is pulsating d-c., some means must be provided to keep the relay from chattering. This is accomplished by shunting the relay coil with a condenser and by the use of a small shading coil on the relay armature. The contacts of the relay are coin silver, providing low contact resistance and ample carrying capacity in a small contact. The contacts are carried on long flat phosphor bronze springs. These springs are worked under very small stress and should give exceptionally long life.



Photocell and relay circuit.



Photoelectric relay with photocell attached to 2-foot flexible connecting cord as used for indoor service. Cabinet door opened showing amplifier tubes, relay, and related equipment.

The relay may be supplied with normally open, normally closed, or both types of contacts.

The contacts will carry and break 10 amperes, 110 volts, a-c., non-inductive load.

Power Supply

The photoelectric relay equipment described above will operate only on alternating current of commercial frequency. It may be supplied for various line voltages and frequencies.

The speed of operation is normally limited by the mechanical devices in the circuit, such as relays, counters, etc. This may not be true in cases where the photocell is mounted externally, then the electrostatic capacitance of the cable is comparable to the controlling impedances at low light intensities. This has the effect of giving the control circuit an appreciable time constant. The time lag in the tubes, and the remaining portion of the electrical circuit, is only of the order of a few microseconds. The present photo relays will close the relay contacts in 1/10 second.

The minimum differential in light intensity necessary to give positive operation is approximately 10 foot candles. In special cases, this may be made considerably smaller.

The adjustable condenser provides for wide range in operating light intensity over which the differential is substantially constant.

Installation

The two discharge tubes and the photoelectric cell are inserted in their proper sockets, and the supply voltage is connected to the terminals provided. The tap on the primary of the transformer should be changed to the one which is nearest to the actual normal value of line voltage. The light source is then set up and light allowed to fall on the photoelectric cell.

The small condenser adjustment at the top left-hand corner of the cabinet is then adjusted with a screw-driver until the relay turns on and off when the light beam is interrupted.

*Allen-Bradley Company.

The design and development of the high-power oscillator or amplifier tube UV-862

By R. W. Larsen*

Herewith is an authoritative and understandable technical account of the development of the UV-862 transmitter electron tube, designed for Class B and Class C amplifier service.

History

During the world war a few types of small air-cooled transmitting tubes were in regular production. The development of larger types was given additional impetus by the increasing demand for reliable means of communication in warfare. There was a constant demand for higher antenna output. This demand could be met by parallel operation of available tube types or by the development of larger and more powerful tubes. Both of these means were subsequently used but in this country, at least, it soon became apparent that in high-power transmitters the use of comparatively large tubes had certain advantages over the parallel operation of several smaller tubes. In general, these advantages were:

1. Lower tube cost per hour per kw. of antenna output.
2. Fewer items of auxiliary equipment required.
3. Better continuity of service.
4. Less space required.
5. Simplified transmitter design.

While the conventional type of anode used in air-cooled tubes can safely dissipate approximately 30 watts per square inch, a water-cooled anode can dissipate approximately 400-500 watts per square inch. It is obvious from these figures that an air-cooled tube designed to have a useful output of 10-20 kilowatts would be unreasonably large and expensive as compared to a water-cooled tube. Therefore, development work was started which resulted in the construction and operation of transmitting tubes in which the plate (or anode) was cooled directly by a flow of water. Details of design and methods of manufacture have been continuously improved to bring these tubes to their present status of useful life and reliability.

Further development of new types of water-cooled tubes was conducted along two lines; higher frequencies and higher power. This article deals with the trend to higher power. Fig. 1 illustrates some of the steps in the evolution of the water-cooled transmitting tube.

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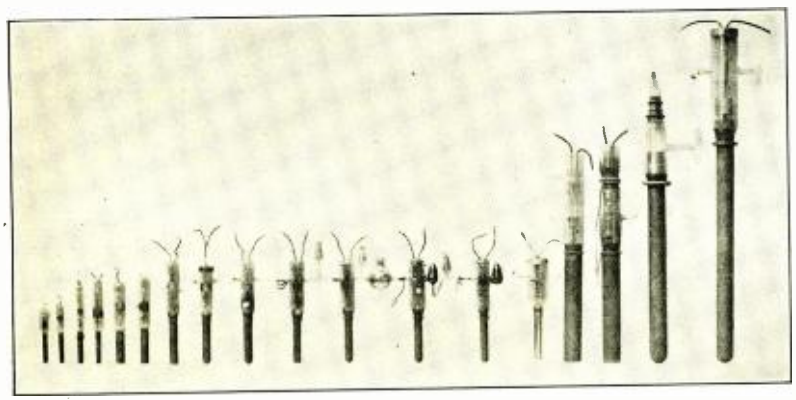

Fig. 1. Evolution of the water-cooled tube.

Technical Data on Radiotron UV-862

The largest of the Radiotron family, the UV-862, is a direct step from the older UV-207. Table I gives a tabulation of the summarized technical data of these two types.

TABLE I

General Information	UV-862	UV-207
Filament Voltage	33.0	22.0 volts
Current	207.0	52.0 amps.
Type—Tungsten		
Avg. characteristic values		
Amplification factor	48	20
Plate resistance	2800	3500 ohms
Grid-plate transconductance	17150	5700 mmhs.
Approx. direct interelectrode capacities		
Plate to grid	80	27 μμf
Grid to filament	52	18 μμf
Plate to filament	2	2 μμf
Max. overall dimensions		
Length	60⅜	20¼ inches
Diameter	6⅛	4 5-32 inches
R-F. Power Amplifier—Class B		
Max. operating d-c. plate voltage	20000	15000 volts
Max. unmodulated d-c. plate current	5.00	1.0 amps.
Max. plate dissipation	100000	10000 watts
Max. r-f grid current	60	30 amps.
Typical operation		
Plate supply voltage	18	12 kv.
Unmodulated d-c. plate current	4.20	0.90 amps.
Peak output	100000	14000 watts
Carrier output—Mod. factor 1.0	25000	3500 watts
Oscillator & R-F. Power Amplifier—Class C		
Max. unmodulated d-c plate voltage	20000	15000 volts
Max. d-c. plate current	*10.00	2.00 amps.
Max. d-c. grid current	1.00	0.2 amps.
Max. plate dissipation	100000	10000 watts
Max. r-f. grid current	60	30 amps.
Typical operation		
Plate supply voltage	18	12 kv.
Output	100000	15000 watts

If plate modulation is used, divide this figure by (1 + modulation factor) to get the maximum d-c, plate current.

The following are the Institute of Radio Engineers definitions of class B and class C amplifiers:

Class B Amplifier

A class B amplifier is an amplifier which operates in such a manner that the power output is proportional to the square of the grid excitation voltage.

This is accomplished by operating with a negative grid bias such that the plate current is reduced to a relatively low value with no grid excitation volt-

Fig. 2. Assembly of tube elements.

age, and by applying excitation such that pulses of plate current are produced on the positive half cycle of the grid voltage variations. The grid may usually go positive on excitation peaks, the harmonics being removed from the output by suitable means.

The characteristics of a class B amplifier are medium efficiency and output with a relatively low ratio of power amplification.

Class C Amplifier

A class C amplifier is an amplifier which operates in such a manner that the output varies as the square of the plate voltage within limits.

This is accomplished by operating with a negative grid bias more than sufficient to reduce the plate current to zero with no excitation. An alternating grid excitation voltage is applied such that large amplitudes of plate currents are passed during a fraction of the positive half cycle of the grid excitation voltage variation. The grid voltage usually swings sufficiently positive to allow saturation plate current to flow through the tube. Thus the plate output waves are not free from harmonics, and suitable means are usually provided to remove harmonics from the output.

The characteristics of the class C amplifier are high plate circuit efficiency and output with a relatively low ratio of power amplification.

In rating transmitting Radiotrons, certain values are given as *maximum;* that is, the values beyond which it is unsafe to go from the viewpoint of life and performance. For example, the maximum operating plate voltage can be obtained from Table I and the amount of plate voltage fluctuation due to line voltage variation, load variation, and manufacturing variation in the apparatus must be determined or estimated. An average value of plate voltage must then be decided upon so that under the usual operating variation the maximum rated plate voltage will never be exceeded.

Typical operating conditions for each recommended class of service, A, B, and C amplifiers, are also given in Table I. These values must not be considered as ratings, since the tube can be used under any suitable conditions within the maximum ratings to secure the required output. The output values are approximate tube outputs; that is, tube input minus plate loss. Circuit losses must be subtracted from tube output in calculating useful output. These output figures are therefore approximate tube outputs under certain typical operating conditions and must not be used as output ratings.

Design Features

In designing a new type of tube all the factors involved must be so coordinated that the final design is balanced in so far as possible both from the economic and the technical points of view. The major technical requirements are efficiency, emission, dissipation, and excitation. In the final design, optimum efficiency with reasonable excitation should occur at, or just below, the points of maximum safe dissipation and maximum available emission, assuming the most exacting of typical classes of service. If more than this emission is provided the operating cost in the customer's transmitter will be unnecessarily high. If more than the required plate dissipation is provided the first cost will be increased unnecessarily. The design and the procedure in manufacture must be so unified that no material is used and no labor is required which does not pay its way. Unnecessary material is particularly objectionable in that the time, equipment, and labor required on final exhaust are increased.

The Filament

The filament of Radiotron UV-862 is of pure tungsten and approximately 8 feet of .050 inch wire are used. This wire forms three parallel paths which may be considered as three V's.

The design of the filament involves, in addition to the mechanical problems, the following factors:

1. Total peak emission required.
2. Emission per watt.
3. Filament life.
4. End cooling and lead losses.

In the case of pure tungsten filaments it is not true that the filament with the longest possible life is the most desirable or economical. The problem must be considered primarily with regard to

Fig. 3. Assembling a type 862 tube.

minimum cost per hour per kilowatt of transmitter output.

We have assumed that we are to design for a particular class of service. The general requirements, such as approximate normal plate voltage, normal plate efficiency and required output, must be known or calculated. From these requirements we can calculate the d-c. plate current and the emission which must be supplied by the filament. The two important factors in the operating cost of a tube with pure tungsten filament are: cost of filament excitation per hour, which in cents we will call a; and tube cost per hour, which in cents per hour we will call b. These values a and b vary with filament temperature, which we will call t. By calculating and plotting curves of a = f.t and b = f.t and then plotting a + b = f.t, we can find the temperature at which the cost of operation is at a minimum. These data can be calculated from the characteristics of pure tungsten wire.

The chief consideration in the mechanical design of the filament are thermal expansion and rigidity of the wire. In the UV-862 the expansion is cared for by a large tungsten coil spring at the lower end of the filament assembly. To prevent distortion of the filament, alternate wires are tied together at equipotential points at the middle of the span by Y shaped yokes of fine tungsten wire. In addition, the tungsten filament wire must be carefully selected for its sag characteristics. Wire which is too hard will break during the shipment of the tube and wire which is not sufficiently rigid will sag during the operation of the tube. Sagging will eventually short circuit the grid and filament electrodes, rendering the tube inoperative.

The filament heating current is conducted to the filament from the outside of the tube through two heavy leads. These leads are securely bound to each filament leg through a set of fingers; are sealed to the glass by copper seals and, after passing through the metal cap or base at the top of the glass envelope, end in large switchboard-type copper lugs. The copper seals are miniature models of the large anode seal which connects the glass bulb to the anode proper. During operation of the tube the filament seals are cooled by an air blast. The filament base is provided with air tubing which is connected during operation to the blower system of the transmitter. Below the filament base, within the filament stem tubing, the air tubing is divided into two nozzles which properly direct the flow of cooling air against the two filament seals.

The Grid

The design of the grid can also be divided into two parts—electrical and mechanical. Some of the electrical considerations are: amplification factor, interelectrode capacity, grid current characteristic, space charge loss, resistance and inductance of leads, and uniformity of characteristics. Since the UV-862 was designed for class B and class C amplifier service, the amplification factor is relatively high—50. The grid-filament spacing is designed to effect the optimum compromise between low space charge loss, low interelectrode capacity, and low heat transfer by radiation from the filament. The amplification factor and space charge loss can be predicted with considerable accuracy from theoretical calculations.

The mechanical design of the grid involves: rigidity, strength, mass, simplicity of assembly, and uniformity of characteristics. The UV-862 grid is fabricated almost entirely of tungsten wire with the exception of the molybdenum clamps, bands and shields. The grid as made has six stay wires, and a spiral grid winding interlocked by means of a binding spiral. This design is especially rigid and results in mechanical uniformity. Although the grid is supported at both ends, nevertheless, the design of a structure sufficiently strong requires considerable care since the overall length of the grid is 40 inches and the diameter only 2¼ inches. Fig. 2 shows the grid assembly.

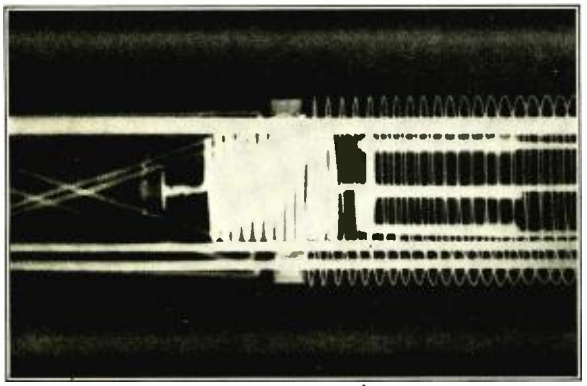

Fig. 4. X-ray examination of mechanical condition of tube electrodes.

Fig. 5. The tube complete.

The Plate

The safe plate dissipation per square inch for a copper anode in a water-jacket was known from experience with smaller tubes. We could therefore calculate the required anode area for the dissipation rating which was required. It then remained to determine the relative length and diameter of the anode. This determination involved a calculation of the characteristics and consideration of the mechanical design.

In the construction of the anode we were assisted by developments in the art of drawing of copper. These anodes are drawn by a series of dies from a flat sheet of specially selected copper. When received from the factory where the drawing is done the anode is in its final shape, 4.2 inches outside diameter and 40 inches long with a slight flare at the open end. The wall thickness is approximately .100 inch. The flared end is then turned to the proper taper for the seal and a copper flange is forced onto the outside and soldered just below the flare to provide a surface for the gasket in sealing the water-jacket.

Assembly

The assembly of a tube as large as the UV-862 is something of a problem in itself. The three electrodes are mounted rigidly with respect to each other at the top of the tube by three concentric insulating glass cylinders. The electrodes are so long that they must also be supported at the bottom end. This is accomplished by the use of a fused quartz rod about 11 inches long and half an inch in diameter, mounted in the axis of the tube. The top of the quartz rod is fastened to the lower end of the filament spring which is mentioned above. The center of the quartz rod is fastened rigidly to the bottom of the grid support stays. A molybdenum disc which fits inside the anode with only a few thousandths of an inch clearance is mounted on the

lower end of the quartz rod. The quartz rod maintains tension through the spring on the filament wires and also serves to keep the three electrodes in good alignment at the lower end of the tube. After the grid and filament have been mounted together so that the proper spring tension is applied to the filament, these electrodes are sealed into an anode on which the glass cylinder has already been sealed. Fig. 3 shows the tube being prepared for the last operation in assembly. This final assembly is done in a large vertical sealing-in machine which rotates the electrodes at a constant speed, while a dozen gas flames are applied to the flare seal at the top of the tube. The grid seal is later made by hand and the tube is ready for the exhaust treatment.

