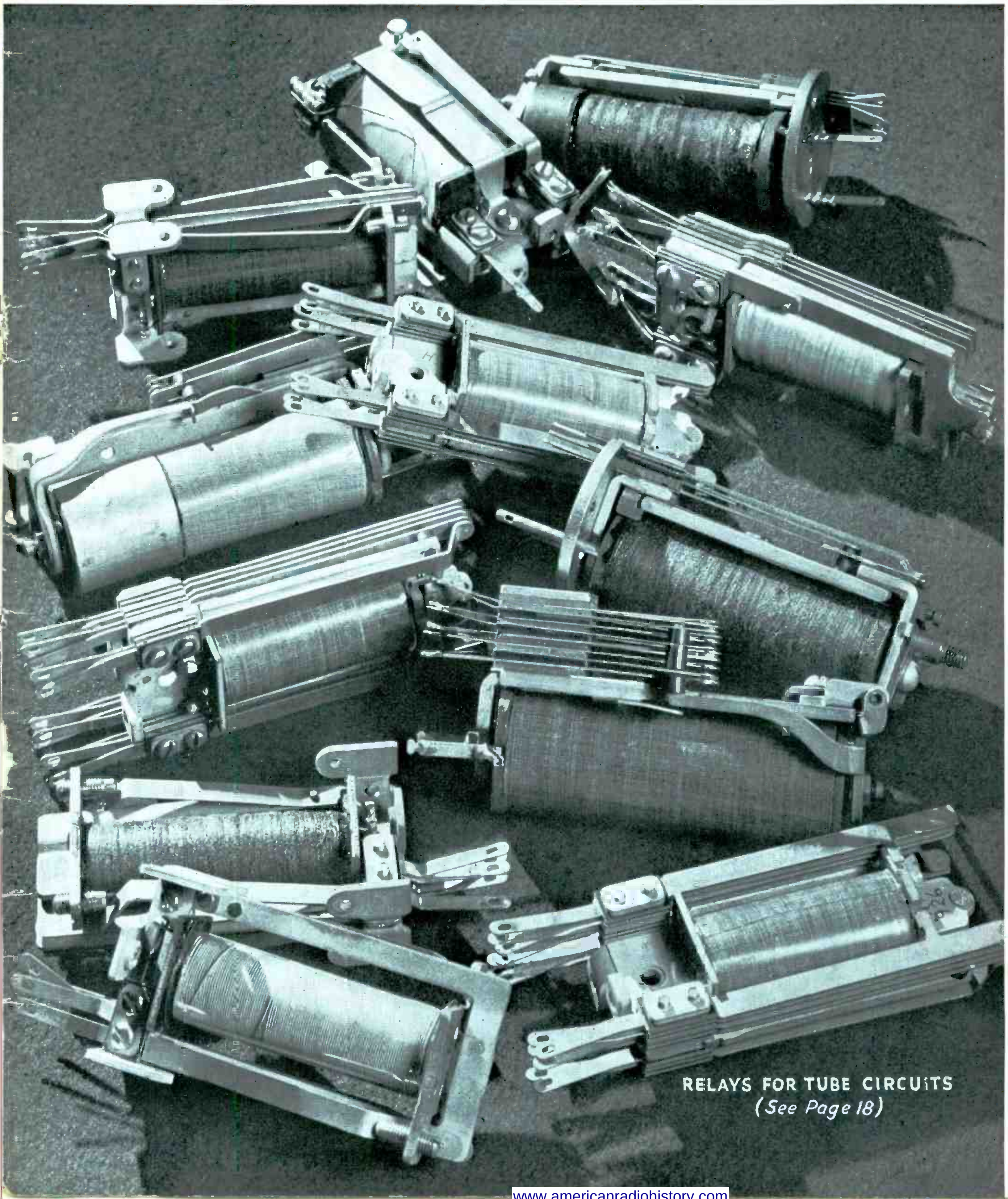
electronics

radio, communication, industrial applications of electron tubes . . . engineering and manufacture



RELAYS FOR TUBE CIRCUITS
(See Page 18)

MAY 1938

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electronics

RADIO . . . COMMUNICATION AND INDUSTRIAL APPLICATIONS OF ELECTRON TUBES . . . DESIGN . . . ENGINEERING . . . MANUFACTURE

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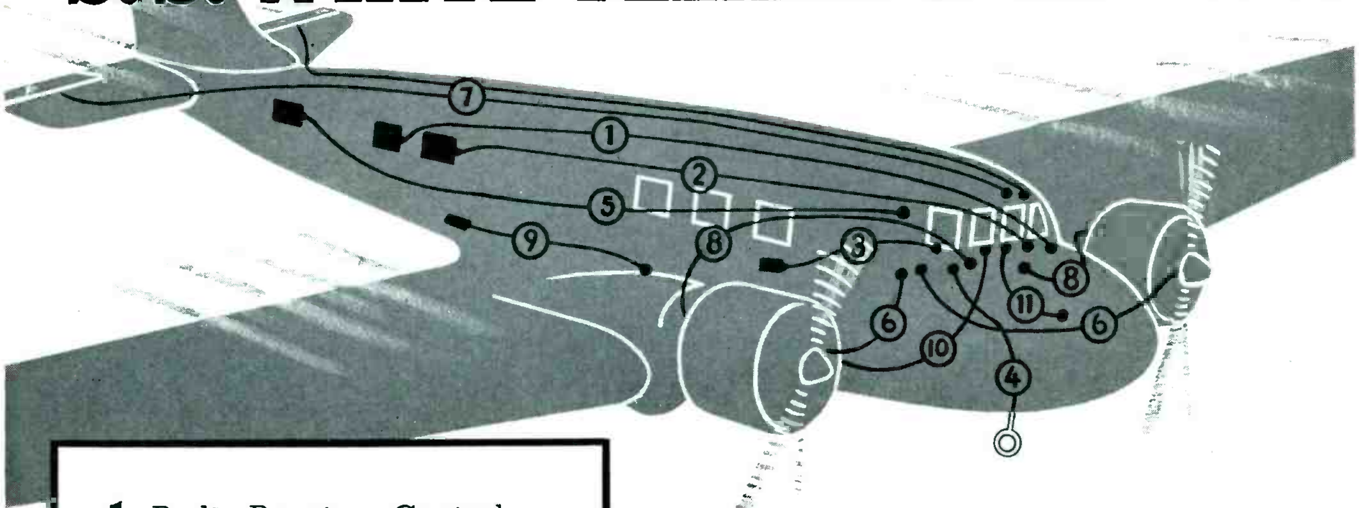
CONTENTS—MAY, 1938

DEPARTMENTS

AIRCRAFT applications confirm the utility and reliability of

S. S. WHITE FLEXIBLE SHAFTS



1 Radio Receiver Control.
2 Radio Transmitter Control.
3 Beacon Receiver Control.
4 Radio Compass Loop Control.
5 Antenna Reel Remote Control.
6 Variable Pitch Propeller Adjustment.
7 Tab Controls.
8 Tachometer Drive.
9 Fuel Pump Drive.
10 Windshield Wiper.
11 Gyro Pilot Control.

. . . and others in process of development.

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1ST. commercial water-cooled amplifier tube for short waves. (240 type with built-in water jacket, used in transatlantic telephony.)

1ST. commercial vacuum tube with grids in register.

1ST. commercial vacuum tube using a molded glass dish stem. (The 316 "door-knob" tube.)

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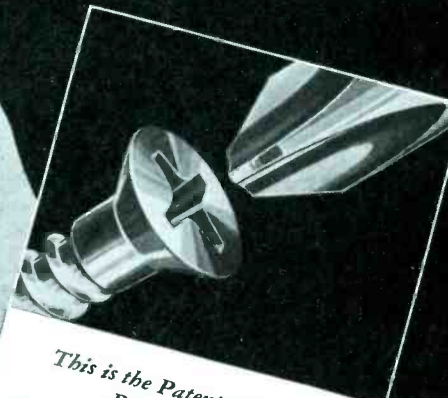

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ELECTRONICS

MAY
1938

KEITH HENNEY
Editor

Crosstalk

▶ **EDITORS AFIELD** . . . What with Spring the editors find New York and environs pleasant to cruise about in, and having dug themselves out of their editorial winter office, have been trying to find out what the depression has done to the laboratories.

Despite personnel changes of considerable magnitude the places where research goes on are busy; the front office may be sad about sales but there is no need to worry about new things coming along to sell. There is no dearth of new materials, new products, new tools.

At Radiotron there is a whole galaxy of new tubes in various stages of development. One of these, the OA4-G, is described in this issue of *Electronics*. It has interesting possibilities outside the field of communication. Other tubes will push further into the ultra short wave regions; and still others will prove to be of material aid in television. This is not all that is going on under Messrs Ulrey, Thompson, Ritter, Schmit, Zworykin, Spitzer, et al, but most of this work cannot be mentioned at the moment.

At W. G. H. Finch's laboratory the editors found engineers making high speed motion picture studies of certain of the mechanical motions in the facsimile recorder which has attracted such great attention from broadcast stations. One of these recorders will be in service in *Electronics*' offices by the time these lines are in print.

At the RCA License laboratory one of the finest television pictures yet seen was on tap. In the laboratories of Continental-Diamond Fibre company, near Philadelphia, the editors saw new equipment for measuring the characteristics of insulating material at frequencies up in the megacycles. And in *Electronics*' own laboratory a television receiver neared completion. On the night of April 21, NBC's one-hour "telecast" show was enjoyed.

During the month, new and more efficient methods of lighting were demonstrated by General Electric and Westinghouse in New York. These applications of electronics and atomic physics are vapor tubes with hot cathodes. Their luminous efficiency is high, of the order of 70 lumens per watt for those lamps which emit a green color. Tubular in shape, these lamps employ certain phosphors which emit various colors when excited by the ultra-violet lines in the mercury spectrum. Green, red, yellow, pink, "warm white" and "day light" white present new possibilities to the architect, the decorator, and the advertiser.

▶ **PATENTS** . . . Late in April Dr. Sydney N. Baruch had granted to him U. S. Patent 2,113,392 on a continuously controlled gas tube. Dr. Baruch feels that his tube, in which the grid can stop the flow of current as well as initiate it, has distinct possibilities. In the thyratron only the starting of current flow is under control of the grid.

During the month, U. S. Patent 2,114,939 with some 83 claims was granted to Albert A. Radtke. According to Leonard Day, Radtke's patent attorney, many of the claims are basic in the arts of sound-on-film reproduction, facsimile transmission, television and all high speed amplified photo-electric circuits. Seventeen years of litigation lie behind this patent. Six thousand pages of testimony represent the court struggles. Radtke's work dates back to 1916.

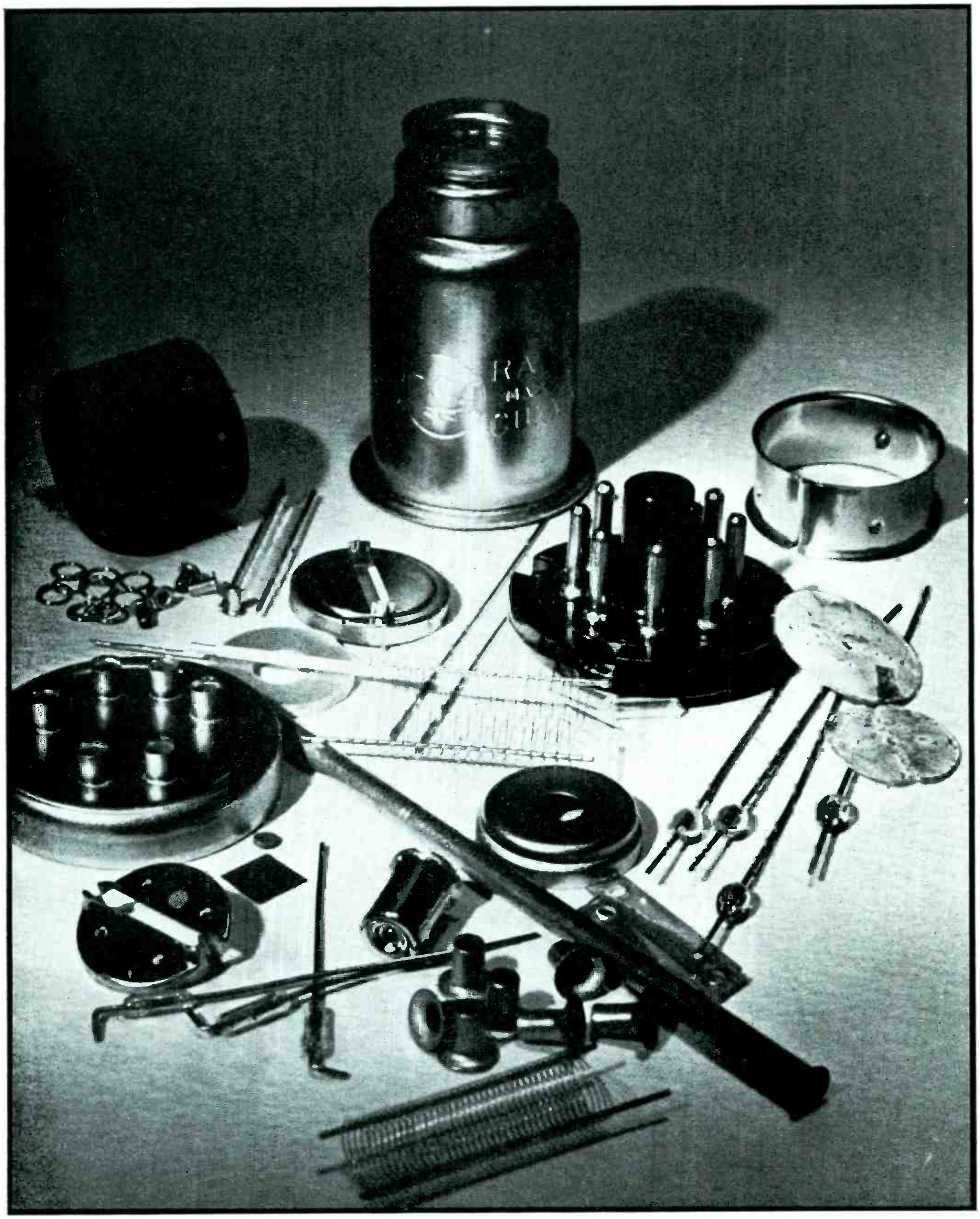
▶ **JOKE** . . . A Chinest observer in an Eastern firm's armature windery was admiring a welder who was using a torch to strip the cotton insulation from two wires and to join them permanently in one operation. In his choicest Canton University English the Chinese queried: "I beg your pardon, but don't you contaminate this joint by such procedure?" The welder, astonished at the apparent colloquialism turned to the white-collared guest and grinned: "Oh heck, no! This here place is big enough to hold at least twenty more welders and still it wouldn't smell much."