Exhaust

Most of the metal parts have been hydrogen fired and some, in addition, have been preheated by high frequency eddy currents in vacuum prior to assembly. The final exhaust therefore consists mostly of glass "bake-outs," anode heating, high temperature filament operation, and grid bombardment. Since the tube is exhausted without a water-jacket, the anode reaches a temperature just below the melting point of the copper and well above the point where the copper begins to lose mechanical strength. It is therefore necessary during the entire exhaust to maintain a rough vacuum on the outside of the anode by the use of a metal container attached to a vacuum system. Since there is a good vacuum inside of the anode, the high temperature of the anode would result in its collapse due to atmospheric pressure on the outside if these precautions were not taken. The exhaust procedure is designed to bring all of the tube parts to temperatures well above those encountered during normal operation. These temperatures are maintained, high speed vacuum pumps removing the evolved gas, until the gas pressure within the tube has remained at a very low value for about half an hour, indicating that the further evolution of gas at this temperature is so slow as to be negligible.

Testing

The next step in manufacture is the test procedure which is intended to accomplish the following:

(a) To detect tubes which are slow leakers through the metal anode or the glass seals.

(b) To test for degree of exhaust.

(c) To test for uniformity of characteristics.

(d) To test for filament emission.

(e) A full load test simulating actual operating conditions as a final check on the quality of the tube.

The preliminary tests—a, b, c, d, above —are much more sensitive than the final full-load test and, therefore, minor variations in quality can be detected and corrected in manufacture before they seriously affect production. One of these preliminary tests is a shelf test of sufficient duration to demonstrate that the vacuum in the tube will not deteriorate in storage. X-ray photographs are used wherever necessary to check the mechanical conditions of the electrodes within the tube (see Fig. 4). Fig. 5 shows the completed Radiotron UV-862.

Shipment

Due to the unit value of these large tubes and the fact that radio transmitting stations are often in rather out-of-the-way places, special attention is given to the packing of these tubes for transportation. The tube is shipped in a crate which resembles a truncated pyramid. This crate is approximately 6½ feet high and 3 feet square at the bottom. In the crate the tube is supported by a mounting designed to prevent the transmission of a shock to the tube. The crated tube ready for shipment weighs approximately 175 pounds. Fig. 6 shows the tube in the shipping crate.

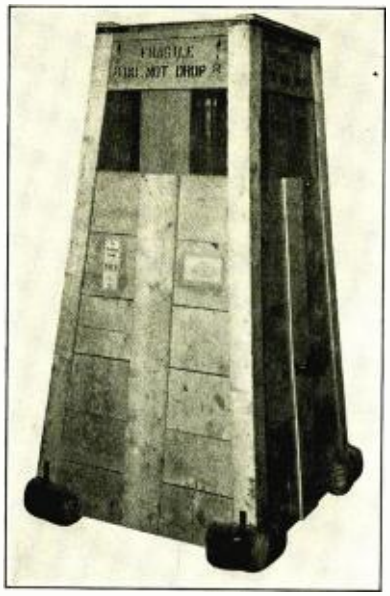

Fig. 6. Shipping container for the 862.

General

Safety factors in vacuum tube design can be approached entirely from the economic point of view. Apparatus can be built into a transmitter at reasonable cost to adequately protect the tube from excessive currents, voltage and energy dissipation. Such equipment can be designed to insure correct operating conditions at all times. It is more economical to protect a tube in the transmitter in this way than to design the tube with such large safety factors that it will not require external protective apparatus.

There is one important difference between design and development in high powered transmitting tubes and in receiving tubes. In receiving tube manufacture, the cost of each unit is small and the production of these units per month is very large. The unit cost of a UV-862 is relatively large and the production of units per month is small. While a change in design of a receiving tube to effect a saving of a fraction of a cent per unit may be justified, a similar change in design of a large transmitting tube intended to effect a saving of dollars may prove to be bad economy when one or more units are lost during the change in production. Furthermore, it is not economically feasible to run life tests on representative samples of large tubes in quantities sufficient to give data of any value. Therefore, every step in the design must be worked out with the utmost care since "cut and try" methods are very expensive. Design data are obtained, to a considerable extent, by careful examination of returned tubes from service. Such information, accumulated during the development of smaller water-cooled tubes, has proven to be of immense value in the design and development of the UV-862.

Installation

The water-cooling system for the plate of Radiotron UV-862 usually consists of a source of cooling water, a feed-pipe system connecting the source to the inlet of the cooling jacket and a discharge-pipe system connecting the outlet of the cooling jacket to the source where the water is cooled again. The use of distilled water is recommended because it prevents the formation of scale on the plate.

One system of cooling, which is commonly used consists of a relatively large water-cooling unit such as an outdoor tank, a well, or a large radiator, a pump to supply water under pressure, and lengths of rubber hose to carry water from a grounded point in the pipe system to and from the tube jackets. The hose should be of sufficient length so that the water column contained therein has a resistance high enough to reduce the leakage current to a negligible value. Water with a specific resistance not lower than 4,000 ohms per cc. should be used.

Cooling the Plate

Cooling of the plate of the tube is accomplished by using a water jacket. It supports the tube in the correct vertical position with the glass end up and is provided with a corona shield to pro-

tect the glass of the tube against puncture. To insure proper cooling of the plate, there exists an optimum clearance between the plate and the inner water jacket wall.

The flow and temperature of water in the jackets are important. The water should not be allowed to boil and the flow should be large enough to prevent steam bubbles forming on the plate surface. A flow of 12 gallons per minute is ordinarily sufficient except in cases of scale formation when an increased flow is beneficial. If the water flow fails, even for a short time, the Radiotron will be damaged. For this reason, it is advisable to interconnect the filament and plate supply with the water supply so that if the water flow is less than that recommended above, the voltages cannot be supplied. Without the cooling water, the filament heat alone is sufficient to damage the Radiotron.

Mention has been made of scale formation on the plates of Radiotrons when water other than distilled water has been used. Such formation must not be allowed to occur, since the accumulation of scale prevents the proper transfer of heat from the plate to the water. When scale occurs, it is found ordinarily that the water contains a high percentage of mineral matter, especially sulphates and carbonates. When the hardness of the cooling water is above 10 grains per gallon, and the dissipation, flow and outlet temperature are normal, there is possibility of scale formation. Another possible danger is the use of water having a specific resistance lower than the recommended value of 4,000 ohms per cm. cube. A sample of the cooling water should be analyzed before plans are made for the water system.

The air-cooling system for the UV-862 Radiotron is usually interconnected with the filament and plate supply to prevent the application of voltage without suitable air cooling. The air-cooling system consists of a blower and air-ducts of large cross-section. These ducts lead from the blower to the perforated hollow ring supplying the air to the bulb just above the anode seal and also to the nozzle supplying the air to the filament stem. The perforated hollow ring is part of the water jacket and acts as a combination air nozzle and electrostatic shield. An air flow of approximately 25 cu. feet per minute is usually required. The pressure at the inlet to the nozzle under this condition is equivalent approximately to ¾ inch of water. The filament seal nozzle is incorporated in the base design and consists of a tube extending down inside the filament stem. An air flow of approximately 5 cu. feet per minute is usually required to maintain correct stem temperature.

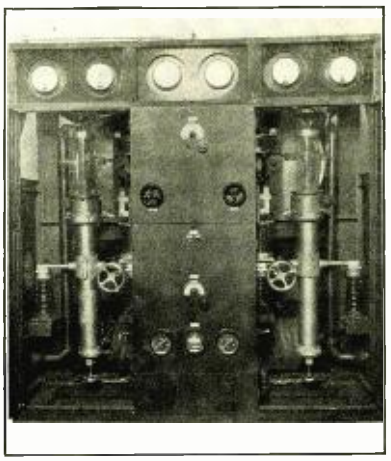

Fig. 7. Tube mounting in broadcast transmitter.

The associated electrical apparatus required for Radiotron UV-862 is similar in most respects to that required for lower power tubes except that, as with other power equipment of high capacity, more attention is given to the provision of protective equipment.

Filament Circuit

The filament circuit for the UV-862 carries a fairly large current at low voltage. Therefore, the usual precautions must be taken against loss of voltage and heating due to poor connections. Filament power may be either alternating current, furnished by a transformer, or direct current, furnished by a generator. The power supply must be arranged with suitable resistors or regulators to raise the filament voltage gradually on starting or in several steps. The reason for this lies in the very low resistance of a cold tungsten filament which results in an initial current of about ten times normal in the case of full voltage suddenly applied. This, combined with the sudden heating, would set up undesirable mechanical strains in the filament structure. The instantaneous value of filament current in starting should not exceed double the rated value. For broadcasting or similar service, the filament is best supplied by direct current to insure minimum hum of the carrier wave. The filament of the Radiotron should be operated at constant voltage rather than constant current. If the Radiotron is used at relatively low output, the plate current will be less than normal, requiring less than the normal emission of the filament. The filament may, therefore, be operated at a slightly lower temperature, giving longer life than at normal temperature. Care must be taken, however, that sufficient emission is provided; otherwise, instability of operation may be experienced or the rated plate dissipation of the tube exceeded. The filament should, of course, be allowed to reach normal operating temperature before the plate voltage is applied.

The plate circuit must be provided with a protective device to prevent the Radiotron from drawing a heavy overload. For this purpose, the coil of an instantaneous overload relay may be placed in the ground lead of the plate return. This is set for slightly higher than normal plate current and operates to open the circuit breakers in the primary winding of the rectifier transformer.

R-F. Power Amplifier—Class B

The maximum safe plate voltage is 20,000 volts when the tube is used singly at a frequency less than 1,500 kilocycles. When these tubes are used in parallel the plate voltage and output per tube must be decreased and in addition, precautions must be taken to balance the load between tubes. The normal peak power output is usually approximately 100 kilowatts at a plate voltage of 18,000 volts. This means that with conditions such that a modulation factor of 1.0 may be used, the carrier output is approximately 25 kilowatts. Under these conditions the d-c. plate current is about 4.2 amperes. The following tabulation (Table II) gives voltages and certain typical operating conditions which correspond to the various plate voltages which may be used.

TABLE II

Plate voltage	Typical peak output kw.	Approx. grid bias volts	*Typical Value of carrier output kw.	Plate current	Plate loss kw.
18,000	100	—380	25	4.2	50
15,000	70	—310	17.5	3.5	35
12,000	45	—240	11	2.8	22.5
10,000	30	—200	7.5	2.3	15.5

**The values given are for conditions such that a modulation factor of 1.0 can be used. The values themselves are those taken when no modulation is being applied, the output being pure carrier.*

R-F. Power Amplifier—Class C

The tube can be used either as an oscillator or as a radio-frequency power amplifier, the ratings being the same for each. The typical operating values given in Table III are based on good efficiency and proper circuit adjustment.

TABLE III

Plate volts	Typical Output kw.	Typical plate Current amps.	Approx. Grid-bias volts
18.000	100	8.4	4000
15,000	75	7.0	3300
12.000	45	5.6	2700
10,000	30	4.5	2200

The values of grid-bias volts given in the Table III are the total grid-bias voltages, regardless of the method of obtaining this voltage. With the rec-

(*Concluded on page* 30)

Portable speech-input equipment†

By E. G. Fracker

IN the early days of broadcasting, program directors, quite naturally, found it desirable to undertake the transmission of programs taking place outside of the studio. Athletic events, speeches by prominent people, or excerpts from plays picked up directly from the stage, all seemed desirable material. To take advantage of such programs, however, required that complete speech-input equipment be installed fairly close to the actual program. In general it was not possible merely to install the necessary microphones at the scene of the program because their output was at too low a level to be transmitted to the studio over any considerable length of circuit without suffering objectionable interference.

Speech-input equipment includes, in addition to the one or more microphones, mixers which combine in the desired proportion the output from the various microphones, and amplifiers which raise the level of combined output to a value satisfactory for transmission to the broadcasting studio. Switching and power-supply equipment is also required at the speech-input point. The equipment originally employed for this service was that designed for use at the broadcasting station and was arranged for permanent mounting on relay racks. Considerable work was required, therefore, to install and connect such rack-mounted speech-input equipment whenever a program was to be picked up at a location not permanently equipped as a pickup station.

To improve this situation, the units of the rack-mounted system with some modification were arranged in trunks, thereby providing a semi-portable equipment. Its general appearance and method of use are shown in Fig. 1. After this 6-A speech-input equipment, as it was called, had been in use for some time, sufficient data were obtained to form the basis of an entirely new design which would combine all the required features in more portable apparatus. Embodying the latest developments in the amplifier art, the resulting equipment is smaller, much lighter, and more convenient than the equipment it supersedes. Omitting accessories, the new equipment is contained in two cabinets of suit-case size, and a small battery box, as shown in Fig. 2. It is intended that the battery box, cords, transmitters, subscriber set, monitoring headset and other material required in addition to the amplifier and control cabinet for picking up programs will be carried in an ordinary suit case. One of the major units is the 710-A control cabinet which is used as a mixer, and the other, the 55-A amplifier which increases the output of the mixer to a level suitable for transmission to the broadcasting studio. The 55-A amplifier may be used alone when only two microphones and no mixing is required.

The development of these new units required consideration of many unusual factors and the solving of many electrical and mechanical problems. The new equipment not only serves its purpose as well as and even better than the equipment it replaces, but it occupies a space of only 3.7 cubic feet and weighs but 149 pounds, as compared with 12.1

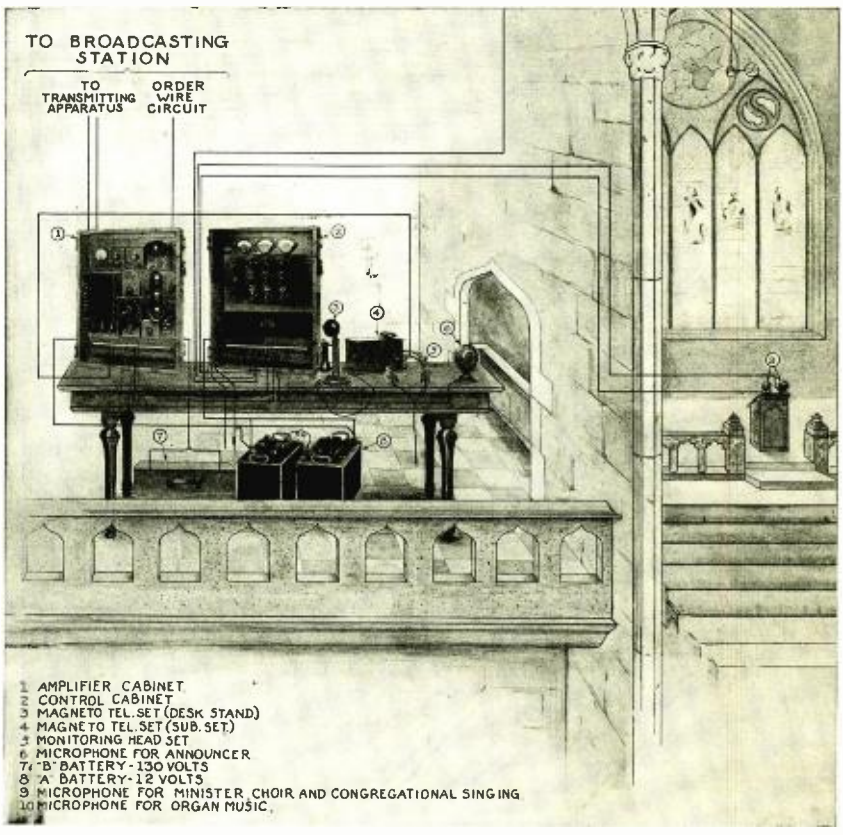

Fig. 1. The use of speech-input equipment is shown by this schematic illustration of the semi-portable 6-A equipment.

†*Bell Laboratories Record*, October, 1931.

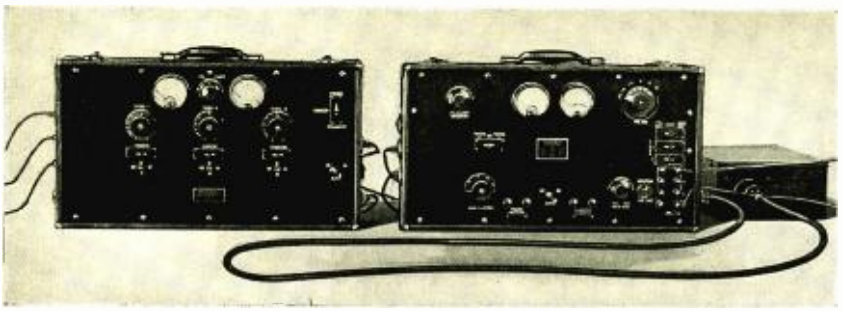

Fig. 2. The new speech-input equipment, reduced to a much smaller compass, is completely portable.

cubic feet and 558 pounds for the equipment illustrated by Fig. 1. The net result is a considerable saving in operating time, in first cost, in transportation time and expense, and a reduction in the personnel.

The control cabinet, at the left of Fig. 2, has receptacles on its left end for connection to three microphones, and on its face has three potentiometer dials for regulating the relative volume of each microphone. Directly beneath these dials are three lever-type keys used for measuring the current in either button of two-button microphones, and beneath them are three other keys for switching on or off each of the microphones. An ammeter is provided which by use of a lever-type key may be used for measuring either the microphone-button current or the filament current of the vacuum tube employed as a single-stage amplifier. A volume indicator, a battery switch, and a filament rheostat complete the equipment on the front panel.

A schematic of the control circuit is shown in Fig. 3. The amplifier is designed to make up for the loss in the mixing potentiometers only. Since the 239-A tube is employed, only small batteries are required and these are contained within the cabinet. The interconnected potentiometers serve to mix the output of the three microphones in any desired proportions, and their output, through the amplifier, furnishes the input to the main amplifier contained in the other cabinet.

This amplifier cabinet, shown on the right of Fig. 2, carries on the left end receptacles for two microphone connections—one of which would be connected to the control cabinet—and on the other end a five-point receptacle for connection to the battery box. Terminals are provided on the lower right-hand corner for three lines to broadcasting stations, and for a telephone set. In addition, two jacks are furnished: one for monitoring and the other for a telephone. An ammeter and a volume indicator are mounted on the upper part of the face, and dials for gain control, filament current, and two for control of the volume indicator are also provided. In addition there is a lever-type key for connecting either of the two microphone receptacles to the amplifier, a battery switch, push keys for measuring filament or microphone current, and three lever-type keys, on the right, for connecting any of the outgoing lines either to the output of the amplifier or to the telephone set so that any line may be used as an order wire.

A schematic of the amplifier circuit is shown in Fig. 4. A three-stage amplifier is employed, the last stage of which is connected push-pull. A transmission gain of about 67 db. is provided at 1000 cycles, and over the frequency range from 40 to 7000 cycles the variation in gain is not more than ± 1.5 db. The final push-pull stage minimizes distortion and makes possible an output level of + 8 db.

The volume-indicator circuit includes a potentiometer for adjusting the initial grid bias of the vacuum tube and a six-point dial switch for selecting the proportion of the output voltage to be applied to this tube. The points are marked to correspond to the level being transmitted when the switch is adjusted properly in conjunction with the reading of the meter. A three-point receptacle for connecting the circuit to an external volume indicator, so that the output level may be observed remote from the amplifier, is also supplied. The volume indicator on the control cabinet is commonly employed for this purpose.

Cases of both control and amplifier cabinets are made of plywood covered with fibre. Structural members have, wherever possible, been made of duralumin or aluminum to make the cabinets as light as possible. The cabinets, weighing less than 60 pounds apiece, are arranged in the form of suitcases and one man can carry both for short distances. With this development, completely portable speech-input equipment is available which may be carried by train or taxicab to the required location on short notice so that programs may be broadcast with a minimum of delay where there is no permanent speech-input equipment.

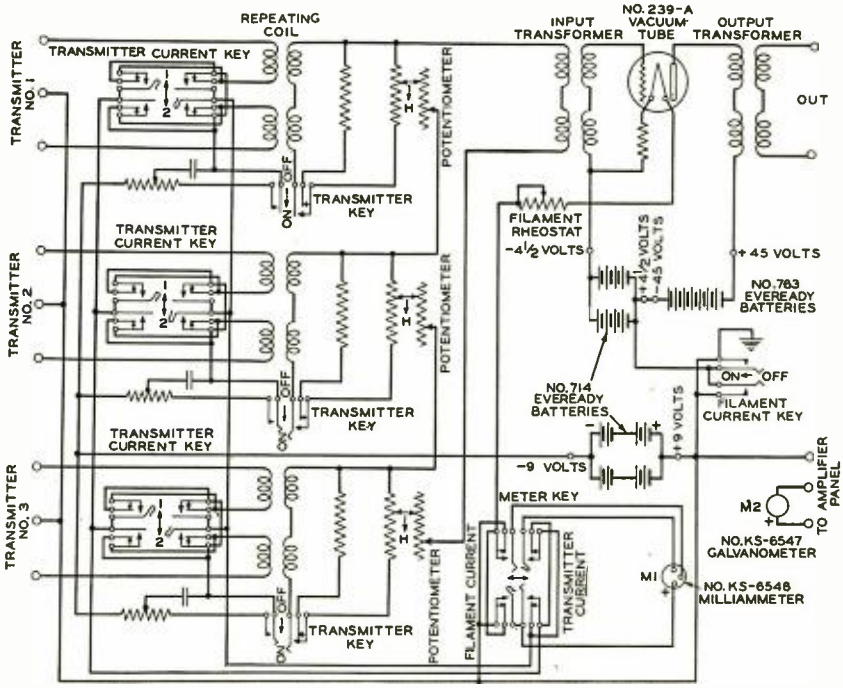

Fig. 3. Schematic for control circuit of speech-input equipment.

The amplifier circuit layout here shown is a three-stage system, the output stage being connected push-pull. At 1,000 cycles a transmission gain of 67 db. is provided for, and over the frequency range from 40 to 7,000 cycles there is not more than plus or minus 1.5 db. variation in gain. An advantage of the output push-pull stage is that distortion is minimized, although the output level is 8 db.

By means of pin-jack control this amplifier is flexible in operation, enabling attendant engineers to insure positive performance.

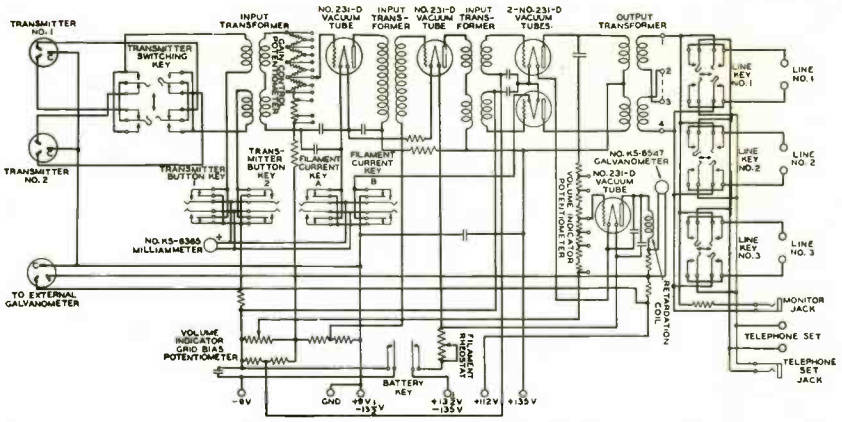

Fig. 4. Schematic diagram of amplifier circuit.

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SPECIAL CIRCUITS TO IMPROVE QUALITY OF MUSIC OVER RADIO NETWORKS

WHILE the average radio listener has probably not realized it, there has been a distinct improvement in the tonal quality of programs being transmitted by stations in the big nation-wide broadcasting networks, radio engineers and tone experts declare.

The reason for this improvement, they explain, has been the recent installation of a new type of cable for the telephone lines linking the various stations on the main hookups connecting most of the cities between New York and Chicago. Further extensions of the new type facilities to other points are contemplated in accordance with the requirements for them.

Heretofore practically all of the program transmission service to cities in the networks has been furnished over open wire telephone circuits. But for some time increasing use has been made of long-distance cables to provide the necessary growth and to supplement the open wire facilities.

Anticipating future improvements in such broadcasting equipment as radio transmitters, receivers and microphones, it was thought that the ordinary telephone cable would not be sufficient. Consequently, to meet the more exacting requirements the new type of cable with special broadcasting circuits was developed by the Bell System engineers.

This new cable enables the radio circuit to carry a wider frequency or tone range than has hitherto been possible over the ordinary telephone circuit. It permits a frequency range from 30 to 8,000 cycles instead of the ordinary telephone wire range from 150 to 5,000. Thus many of the lower and higher notes which previously could not be reproduced with any high degree of perfection are now brought to the radio listener almost perfectly, provided, of course, that his receiving set is in good working order. Today the piano's low C, at 32 cycles, should be heard as well as squeaks and chirps above 5,000 cycles, hitherto outside the range of radio.

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I. R. E. 1932 CANDIDATES

THE Institute of Radio Engineers, with headquarters in New York City, announces as candidates for the office of president for 1932, the names of W. G. Cady, and L. E. Whittemore.

Dr. Cady is professor of physics at Wesleyan University, Middletown, Conn. He is perhaps best known to those in the radio field for his work on the use of quartz crystals in the control and measurement of frequency.

Mr. Whittemore is special radio representative of the American Telephone and Telegraph Company and has taken a leading part in the legislative and regulatory branch of radio, having represented the Bell system at practically all of the important radio conferences held both here and abroad.

The nominees for the vice-presidency for 1932 are Professor E. V. Appleton of Kings College, London, England, and Dr. Balth van der Pol of the Phillips Lamp Works in Eindhoven, Holland.

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TECHNICAL DATA OF GREAT VALUE

BEGINNING in the January, 1932, issue of RADIO ENGINEERING, *and continuing serially for one year, or longer, will appear a chronological history of the important events in electric communication — telegraphy, telephony and radio. This historical engineering data has been twelve years in the making and will record accurately inventions, discoveries, development, statistics, with dates and names, from the beginning down to modern times.*

There will be a large demand for the issues of RADIO ENGINEERING *for the year* 1932. *You will do your non-subscriber friends a favor by telling them to begin their subscriptions with the January issue.*

BOOK REVIEW

"ELECTRICITY, WHAT IT IS AND HOW IT ACTS." VOL. 2, by Andrew W. Kramer, 287 pp. Technical Publishing Co., Chicago, 1931.

Here is a first rate book on the physics of radio and other forms of high-frequency radiation, including X-rays, light, photoelectric phenomena, etc. Some works on elementary electricity and magnetism have chapters on radio and radiant energy but in most cases the matter incorporated is quite elementary and not always quite up to date. The present work is not lacking in this respect: it is a thoroughly modern exposition of the mechanism of electric wave propagation.

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"RADIO AND ELECTRONIC DICTIONARY," by Harold P. Manly. 300 *pp. Frederick J. Drake & Co., Chicago,* 1931.

Various attempts have been made to turn out a useful dictionary of radio terms, phrases, names, etc., but most of the books published are either too bulky for handy use or are so limited in the number of terms defined that their incompleteness renders them of little value. Mr. Manly's excellent book reflects prodigious research and careful selection of the thousands of terms used in everyday radio engineering, manufacture and operation. The book sells for $2.50.

Wireless synchronization

By Verne V. Gunsolley

THE ideal method of eliminating rapid fading, fluttering, and guttural distortion of signals would be for the Federal Radio Commission to operate or control a low-frequency high-power station centrally, so as to secure continental coverage, and require all stations to use its carrier, or harmonics of the modulation of such a carrier as the basis of frequency control. The crystal control of the ordinary station would be supplanted with frequency multipliers, and its frequency would then be under the control of the Commission at all times. All stations on the same channel would have identically the same frequency and phase, eliminating entirely the fading and distortion due to heterodyning. While this method leaves cross talk as a form of interference, it still is an enormous improvement over the scramble of signals that now result on every shared channel.

While the foregoing plan is ideal, it is not probable that the Federal Radio Commission will put such a plan into effect. If it should consider the matter seriously, the wheels of government grind so slowly that it would be a long time before any such plan were adopted. Meanwhile, those stations which despair of ever having such a universal timing wave put on the air may consider the adoption of the following principles and plans as an alternative. Discussion of the difficulties and objections to the method will be reserved until the last.

Assume a receiver tuned to a station that is fully modulated. In the same room have an oscillator capable of extremely fine frequency adjustment; as with a micro-drive condenser. Start the oscillator at a frequency difference of 500 cycles per second. Reception from the station will now have the usual 500 cycle heterodyne note. Now slowly adjust the frequency to agree with that of the station carrier. The note drops in pitch. As the frequency difference continues to lessen, the heterodyning gradually approaches inaudibility, but continues to interfere as evidenced by a fluttering of the signal accompanied by excessive distortion and loss of intelligibility. The next lower difference in frequency results in rapid fading with distortion only during the fading. At frequency differences of one-tenth cycle per second, the fading periods are of five seconds duration. The distortion is especially noticeable on receivers having automatic volume control since the distortion is amplified more than in the case of manual-control receivers. As synchronism is finally attained, the fading stops, but whether the distortion remains or is absent depends upon whether the two carriers are additive; in phase, or whether they are subtractive; 180° out of phase. Between these two extremes, all possible degrees of distortion may exist; depending on the phase displacement between the carriers at the moment of synchronization.

As is well known, the station signal consists of a carrier and two sidebands. Since the oscillator neutralizes a portion or all of the station carrier, but not the side-frequencies, the carrier is reduced in effectiveness but the side-frequencies remain unaltered. The result is that during fading periods the small net carrier is over-modulated, causing the usual over-modulation distortion. If at the instant synchronization is accomplished the oscillator carrier is in opposite phase relation to the station carrier, the net carrier amplitude remains insufficient relative to the sidebands, and the over-modulation and distortion remain permanent. If synchronization occurs when the carriers are in additive phase relationship, then the net carrier amplitude is more than sufficient to absorb the modulation from the sidebands, and if the station originally had any tendency toward over-modulation the signal quality will be improved; for, the net modulation factor is less than unity.

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A method of synchronization whereby the need of an interconnecting land line is partially or wholly eliminated. Means are described whereby it is possible to control the frequency of a station wholly by the character of the resultant of the interfering waves of two broadcasting stations sharing the same channel.

It would appear that the conditions necessary for distortionless synchronization are: (1) A modulation factor of slightly less than unity to allow for failure to exactly synchronize the carriers in additive relationship. (2) Constant maintenance near maximum additive relationship.

From the foregoing it is plain that if two stations partially neutralize each other's carriers, the net carrier wave is over-modulated unless the sidebands are likewise lowered in amplitude by a reduction in the modulation factor.

It has been assumed that the phase angle is zero when the carriers are exactly additive and in synchronism. The detector circuit will have a plate current due to the sum of the two carriers and an ammeter placed therein would indicate a maximum; let us say 100. If now the oscillator is allowed to slowly gain or lose frequency until it is 30° out of phase, lagging or leading, and synchronism then held, the meter will indicate a value which is the vector sum of the two carriers which, let us estimate, is now only 86.