▶ **RELAYS** . . . In this issue will be found a dissertation on relays for vacuum tube circuits. Originally planned as a complete survey of the field it was soon found that an entire issue of *Electronics* could be devoted to the subject.

It has been impossible to discuss the types of relays, their applications in the electronics field, to give contact ratings, to specify average or representative coil characteristics, to give the tolerances which might be expected for the pull-in and release currents, to list the various possible contact sizes, shapes, and materials, to answer the thousand questions which may be asked.

However, answers to all of these questions can usually be found from the manufacturer. Even though he may not know the answers to all questions asked of him, a man may still be a good engineer if he knows how and where to get the information. The editors acknowledge with pleasure the most helpful cooperation of manufacturers in supplying data for this article.

▶ **PROBLEM** . . . Alan S. Fitzgerald, who is doing things with rectifiers that would make your head swim, sends along this problem. Imagine a series circuit made up of a 15-volt, 60-cycle supply, 10 ohms resistance, a rectifier, an inductance of 0.6 henry and 10 ohms resistance and an ammeter. Across the inductance and ammeter is a 10-ohm resistor and a switch. With the switch open, the ammeter reads 30 milliamperes. With the switch closed the current through the meter reads 200 milliamperes. Explain that.



The works of a metal tube. A Leica photo by Arthur Van Dyck showing the 50-odd parts that go into the making of a metal-shell amplifier. Recent changes in design have changed somewhat the appearance of the header and certain of the smaller parts

". . . To promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries."

This is the eighth power granted to Congress by the Constitution of the United States. It is the basic patent law of the land. It grants a monopoly as a reward for development and discovery: on this principle has been based nearly all of the revolutionary technological and mechanical progress that has occurred in the last hundred years.

But the Administration is in a drive against monopoly. One cannot grant monopolies on one hand; and on the other hand drive them out. The Patent Law, therefore, seems to be in for a change. Before the House Committee on Patents there is a bill (H. R. 9259) introduced by Representative McFarlane of Texas which proposes to grant the licensee of a patent an exclusive monopoly for 5 years. Then an application for a license to manufacture under this patent can be filed with the Commissioner of Patents provided the patent is not being used; or that the domestic supply of the product made under this patent is insufficient to satisfy the public demand or that unfair trade practices or prices prevail. If the evidence on these points is satisfactory, if the applicant is financially responsible and able to manufacture, if the public interest will be advanced and if the applicant submits reasonable terms for royalties, etc., it is presumed that the Commissioner will grant the applicant his license. The bill does not prevent the patentee or owner from going to court if he does not wish to grant the license.

It is extremely doubtful if such a bill will pass at this session; but it is also extremely likely that hearings on the proposal will develop information upon which a future bill will be drafted.

The use of electron tubes is thoroughly tied up with patents issued, expired, and still to come. Therefore any bill which proposes to change the rules of the patent business must be of particular interest to engineers who must operate under these patents.

The following article was submitted to *Electronics* several months before the McFarlane bill was presented; it is written by a man who has patents in his own name; who has worked for large companies; and who has had his own concern manufacturing and selling devices patented by him. It is one man's viewpoint; and it does not necessarily represent the attitude of the Editors of *Electronics*. It is offered as a starter in a discussion of the patent problem; and it is hoped that readers who believe that the proposed change in the patent law is a good, or bad, idea will let other readers know their opinions through these pages.

—THE EDITORS.

WAYS TO IMPROVE THE U. S. PATENT SYSTEM

OUR patent law is just over 100 years old. With its assistance American inventiveness has created an industrial empire never before equalled in the history of the world.

It is a fair assumption that the patent system had a considerable share in building up our industrial enterprises. Certainly patents have had a strong place in popular imagination. Such names as Colt Patent Fire Arms, patent medicine, patent leather indicate that a patented article has had a strong sales appeal. There are still thousands of people who believe that if they could just get a patent on some gadget or other of their own inventiveness, their economic troubles would be over. And yet, today, a patent is too commonplace to be a badge of distinction.

The patent statute itself was quite adequate in the days of simple processes and mechanical inventions made up of uncomplicated elements. It falls woefully short of even modest expectations in our day of electrons, catalyzers and super vacuums. Let it be said here, however, that no criticism of the statute itself is meant. It was evidently conceived in a spirit of high idealism with proper thought of the interests of the inventor and of the public. But broadmindedness of the law itself leaves too much leeway for varying interpretations to make the statute serviceable in our time of overwhelming complication and detail.

The evolution of engineering from things which can be seen, felt, or measured and which can be grasped by untrained minds to the things invisible and elusive and often immeasurable—which even the best minds can interpret only with difficulty—has put a great strain on our patent system.

Definitions Become Difficult

To be of value to the patentee a patent should clearly describe the invention, in such a fashion that no doubt can arise as to what the patent covers. The public interest requires that the description circumscribe the invention clearly so that the specification may not be interpreted to cover anything the inventor did not invent.

That is next to impossible under prevailing conditions in the patent field.

We must remember that inventions resulting purely from rough experiments may involve abstruse principles, that these principles have to be made part of the patent specifica-

Serious questions are raised by the proposed change in the patent system. How prove a patent is not being used? Or that there is an insufficient supply of the patented article to satisfy the public demand? Would there be more, or fewer, abuses than now exist?

tion, no matter whether they result from a thorough investigation or whether they have been just guessed at. It is quite obvious that principles which have been hardly grasped by the inventor must present a formidable hurdle to the patent attorney charged with drawing up the application and the examiner who must thoroughly analyze it.

At first glance these contentions may be startling but they are amply borne out by our experience with early radio patents. Many of these patents covering most useful devices antedated by several years a thorough understanding of underlying phenomena. We need only think of Marconi's whip-lash theory of the spark transmitter, or De Forest's emphasis on ionization as the basic phenomenon in his vacuum tube. We know now that ionization was not necessary to the function of the tube.

This precarious situation is well defined by those who claim a patent to be only a license to fight.

Priority Hard to Establish

If the proper description of an invention is a nearly impossible task, the establishment of novelty is fraught with even greater uncertainty. The patent laws of other countries cut this corner by arbitrarily making the filing date the date on which priority is based. Only patents applied for or in public use before this date, or prior publication, are considered as prior art. Once a patent is granted it is seldom invalidated. This method of dealing with patents is, of course, very practical and expedient but it does not protect the actual inventor and considers the patent office as infallible.

This is a policy which is repugnant to American thought. We consider the original inventor as the only man entitled to patent rights. Therefore we delve into laboratory journals, wastebaskets, attics purporting to contain old models, even into the brain of the inventor and the witnesses until they remember things they have never seen or heard of. As we think the patent office very fallible we carry our litigation to the highest court of the land.

A system so uncertain is highly idealistic in its conception but it actually makes patent litigation an excellent instrument of monopoly, a wonderful field for clever lawyers. It makes money invested in a patented invention a gamble, pure and simple, and in no way does it protect an impecunious inventor.

The difficulty in establishing priority is caused largely by a totally erroneous conception of the genesis of inventions. According to popular belief an invention springs from the brain of the inventor quite finished in form. This belief was evidently held by those who devised the patent system and it can still be traced through all the ramifications of our patent lore.

Nothing could be further from the truth than this fairy tale. An invention is often suggested years before the means are available for working it out practically. Paddle-wheels were used on steamboats long after screw propellers had been suggested. The electron tube rectifier did not come into use until long after Edison made the first diode. There was no demand for rectifiers. Practical electronic rectifiers had to wait the development of tungsten and oxide coated filaments. Tungsten filaments were developed for incandescent lamps with no thought of their subsequent use in electron tubes. Coated filaments were available before the shortcomings of tungsten sent research men scurrying for something better, a hunt which produced the coated cathodes of today.

Before Edison could make a good lamp he had to make a good generator; but the idea of enclosing a filament in a glass bulb and heating it by electricity was suggested, and tried, before Edison made his generator or his filament contributions.

Inventions are not born within the brain of one particular man merely as an expression of his genius. Actually they grow over a long period of time in the consciousness of research men, experimenters as a cumulative product of prevailing ideas, the availability of means for their accomplishment, and of growth of favorable markets.

New Definition of Invention

If ideas are hard to define and to tie up with definite dates, they are also too plentiful to serve as a proper basis of patent rights. After all, neither the inventor nor the public can derive any benefit from an idea until it is reduced to something that can be marketed.

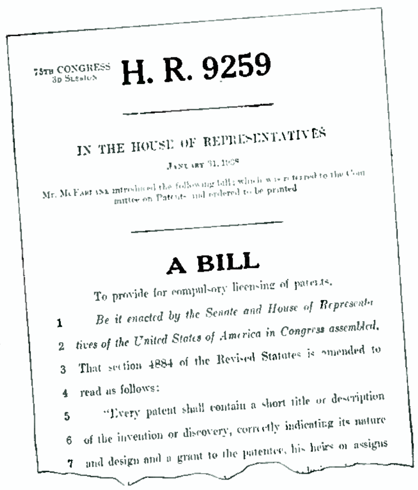
Suppose, therefore, we limited patents to cover workable devices designed and built to serve a definite useful purpose. The purpose is to be clearly indicated. Workability must be actually proved first by blue prints and working drawings giving all information necessary to build the device or execute the process or by a working model.

If drawings are accepted as proof of workability the patent may later be held invalid if the drawings are proved insufficient. A workable model, however, should be accepted as prima facie evidence of workability.

Let us illustrate this by an example. An oscillator consisting of a power supply and an oscillator tube is not a useful device per se. An oscillator equipped for use as signal generator, as a diathermy apparatus, as a radio transmitter, as an induction heater is a useful device. Each one is an invention in itself and should be patentable as such without regard to the fact that all contain the same basic principle. This is of course a radical departure from tradition, but only radical changes can bring our patent system up to date.

At first glance this proposal appears to put too narrow a construction on an invention but this is hardly so. The fact that a mere circuit patent would be no protection will set the laboratories scrambling to evolve practical applications. After all that is what we want.

Coming back to our oscillator example, it might be held with considerable degree of justification that oscillations are so prevalent, with hard tubes that any skilled worker in the art could not have failed to observe this phenomenon as soon as he had highly evacuated tubes to work with. The application of oscillating tubes to radio transmitting or their use in a regenerative receiver were not quite so obvious at the time of their invention. At any rate they were useful inventions. Patents should have been issued to cover these uses and not to cover a natural phenomenon. The fact that all devices using oscillators are subject to the original oscillator patents even if the original inventor did not think of the new use has been a deterrent to many people and a lure to easy profits for the less scrupulous who consider patent infringements as just another exciting and lucrative game.


75th CONGRESS
3d Session

H. R. 9259

IN THE HOUSE OF REPRESENTATIVES

January 31, 1938

Mr. McFarlane introduced the following bill; which was referred to the Committee on Patents and ordered to be printed

A BILL

To provide for compulsory licensing of patents.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That section 4884 of the Revised Statutes is amended to read as follows:

"Every patent shall contain a short title or description of the invention or discovery, correctly indicating its nature and design and a grant to the patentee, his heirs or assigns

Novelty

An invention must be new. It is proposed that an old device modified and altered to serve a new purpose should constitute invention as well as the application of a new device or process to a known purpose.

The well known principle that technical skill is not invention should be retained but it might be defined more closely. We might decide that mere extrapolation on the basis of known art is not invention but if the basic law is changing in the region of the new embodiment this fact would make it a new invention.

An example will illustrate this principle. Let us assume that the gas or vapor tubes with pressure sufficient ot produce complete elimination of space charge have been invented first and later by increasing the vacuum the high vacuum tube was produced.

It is clear that the two types of devices respond to different laws in many respects, yet a difference in degree of vacuum may be their only physical difference. In this case the high vacuum tube is an invention quite distinct from the vapor tube, yet the modern high vacuum tube would not be granted novelty over the old De Forest tubes, because the latter followed substantially the same laws, the higher gas pressure constituting only an imperfection. The manufacturer of the new high vacuum tube might however be entitled to patents for processes for obtaining the high vacuum if they stand the test of novelty.

An amended patent statute should clearly express the principle that an inventor can never claim devices or processes which he has not invented. In spite of its apparent absurdity such a statement is necessary to preclude a type of injustice which is frequent under customary interpretation of the law.

A striking example is that of De Forest's invention of the three element tube. Professor Fleming did not invent the grid controlled vacuum tube of today. His invention was the use of a diode as a detector for radio communication, yet his patents were held to dominate De Forest's invention.