Thus we see that if the oscillator changes frequency slowly so as to shift the phase from 30° lagging to 30° leading, the ammeter will slowly vary its indication from 86 to 100 and back to 86. If synchronization is not held at this point, the indication will continue to fall through minimum when the carriers are subtractive, and come back to maximum again as the slow phase displacement due to frequency difference restores the additive condition. Thus the meter indicates the beating of the carriers due to their alternative additive and substractive polarity; otherwise known as inaudible heterodyning and evidenced on the receiver as fading.

Since either increasing or decreasing the oscillator frequency will decrease the indication of the meter from maximum the operator will need to use experimental methods of determining which way to move the oscillator condenser to maintain maximum indication. This will have to be done by "hunting"; by varying the condenser setting but slightly either way in order to determine which way to move it to restore maximum indication. This will require a constant eye on the meter and practice on the part of the operator. It is evident therefore that if automatic control is to be possible, some method must be employed for detecting whether the

loss of indication is due to a loss or gain in phase; that is, whether it is due to a slow loss or gain in frequency on the part of the oscillator or the station. If the station is crystal controlled, for purposes of discussion, we may consider it as being of constant frequency.

As a proposed remedy for this situation, suppose that instead of the exact additive relation the oscillator is synchronized 30° out of phase and lagging. The meter reading is then 86. If the oscillator gains frequency the meter will gain in indication. That is, if the oscillator gains, the meters gains, and a gain on the part of the meter will be a positive indication of a gain in frequency. The operator may immediately decrease the frequency of the oscillator to restore the meter reading to 86. This at once suggests a means of obtaining automatic stability.

If the meter movement is made rugged enough to drive a condenser vernier, and this vernier is so related to the condenser and meter movement that a gain in the indication increases the capacity, the frequency will be lowered and the indication lowered thereby restoring the normal indication corresponding to 30° lag in the oscillator carrier behind the station carrier. If the oscillator loses frequency, the lag will increase, the meter will lose indication, the vernier will reduce the capacity and restore the frequency to normal.

If the station carrier should increase in intensity the meter indication must likewise increase exactly as for an increase in frequency on the part of the oscillator, resulting in the same series of events as before, but the final phase displacement is now more than 30° behind the station carrier. Thus such a system is also an automatic volume control within reasonable limits and will have some control over atmospheric fading. If the atmospheric fading is so bad as to cause maximum additive relationship then the device becomes unstable and inoperative, merely hunting until the signal of the station returns, whereupon it takes up control of the oscillator once more.

Due to the nature of the sine function, considerable phase displacement is allowable before seriously reducing the amplitude of the resultant or net carrier. It is not necessary therefore to seriously reduce the modulation to accommodate the slight reduction in the net carrier when a station using normally full modulation replaces the oscillator we have been using as a demonstration. If either station normally uses less than full modulation anyway, there is no need to consider this phase of the problem critically. The meter can then be worked at considerably less than maximum indication,

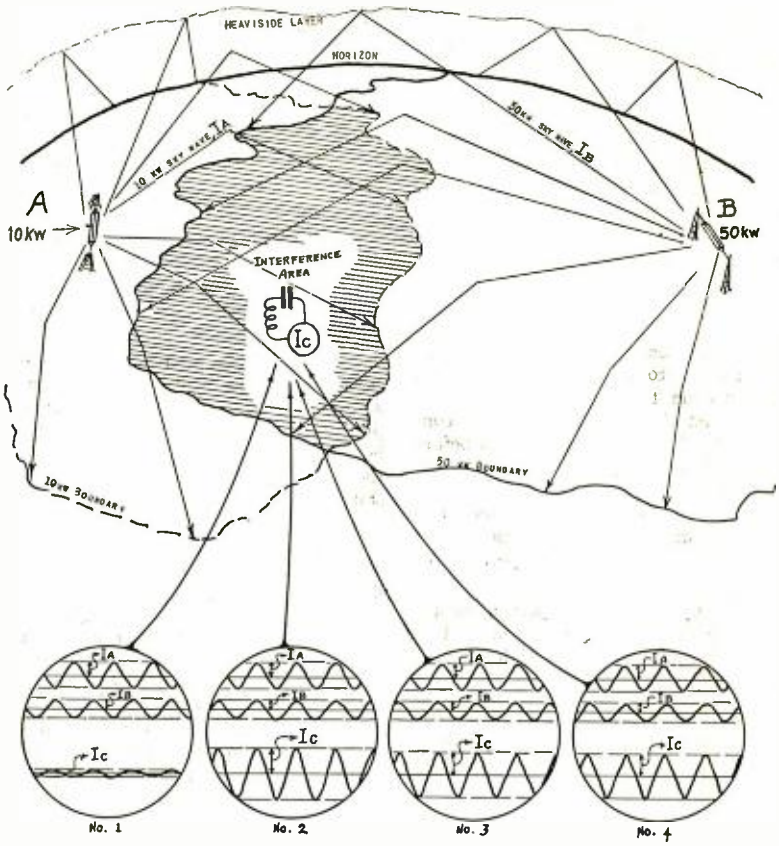

Fig. 1. Representation of two stations sharing the same channel. In this diagram of a hypothetical broadcast area is shown the interference region due to the overlapping of two station carriers sharing the same frequency. In the graphs 1 to 4 the side frequencies are omitted, leaving only the unmodulated carrier. It is assumed that the stations are in exact isochronism and that only the phase angle between carriers is adjustable from graph to graph.

No. 1. Station carrier I_b is isochronous with and lagging station carrier I_a by 180°. The carrier waves are in direct opposition and subtractive. The meter in the receiving circuit indicates the resultant of the two carriers which is I_c. This net carrier amplitude is seen to be much smaller than either I_a or I_b. It is greatly over-modulated therefore by the side frequencies, which, not being in isochronism, are undiminished in amplitude. The result is great distortion.

No. 2. Station carrier I_b is now at zero phase angle with station carrier I_a. The carrier waves are in synchronism and the net carrier amplitude I_c is equal to the sum of the carrier amplitudes I_a and I_b. Since there is sufficient carrier amplitude to accommodate both sets of side frequencies, there is no over-modulation and no distortion.

No. 3. Station carrier I_b is now made to lag carrier I_a by 30°. The net carrier I_c is now only slightly less than in No. 2; about 86 per cent. of the sum of the carriers. If both stations are modulated 100 per cent., slight over-modulation and distortion will result. If one or both of the stations are using less than full modulation, no distortion will result, since the net carrier amplitude is still large enough to absorb the combined amplitudes of both sets of side frequencies.

No. 4. Station carrier I_b is now made to lead the other by a phase angle of 30°. It is at once evident that the net carrier amplitude I_c is the same as in No. 3, which means that all the other conditions regarding distortion are the same.

By shifting the phase angle between the carriers, the net carrier amplitude may be made any value between the minimum in No. 1 and the maximum in No. 2. Since No. 1 corresponds to maximum fadeout and distortion, it is desirable to keep to the conditions in No. 2 as nearly as possible.

making for much easier and less critical control.

As is well known, the frequency of a crystal circuit may be shifted considerably by adjusting the plate circuit condenser in the first tuned stage. Therefore if we put a microdrive on this condenser, and actuate it with the rugged meter movement, it will be possible to hold the frequency of the station to synchronism with the interfering station, provided the interfering station is also crystal controlled and its crystal ground to and adjusted for the same frequency to within a very few cycles.

When we come to the problem of obtaining a sample of the signal in the interference area, we find that we must consider first some means of transmitting a sample to the station to be controlled. This is possible by means of: (1) Land lines; (2) Carrier current over power lines; and (3) Short-wave transmission. The choice of transmission methods depends upon all the factors entering into each individual problem. For the sake of illustration the simplest method will be chosen, which

is that of land line transmission. None of these methods require interconnection with the other station.

As shown by the illustration accompanying this article, a receiver is set up as near as possible to the station to be controlled and yet as far out in the interference area as it is desired to protect the program. The receiver is so located that imaginary lines joining it with the stations are at a sufficient angle to permit its directive loop to select either station at will or to obtain the desired ratio of reception from the two stations. The output of the detector is fed to the land line shown and transmission to the local station completed. At the station the line is connected to the indicator which as before explained takes up control of the frequency.

Reference to the illustrations and their accompanying explanations will give a clearer idea of the operation of the system.

In the opinion of an expert, there are four chief objections to this method of synchronization. They will be treated in order.

(1). "There is no likelihood of the Federal Radio Commission operating a radio monitor station. The Bureau of Standards operates the station at Grand Island, Nebraska, and now transmits signals of standard frequency on 5,000 and 10,000 kc. These might be useful in monitoring broadcast stations."

It really makes no difference what branch of the government service operates a station broadcasting a universal timing wave. It would still be under the supervision of the Federal Radio Commission. Such transmissions as are now issuing from Grand Island are useless because they do not give national coverage, nor are they of a frequency that is useful to all stations. Such a system as proposed would need a very low frequency of very high power in order to secure continental coverage for the United States and at the same time through international courtesy be available for Mexican and Canadian stations if they desired to avail themselves of greater freedom from U. S. interference for their listeners. Furthermore it must be modulated at a frequency that will permit any station in the broadcast band to find a harmonic suitable for its use. Such systems have already been worked out and are in laboratory use. How long it takes the forces of government to get into action towards the solution of the present broadcasting dilemma will depend somewhat on just how many progressive stations there are in the country with sufficient energy to stir the government into action. Until such a time as action is taken, if ever, the alternative explained in this article offers some hope of solution.

(2). "It is too much to expect that two stations maintaining carrier waves in exact time phase would remain in phase in space. Transmitting antennas sending out identical frequencies still have space relations which cause points of minimum and maximum intensity when the true waves are intercepted by a receiving system."

Herein lies the great advantage of this system over others. It does not maintain the stations in exact phase relation but maintains only the controlled station in phase with whatever signal arrives no matter how much out of phase with its sending station it may be in space. Thus we may expect that the actual phase relation between the stations themselves may shift very much if there is any great variation in the space phase relationship issuing from the distant station. It must be realized that any shift in phase at the receiver corresponds to a momentary slight shift in frequency for the duration of the phase shifting. Even though the sending station has not shifted phase, its sky wave has, and since the receiver works only on the actual wave in the interference area, the controlled station will shift frequency accordingly to keep the phase displacement 30° at all times. If the interference area is extremely large, as between Chicago and San Francisco stations, then it cannot be hoped that the shift in space phase will be homogeneous throughout the interference area. In this case the phase can be maintained only for that area surrounding the receiver which remains homogeneous. Since this area varies with reception conditions; steadiness of the KHL, there is no way of determining just what that area will be.

John V. L. Hogan, before the Radio Commission, testified that a 500-watt station on the west coast would reduce the service radius of a 5,000-watt station in Chicago from about 100 miles to 20 miles, while if the coast station is increased to 5,000 watts the radius is reduced to 15 miles.[1] The writer knows of an actual case where a 10,000-watt station on the east coast reduces the service area of a Minneapolis station also of 10,000 watts to a radius of about 10 miles. When the coastal station starts up it is frequently impossible to understand either words or music from the Minnesota station at a radius of 12 miles. The telephone switchboard of this station is blocked for two hours or more at a time with complaints from an area some 18 miles in radius containing a little over a million people. All day long the operator is taking complaints that have hung over from the night before. This interference is not from cross talk, but from the rapid fading and distortion that results from the beating of the carriers at frequencies varying from zero to 10 cycles per second. When cross talk is intelligible it is very faint, showing that the main cause of interference is due to the relatively much larger power in the carrier than in the sidebands, and that if the stations were phased, the cross talk would be a very minor objection.

Now all we ask of such a system therefore it that it extend the service range of the station until it will cover the local audience. By local audience is meant a body some 100 miles in diameter. Beyond that area it would be nice if we could give service, but it is not essential to the life of the commercial contract and may be sacrificed. It is only necessary therefore that the phase shift of the interfering station be homogeneous throughout an area about 100 miles in diameter. If it is less than this, there is still an enormous improvement in service over an extremely wide area, because there is always a large area, or a number of smaller areas in which the phase shift is similar, and thus in which the reception remains undistorted.

Now it is well not to overlook the fact that though there will be some fading in other areas, it will not be complete since the interfering station signal is not as strong as the local station. Furthermore it will not be a minimum except at one point or at points separated by the wavelength of the beat frequency. If the stations drop their modulation to about three-fourths full modulation the signal may fade enormously without causing distortion. This means that fading due to phase shifting, and which is comparatively a very slow atmospheric occurrence usually, can be overcome by the listener by using his volume control if he must hear the program at all costs, and if he happens to have a receiver with an automatic volume control, his troubles are over, and he rapidly returns to the status of a "satisfied customer."

In concluding the answer to this objection. it is well to keep in mind that whether the phase shifts or not, the waves are always in synchronism. This eliminates the havoc that is raised by the beating of powerful carriers. Since even with full modulation, only one-third of the power is in the sidebands, cross-talk is a very minor offense compared with heterodyning. Even in areas where the interfering cross-talk is louder than the program from the local station the two programs can be separated by the ear most of the time. However when the carriers start beating, all in-

[1] *"Radio Facts and Principles." Government Printing Office.*

telligibility is lost, and switchboards become useless for their ordinary purpose.

(3). "The factor of fading also must not be lost sight of. Adjustments made by means of an indicating instrument, between a fading and a non-fading signal would be precarious."

It has been pointed out previously how the device operates as an automatic volume control. If the fading extremes are too great or the percentages of modulation employed so high that considerable phase displacement over 30° is not permissible, then it will be necessary to install two loop receivers in the interference area, one of which has an automatic volume control. The auto-receiver is tuned to the interfering wave, while the other is tuned to the local station. The outputs of these two receivers are then coupled together and fed to the indicating instrument through the transmission line as usual.

It is well to note here that the land line transmits no radio frequency. It is made to transmit only the slow pulses that result from beating or through phase shifting. None of the troubles due to high-frequency transmission in other systems will be encountered, and this means that extremely long land lines may be used without appreciable distortion.

(4) "Plate circuit condenser control of frequency has its troubles. Ratio of capacity to inductance in the plate circuit of a piezo-electric oscillator affects the power output of the oscillator. With piezo master oscillator any change in the plate circuit condenser would alter the power output. This, multiplied by succeeding amplifiers might play havoc with the transmitter output."

The correction required is on the order of 10 cycles for two crystal controlled transmitters of modern design. In the experiments with the oscillator a Hartley circuit was used. A dynatron oscillator would have much greater stability and require less range of adjustment. If such an oscillator can be held to a broadcast station, then it is also possible to control a transmitter in the same way. If the crystal controlled circuit may not be used it may be switched out of operation and a dynatron master oscillator used during interference periods. It is certain that this objection is not serious, as it is the most easily solved of all the problems involved.

(5) "With reference to using short waves for transmission and monitoring, the distances involved are too great for very high frequencies—above 30,000 kc., and the other channels are already crowded."

Short waves are mentioned merely as a possibility, however small. The distances to be covered vary from five to

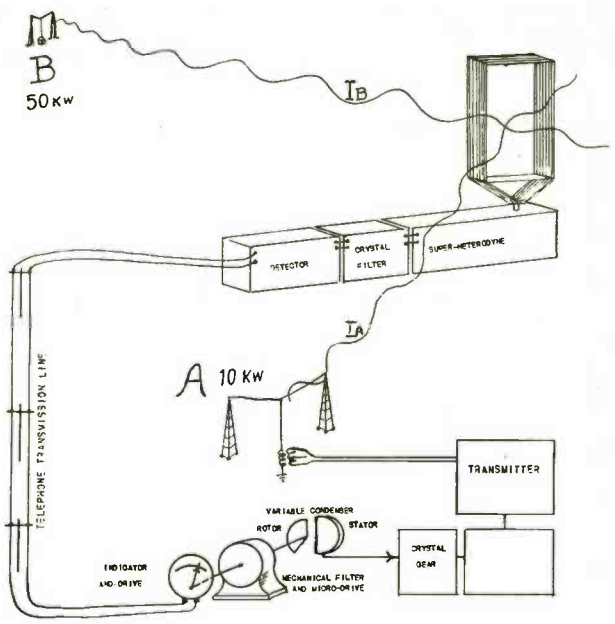

Fig. 2. Schematic diagram of operation. Let A be the station whose frequency is to be controlled. B is the interfering station. As soon as reception conditions become favorable, I_B becomes strong enough to cause rapid fading, fluttering, or audible heterodyning as the case may be. The superheterodyne, which is located in the interference area at such an angle as to permit separation of the stations to a reasonable degree, is turned on, and the loop is adjusted at an angle that will permit the desired ratio of reception from A and B. A crystal filter is placed before the second detector to eliminate the sidebands as much as possible. All the desired amplification is obtained in the radio-frequency amplifiers as the detector output which will be the envelope of I_c will be of such low frequency as to prevent effective amplification. The telephone line has to transmit only a direct current of an amplitude, depending on the frequency difference and the phase difference of I_a and I_b; frequency difference while heterodyning but only phase difference when in isochronism. This direct current which is the envelope of I_c causes the indicator to operate as an ordinary meter, which further drives a mechanical filter to further reduce sidebands and static, and which filter at the same time acts as a reduction gear to the rotor plate of the variable condenser. The stator plates are in the plate circuit of the crystal oscillator so that motion of the rotor will either increase or decrease the station A frequency slightly.

Assume that heterodyning has been stopped and that the conditions in No. 4 graph obtain. Then A is lagging behind B by 30° and the indicator points to 86 per cent. of maximum, say. Any tendency for A to gain frequency or for B to lose frequency will cause the phase displacement to lessen and I_c therefore to increase. This in turn causes the indicator to move the rotor plate closer to the stator, thereby offsetting the tendency of the frequency to increase, or, to lower the frequency to meet the drop in frequency on the part of B.

Had the frequency tended to decrease, or had B increased in frequency, then the phase displacement would have increased and I_c would have become smaller, causing the indicator to show less, thereby moving the rotor away from the stator and offsetting the tendency to lose frequency and restoring synchronism.

fifty miles depending on the extent of coverage desired. Carrier current systems on power lines have been used successfully over 200 miles. If the station happens to be connected to the same network, it is a simple matter to install carrier apparatus by arrangement with the power company. For the most part, land lines will be the more available plan. Telephone facilities may be engaged for the period of interference daily or a special line may be built, depending on the inclination of the company.

There is one objection that might arise which apparently has been overlooked. It is principally the fact that it is applicable to only two stations at a time on a channel. It is believed that the proper solution to this problem which certainly would exist on the channel of 1,200 kc., is to assign one station much larger carrier power, but limit its modulation so that its sidebands are not increased; thereby increasing its carrier power without increasing its signal strength. All other stations on this channel that are near enough to obtain steady reception from the high power carrier could use it to tie to, in the ordinary manner as described. Naturally this station would have to be subsidized by the other stations to pay it for operating on the increased power, which it does without additional advantage to itself.

As to the troubles that may arise in the operation of the system in any manner, the writer has no doubt there would be plenty. We have troubles with automobiles, radio receivers, locomotives, airplanes, electric lights and flat irons, but they do not prevent us from using the devices. With all their troubles they are still much better than nothing, and the congestion of the broadcast band is now at a point where almost any kind of a change will be an improvement.

I. R. E. November meeting at Rochester

THE Fall meeting of the Institute of Radio Engineers held at Rochester, N. Y., on November 9 and 10, was largely attended by engineers and manufacturers. Manufacturers of radio receiver parts and accessories had on display a wide variety of the latest products of the shops and factories. This year, exhibitors' engineers were given opportunity to address the meetings for the purpose of describing their products. The invitation was taken advantage of by most of the forty exhibitors.

A list of the parts manufacturers who exhibited at the show follows:

Aerovox Wireless Corporation
Allegheny Steel Company
Allen-Bradley Company
Bastian Brothers
Cable Radio Tube Corporation
Carter Radio Company
Central Radio Corporation
Central Radio Laboratories
Chicago Telephone Supply Company
Continental Carbon Company
Cornell Electric Mfg. Company
Electrad, Incorporated
Erie Resistor Corporation
General Electric Company
General Industries Company
General Radio Company
Hammarlund Mfg. Company
Hardwick, Hindle, Incorporated
Hygrade Sylvania Corporation
International Resistance Company
Isolantite, Incorporated
Jewell Electrical Instrument Company
McGraw-Hill Publishing Company
Ohio Carbon Company
Polymet Mfg. Company
Precise Products, Incorporated
Radio Condenser Corporation
Radio Engineering
RCA Radiotron Company, Inc.
RCA Victor Company, Inc.
Sangamo Electric Company
Scovill Mfg. Company
Stackpole Carbon Company
Stromberg-Carlson Telephone Mfg. Co.
U. S. Magnetic Products Corporation
Utah Radio Products Company
Ward Leonard Electric Company
Weston Electrical Instrument Corp.
Yaxley Mfg. Company

Among the technical papers presented at the four technical sessions the following were read from prepared material:

"Battery Design Problems of the Air-Cell Receiver," by F. T. Bowditch, radio engineer, National Carbon Company.

"European Reception Conditions," by W. A. MacDonald, chief engineer, Hazeltine Service Corporation.

"Pentode Circuit Operation," by David Grimes, engineer in charge, RCA licensee laboratory.

"Mica Capacitors in High Frequency Circuits," by I. G. Maloff, development engineer, RCA-Victor Company.

"Magnetic Cores for High Frequencies," by W. J. Polydoroff, director of research, Johnson Laboratories.

"Experimental Visual Broadcasting," by A. B. Chamberlain, chief engineer, Columbia Broadcasting System.

"Advances in Ultra Short-Wave Transmission and Reception," by Eduard Karplus, research engineer, General Radio Company.

"Correlation of Radio Tube and Receiver Designs," by R. M. Wise, chief engineer, Sylvania Division, Hygrade-Sylvania Corporation.

"Recent Developments in Amplification and Detection Systems," by P. O. Farnham, development engineer, Radio Frequency Laboratories.

"Use of Suppressor Grids in Radio Tubes," by E. W. Ritter, development engineer, RCA Radiotron Company.

"An Examination of Selectivity," by R. H. Langley, consulting engineer.

The technical sessions were presided over by R. H. Manson, president, and by C. P. Edwards, vice-president of the Institute. The engineering exhibit sessions were presided over by L. C. F. Horle.

The general committee in charge of the meet was made up of:

Executive, Chairman, Virgil M. Graham; Vice-Chairman, Howard Brown; Secretary-Treasurer, H. J. Klumb. Publicity, R. A. Hackbusch. Finance, H. J. Klumb. Transportation, M. A. Wood. Electrical, A. E. Soderholm. Program, H. E. Gordon. Entertainment, E. C. Karker. Exhibits, Howard Brown. Trips, A. L. Schoen. Hotels and Registration, O. L. Angevine.

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THE DESIGN AND DEVELOPMENT OF THE HIGH-POWER OSCILLATOR OR AMPLIFIER TUBE UV-862

(*Concluded from page 22*)

ommended grid-leak resistance the d-c. grid current must not be greater than 1.0 ampere. The exact value for best adjustment will vary with individual tubes and circuits.

Existing Installations

Although antenna outputs of as much as 400 kilowatts have been obtained from a class C amplifier suitable for radio telegraph service, using four UV-862 tubes in a push-pull circuit, the most common application at present is in the RCA-50 kilowatt broadcast transmitter. These transmitters use two UV-862 tubes in a push-pull class B amplifier to generate peak antenna output of 200 kilowatts at modulation factor equal to 1.0. The UV-862 stage of a typical RCA transmitter is shown in Fig. 7. There are at present nine broadcast installations of this type in the United States and one in Italy using Radiotron UV-862 in the last stage of amplification. Other installations are proposed or in process of construction.

It is interesting to prophesy regarding the further expansion of the high powered transmitter field. Will the trend be toward a multiplicity of low-power transmitters or toward a small number of super-power stations? Perhaps Radiotron UV-862 will be one of the smaller transmitting tubes in use ten years hence.

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CROSLEY RADIO CORPORATION

For six months ended September 30 reports net loss of $60,952 after expenses, taxes and depreciation, etc., against net loss of $323,479 for the six months ended September 30, 1930. For the quarter ended September 30 net profit was $84,005 after above charges, equivalent to 15 cents a share on $540,800 no-par shares of common. This compares with net loss of $144,957 in the preceding quarter and net loss of $223,409 in the September quarter of last year.

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IMPROVEMENTS RELATING TO SEALING-IN BODIES FOR VACUUM TUBES

THE sealing-in body consists of a hollow metal tube (adapted to be surrounded by the glass envelope of the vacuum tube), made from a material which has substantially the same coefficient of expansion as glass and is formed by a metal chemically or electrochemically applied to a core. The sealing-in member is closed at one end by a closing member of special form made from molybdenum or nickel.—— *N. V. Philips Gloeilampenfabrieken, British Patent* 354,620. *Issued: August* 13, 1931.

Difficulties of the small broadcast stations and how to effect remedies

By Ralph C. Powell*

ONE of the most important developments taking place in radio broadcasting at the present time is the increasing use of the low-power station by both the local and national advertiser.

The national networks have in the past been responsible for the general growth of radio advertising since through their organization and resources they have been able to provide programs and continuity which attracted a large portion of the radio audience and as a consequence produced desired results for the advertiser. The demand for network facilities during the past two years has been so large that advertisers are finding it difficult to obtain desirable time for their programs. As a result the advertisers are looking to the independent commercial stations which in numbers constitute over 50 per cent of the broadcasting facilities of the country. It is believed by many persons that by means of electrical transcriptions the advertiser may control the quality of his program and by the use of a large number of local stations obtain more coverage at a better price than through the use of the chains.

Unfortunately, however, there are certain drawbacks which make the advertiser hesitate to use these stations. One objection is that many stations use inefficient or obsolete equipment which prevents them from obtaining the coverage which should normally be expected. Advertisers are told that a number of these stations do not comply with federal regulations and that their licenses are frequently in jeopardy on this account. Financial instability and a consequent lack of organization is a common condition. With no money available for programs many of these stations have been unable to build up a listening audience.

The small broadcaster has had to endure many hardships. In the first place the programs and technique of the national networks improved so rapidly that the small station has been unable to compete on even terms. Because of the unfavorable comparison in programs it has been difficult for the low-power broadcaster to convince the local business organizations that his station has a satisfactory audience. Although the high-power chain station 50 or 100 miles away is not competing for the business of the small station it is nevertheless detracting from its means of doing business.

Sale of "Time"

In its struggle for existence the small station has been thrust into further difficulties. Take for example the activities of groups of high-pressure salesmen who travel from station to station with glowing offers to "make" the station overnight. With or without the consent of the station owner they canvassed the towns, selling the merchants all the time they wanted for anything they were willing to pay: anything to get a check and of course, their percentage. At the end of the week some were considerate enough to divide the proceeds with the station owner. Following the departure of these solicitors the station owner, examining his contracts discovers that in some cases his time on the air has been sold out for several months at two or three dollars an hour, leaving him in the embarrassing position of operating at a loss or repudiating what apparently were bona fide contracts.

A further and unavoidable obstacle has been the development in technical equipment. The Federal Radio Commission being charged with the responsibility of providing the best possible public service in the overcrowded broadcast bands had no alternative but to insist that any new development that would help the situation be applied to sending stations at the earliest practical moment. The use of automatic frequency control and high modulation

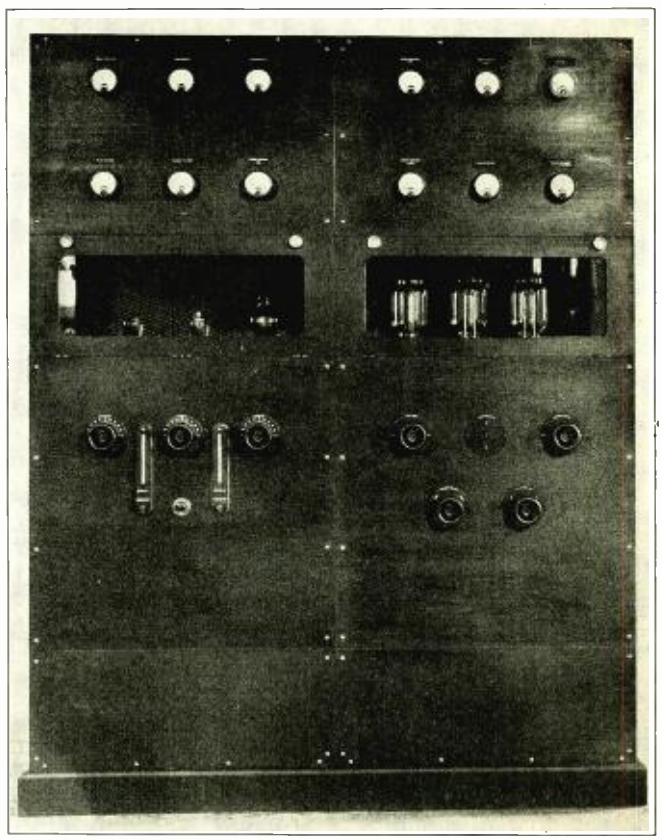

Fig. 1. 100-150 watt broadcast transmitter.

*President, R. C. Powell & Co., Inc., New York City.

efficiency were readily accepted at the large stations having a going business, but the small station found improvements of this nature only an added burden of expense. Some delayed too long and were either deprived of their licenses or forced to defend their operation at great expense, before the commission.

The small station has a definite value in broadcasting. The trend is now in favor of these units and it is to be hoped that within a short time their operation will become generally sound and profitable. The well equipped stations operating economically and efficiently will be the first to receive the benefit of the new business which is now before them.

The erection of low-power stations is essentially the field for the smaller manufacturer, who should understand the problems, recognize the limitations of present income and be able to plan expenditures wisely. It is of paramount importance that these small stations comply with federal regulations regarding frequency stability, modulation efficiency and power output. The manufacturer should comply with these regulations as a matter of course. He should go further than this, however.

Too many stations are using transmitters with power ratings from four to ten times their allotted power. Their maintenance and power costs are all out of proportion. Some have been induced to spend on antenna towers and buildings an amount exceeding their gross annual income. Granting that the high-power stations find it worth while to spend thousands of dollars to increase their efficiency a few per cent, such expenditures have little or no value to the small station. The management must judge the probable return from operation and stay within the income, obtaining the largest satisfactory service area per dollar of investment and running expense. The transmitters illustrated in the photographs accompanying this article are designed to provide the small station owner with suitable equipment which, while meeting all federal requirements, and consist only of essentials necessary for satisfactory operation.