How Much Monopoly?

Under the definition of a patentable invention here suggested De Forest would not have been dominated by Fleming because the De Forest device differed considerably from that of Fleming for the reason that it added the effect of the grid to it and because it performed as a detector substantially better than Fleming's valve and also because it was capable of functions other than those of the Fleming valve.

Another question to be considered seriously is the degree of monopoly to be granted the patentee. Up to date he has not only a complete monopoly on his actual invention but he can put serious obstacles in the way of others by claiming a lot of combinations which cover devices very different from his original invention. He can withhold his patent from being manufactured and sold, he can prevent anyone from marketing even substantial improvements of his device.

This situation is hardly in the public interest. After all, patents should stimulate industry instead of retarding it. It is very well for the patentee to make large profits if he does it by producing large quantities of the patented article efficiently. He should not, however, be able to impede progress by withholding inventions from commercial production.

Some countries have attached to holders of granted patents the obligation to manufacture and sell, but such provisions in the law have not proved particularly effective because it became easy to evade the law by a few staged sales.

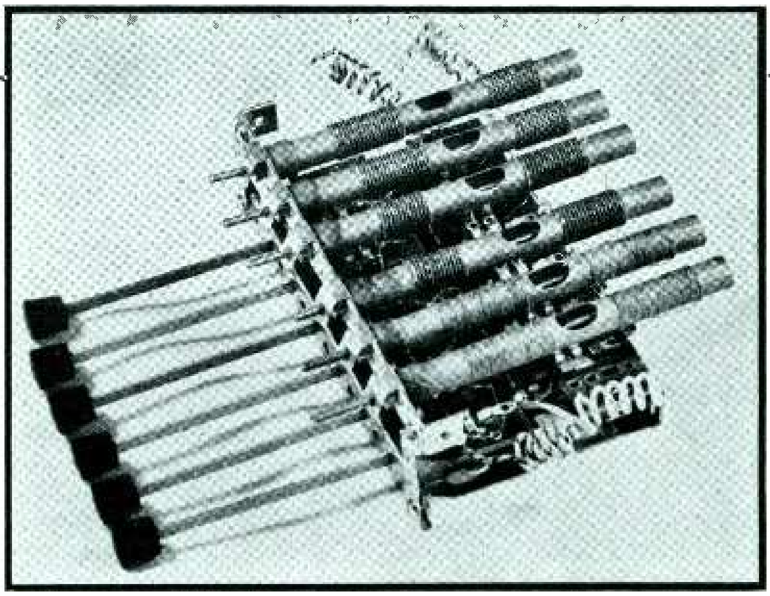
Considering this problem of patent monopoly from several points of view it seems that all parties concerned would be best served if the patentee would be given only a right to claim substantial royalties, (say 10% of list price) but not the right to prevent others from manufacturing.

This form of monopoly would leave the patentee a sufficient advantage over his competitors but it would produce enough competition to stimulate the original patentee to keep progressing in manufacturing and sales methods or improvements lest his royalty differential be nullified by the better methods of his competitors. Such a patent system could be very useful. At present, in many of the newer arts, control may rest in the hands of a single, or a very few, large companies. With a few licensees, this controlling group may be surrounded by a flock of chiselers and professional patent infringers doing business in racket style annually exacting considerable toll from the patent holders in the form of litigation expenses. Such an atmosphere is not one to lend general public approbation to the art.

If the patentees were entitled only to royalties there would be limited

(Continued on page 34)

A PERMEABILITY TUNED PUSH BUTTON SYSTEM



Experimental permeability tuned assembly and switch minus tuning condensers

By JOHN P. TUCKER

Chief Engineer
General Manufacturing Co.,
Chicago, Ill.

INCREASING interest in recent months in radio receivers employing push-button station selecting systems has led to the development of several distinct methods of accomplishing this type of tuning.

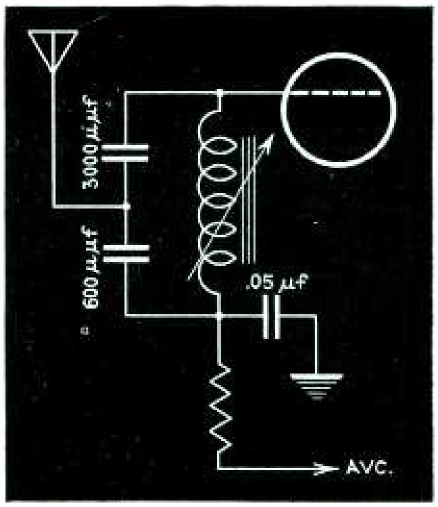
These systems may be divided into several classes, viz: (a) motor driven, (b) mechanical, by cam and lever, (c) electrical tuning by mica compression condensers, (d) permeability tuning of antenna and oscillator circuits. Systems a, b, and c each have their own merits and no attempt will be made to cover them in this discussion. This article will be confined to a system employing ganged permeability tuning of antenna and oscillator circuits.

Considering the fact that the ultimate customer is the person who must decide which stations are desired and who may, in many cases desire, (or be required as in the case of mobile equipment operating for short periods of time in various localities) to make these adjustments himself, it is the duty of the set designer to produce an automatic tuning system simplified to the point where only one adjustment is necessary per station. This adjustment should be simple enough to be readily made by the layman without special instructions or service equipment, and should be of such a nature as to be readily accessible to the operator.

A system employing ganged permeability tuning of antenna and oscillator circuits for use in the conventional superheterodyne circuit reasonably fulfills these conditions. This system provides the following: Station selection by single control and with an ease of tuning that can be compared to the conventional variable condenser equipped with a high ratio dial; instant selection due to absence of mechanical arrangements and moving parts; and ease of adaptation to modern set design without expensive tooling charges on the part of the set manufacturer.

Since switching is to be accomplished by push button, and in order that this will not become too complicated, and for economic reasons which are quite evident, magnetic coupling has been avoided. (The use of magnetic coupling either requires the use of an individual primary for each coil or the use of an end inductance coupled to a primary and common to all coils. The individual primary presents certain coupling problems as the core position changes within the coils.) A two-terminal antenna coil employing capacity coupling as illustrated in Fig. 1 has therefore been utilized. The oscillator circuit is subject to the same limitations and since a two-terminal oscillator coil is desirable a Colpitts oscillator has been employed rather than a two-terminal oscillator coil utilizing a two-tube circuit. Figure 2 illustrates the Colpitts circuit. In most cases it is desirable to use the same tube complement in both manual and automatic tuning positions. An examination of Fig. 3 will reveal the use of these circuits in conjunction with the 6A8 tube as a Colpitts oscillator and mixer tube in the automatic tuning position and as the con-

Fig. 1—Two-terminal antenna coil with capacity coupling



ventional pentagrid oscillator in the manual tuning position.

Switching from automatic to manual position is accomplished by the band switch S_1 S_2 S_3 S_4 although it is entirely feasible that an extra button could be provided for this purpose, providing that present designs of push button switches lend themselves to the proper contact arrangements. In view of the fact that many receivers incorporating touch tuning will also have not only the conventional broadcast band but at least one short wave band, change-over switching by the band switch will probably prove more practical.

It would be highly desirable to be able to select any station in the broadcast spectrum on any push button, but because of present core limitations it is not feasible to produce a coil designed around simple iron shapes that will have a tuning range of greater than about 2.2 to 1. In this particular design the maximum range is 1.9 to 1.0 which therefore limits the assembly to the following ranges: 540 kc. to 1000 kc. and 870 kc. to 1650 kc. However, for other reasons the high frequency range in this setup covers only from 1000 kc. to 1600 kc. Since these two ranges provide for no overlap to accommodate stations in the intermediate portion of the broadcast band it was deemed advisable to include a third range of 600 kc. to 1100 kc. To allow grouping in certain localities where desired station frequencies may be crowded into a small portion of the broadcast spectrum it may be necessary to use various combinations of these three ranges rather than two coils of each range for a six station setup. This is left to the discretion of the set designer as dictated by requests from the field.

Since the frequency coverage of each range is limited by the antenna coil, it is essential to design this coil to utilize the maximum effective permeability of the core. This is accomplished by proper design of coil form factor with respect to core form factor. These data were derived from empirical curves plotted on various types of windings on which different parameters were successively varied.

Oscillator Circuit Design

Having provided for maximum frequency coverage by proper antenna coil design the next consideration is the design of the oscillator coil to provide a substantially constant frequency difference between the signal frequency and the oscillator frequency with the same linear displacement of antenna and oscillator coil cores. This "tracking" can be accomplished by one of several methods: i.e. (a) form-factor of coils with respect to form-factor of cores (similar cores), (b) form-factor of cores with respect to form-factor of coils (similar coils), (c) similar coils with cores of different permeabilities, (d) similar coils and the addition of tracking inductance, (e) combinations of the above. In this particular design the tracking is accomplished by proper design of coil and core form factors, (a combination of methods (a) and (b)).

With regard to the choice of tuning capacity, it is desirable for production reasons that it shall be large with respect to wiring capacities, so that variations from set to set in receiver production will prove to be no handicap in the alignment of the push button assemblies. As a practical working value 500 $\mu\mu f$ has been chosen and coil design was carried along on this basis. Any other desired capacity could have been used as the basis for design without involving any particular complications.

The choice of intermediate frequency is left to the desire of the set designer. Probable frequencies being 262 kc. for automotive use and 456 or 465 kc. for household receivers. The assembly illustrated was designed for 262 kc.

The antenna and oscillator coil Q

(*Continued on page* 34)

Fig. 2—Colpitts oscillator for two-terminal inductance

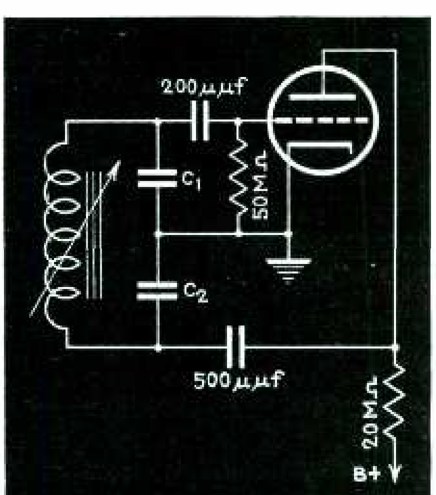


Fig. 3—Colpitts oscillator and mixer automatic tuning position; conventional pentragrid converter in manual tuning position

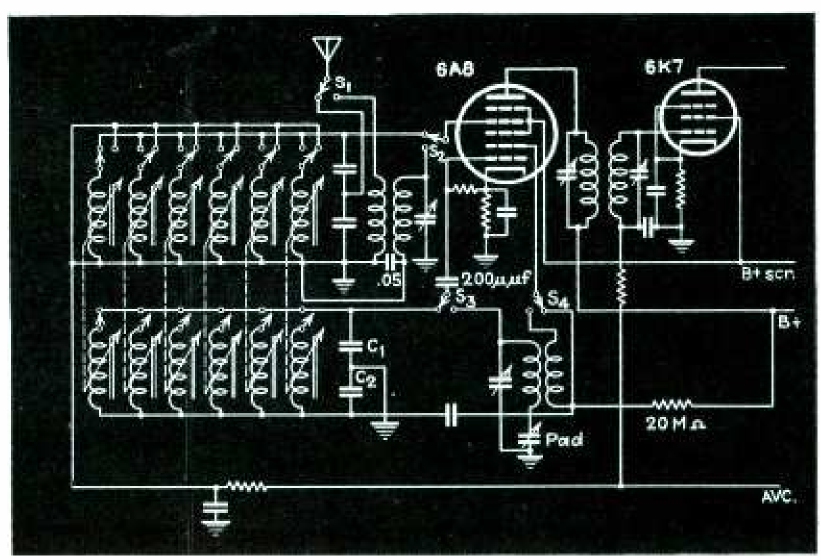
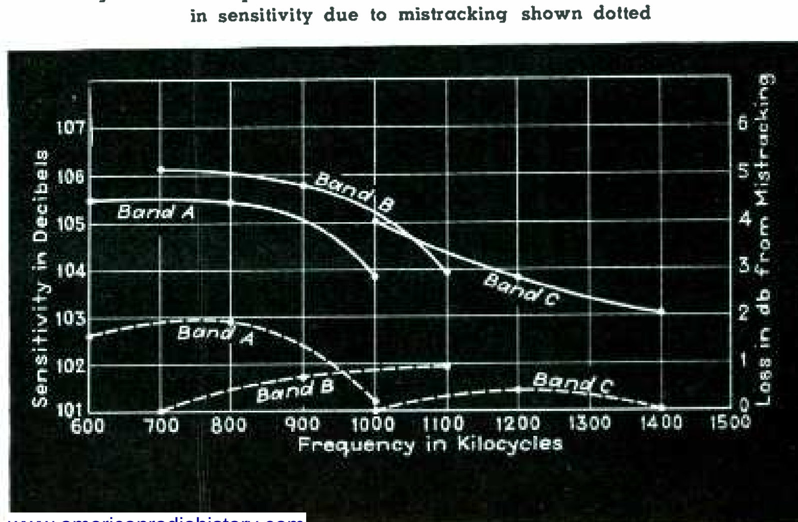


Fig. 4—Sensitivity in microvolts below 1 volt at antenna (solid). Loss in sensitivity due to mistracking shown dotted