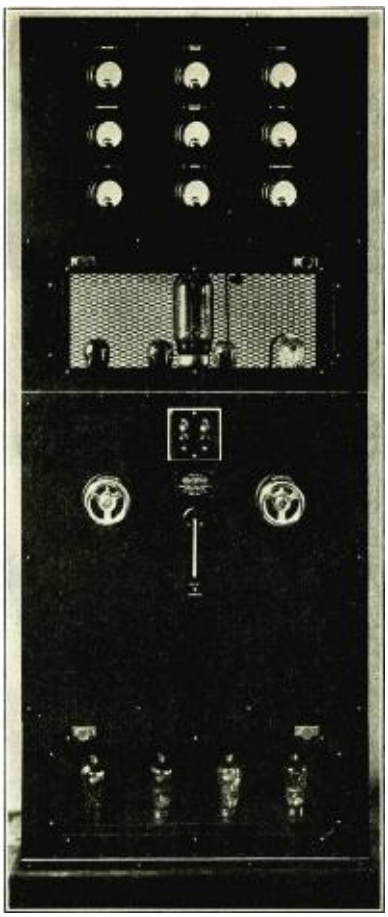

Fig. 2. A 100 watt broadcast transmitter. These panels may form sections of a 500, 1,000 to 5,000 watt unit.

In design consideration is given not only to the initial cost but also to the conservative use of tubes and other parts which require periodical replacement, constituting upkeep expense. In so far as possible all wiring and accessories to the installation are constructed at the factory before shipment to reduce the time and expense required for installation. At the time of installation final tests were made of the frequency stability, modulation efficiency overall frequency response, harmonic content at peak modulation, antenna resistance and efficiency of power conversion. These tests requiring the use of hundreds of dollars worth of test equipment are charged only at the time rates of the engineers engaged in the work. When the work is completed the station owner is assured of having an efficient and reliable plant, an investment upon which he can earn a satisfactory return and the opportunity to devote his time to the production of programs and the sale of advertising upon which his success will depend.

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CHOOSING A SCREEN GRID TUBE

(*Concluded from page* 16)

form in Fig. 4-D. It will be noticed that in order to realize any appreciable gain from such a system the value of series resistance R_2 should be as small as possible. This condition is realizable when the values of R′ and R_p are made comparatively small. However, the value of R′ cannot be reduced too much or it will materially affect the load. No lower limitation is imposed upon the value of R_p however. In the screen-grid tube term $(R'/R' + R_p)$ is numerically equal to about 0.1. This is a definite limitation of such a device since the voltage amplification obtainable from it is limited to $0.1 \times$ MU. Consequently with a given value of R′, the optimum value of which is dependent upon the load into which its works the only means of obtaining more gain would be to reduce the value of R_p or increase u.

Since, except for comparatively small changes, the value of R_p is definitely determined by R′, the only means of increasing the gain would be to increase u. This offers no theoretical difficulties.

TABLE I

Make of Tube (224s)	MU	R_p(a.c.)	I_p(ma)	Sm	R′(d.c.)u	$\left(\frac{R'}{Rp + R'}\right)$
A	530	625,000	3.95	850	45,000	.36
B	475	450,000	4.20	935	43,000	42
C	575	600,000	3.30	960	54,000	47
D	485	450,000	4.20	1080	43,000	42.3

It is in respect to this particular point that most tubes vary. For in spite of the fact that the value of Sm may be quite uniform the value of u and R_p vary considerably. Which accounts for the wide variations in realizable gain.

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CATHODES FOR ELECTRON DISCHARGE DEVICES

A VESSEL of vitrified inert material of high melting point such as chromium oxide is provided with an inner lining of thermionically active material such as oxides of barium, strontium and calcium; cathode material such as platinum-nickel alloy is placed in the vessel; and the vessel and its contents are heated sufficiently to cause the reactive lining to combine with the melt to produce a thermionically active product. This is formed into cathodes.——*H. T. Reeve (Assigned to Western Electric Company) United States Patent* 1,809,067. *Appl. October 7,* 1924 *and June* 9, 1928. *Issued: June* 9, 1931.

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THE RADIAN

A radian is an arc of a length equal to the radius r. There are

$\frac{2\pi r}{r} = 2\pi = 6.283$ radians to a circumferance, or

a radian $= \frac{360°}{6.283} = 57.3°$, nearly.

Grid controlled vapor rectifiers

Dr. Paul G. Weiller

The future will see many useful applications of hot cathode rectifier tubes. This technical article presents a review of the present state of development of rectifier tubes.

In a previous article the writer predicted that while the high vacuum tube had opened the field of oscillatory currents for all cases where high voltages and relatively low currents could be used and where efficiency was not of paramount importance, the vapor tubes would be able to handle large powers at ordinary commercial voltages with good efficiency.

This prediction bids fair to come true in the near future. Thyratrons are being experimented with for interconnection of power systems. Such a connecting link consists of a rectifier unit, its d-c. output being fed to an oscillator or, as it is usually called, "inverter."

The advantage of such a system lies largely in the fact that, while one system can freely take power from the other, transients or surges created in one system by some fault are not transmitted to the other. It is also possible to interconnect by such links d-c. and a-c. systems or systems with different frequencies. The development of practical uses for gas tubes must, however, be slow because of their complex characteristics.

The function of a vacuum tube of the three-element type follows relatively simple laws.

Variations from theoretically predicted behavior are caused by such phenomena as secondary emission, contact potentials of various kinds, changes in the work function of the filament material caused by surface changes and influence of carbon or other coatings on the plate. Even X-rays generated on the plate, and electrons generated by the photoelectric effect of the light emitted by the filament have been blamed for some of the deviations from normal.

While this is a formidable array of possible disturbing effects, their aggregate influence in a well-made receiving tube is unimportant in practice. In large transmitting tubes these effects are more troublesome and have caused tube manufacturers considerable worry.

In gas tubes, however, secondary effects assume important dimensions. In many cases they are detrimental and cause what is often complained of as the erratic behavior of gas tubes. In other cases these effects are useful, as in some types of gas tube oscillators.

As the cold cathode tubes are of limited technical importance because of their high voltage drop, small current carrying capacity and erratic performance we shall deal here only with hot cathode tubes. A compilation of the most important characteristics of hot cathode vapor tubes should prove of interest. The reader should remember that the subject is comparatively new and extremely complex and that the amount of work done so far in this field has been rather limited. Hence, anything said here should be taken as a survey of a field which is just being scratched. It can be neither complete nor detailed.

The plain hot cathode vapor rectifier in itself exhibits complex phenomena; considerably augmented when a grid is added. So long as the positive peak voltage on the plate is below the ignition voltage the rectifier behaves substantially like a high vacuum tube.

When the positive peak voltage on the plate is raised to the "ignition" voltage the discharge forms and the voltage across the tube falls instantaneously to the operating voltage. As the tube heats up this drop gradually decreases until a temperature balance is established. The influence of the load on the drop is slight until the limit of the filament emission is reached, when the drop increases rapidly.

If the filament has a definite emission limit; or, in more scientific language, if the filament shows a definite saturation point, the drop will increase suddenly when saturation is reached. If R is the load resistance, Im the saturation current at a given filament temperature and E the voltage of the power source, the voltage across the tube will always be $e = E - RIm$. This property of rectifiers may become very valuable for measuring or control purposes. From no load to maximum permissible load the characteristic is partly falling, partly rising.

Because of the temperature effect of heavy plate currents on the filament the shape of this curve may be due in part or wholly to temperature changes in the filament due to changes in plate current. This relation is also quite complex.

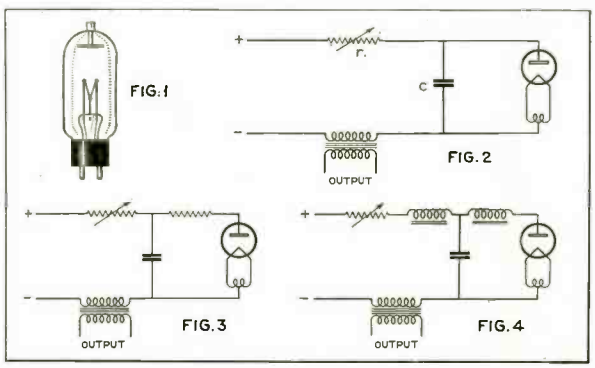
The plate current must of course pass through the filament material and cause some heating. This heating effect is, however, not uniformly distributed over the entire filament as the full space-current does not flow through all cross-sections of the filament.

The energy absorption caused by the work function causes a cooling of the filament. This effect is quite noticeable in large tubes. Positive ion bombardment, if it assumes noticeable proportions, would cause heating of the filament.

Filament Temperature

A study of temperature conditions of the filament by the usual optical pyrometer method is not feasible because of the luminescence surrounding the fila-

Circuit elements and circuit variations.



ment at high current densities. The operating drop in the tube, as well as the ignition voltage, are dependent greatly on the vapor pressure and temperature. The magnetic field of the filament current has also some effect on the drop. Static charges on the glass walls also have an effect.

The ignition voltage depends very greatly upon the spacing of the electrodes. The tube sketched in Fig. 1, for instance, has an ignition voltage of 35 volts and an operating drop of 12 volts. The size of the bulb is that of a 50-watt tube.

For practical purposes it can be assumed that the operating drop from tubes of this type can be made between 3 and 15 volts.

Another important characteristic of the rectifier is the inverse breakdown voltage. In rectifiers commercially manufactured at present the maximum attained seems to be about 30,000 volts. It is, however, probable that considerably higher figures can be attained by specially designed tubes.

To obtain high voltage it is necessary to provide for good heat dissipation, as the inverse breakdown voltage is very greatly dependent on vapor temperature and pressure. When a grid is added to a rectifier other complexities are introduced. The control action of the grid is based on the same principle as in high vacuum tubes. If the grid has wide meshes it is only effective before the glow discharge is formed.

As we have seen, the tube then behaves like an ordinary vacuum tube; until the discharge forms. If the negative bias on the grid is sufficient to cut off the plate current entirely, the glow discharge cannot form. As soon as either the grid bias drops below the cutoff voltage or the plate voltage increases sufficiently a space current will flow, the gas will ionize, and the glow discharge will be started. As soon as this is the case the grid loses its control.

If the plate voltage is an a-c. voltage, no current will pass at the beginning of each cycle until the plate voltage has reached the ignition voltage determined by the grid bias. Then the discharge will form and the current will pass until the plate voltage has again dropped below the operating voltage, when the discharge is extinguished.

It is clear, therefore, that up to one-half of each half cycle can be eliminated by a d-c. grid bias. If the grid bias is also an a-c. voltage in suitable phase relation to the plate voltage, regulation can be accomplished from full current to zero. The grid controlled rectifier is of course still subject to the effects of vapor pressure temperature and charges on the glass walls and the magnetic field.

There is a small amount of grid current at negative grid potential and a more substantial amount at positive grid potential. This part is important because grid controlled rectifiers with large spacing and amplification factors of one thousand or higher are often operated with a positive grid bias.

In grid controlled rectifiers with a fairly close mesh grid it will be noticed that the grid does not lose its effects entirely after the discharge is forced. If the meshes are sufficiently closed such tubes can be operated to some extent as gassy amplifiers, although few details of this type of grid controlled rectifier are known so far.

From data available it appears that power amplifiers for large currents are practical and also that the hot cathode vapor tube may replace the high vacuum receiving tubes, giving a much greater latitude in characteristics.

Frequency Stability

Given characteristics as described, it is obvious that even the plain rectifier without a grid can be made to oscillate, as well as the grid controlled rectifier. It is also easy to predict from the great number of factors influencing the discharge that it is not an easy task to design an oscillator with good frequency stability.

Most gas tube oscillators are necessarily of the relaxation type. The simplest one is diagrammatically sketched in Fig. 2, in which r is a resistance, c a condenser. The frequency of such an arrangement will depend on the time factor of the resistance condenser combination and on the differences between ignition and extinction voltage on the supply voltage. The condenser is being charged within a time element determined by resistance, capacity and voltage; the voltage across the tube rising along a straight line until the ignition voltage is reached. Then the condenser discharges through the tube virtually instantaneously. The voltage waveform is saw-tooth like. It is quite useful for the base line in cathode ray oscillographs and for various other purposes.

If this circuit is modified as per Fig. 3 by inserting a resistance between the condenser and tube the discharge of the condenser will be stretched over a time element comparable with that of the charging period. The waveform will be accordingly changed.

An analysis shows that in this type of oscillator a considerable amount of energy is consumed in the resistances. Part of the resistance in the circuit may be replaced by inductance with the attendant increase in efficiency. See Fig. 4. The power output of such oscillators increases with the frequency, the capacity, the difference between ignition and extinction voltage.

The ignition voltage can be raised to

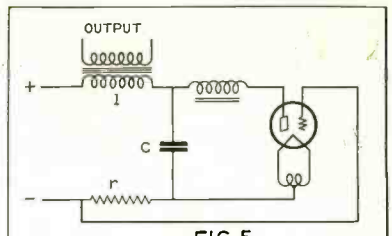


FIG.5

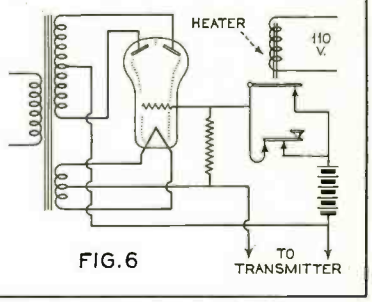


FIG.6

Fig. 5
Raising ignition voltage by use of biased grid

Fig. 6.
Grid controlled rectifier as keying relay and time lag relay

that of the d-c. supply by interposing a suitably biased grid as in Fig. 5, with great increase in efficiency. By using two tubes with grids connected in proper phase relation it is possible to construct an oscillator or "inverter" with a sine wave output.

All these oscillators require a complete extinction of the discharge after completion of each cycle. They are therefore limited by the speed with which deionization of the gas atmosphere in the tube takes place.

Output

At the present stage of the art we cannot go much over 1,000 cycles. The output of oscillators is a function of frequency, capacity and voltage. It increases with the increase of these three variables.

At a given frequency the maximum capacity is determined by practical limitations and by the high cost of large condensers. Oscillators making use of the falling characteristic of the glow discharge itself are less limited in frequency. Oscillators constructed on this basis will deliver even radio frequencies. Their efficiency is, however, very poor as the potential difference available is necessarily only a few volts, as it can be only part of the operating drop of 12 volts.

If a magnetic field is applied in a plane at right angle to the electrostatic field in the tube it has the effect of increasing the drop, and with it the output and efficiency of the oscillator. Such an oscillator becomes quite similar to the old arc transmitter. It is also possible to have the plate current react on

the magnetic field and thereby generate oscillations.

There are at present several difficulties in the way of designing a practical oscillator according to these principles. Some of these are connected with the fact that coated cathodes have a way of sputtering violently under such conditions. When more durable cathodes are produced the magnetic oscillator may find its way into practical use.

The grid controlled rectifier with a close meshed grid can, as we have seen, be used as a power amplifier. Off hand, it might appear that all we had to do to produce a practical, large scale oscillator would be to place an alternating voltage on the grid of a large capacity tube of this type. The output would be a sine wave, but the efficiency would be less than 50 per cent. The tube acting simply as a variable resistance would absorb half the energy.

To obtain practical efficiencies the tube must be operated as near as possible to a square wave. This must be converted into a sine wave where necessary by suitable filters. It is, however, likely that for many purposes a square wave would be suitable.

There is a large field in radio and in the industries for grid controlled rectifiers in control work. The keying of transmitters offers a problem which has been solved in many ways. The use of a grid controlled rectifier as keying relay and time lag relay at the same time may be accomplished according to Fig. 6. A grid controlled full-wave rectifier is used for the power supply unit.