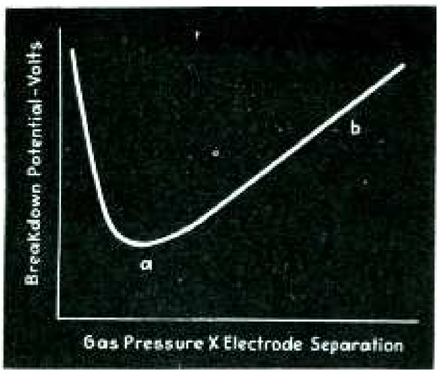


Fig. 1 — Paschen's law on which gas tube depends

A NEW COLD-

By W. E. BAHLS
and C. H. THOMAS
*Research and Engineering Dept.
RCA Manufacturing Co., Inc.
Harrison, N. J.*

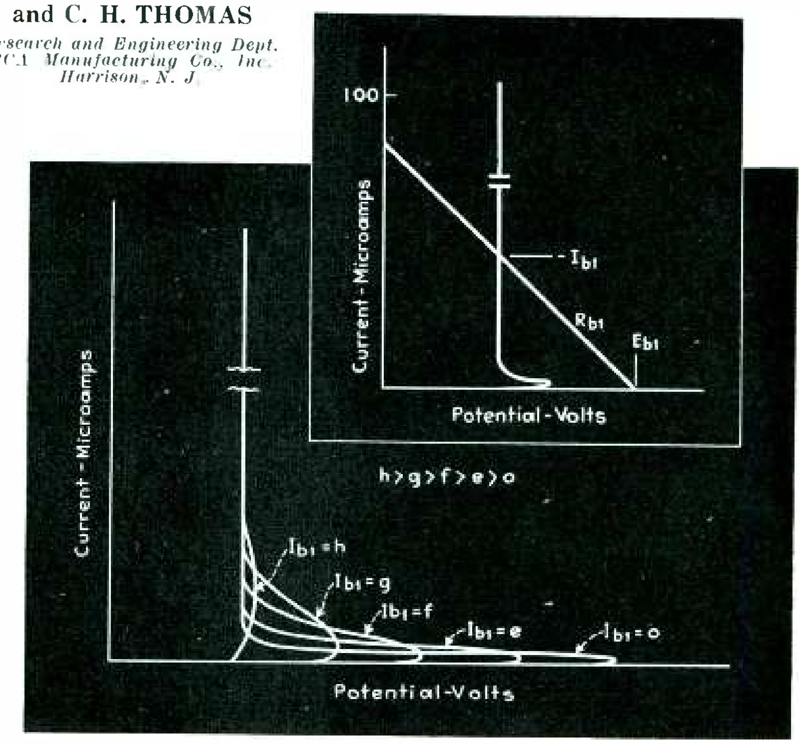


Fig. 2—First anode breakdown characteristic

Fig. 3—Second anode to cathode breakdown characteristic

MANY methods for remote control of radios or appliances have been devised. Most of these require that a low energy signal be sent to the apparatus to be controlled, where it is amplified to a sufficient strength to actuate a relay or other mechanism. At least one tube at the receiving end must always be available for instantaneous operation, and, therefore, if it is of the ordinary vacuum type, its cathode must be maintained at operating temperature continuously.

A new method of remote control,* which obviates this undesirable feature, was recently described by C. N. Kimball. This method employs a cold-cathode, gas-triode instead of a vacuum tube. Such a tube is always ready for operation, and requires no power during the standby period.

The newly developed OA4-G is a tube well-suited for this application. It is the purpose of this paper to describe some of its features and how it operates.

This tube is a cold-cathode, gas-triode of the starter-anode type. It is designed primarily for operation of a relay from the 115-volt a-c supply line, when a low energy actuating signal trips the tube. This signal may be either low frequency or radio frequency.

Since there is no hot cathode present to supply electrons for the conduction of current, they must be supplied by ionization by collision within the gas. The resulting current flow is limited only by the load impedance. The tube has a specially activated cathode in order to obtain a low tube voltage drop so that it will conduct over a considerable portion of the positive a-c half cycle, and not require too high peak currents. Structural relationships are such that the tube is rectifying in action. The resulting current flow, when the tube is used on an a-c supply, is unidirectional and pulsating, and the relay must be designed accordingly.

The tube is mounted in the standard, dome-type ST-12 bulb and has an octal, six-pin base.

General Theory

The OA4-G depends, for its operation, upon two well-known principles of gaseous discharges; first, the breakdown potential between two electrodes in a given gas at a fixed pressure is dependent upon the spacing between the electrodes; and, second, the breakdown potential is lowered when ionization is present in the gas.

Let us consider the case of two plane, parallel electrodes mounted so as to be movable with respect to each other, in a container in which the gas pressure can be varied. If we study the breakdown potential between these electrodes for all combinations of gas pressure and electrode separation, we find that it is a function of the product of electrode spacing and gas pressure. This relationship is known as "Paschen's Law."

Although this relationship is true only for plane, parallel electrodes in a pure gas, the same general shape of curve is obtained for more complex electrode configurations, if we plot breakdown voltage as a function of electrode separation in a gas at a fixed pressure.

Let us consider, therefore, a tube having a large cathode (K) and a first anode (P_1) separated from the cathode by a distance "a" and a second anode (P_2) separated from the cathode by a distance "b". Potentials may be applied to the various electrodes as indicated by the circuit of Fig. 4. As the potential of electrode P_1 is raised, a value is reached where breakdown in the gas occurs, and current is limited only by the impedance in series with the elec-

* A New System of Remote Control, Charles N. Kimball, *R. C. A. Review*, January, 1938; demonstrated at Rochester Fall Meeting, 1937, and at N. Y. Meeting of I. R. E.

CATHODE GAS-TRIODE . .

trode. The volt-ampere characteristic is of the form shown in Fig. 2, where the maximum value of potential is the first-anode breakdown potential and the potential indicated by the vertical straight line is the cathode-to-first-anode drop of potential.

Similarly there is the same general type of characteristic curve for breakdown between the second anode and the cathode. However, the breakdown voltage will be higher because of the longer spacing (see Fig. 1) and in addition the cathode-to-second-anode drop of potential will be slightly higher. The volt-ampere characteristic is as shown by the curve marked $I_{b1}=0$ in Fig. 3.

If the volt-ampere characteristic is taken for the cathode to second anode after a discharge has been initiated between the cathode and first anode, it is found to be modified in breakdown potential by an amount depending upon the magnitude of I_{b1} flowing to the first anode. This is indicated by the curves of Fig. 3 marked $I_{b1}=e$; $I_{b1}=f$, etc.

Plotting the values of breakdown voltage between cathode and second anode as a function of the current flowing to the first anode gives a curve of the type shown in Fig. 5. For the conditions under which this curve was taken, it is convenient to think of the discharge as having transferred from the first anode to the second anode; consequently, this curve is called a *transition characteristic*.

Since the first anode (P_1) serves the function of starting a discharge and lowering the potential at which a discharge will initiate to the second anode, it may be termed the *starter-anode* or *starter* and in all the following discussion will be spoken of as such. The term *anode* then will refer to the second anode (P_2). In the OA4-G the circular disc is the cathode, the wire loop just above it is the starter-anode, and the wire extending out of the glass sleeve is the anode. (See page 16.)

The principal mode of operation of a starter-anode type tube then is as follows: (a) a potential is applied to the anode, which at no time exceeds the anode-cathode breakdown potential when there is no starter current flowing; (b) an energizing impulse is applied to the starter so that the starter potential exceeds the value of the cathode-to-starter breakdown potential for a time sufficient to initiate a discharge to it; (c) the resulting starter current, as determined by the starter circuit impedance, lowers the breakdown potential to the anode sufficiently that a discharge starts to it; (d) the anode current actuates a relay or performs whatever function is allotted it.

For any gas-discharge tube containing three electrodes, it is possible to initiate a discharge between any two of them, and with either one of these electrodes serving as the instantaneous cathode and the other as anode. Therefore, there are six different values of potential which describe the breakdown characteristics of a gas triode of the type under discussion. In addition the potential on the third electrode may so influence the potential distribution that the breakdown potential between the other two electrodes is modified by it.

Consequently the only accurate way of describing the breakdown characteristics is by means of a graphical representation in which the potentials of all electrodes may be given.

To be specific, all further discussion will pertain to the characteristics of a typical RCA-OA4-G.

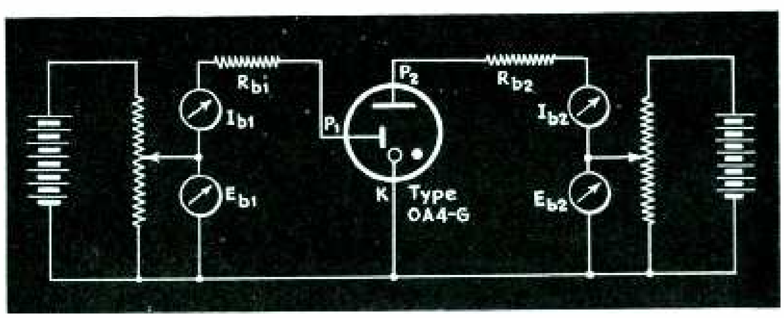


Fig. 4—Circuit for examining characteristics of gas tube

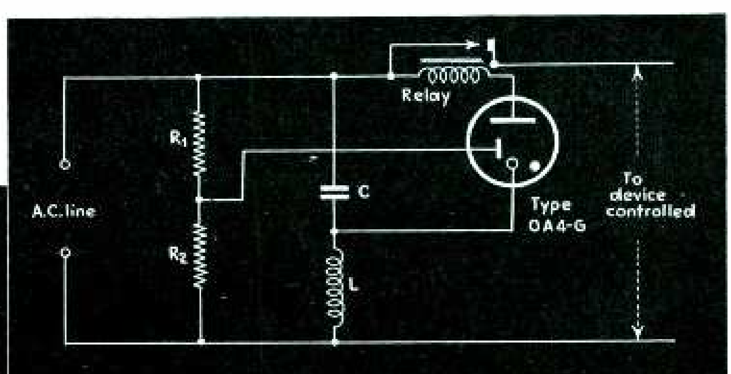


Fig. 6—Circuit for remote control of radio set or other device

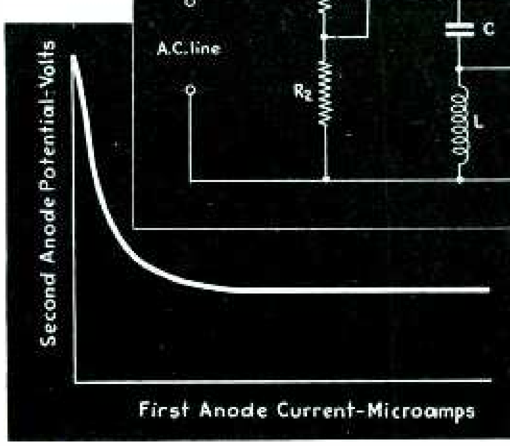


Fig. 5—Breakdown characteristic as function of first anode current

Characteristics of the OA4-G

The breakdown characteristics for the OA4-G are given in the curve of Fig. 8. If the anode and starter potential at any instant before conduction define a point within the closed curve, no breakdown will occur. A discharge will initiate when the point thus defined crosses outside the closed loop. The electrodes between which the discharge takes place depends upon the region of the curve crossed.

The section A of the curve defines under what conditions breakdown takes place between cathode and

Photograph showing internal structure of new gas tube

starter. It corresponds to the maximum of the volt-ampere characteristic shown in Fig. 2. Section A is almost a vertical straight line, from which we may conclude that the breakdown from cathode to starter is not influenced to any noticeable extent by the anode potential.

The cathode-to-starter drop of potential is approximately 60 volts and if the starter-supply voltage and resistance are known, the starter current can be determined by

$$I_{b_1} = (E_{b_1} - 60)/R_{b_1}$$

The transition characteristic then shows whether or not this current is sufficient to cause the anode discharge to initiate for the applied value of anode potential.

The section B of the breakdown characteristic defines the conditions for which a discharge will initiate directly between cathode and anode. It may be seen that the starter potential affects the breakdown somewhat, for if there were no effects, this portion of the curve would be a horizontal straight line.

Section D shows the region in which a discharge will initiate between the starter and the anode. Due to the close proximity of the cathode to the starter, the discharge will transfer to the cathode for very low values of current between the starter and anode.

If the cathode potential had no effect on the starter-to-anode breakdown voltage, then the difference between anode potential and the starter potential would be constant. As may be seen from the curve, this is not quite true. The cathode potential plays a considerable part in modifying the starter-to-anode breakdown.

Over the region D a breakdown again takes place between the starter and cathode electrodes. The starter,

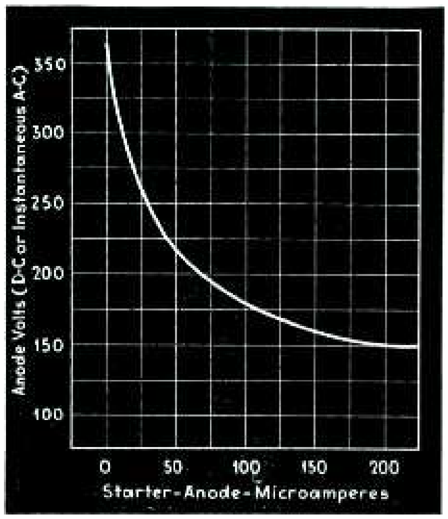


Fig. 7 — Average transition characteristic of the OA4-G

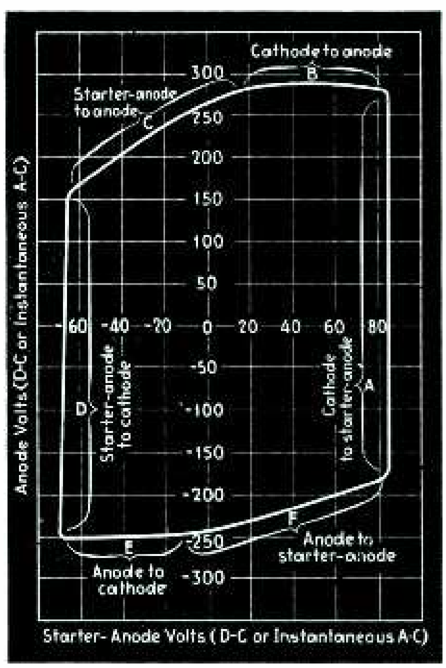


Fig. 8—Breakdown data for the OA4-G

however, is serving functionally as the cathode. The discharge can transfer to the cathode-to-anode region if the anode potential is above the tube drop of potential and the current between starter and cathode is sufficient. The transition characteristic for this type of operation is somewhat similar to Fig. 7 but the current required is lower.

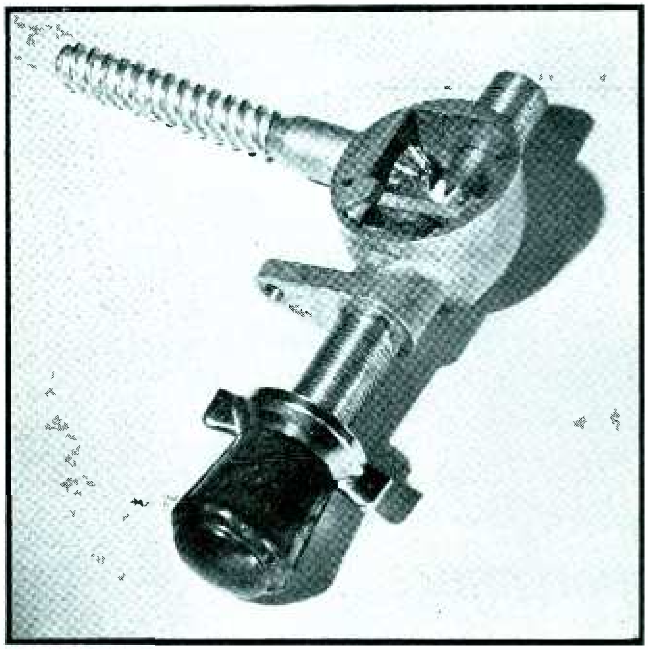
When the anode is negative, the discharge can transfer to it acting as a cathode. However, due to the high drop of potential in this mode of operation, the current that will flow will be very low. This current will, in general, not be enough to cause operation of the relay and consequently the only indication that a breakdown has taken place within the tube will be a light purple glow about the anode. This is also true in the regions E and F where breakdown takes place directly to the anode electrode acting as a cathode.

The curve of Fig. 8 shows all the six possible ways in which breakdown can occur in the OA4-G. The only manner in which the tube is intended to give consistent and uniform operation, however, is by the initiation of a discharge to the starter which in turn transfers to the anode to complete the operation. Consequently definite variation limits are placed on the portion A of the breakdown characteristics. In addition, in order that the peak of the supply potential shall not exceed the value of the cathode-to-anode breakdown voltage, as defined by the portion B of the characteristics, a minimum value is selected for this characteristic with considerable allowance being made for possible non-sinusoidal supply voltages and line voltage surges. The other breakdown characteristics, since they are of relatively little importance in the normal operation of the tube, may vary over quite a range, in general, having a considerably greater value than indicated in the typical characteristics of Fig. 8. A limit is also placed on the value of the starter current required to complete the transition of a discharge to the anode.

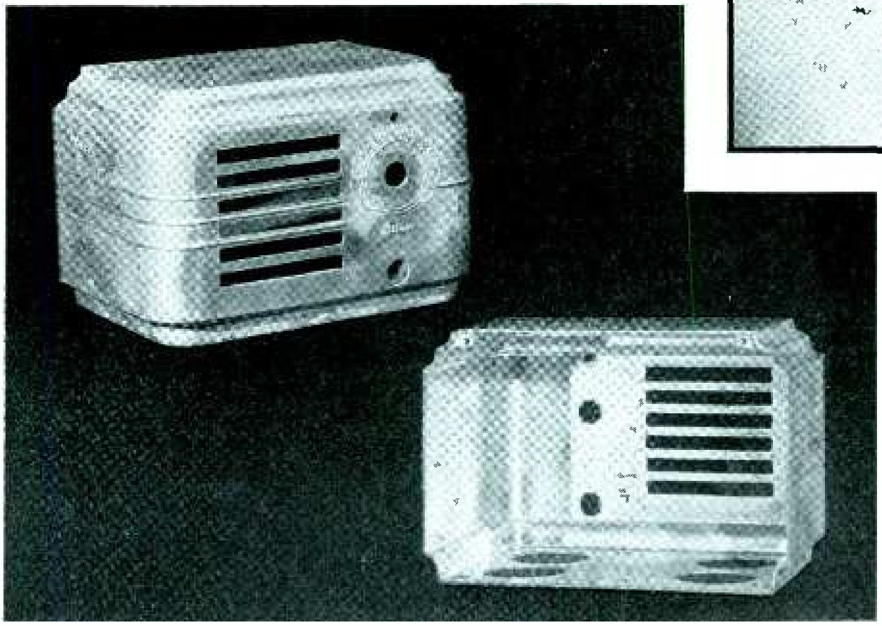
All the characteristics which have been described are of the so-called static type. They may be applied for instantaneous values of a.c. at low frequencies with considerable accuracy. At high frequencies, however, there may be a considerable departure from the static characteristics due to the appreciable time re-

(Continued on page 72)

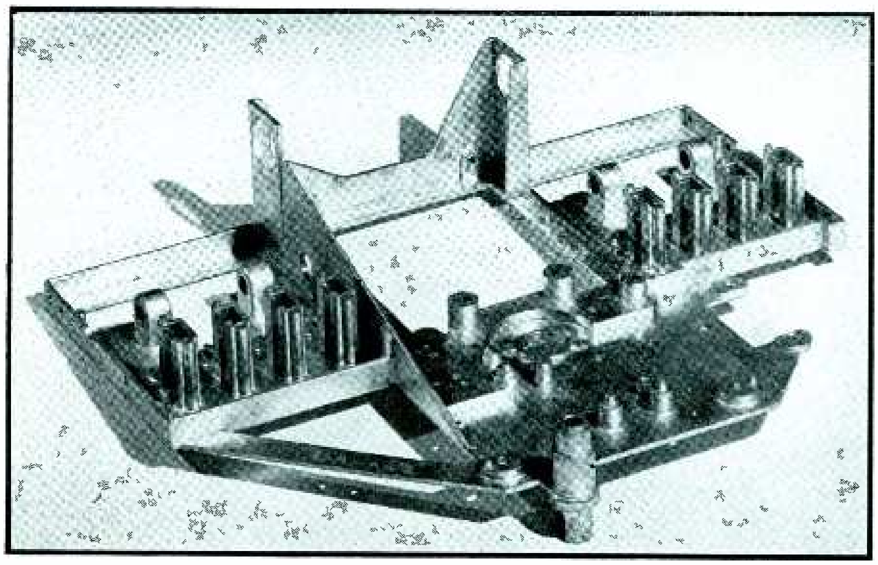
Recent Die Castings For Radio Receivers



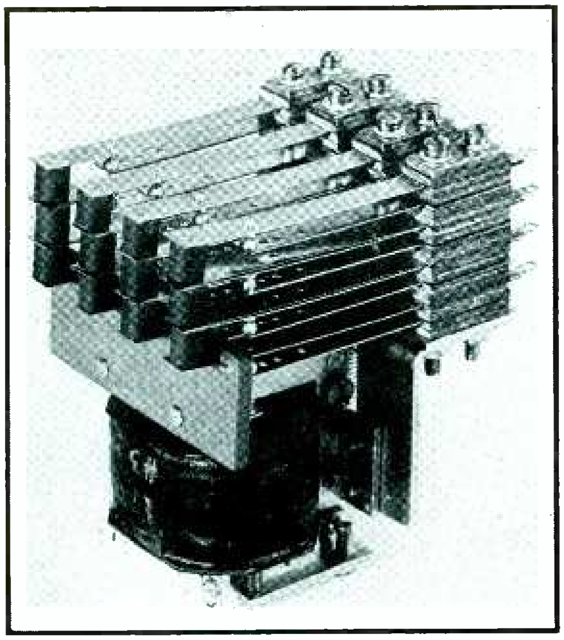
Compact, inexpensive automobile radio control made by Star Machine Company. Housing, gears and bezel are die cast in zinc alloy; held within tolerances of ± 0.001 in. for all important dimensions. Most of the other parts, except the plastic knob are made from screw machine products including worm for operating dial. Sleeve between threaded stem and knob shaft actuates small cam for throwing switch and knob shaft is connected, in service, to a flexible shaft leading to set on car dash

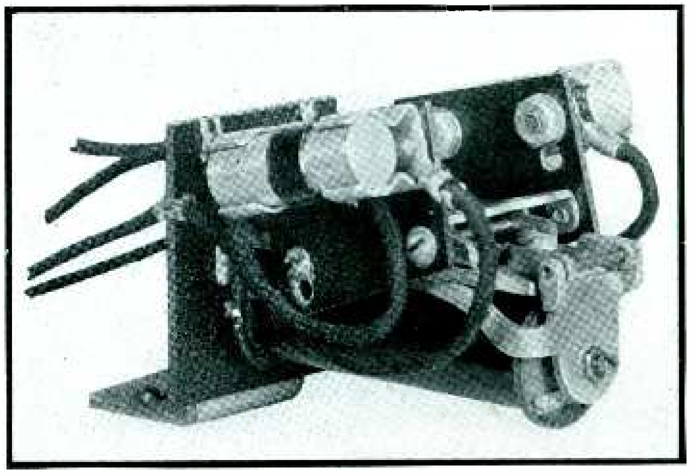


Views of new Silver midget receiver case. Measures 6¾ x 4½ x 4⅜ in. weighs 28 oz. Zinc alloy used is high in impact strength, readily cast in sections as thin as sheet metal for same purpose is likely to be. Surfaces remarkably smooth as they come from the die. All holes seen in front view are cored and the beading, dial figures, and trade mark are formed by die as are the integral mounting bosses. The case is capable of taking any one of the many organic or electro-plated finishes



Complex zinc alloy die casting, frame for electric drive tuning, Wells Gardner radio. Opening in front right corner provides space for mounting drive motor; bosses in foreground serve chiefly as rigid supports and/or pivots for reduction gears, clutch, pulleys. Reversing switch mounted above triangular opening and 4 vertical slotted posts at each side accommodate tuning plungers. Uprights at back provide bearing supports for setting-disc shaft. Motor switch, levers, spring supports, brackets, etc. also mounted on casting. Only by die casting can a unit structure of this complexity be made with acccurate dimensions and smooth surface at moderate cost

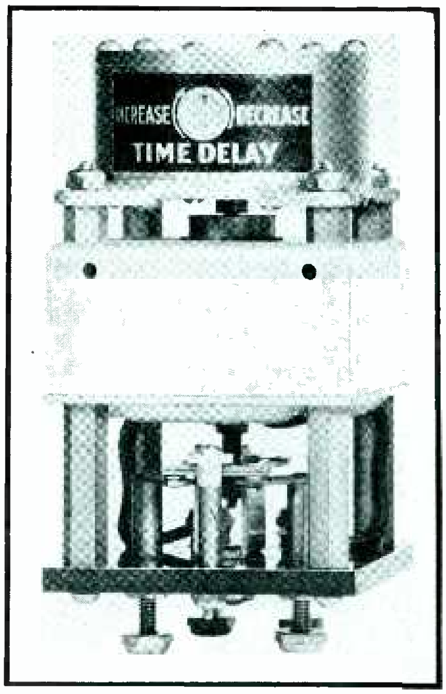




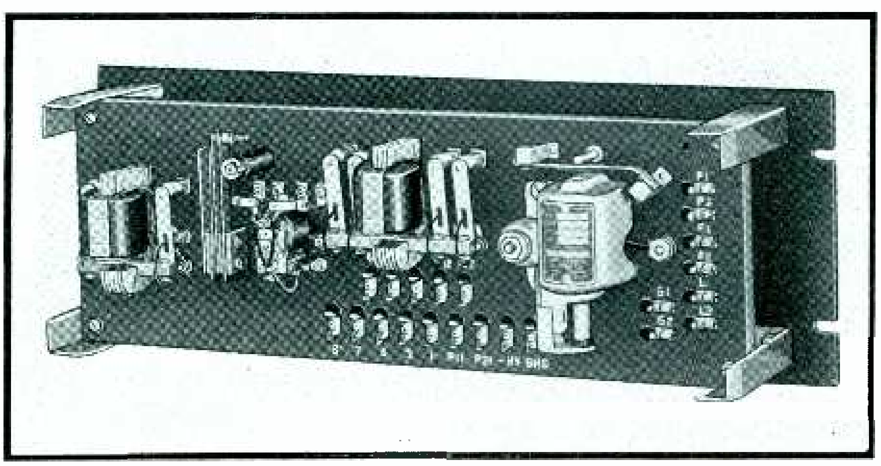
A telephone type relay with two metal clad mercury contacts which will control 15 amperes at 110 volts, a.c. The cartridge type contacts are interchangeable

Above. Relays are available with a wide variety of contact arrangements and contact sequence of operation. The power required to energize the relay depends upon the number of contacts which are actuated

Right. A totally enclosed time delay relay which depends for its delay interval upon the flow of air between two chambers. Time delay may be varied by means of a screw driver adjustment



Below. Relay rack transmitter control panel providing automatic control and protective circuits, for applying the voltage to the electrodes of electron tubes in the proper sequence



RELAYS

By BEVERLY DUDLEY
Associate Editor, Electronics

As its applications in the fields of measurements, industrial control, and communications steadily increase from year to year, the electron tube is being called upon continuously to perform more detailed, intricate, and extensive functions than ever before. With a better general understanding of the functional operation of the tube, and with greater uniformity of the manufactured article, there is also an increasing tendency toward making tube circuits as fool-proof and automatic in operation as possible. The extensive and intensive applications of electron tubes which have taken place during the past decade or so, have demanded that tubes be used with auxiliary control equipment of one kind or another. Of this auxiliary equipment, that class of devices commonly known as relays, is perhaps the most important.