The key and a very small thermostatic switch, the latter normally closed, connect the grid of the rectifier with a source of negative bias. A leak between grid and filament takes care of any charges on the grid and prevents delay by charges which might linger on the grid. The thermostatic unit is in parallel with the key. When the power switch is closed the current passes through its heater. After the desired time the contact opens and the key is ready for operation.

It is easy to build such tubes so that the voltage from an ordinary B battery will control a few thousand volts in a satisfactory manner. Similar tubes are used in remote control of receiving sets.

In designing circuits for the use of grid control rectifiers their dependence on operating temperature must be taken into consideration. This is particularly true of the types with large spacings and high amplification. It is quite possible to make a tube to shut off 110 volts with a negative control voltage of .3 volt. It is possible to design tubes which are less sensitive to temperature changes, but as a rule this is obtained at the expense of sensitivity.

It is the writer's opinion that for the present at least the most practical solution of the problem would be to enclose the tube in a receptacle with some form of temperature control. Tubes which are filled with rare gases instead of mercury vapor are less subject to temperature influences, but are not quite so satisfactory at higher voltages.

A suitably biased grid-controlled rectifier can be used for over-voltage protection. The grid bias is so chosen as to make the ignition voltage above the peak voltage on the line. Any higher voltage will start the discharge, which will then present a drop of only about 12 volts to the surge.

A resistance in series prevents wrecking the tube. Unless further provisions are made the tube will block again at the end of the cycle, during which the breakdown occurred. A similar arrangement can be used to counteract the effect of the opening surge in solenoids used for operating brakes or valves.

In television the amplifier with a close-meshed grid may be used as kinolamp and power amplifier combined. It replaces the last tube in the amplifier and the lamp itself. This arrangement will permit the handling of much larger powers than at present without increase in the number of tubes and, therefore, greater luminosity.

Being aware of the fact that the word revolutionary has been used and abused so much lately, especially in describing new things in radio, which were sometimes new but hardly ever revolutionary, the writer nevertheless dares to predict that vapor rectifiers of the grid-controlled varieties will actually revolutionize many fields. The change will be gradual until the power fraternity have become accustomed to thinking in terms of vacuum tubes and until they have given up their dislike for any device of which glass and heated filaments form elements.

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Advance in radio receiver merchandising

MILLIONS of dollars now lost to the radio industry will be brought into the legitimate channels of radio distribution with the inauguration of a secondary selling season.

Vigorous selling will be carried right on through the winter and into the spring under the plan, with more sales and greater profit for all. "Dumping" and "gyp" selling will be eliminated.

The secondary selling season for radio begins after the holiday slump and will continue on into the spring. When the idea has had a chance to prove itself in 1932, there is a real possibility that the secondary season may even surpass the so-called primary selling season in sales volume.

In the early days of radio there was a sound reason to concentrate on sales in the final quarter. But with high class broadcasting programs available all the year around, excellent receivers and high powered stations, the radio set is used and enjoyed, every day, all the year around. The secondary selling season will be publicly launched for the benefit of the entire nation, the week of the Chicago Radio-Electrical Show, Jan. 18-24, 1932. Newspaper publicity, from coast to coast, and network broadcasting will create immediate acceptance for the new selling season, just as the New York show does in the autumn.

It was purposely to insure the secondary selling season getting under way without lost motion that the Chicago show was postponed from October. The majority of manufacturers realized that without such a vehicle as a national trade and public show to generate countrywide interest, it would be impossible to impress the idea forcefully upon the public.

Both for consumer and trade, the Chicago show is ideally timed—near the end of the holiday slump. Members of the trade will have the time to attend the exposition in January, and the public will have ended its holiday visiting.

With Chicago so centrally located, thousands of members of the trade will find it convenient to come to the Show, to exchange views and to inspect new models and to have the benefit of both trade and consumer acceptance in making their own buying decisions.

Many manufacturers are already making plans for trade meetings during Show week.

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Leaders of industry approve new merchandising idea which will be launched nationally at Tenth Annual Chicago Radio-Electrical Show, January 18-24, 1932

NEWS OF THE INDUSTRY

RMA STANDARD COLOR-CODE CHART

The RMA standard color-code, now in practically universal use, can still be sometimes puzzling to the serviceman without some chart for ready reference. There are, for example, over 400 different resistor values now in use, each with its own 3-color "signature." A new celluloid vest-pocket indicator, which may be procured from the Tilton Mfg. Co., 15 East 26th St., New York, gives the correct color-combination for every possible value, in a flash. Actual size is approximately 4 inches by 1 inch.

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J. C. VAN HORN ADVANCED

Announcement of the election of J. C. Van Horn, of Philadelphia, as a vice-president of RCA Institutes, Inc., was made by D. O. Whelan, president of the Institutes, following a meeting of the Institutes' Board. The new vice-president will be in charge of the four resident schools at New York, Chicago, Philadelphia and Boston.

Mr. Van Horn has a service in radio extending over a period of twenty-two years. His connection with instruction activities started in 1911, when the Philadelphia School of Wireless was formed. This school became a unit of the RCA Institutes two years ago.

Mr. Van Horn served for four years as chairman of the Philadelphia Section of the I. R. E. He is a member of the A. I. E. E.

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ERNEST SEARING, President
International Resistance Co.

RALPH B. CLARK, SALES ENGINEER

With headquarters established at Toledo, Ohio, R. B. Clark is organizing to aggressively represent electrical and radio manufacturers for the territory of Ohio, Michigan and Indiana. He will reach electrical and radio buyers with manufacturers, wholesalers, electric power and telephone companies, and syndicate or chain store organizations.

Mr. Clark's broad background of experience fits him admirably for this work. He is a graduate of the Case School of Applied Science, Cleveland as electrical engineer.

He has been connected with the National Lamp Company, Cleveland, U. S. Light and Heat Corporation, Niagara Falls, New York, and the National Carbon Company, Cleveland, in various capacities as sales engineer, branch manager, division sales manager. Since 1919, he has been functioning as manufacturers' representative or sales manager for electrical and radio manufacturers.

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RADIO SET ANALYZERS

A new book of 59 pages with the title, "Radio Set Analyzers," has been published by Gernsback Publications, Inc., 98 Park Place, New York. This little book sells for 50 cents and will be found instructive by all those who have to do with set analyzers.

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INTERNATIONAL RESISTANCE ELECTS NEW OFFICERS

The directors of the International Resistance Company have announced their reorganization plans necessitated by the untimely death of their president, Francis R. Ehle, who was instantly killed in a recent airplane crash.

Ernest Searing, former vice-president and director of the company, will succeed Mr. Ehle as president. Mr. Searing before becoming associated with the International Resistance Company was eastern manager and director of the Johns-Manville Company, and has for the past two years been very closely associated with Mr. Ehle and the activities of this company.

William G. Porter has been elected vice-president and a director of the company. Mr. Porter was an intimate friend of Mr. Ehle's, and has only recently joined the company. For the past fifteen years, he has been actively engaged in the planning and selling of Victor records, having been for the past two years manager of record sales for the RCA-Victor Company of Camden.

Miss Ruth N. Shires, formerly secretary of the company, has been elected secretary and treasurer. Miss Shires has been with the company since its inception, and is thoroughly versed in the company's many activities.

HOUCK JOINS KOLSTER RADIO

After a ten-year association with the Dubilier Condenser Corporation and predecessor, Harry W. Houck has resigned as chief engineer in order to join Kolster Radio.

Although best known for his engineering work in the condenser field, Houck has contributed unsparingly to the development of radio reception. He was associated with the development of the original superheterodyne circuit at the Research and Inspection Division laboratories of the U. S. Signal Corps in Paris during the World War. He has been granted numerous patents on radio inventions. His radio career dates back to 1910 as a wireless amateur. He operated one of the first licensed stations in Central Pennsylvania in 1912. He has been active in the I.R.E. and Radio Club of America.

Houck has joined the Kolster Radio organization as assistant chief engineer, and will be stationed at the engineering laboratories in Newark, N. J.

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VOLTAGE DIVIDERS

The Ward Leonard Electric Co., Mount Vernon, N. Y., has issued Circular No. 514 listing a line of voltage dividers for the various makes and models of radio receivers now on the market. The circular gives the resistance in ohms and the length of the resistor.

The circular lists sixty-five receiver models of twenty radio manufacturers, to all of which these voltage dividers apply.

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WM. G. PORTER, Vice-President
International Resistance Co.

RIDER WRITES BOOK ON SERVICING OF SUPERHETERODYNES

Announcement has been received from the Radio Treatise Co., Inc., 1440 Broadway, New York City, that John F. Rider has completed the writing of a book on the servicing of superheterodyne receivers. What with the tremendous number of these receivers being placed upon the market and the dearth of information available about the subject this book is destined to fill a long felt want.

Mr. Rider who for many years has been engaged in the compilation of radio service material is the author of the *"Perpetual Trouble Shooter's Manual,"* a 1,000-page compilation of wiring diagrams and other service information. His new work entitled *"Servicing Superheterodynes"* was written for the serviceman who finds himself in a quandary when called upon to service a modern superheterodyne. The text is divided into sections covering the phenomena of beats, heterodyning, a breakdown analysis of the function of the different parts used in a superheterodyne, troubles in superheterodynes, symptoms indicative of certain troubles, the adjustment of the trimmer condensers, the application of set analyzers and i-f. and r-f. oscillators, variable-mu and pentode tube replacement, the design and construction of i-f. and r-f. oscillators and peculiarities in commercial superhets.

This book contains a great deal of material which is to be found only in manufacturers' service manuals and the type of material of value to the serviceman that never appears in public print. The book is typeset and bound in a stiff canvas cover. Its size is 5 x 7⅜ inches, and fits into the average pocket or within the cover of the average set analyzer. The list price is $1.

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REGISTERS USING PAPER TAPE

Tape registers are available operating in one to four circuits by means of which code or numerical records on paper tape are registered. Automatic marking on the tape records circuit interruptions. These registers also have many applications in line and in radio telegraph code signaling where tape records are desired. They are manufactured by J. H. Bunnell & Co., 215 Fulton St., New York.

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DE FOREST TO CONTINUE IN TUBE BUSINESS

A special statement by William J. Barkley, vice-president DeForest Radio Company, reads as follows: "The conservative sales policy of the DeForest Radio Company has been misinterpreted in many quarters, giving rise to unfounded rumors. It may be a strange sight today to see a radio tube manufacturer actually trying to make a profit on the business transacted, and positively refusing to do business at a loss. Hence, the rumors concerning the DeForest Radio Company quitting the receiving tube business.

"The truth of the matter is that the DeForest Radio Company has no intention of quitting the receiving tube business. During recent months the DeForest plant at Passaic, N. J., has been operating steadily, turning out a considerable volume of receiving tubes to meet profitable orders on hand. However, it is true, and we are proud so to state, that the DeForest organization has refused to solicit business entailing a loss. Consequently, the DeForest name is not to be found among those of tube manufacturers seeking business at any price.

"The DeForest organization has built up a production process second to none. Remarkable and unique tube producing equipment has been developed. DeForest research and engineering development have produced many important improvements and refinements in tube designs. DeForest quality is firmly established today. In the matter of price, the DeForest organization is in position to meet any production cost that may be set by any manufacturer. Nevertheless, the DeForest organization refuses to sell its tubes without profit. Twenty-five years of experience in the development, production and sale of radio tubes—the outstanding pioneer of the entire industry—has driven home the great lesson that business must be done at a profit if business is to survive.

"Meanwhile, it is also true that we are actively engaged in the production of transmitting tubes of all types. Our audion line is complete from the smallest dry battery tube to the largest water-cooled transmitting tube, with all the special purpose types in between. Furthermore, the DeForest organization is producing complete transmitters, special amplifiers and other equipment to meet the demands of radio communication and program distribution. Despite this very considerable proportion of its activities, the DeForest organization will continue producing and merchandising receiving tubes, as it has done during the past quarter century, rather than discounts."

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KESTER WINS PATENT SUIT

Kester Solder Company announces the success of its suit concerning the patent on Kester plastic rosin-core solder. It was recently necessary for the Kester Solder Company to institute infringement litigation against Silva Wares Company, Inc., and the New York Solder Company, Inc., for infringement of the Ripley patent No. 1,724,680 covering Kester plastic rosin-core solder.

This patent, but one of a number of patents and an application for patent, owned by the Kester Solder Company has been adjudicated in the United States District Court for the Southern District of New York. His Honor, Robert P. Patterson, United States District Judge, on August 13, 1931, handed down an opinion holding the Kester patent valid and infringed by the plastic-rosin core solder which the above mentioned companies had been selling up to the time of the trial which occurred in June of this year. The decree based upon this opinion was entered in the District Court by Judge Patterson on October 30, 1931.

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NEW PRICES ON I. R. C. METALLIZED RESISTORS

In keeping with the times, new low prices on I. R. C. metallized resistors enables the dealer and the serviceman to obtain a quality resistor at the same price he formerly paid for inferior makes of resistors.

Increased production has enabled the International Resistance Company of 2006 Chestnut Street, Philadelphia to reduce prices approximately 40% on all types of metallized resistors, one watt resistors that formerly sold for 50 cents list can be bought for 30 cents list; 2 watt resistors that formerly sold for 75 cents list can be purchased for 40 cents and three watt resistors that formerly sold for 80 cents list are now reduced to 50 cents list. There has been no let-down in quality and in spite of the drastic reduction in list prices, increased service helps are given to the dealer and serviceman free of charge. The same dealers' and serviceman's discount of 40% from the list price still applies.

A wide range of types of resistors are in stock at all jobbers and the International Resistance Company reports a steady increase in their jobbing business.

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TRAV-LER IN TELEVISION

The Trav-ler Manufacturing Corp., will hereafter be known as the Trav-ler Radio & Television Corp., of St. Louis, Mo., believing the new name will better describe the aims and activities of the organization.

The corporation is now in production of television equipment, short-wave television receiver kits and television scanning kits, complete short-wave television receivers and television scanning receivers, and complete combination radio and television receivers.

▲

DUBILIER HIGH-FREQUENCY CAPACITOR

A new line of high-frequency capacitors, Type PL-341-62, is announced by the Dubilier Condenser Corporation, New York City. This type comprises a special dielectric section encased in a cylindrical aluminum shell with insulated top terminal and mounting base. The metal is reduced to a minimum in limiting Eddy current losses so prevalent at extreme frequencies; in fact, the extremely low losses in this type capacitor approach the efficiency attained in air condensers.

Type PL-341-62 Dubilier capacitors are available in .000025 and .00001 mfd. values. They can be employed as neutralizing condensers because of their low capacity. Also, they may be employed in parallel with the variable condenser in a tank circuit for increased capacity values, or again alone as a tank condenser. These capacitors are especially applicable to frequencies over 10 megacycles.

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ARCTURUS EXTENDS ACTIVITY INTO POWER TUBE FIELD

In line with its expansion in other fields of the thermionic art, the Arcturus Radio Tube Company, Newark, New Jersey, announces that it is now completing the development of large power tubes for broadcasting and industrial uses.

Allan B. DuMont, formerly chief engineer of DeForest Radio Company, in charge of transmitting tubes, has been retained by Arcturus in a consulting capacity on this added line.

A thorough study has been made not only of the transmitting tubes designed in the United States but also of the unique features and special advantages of foreign-made power tubes. With an established reputation for building quality broadcast receiving tubes it is expected that the new Arcturus transmitting tubes, when introduced to the trade, will be a decided advance over the present-day transmitters.