The manner in which relays may be used in connection with electron tube circuits, and the functions which these two types of devices working in conjunction, may be called upon to fulfill, are almost without number. Relays in the plate circuits of vacuum tubes may be used to control considerable amounts of power from minute voltage variations. Especially in gas or vapor filled tubes, relays may be used to provide voltages to the tube electrodes in proper sequence in order that damage to the cathode due to ion bombardment, or damage to associated equipment may be avoided. In communication applications, relays are used in tube circuits for protecting these circuits from underload or overload conditions, for automatic break-in, wave changing, and keying, or for minimizing shut-downs due to arcs and high voltage transients. (See Electron Art Department, this of current for which the coils are designed, and sometimes according to (9) the type of auxiliary equipment, such as counting and latching mechanisms, with which the relay is provided. For any particular application, it may be well to give some attention to all of these factors, but for the purpose of writing an article (rather than a treatise) on the subject, it has seemed desirable to limit discussion to electromagnetic relays. Such relays, when used with electron tubes, have been somewhat arbitrarily classified into the following groups: (1) a-c relays suitable for operation at frequencies usually used in power circuits, (2) d-c relays, (3) super-sensitive relays operating with currents of 1 ma. or less, (4) sensitive relays operating with currents of from 1 to 100 ma., (5) power relays or contactors operating with currents in excess of 0.1 ampere and usually provided with contacts suitable for controlling appreciable amounts of power, (6) thermally operated relays, and (7) relays whose contacts may be opened and closed in consequence of some time variation function as well as some specified value of current or voltage.

All relays of the type which we are considering consist of three essential parts: (1) the coil assembly (which may consist of several individual and separate windings) for establishing or for aiding in the establishing of the magnetic flux, (2) the core, providing a magnetic circuit of variable

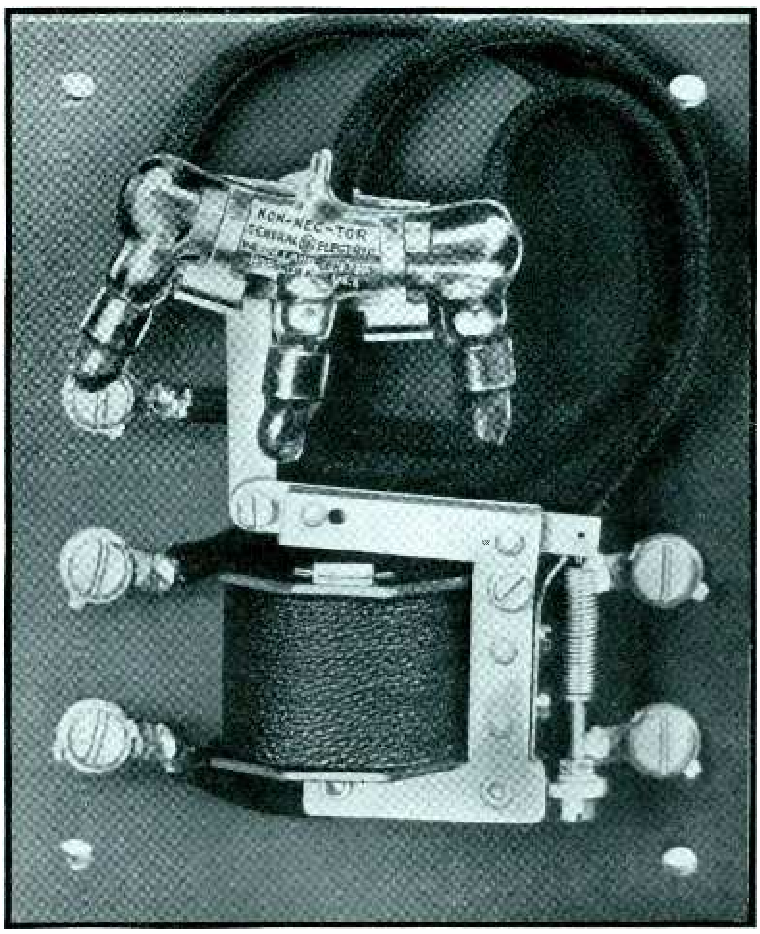
FOR TUBE CIRCUITS . . .

issue.) In the industrial field, the actual and potential applications of relays to extend the usefulness of tube circuits are almost without number.

Because of the practical importance of relays as an adjunct to tube circuits, it is desirable that those who have occasion to use control equipment be conversant not only with the physics of the electron tube and its engineering application, but that they have some understanding of the characteristics and operation of the auxiliary relay devices. Many pitfalls can be avoided, and, consequently, many an otherwise troublesome circuit can be made to perform satisfactorily, if sufficient attention is given to potential sources of trouble during the design period.

Classification of Relays

Relays may be (and a glance through manufacturers' catalogs will show that they are) classified according to: (1) type of physical construction, (2) principle of operation, (3) intended function, (4) voltage, current, or resistance characteristics, (5) type of contacts, (6) sequence of opening and closing contacts, (7) speed of closing and release, (8) type



Relay drawing 8 watts d.c. or 15 watts a.c. provided with mercury contacts which will carry 10 amperes at 125 volts, or 5 amperes at 250 volts in a non-inductive circuit

and relatively low reluctance, a portion of which is subjected to physical motion, and (3) the contact assembly which is actuated by the armature or clapper of the magnetic core.

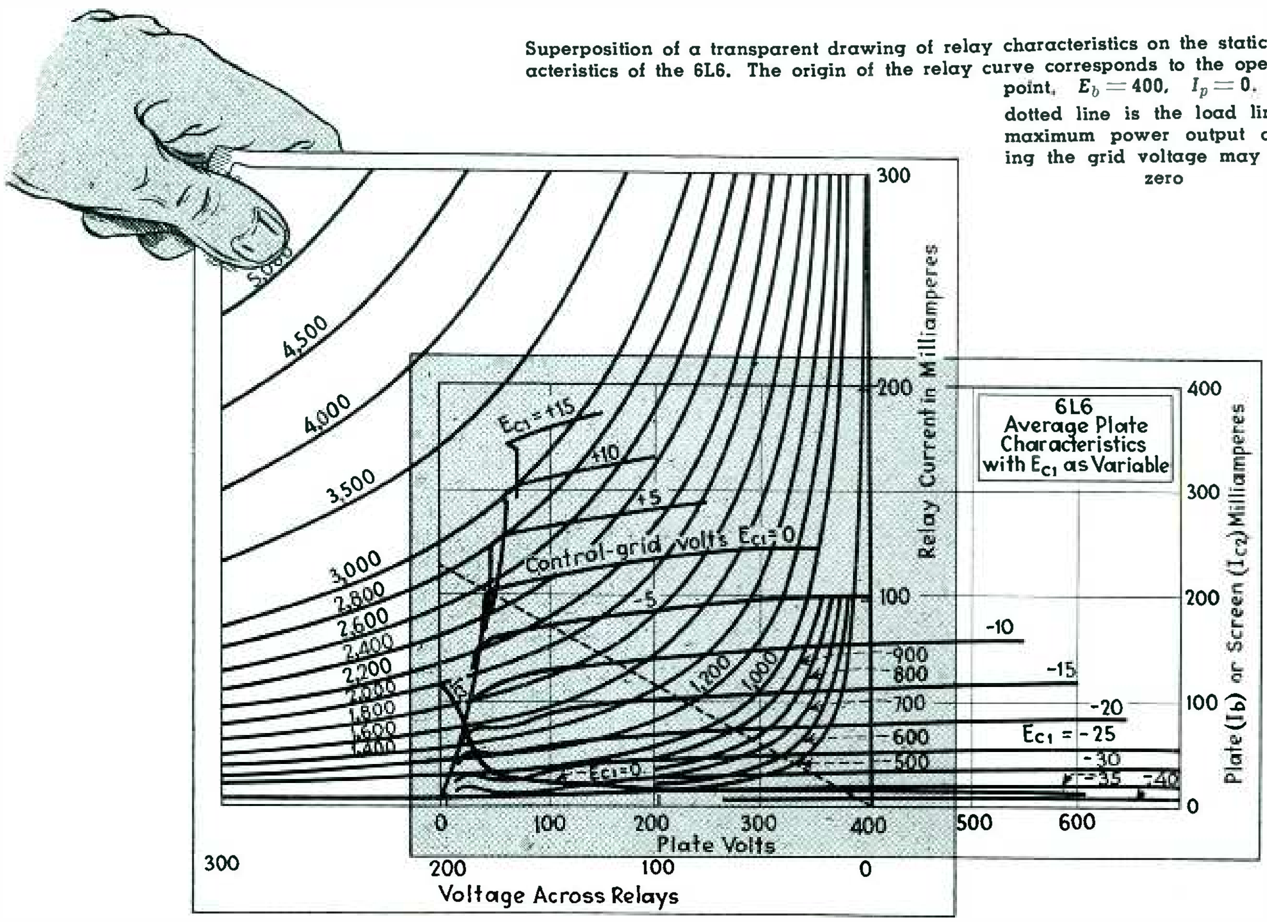
Relay Fundamentals

The essential operation involved in the relay device is the definite opening or closing of one or more circuits through the proper use of contacts which are made to separate or come together when the armature or clapper is moved. The contacts are opened or closed through the motion of the armature whose position, in turn, depends upon the opposing forces established by the magnetic flux set up by the electromagnet on one hand, and spring tension, gravitational pull, or the opposing flux established by some other magnetic circuit on the other hand. In order that the relay operate satisfactorily, it is essential that the open and closed position of the armature be definite and positive in action. Except, perhaps, in the case of relays based on the principle of the d'Arsonval galvanometer where extreme sensitivity is of prime consideration, properly designed relays fulfill this requirement by providing a large leakage flux when the armature is opened. For some critical value of flux, the armature closes, reducing the reluctance of the circuit so that the armature is held tightly, and the contacts are not likely to be affected in operation by vibration.

The construction of electromagnets which actuate the armature or clapper with varying degrees of rapidity is of considerable importance in the design and proper application of relays and is fundamental to the successful operation of relays operating on a.c. The speed or sluggishness of operation is largely determined by the degree to which eddy currents are permitted to flow in conductors which are within the magnetic field of the electromagnet. Induced eddy currents act in such a direction as always to oppose a change in the existing magnetic flux, so that the flux established by the eddy currents effectively reduce that set up by the electromagnet. As a consequence, any system which reduces the eddy currents established in the magnetic field of the relay will assist in increasing the speed of operation, whereas slow operation (or operation from a.c.) may be obtained by providing relatively large amounts of eddy current losses.

Since only small eddy currents are induced in laminated cores made of a bundle of fine, iron wires, such a core is useful in those cases where a quick acting relay is desired. On the other hand, by providing a copper sleeve between the iron core and the coil windings of the relay, or by providing rings or slugs of good conducting material on the core of the relay, slow action, especially with regard to the "release" condition, may be obtained. The degree of sluggishness or delay which may be obtained depends upon the material of high conductivity which is within the magnetic field of the coil. It is quite conceivable that sluggishness of operation may sometimes be obtained unintentionally through improper placing of conducting materials too close to the magnetic circuit of the relay.

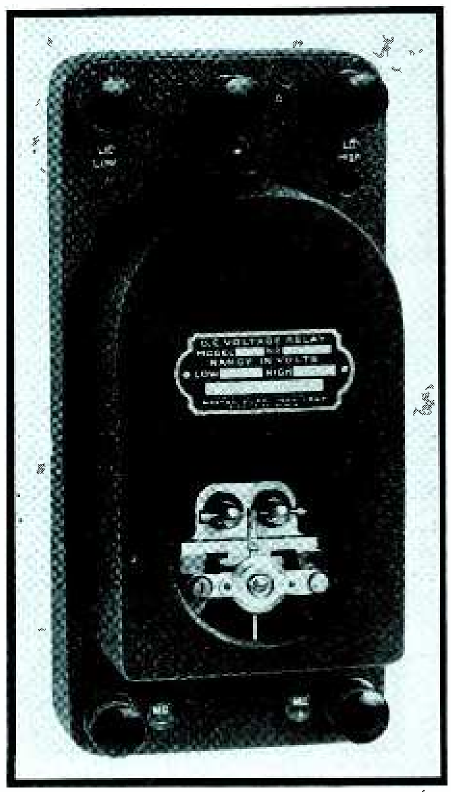
Coil design for relays is an important and specialized branch of engineering. Because of the general availability of relays of many vari-



Superposition of a transparent drawing of relay characteristics on the static characteristics of the 6L6. The origin of the relay curve corresponds to the operating point, $E_b = 400$, $I_p = 0$. The dotted line is the load line for maximum power output assuming the grid voltage may go to zero eties and types, with coils available from stock (or on short order) for almost any application, it is unwise for the individual user to attempt the design of his coils and magnetic circuits for a specific relay application. For a given application, it is quite possible that some stock model relay will be well suited; if not, manufacturers are usually willing and able to provide relays with the required characteristics on special design. By ordering relays for a specific purpose, rather than trying to design and build them himself, the user obtains the benefit of experience, manufacturing facilities, quantity production, and low cost which the relay manufacturer is able to provide. Moreover, the final result is more likely to be satisfactory in operation.

In specifying data from which the manufacturer may wind a suitable coil for the desired relay, it is advisable to provide all of the essential information required in the coil design. At the same time, the manufacturer should be given as much freedom as possible in the actual coil design; the user should not place so many requirements and restrictions on the coil that it cannot be manufactured. Consideration should be given to: (1) the close and release currents required for operating the relay, (2) the permissible voltage drop across the relay coil, (3) the temperature rise of the coil under the conditions of use which will be encountered in practice, (4) the coil resistance, (5) the voltage above ground at which the relay is to be operated, and (6) the function which the relay is to serve. When these data are known, the user can select from stock equipment, or the manufacturer can design, coils most suitable for the intended purpose. In providing information to manufacturers it is important to give sufficient information; a schematic wiring diagram is frequently of considerable assistance.

The question sometimes arises as to the pull-in and release currents which are required for relay operation. When this is a matter of importance, the manufacturers should be so informed. Although it is possible to design relays to operate at specified values of pull-in and release current, such current values are usually not specified by the manufacturer for most ordinary types of stock models. The reason for this is simply that, throughout the life of the relay, the pull-in and release current values are often subject to wide variations as a result of the use to which the relay is put. The accumulation of dust, dirt, oil or other gummy substances, weakening of spring tension, and inadequate adjustment and servicing, all contribute to the manufacturers' inability to guarantee specified limits of operation on stock models not designed for operation where close tolerances are required.



Sensitive relay which may be obtained for operation as low as 15 microamperes or 50 millivolts. Contacts will carry 0.2 ampere at 6 volts

Where relays are used in the plate circuits of vacuum tubes, the relay acts as the load for the tube. When the characteristics of the relay and the tube are known, the overall operation of the tube and relay may be determined by means of the usual "load line diagram" so well known in vacuum tube operation. The resistance of the relay coil determines the voltage drop across it, and the current which will flow through it in a given circuit. This resistance may be used as the load line if the grid voltage variations occur slowly. However, the relay coil possesses considerable inductance as well as resistance, so that for rapid changes of grid voltage, or where alternating voltages are applied to the grid, the relay can no longer be properly considered as a resistive load. Under these conditions, it becomes an impedance load with resistive and reactive components, and, for precise results the simple "load line" diagram no longer applies. For this set of conditions, the "load line" on the E_p-I_p static characteristics becomes a "load ellipse" and requires slightly more elaborate methods of treatment.[1]

A particularly useful and rapid method of determining the overall characteristics of tube and relay has been described in *Electronics*.[2] The method employed is entirely graphical, and requires curves of the static characteristics of the tube, as well as the *E-I* characteristics of the relay to be used. When these two sets of curves are available, the characteristics of the tube-relay combination can be determined quickly and easily.

To make use of this graphical method, the relay current-voltage characteristics are plotted as hyperbolas on transparent paper or tracing cloth. The origin of the relay chart is at the lower right-hand corner, the abscissa is the voltage across the relay, and the ordinate represents the current flowing through the relay coils. The scale of voltage and current for the relay diagram must be the same as the corresponding scales for the static characteristics of the tube with which the relay is to be used.

To determine the optimum load line for maximum power output, the hyperbolic curves of relay characteristics are superimposed on the static characteristics of the tube in such a way that the corresponding voltage and current axes are parallel. The origin of the relay characteristics is placed at the point on the E_p-I_p curve corresponding to zero plate current and the plate voltage, $E_p = E_b$; $I_p = 0$. A line on the tube characteristics from E_b, 0, to the point where the relay characteristic curves are tangent to the zero grid voltage characteristic, determines the optimum load line. The diagram on page 20 shows the application of the relay curves to the

[1] The manner in which an inductive load may be dealt with in tube circuits is discussed in Sec. 59, "Thermionic Vacuum Tube" by H. J. Van der Bijl, or in Sec. 90, "Theory of Thermionic Vacuum Tubes" by E. L. Chaffee.

[2] "Relays in Tube Output Circuits" by E. E. George, *Electronics*, August 1937.

MANUFACTURERS OF RELAYS

MANUFACTURER	A-C	D-C	Supersensitive [1]	Sensitive [2]	Power	Thermal	Time Delay	Accessories
Acusto-Lite Corp., Ltd. 2908 S. Vermont Ave., Los Angeles				*				
Allied Control Co., Inc. 95 Liberty St., New York		*	*	*	*			
Allen Bradley Co. 1305 S. First St., Milwaukee	*	*			*	*	*	
American Gas Accumulator Co. Elizabeth, N. J.	*	*					*	
American Instrument Co. Silver Springs, Md.				*	*	*	*	
Amer. Automatic Elec. Sales Co. 1034 Van Buren St., Chicago		*		*	*	*	*	
Automatic Electric Mfg. Co. Mankato, Minn.		*		*	*			
Automatic Signal Corp. E. Norwalk, Conn.	*							
J. H. Bunnell & Co. 81 Prospect St., Brooklyn		*		*				
L. S. Brach Mfg. Corp. 55 Dickerson St., Newark								G
Central Scientific Co. 1700 Irving Park Blvd., Chicago			*	*		*		
Cutler-Hammer, Inc 1230 St. Paul Ave., Milwaukee		*			*	*	*	
C. P. Clare & Co. 4541 Ravenswood Ave., Chicago		*		*				
Durakool, Inc. Elkhart, Ind.								MC
Eagle Signal Corp. Moline, Ill.	*	*			*		*	
Hugh H. Eby, Inc. 2068 Huntington Ave., Phila.		*		*				
Thos. A. Edison, Inc. W. Orange, N. J.						*		
Electric Controller & Mfg. Co. 2700 E. 79 St. Cleveland	*	*			*		*	
Electronic Products Co. St. Charles, Ill.								RA
Esterline-Angus Co. Indianapolis, Ind.					*			
Etna Electric Works 410 E. 135th St., New York	*	*	*	*				
Gardiner-Levering Co. Haddon Heights, N. J.		*		*	*			
General Control Co. 197 Sidney St., Cambridge				*				
General Electric Co. Schenectady, N. Y.	*	*		*	*	*	*	
General Electric Vapor Lamp Co. Hoboken, N. J.								MC
G-M Laboratories 1731 Belmont Ave., Chicago	*	*	*	*	*		*	
H-B Instrument Co. 2518 N. Broad St., Phila.								
Guardian Electric Mfg. Co. 1627 W. Walnut St., Chicago	*	*	*	*	*	*	*	
Hart Mfg. Co. Hartford, Conn.	*	*			*			

MANUFACTURER	A-C	D-C	Supersensitive [1]	Sensitive [2]	Power	Thermal	Time Delay	Accessories
Kurman Electric Co. 241 Lafayette St., New York	*	*	*	*	*			
Leach Relay Co. 5915 Avalon Blvd., Los Angeles		*						
Lear Developments, Inc. Mineola, L. I.	*	*						
P. R. Mallory & Co. Indianapolis, Ind.								C
Micro Switch Corp. Freeport, Ill.								S
Muter Co., The 1255 S. Michigan Ave., Chicago		*						
Photobell Corp. 96 Warren St., New York								RA
Precision Thermometer & Inst. Co. 1434 Brandywine St., Phila.	*			*	*			RA
Radiart Corp. 13229 Show Ave., Cleveland		*		*		*	*	
Reynolds Electric Co. 2650 W. Congress St., Chicago						*		A
M. H. Rhodes 9 Rockefeller Plaza, New York								TDS
Roller-Smith Co. 233 Broadway, New York		*		*				
Sigma Instruments, Inc. Belmont, Mass.		*		*				
Spencer Thermostat Co. Attleboro, Mass.						*		
Standard Elec. Prod. Co. St. Paul, Minn.		*		*				
Stromberg Carlson Tel. Mfg. Co. Rochester, N Y.	*	*		*	*			
Struthers Dunn, Inc. 125 N. Juniper St., Phila.	*	*		*	*	*	*	
Supreme Electric Products Co. Rochester, N. Y.								SV
Triplett Elect. Instrument Co. Bluffton, O.		*	*	*				
United Electronic Industries 43-37 35th St., L. I. City, N. Y.								RA
Veeder-Root, Inc. Hartford, Conn.								K
Ward Leonard Electric Co. Mount Vernon, N. Y.	*	*	*	*	*	*	*	*
Western Electric Co. 195 Broadway, New York	*	*	*	*		*	*	*
Western Electro-Mechanical Co. Oakland, Cal.	*	*		*	*			
Westinghouse Elec. & Mfg. Co. Newark, N. J.	*	*		*	*	*	*	*
Weston Elec. Inst. Corp. Newark	*	*	*	*	*	*	*	*
Wheelco Instruments Co. 1931 S. Halsted St., Chicago								RA
H. A. Wilson Co. 97 Chestnut St., Newark								C
Zenith Electric Co. 527 S. Dearborn St., Chicago							*	

[1] Less than 1 ma. [2] 1 to 100 ma. A Accessories C Metallic contacts G Gas Relays
K Counters MC Mercury contacts RA Relay assemblies TDS Time delay switch SV Solenoid valves

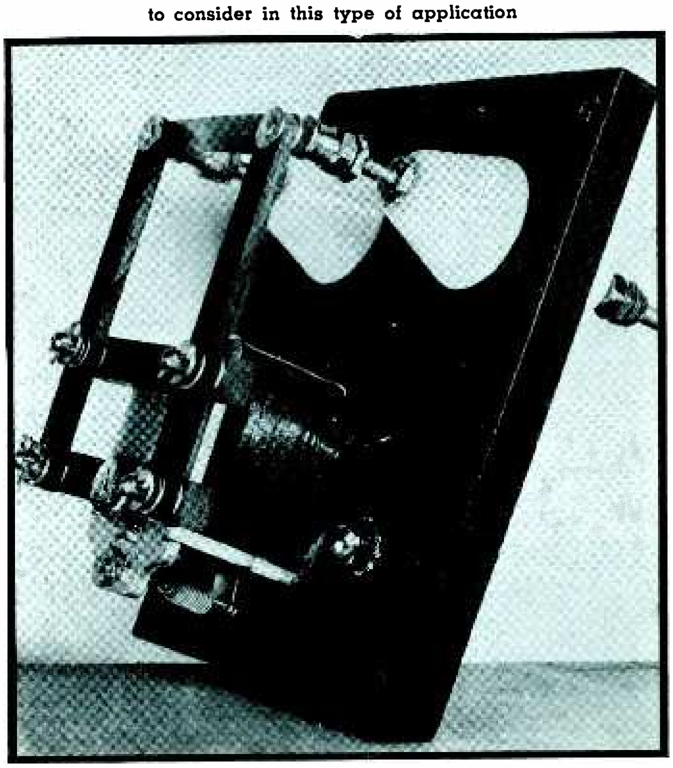
characteristic curves of a 6L6 beam power tube operating with a plate supply voltage of 400. The dotted line is the load line for maximum power in the relay circuit. By selecting a suitable grid bias voltage and determining the excursions of grid signal voltage, the resulting plate current change available for operating the relay may be rapidly determined.

Sequence Operation

It is frequently important that circuits which a tube and relay combination control, be operated in proper sequence. Consequently, not only the number of contacts on the relay but also the sequence in which these contacts open and close is an important consideration which should not—but frequently is—overlooked by the designer of electron tube equipment. Fortunately, relay contacts are available in a wide variety of combinations, both as regards the total number of contacts, as well as their sequence of operation. Before the contact assembly can be completely specified, however, it is necessary to know the order of occurrence of the various operations which the tube and relay control.

A systematic and satisfactory method of determining the necessary number of relay contacts, and their sequence of operations, may be developed in schedule form by considering the functional operations which are to be controlled. The first step in developing the schedule is to list in proper order, the essential physical control operations which are to occur. Such a list will be needed in determining the sequence of operation of relay contacts, or contact assemblies. The second essential step is to assign to each of these control operations, the proper number and combination of contacts for carrying out the intended control operation. This second step determines the number of contacts which will be required and their arrangement. From these two steps, the full complement of relay contacts may be specified, although it may be wise to go through the entire schedule a second time to make sure that the schedule provides for the most satisfactory and economical conditions. When preparing the second step in the schedule, it is also advisable to ascertain the voltage which each set of contacts will be required to break, the current it will be required to pass, and whether it is to be used in an inductive or a resistive circuit. It may happen that the voltage or current requirements exceed the capabilities of the relay contacts, in which case several contacts in parallel may be required.

Relay intended for controlling radio frequency circuit. Good insulation and low distributed capacity are factors to consider in this type of application



For the relay contacts to fulfill their intended purpose properly, the make and break positions must conform with certain specific requirements. In the break or open position, the contacts should be definitely separated from one another for all conditions of temperature, dust, or dirt accumulation which are likely to arise in normal service. The actual separation between the contact surfaces will depend upon the service to which the relay is to be put, the voltage which it is required to break, the resistance and reactance of the circuit, and the adjustment of the armature. In general, it is desirable that the separation be sufficiently large as to preclude any possibility of arcing, or the accumulation of small foreign particles between the contact surfaces. The make and break conditions should be established definitely and without vibration or chattering of the contacts. For this requirement to be fulfilled, both the electrical and mechanical conditions under which the relay is to be used merit consideration.