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JAMES-SHIPLEY, INC., MOVE TO LARGER QUARTERS

Due to the rapid expansion of their business, James-Shipley, Inc., have been forced to seek larger quarters and are now located in the Chanin Building, 122 East 42nd Street, New York City.

James-Shipley, Inc., are marketing a high-class line of cabinets and are also eastern representatives for United Air Cleaner Corporation, manufacturers of Sentinel radios.

The two active members of the organization, Horace Bloom and William M. Shipley, are well known throughout the trade, as they were formerly New York sales representatives for Stromberg-Carlson.

NEW DEVELOPMENTS OF THE MONTH

FILM SOUND RECORDERS FOR BROADCAST PURPOSES

There are reasons to believe that broadcast transcriptions will be recorded on film in the near future. One great advantage of film over disc is that the film can be edited for or by each particular broadcasting station. Local announcements can be inserted and, if necessary, last minute changes can be made before "going on the air." With each station having its individual recorder and reproducer, programs could be recorded and edited days in advance of presentation to the public similar to the talking picture. Using the "toe" method of recording, the negative can be reproduced with excellent fidelity. In the interest of economy, it is possible to put several sound tracks on 35mm film. The frequency range covered exceeds that allowed by the Federal regulations. Frequencies well above 10,000 cycles have been recorded on ordinary positive film. A special model for recording and reproducing programs will soon be available. Linear speed of the film has been increased from 90 to 115 feet per minute, resulting in improved high frequency response. The width of the sound track has been increased, resulting in lower background noise.

Excellent film recording equipment is manufactured by the Canaday Recording Equipment Company, 714 Leader Bldg., Cleveland, Ohio.

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THE WOODRUFF SUPER-THRU

Woodruff & Company, Meridian Miss., announce a new, workmanlike antenna lead-in unit which has a number of attractive features. The entire installation is made through a single 13/16 inch hole. No metal box is used and the unit is adaptable to any thickness wall.

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NEW FILAMENT FOR PRACTICAL 2-VOLT BATTERY TUBES

A new type filament for practical two-volt battery tubes and for future application to other types of tubes, is announced by the engineering department of the DeForest Radio Company. This cobalt alloy filament is said to overcome the handicaps heretofore experienced with the —30, —31 and —32 types of tubes in which a finely drawn nickel filament is employed. With a diameter of .001 inch, the usual nickel filament provides uncertain emission, is subject to premature burnouts, and makes for a short-lived tube.

The cobalt alloy filament, DeForest engineers report, has a much greater hot tensile strength. Furthermore, the increased diameter for a given resistance makes for maximum efficiency in the emission.

The —30, —31, and —32 tubes produced with the new filament have, it is stated, a service life consistently over 1000 hours. The new filament makes for a tube one-third as microphonic as when the usual nickel wire is employed. The cobalt alloy filament is stronger, easier to handle and the tension is more accurately secured, making for greater precision in stem mounting. The operating temperature is the same as for nickel.

The cobalt alloy filament offers a promising field for development because of its low thermal emission. It is entirely probable that the development work on this filament will be extended to other types of tubes by the DeForest engineers.

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MAGNAVOX NO. 150 SPEAKER

The latest addition to the Magnavox family of speakers is the No. 150 model. This has a cone diameter of 5½ inches. The outside diameter of the cone housing is 6-17/32 inches and the transformer, mounted on the rear of the housing, does not protrude beyond this diameter. The mounting holes in the housing are slotted

so that the mounting hole circle may be anywhere from 5-15/16 inches to 6-5/32 inches in diameter for the hole centers. The terminal strip is arranged to be easily accessible from directly back of the speaker and is fitted with a proper cover to guard against electrical hazards. The terminal strip is arranged to be easily accessible from directly back of the speaker and is fitted with a proper cover to guard against electrical hazards. The terminal cover is essentially flush with the level of the field coil casing, thus giving the whole assembly a neat compact appearance. The magnetic structure is of the U-type.

While designed primarily for use in four and five tube sets it will reproduce the low notes in the very small cabinet or baffle in which this type set is usually housed.

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LOW THERMAL EXPANSION CERAMIC

A remarkable scientific development in the form of a ceramic possessing the lowest coefficient of thermal expansion of any known material, is announced by Henry L. Crowley & Company of West Orange, N. J. Known as Crolite No. 7, the new ceramic enjovs a two-to-one advantage in thermal coefficient over Invar, an alloy heretofore representing the lowest thermal coefficient, and a four-to-one advantage at 100° (two-to-one at 1000°) over Sillimanite, the ceramic employed for spark plug cores and other purposes.

Crolite No. 7 has a coefficient of thermal expansion of 0.9 at temperatures ranging from 0° to 100° C., and 1.2 from 0° to 200°. At high temperatures, or up to 1000° C., the coefficient of thermal expansion is 2.7. Invar is 1.5 for temperatures from 0° to 100° C. The thermal expansion curve of Crolite No. 7 is absolutely smooth and uniform.

The lowest coefficient of expansion attained in Crolite No. 7 means that this material undergoes less change in size for temperature variations than any other material now in use. Also, the absence of appreciable thermal expansion means that the material is free from internal stresses and can therefore be subjected to severe heat shock without cracking. In fact, it will not be destroyed even when heated to incandescence and then plunged in cold water.

The new ceramic has certain critical applications, such as in precision instruments where changes of material must not upset characteristics.

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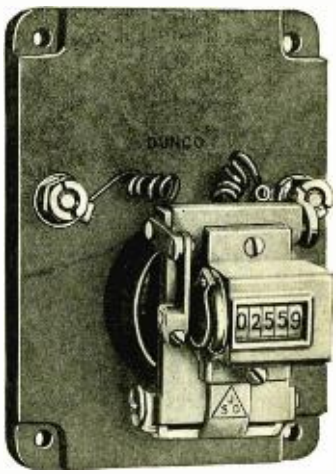
NOW A MAGNETIC COUNTER

The electromagnetic counter here illustrated, manufactured by Struthers Dunn Inc., 127 N. Juniper Street, Philadelphia, Pa., has a wide market in the radio field, and is used with the photoelectric cell; while in the electrical manufacturing field, equipment manufacturers require these on certain types of equipment in order to determine production count. The industrial field in general can make use of these where it is necessary to determine count



at a remote point of a machine. All the electrical trade in general will welcome such a device.

ALUMINUM HORN OFFERS NEW ADVANTAGES

The first size in a full series of all-metal trumpet horns has just been offered the sound projection trade by the Fox Engineering Company, Toledo, Ohio, manufacturers of horns and high-powered electrodynamic units.

While the tone characteristics and physical requirements of the perfect amplifying horn have long been recognized by sound engineers, the actual attainment of these characteristics has been a matter of slow and painstaking development. All-metal horns are not new, but an all-metal horn that is entirely free from rasping and vibration noises is an achievement that will be welcomed by every sound engineer in the country.

This new Fox horn, of conventional trumpet design, has consistently shown, under all conditions, a clear, bell-like tone that has surprised and pleased every engineer that has tested it.

Notwithstanding the fact that these horns are 6 ft. long, and have a bell diameter of 32 inches, they are of spun aluminum and free from lateral joints or seams. This construction makes possible a definite radial uniformity that accounts for its fine tone. Aluminum is not only an ideal medium from the standpoint of resonance and purity of tone, but its light weight is an appreciated factor in many instances. It is easy to set up and take down for temporary use, and when knocked-down into its two integral parts, is extremely easy to store and ship.

These horns are entirely free from the influence of atmospheric and moisture conditions and are almost indestructible in normal use. Weight is only 12 pounds.

▲

TUBE-SELLER FOR SMALL STORES

A smaller and lower-priced tube-seller for the small store has been developed by the Jewell Electrical Instrument Company, 1650 Walnut Street, Chicago, Illinois.

The Pattern 533 tube-seller measures tube value on a three-color scale similar to that used on the larger Jewell tube-sellers. Indications are direct in terms

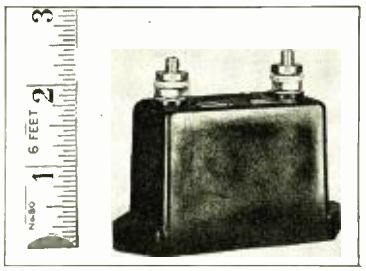
easily understood by the customer—*Satisfactory, Doubtful,* and *Unsatisfactory.* No reference to tables and no calculations are necessary.

A short-checker with indicating lights, line voltage indicating meter and adjustment, and separate test sockets for each type of tube, are some of the features.

Provision is made for testing—without adapters—all standard tubes, including pentodes and variable-mus in a-c. and two and six volt d-c. types.

MOULDED CASE MICA CAPACITORS

A line of moulded case mica capacitors ranging from a few micromicrofarads to .2 microfarad and for working voltages up to 5,000, is announced by the Dubilier Condenser Corporation, 4377 Bronx Blvd., New York City. The distinguishing features are a neat moulded case with firm mounting base requiring a minimum of deck space, as well as sturdy and widely spaced terminals capable of handling up to 200 amperes. The usual losses in transmitting capacitors are in this instance reduced to a minimum by eliminating magnetic material and getting entirely away from the usual loop effect in the clamp-



ing means. Due to the use of a Bakelite case, breakdown from terminal to casing is entirely eliminated.

The Type 6 Dubilier capacitors have many applications. They may be employed as plate blocking capacitors in small transmitters, or as grid capacitors in the medium sized transmitter, and again as filament by-pass capacitors. They are especially adaptable to aircraft transmitters because of light weight and compact dimensions. They can be used in tank circuits. The extra wide strap terminals that may be provided in place of the usual terminals, when so ordered, make these capacitors applicable to ultra-high-frequency circuits.

▲

GRID CONTROL RECTIFIER

VaS Corporation of 125 N. 3d St., Newark, N. J., Dr. Paul G. Weiller, president, has developed a grid controlled rectifier which may be operated on d-c. plate voltage. Type SDC-121 delivers 1 amp. d-c. at 300-volt plate. The flow of current may be stopped by applying a negative voltage of —5 on the grid of the tube.

The tube is a sensitive relay for a-c. or d-c. operation and is adaptable to a simple and compact inverter circuit.

▲

TUNGSTEN SHEET

American Electro Metal Corp., Lewiston, Maine, has succeeded in developing very ductile tungsten sheet. It is being produced in thicknesses as fine as .0002 inch.

This company manufactures the well-known Elmet wire for thermionic tube hooks, grids and plates.

▲

MICROPHONE AMPLIFIER

The single microphone line amplifier Model No. 506, manufactured by Wireless Egert Engineering, 179 Varick St., New York, is used for broadcasting and public-address work. The unit is especially handy for its extreme portability, being entirely self-contained and measuring only 16" x 7¼" x 7½". The weight of the amplifier is only 20 lbs. including all batteries. The unit is built into a metal portable cabinet and is extremely rugged for all outdoor use. The amplifier uses transformers generally accepted as standard by broadcast officials.

The amplifier accommodates a double-button or single-button microphone. The output is designed to work into a 500 ohm line. The gain of the amplifier is 40 db. A filament voltmeter and plate milliameter are supplied for reading microphone, plate and filament current. A plug and jacks are supplied to give current indication on each tube as well as each button of the microphone. An overall gain control is supplied. The frequency characteristic is essentially flat over the entire range between 70 and 6,000 c.p.s. A monitor jack is supplied for headphones.

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PENTODE OUTPUT TRANSFORMERS

A pentode output transformer designed to couple the new single power pentode tube to the voice coil of a dynamic speaker, is now being marketed by the Thordarson Elec. Mfg. Co., 500 West Huron St., Chicago, Ill.

▲

NEW LONG-WAVE COILS

The General Manufacturing Company, 8066 So. Chicago Ave., Chicago, Ill., announces a new four-bank long-wave coil for radio frequency.

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NEW TUBE PRODUCTS

The Cable Radio Tube Corporation, 84-90 North Ninth St., Brooklyn, N. Y., announce the introduction of two new tubes.

Television Lamp

The Speed television lamp differs from those formerly available in that it is of the wall-electrode type. This construction offers marked advantages including improved efficiency and greatly increased high frequency response.

The wall-electrode tube may be operated directly in the plate circuit of a '71A tube. It is not however, recommended for use with the '45 or '47 except where the plate current is limited to 20 ma.

With the '47 Pentode a series resistance of several thousand ohms should be used to improve the load characteristics. With the triode output tubes this series resistance is unnecessary since the operating impedance of the wall-electrode tube is sufficiently high to offer a favorable working load.

The Speed crater lamp is a point source of light for use in an optical television system such as lens discs, mirror wheels, etc. Its brilliance is such that with a scanning system of normal optical efficiency an image of 5 " x 6" in size may readily be obtained. Owing to the differing constants of optical systems employed in commercial apparatus, the Speed crater lamp may be obtained with sources of several diameters. Those carried as standard are .0135", .020" and .040". Other sizes are special.

Because of its relatively low operating impedance the Speed crater lamp should be operated in circuits especially designed for its use. It is not intended for operation directly in the plate circuit of a vacuum tube.

In order that an impedance match between tube and load be more readily obtained it is suggested that the receiver output stage employ two 245 type tubes in parallel.

INDEX OF ADVERTISERS

Wait for the New

ACRACON

DRY ELECTROLYTIC CONDENSER

THE Condenser Corporation of America will soon announce a new line of DRY electrolytic condensers companion to the famous Acracon wet electrolytic unit which is now specified by over 30 leading radio manufacturers.

News of the Acracon DRY unit has been withheld until exhaustive laboratory tests under all conditions have proved its design and construction are absolutely perfect.

The Acracon DRY unit meets the need of manufacturers for an electrolytic condenser that can be conveniently and successfully mounted horizontally or beneath the chassis. Several other exclusive features are incorporated in its design, which is as original in the DRY type as the Acracon wet unit was when it was introduced.

Wait for announcement soon of specifications and characteristics.

*"Acracon" Features Are Protected by Patents Pending

CONDENSER CORPORATION OF AMERICA

259-271 Cornelison Ave. Jersey City, N. J.

Factory Representatives in:

Chicago, Cincinnati, St. Louis, San Francisco, Los Angeles, Toronto

and other Principal Cities

Bakelite Malded tube bases made by Associated Attleboro Manufacturers, Inc, Attleboro, Mass

Protecting the heart of the set

with Bakelite Molded

Tubes are vital parts of radio receivers and of many other electronic devices. Subjected to high frequencies and often to high temperatures for long periods of time, they must be well constructed, and insulated with materials that retain their dielectric efficiency indefinitely under severe service. Bakelite Molded has long been and continues to be the choice for tube bases of many kinds.

Bakelite Molded possesses high dielectric and mechanical strength and its insulating efficiency is unaffected by moisture, age or temperature variations. In addition, this material lends itself to economical production through the use of multiple cavity molds and through the molding-in of metal inserts. Its fine lustrous finish adds attractiveness and enhances the salability of devices for which it is used.

We invite the manufacturers of all kinds of electronic devices to investigate the many advantages of Bakelite Molded. If you have a problem requiring a low-loss material, a heat resisting or some other special insulator, there is undoubtedly some Bakelite Material to fill your need. Write us for booklet 38M, "Bakelite Molded".

Bakelite Engineering Service — We manufacture a wide variety of Bakelite resinoid molding materials, varnishes, lacquers, enamels, cements, and other products. Twenty-one years experience in the development of these materials for electrical and other uses provides a valuable background for the cooperation offered by our engineers and laboratories.

BAKELITE CORPORATION, 247 Park Avenue, New York. CHICAGO OFFICE, 635 West Twenty-second Street

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

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THE MATERIAL OF A THOUSAND USES