Contact Care

Sparking and arcing of the contacts may be reduced through the use of contact surfaces which have been rounded so as not to present sharp edges or corners from which an electric discharge may readily take place. The curvature of the contact faces will, of course, depend upon the service for which the contacts are intended, and will be much greater for small contacts such as are used in telephone type relays than for relays in which the contacts control appreciable amounts of power.

In coming together, it is desirable that the contacts approach one another with a sliding, rolling, or rotary motion, rather than butting together, for by so doing, the contacts tend to be self-cleaning. After having come together, the contacts should be maintained in intimate contact by a definite pressure. This pressure is usually provided by the pull on the armature when the relay coil is energized, although in some cases "snap action" through the use of springs or specially designed switches serve the same purpose.

Not only the contact area, but the material out of which the contacts are made, will depend upon the circuit

(Continued on page 61)

Wideband Television Amplifiers—II

The low frequency response of video amplifiers is treated in this second article by Mr. Everest. Effects of cathode-biasing circuits, and plate impedance correction networks, on amplification and phase shift

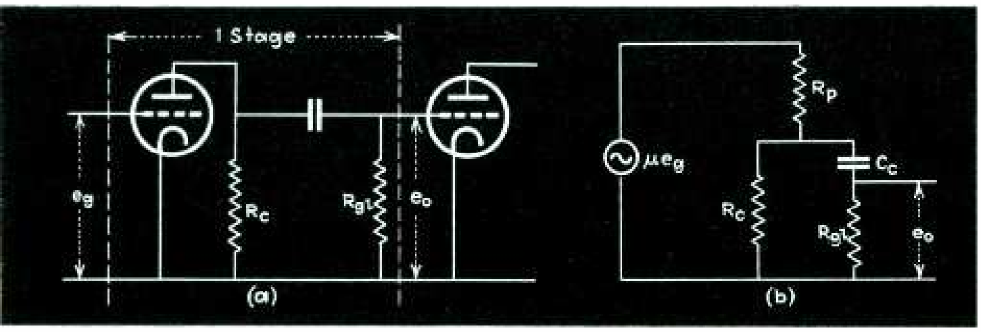


Fig. 1—Actual and equivalent circuits of the simple resistance—capacitance coupled amplifier, for low frequency calculations

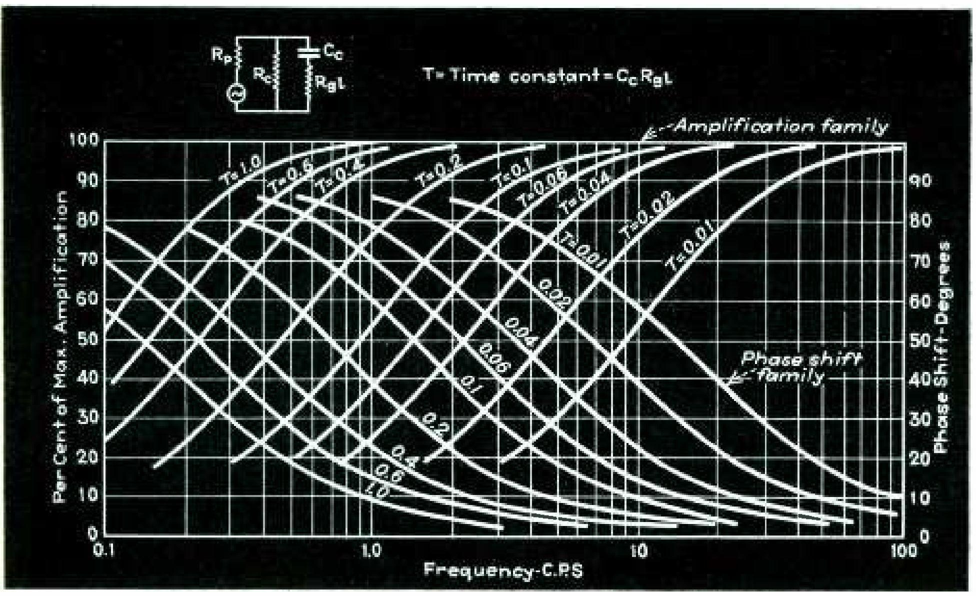
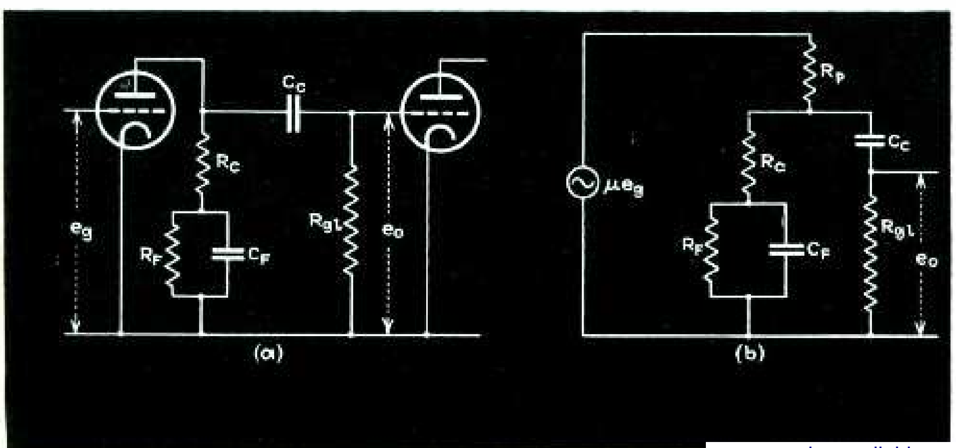


Fig. 2—Low frequency amplitude and phase response curves in terms of the coupling time constant

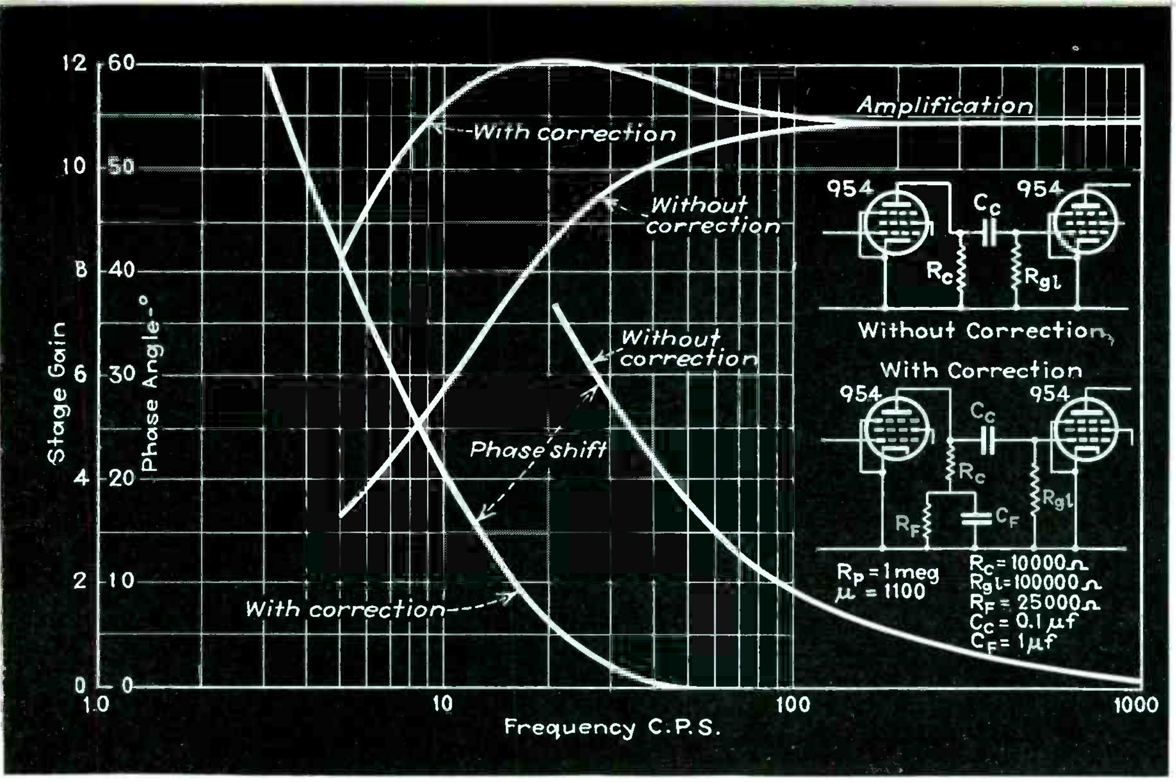
Fig. 3—Actual and equivalent circuits including resistance—capacitance network in plate load impedance



TO transmit the slow changes accompanying the gradual shifting of background illumination in a television image requires that all frequencies down to and including direct current be passed. Therefore we find that the perfect television image calls for a d-c amplifier for the low frequency extremity. As the d-c component may be cared for with other circuits, the next lowest frequency of major importance is the field repetition frequency. This is defined as the number of times the image is fractionally scanned per second. For interlaced scanning the field repetition frequency is usually 60 per second to minimize the disturbing effects of a-c hum on the image.

Low Frequency Response

While the small details of the television image are determined by the high frequency response of the amplifier, a failure at the low frequency end results in false values of lights and shadows. For a completely satisfactory picture it is necessary that these low frequencies be included. The circuit of Fig. 1 (a) shows a diagram of the common resistance-capacitance coupled amplifier which can be represented to a high degree of accuracy by the equivalent circuit of Fig. 1 (b). At the low frequencies under consideration, the effect of the shunting capacitances to ground can be neglected. Solving this circuit gives us the following expression for stage-gain:



By F. ALTON EVEREST
Oregon State College

Fig. 4—(above) Effect on amplification and phase shift of circuit shown in Fig. 3, calculated for a stage employing the 954 tube

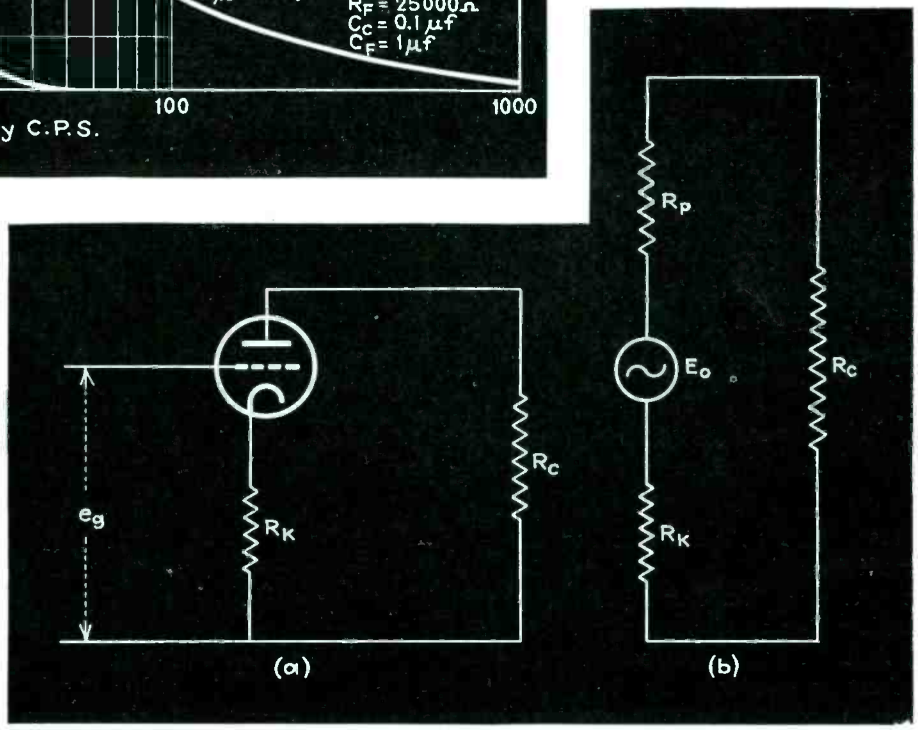


Fig. 5—(right) Circuits for calculating effect of cathode resistor at low frequencies

Stage Gain = (Maximum Amplification) $\times \dfrac{1}{\sqrt{1+\dfrac{1}{\omega^2 C_c^2 R_{gl}^2}}}$ (1)

in which:

Max. Amp. =

(μ of tube) $\left(\dfrac{1}{1+R_p/R_c}\right)$

R_p = plate resistance of the tube, ohms
R_c = coupling resistor, ohms
R_{gl} = grid-leak resistor, ohms (large compared to R_c)
$\omega = 2\pi f$, f being frequency in cycles per sec.
C_c = coupling capacitor, farads.

Equation (1) can also be written as:

Stage Gain =

(Max. Amp.) $\times \left\{\dfrac{1}{\sqrt{1+\dfrac{1}{\omega^2 T^2}}}\right\}$ (2)

where T = time constant = $C_c R_{gl}$. This time constant, T, is the determining factor in the low frequency response of R-C coupled amplifiers. It should be remembered that the product is the important thing and not the absolute value of either C_c or R_{gl}. The significance of the time constant product, $C_c R_{gl}$, is this: the condenser C_c will discharge to within 37% or $\left(\dfrac{1}{\varepsilon}\right)$ of its original value in T seconds.

Equations (1) and (2) neglect the phase angle between e_g and the current flowing through R_{gl}. This phase angle is given by:

$$\phi = \tan^{-1}\frac{1}{\omega T}$$

Figure 2 shows the frequency response family for the more common values of T. Because of the fact that the phase shifts at the lower frequencies are very important, the phase shift family of curves is given also. The low frequency response of any ordinary R-C coupled amplifier may be quickly plotted with the aid of Figure 2 and the expression for maximum amplification under equation (1).

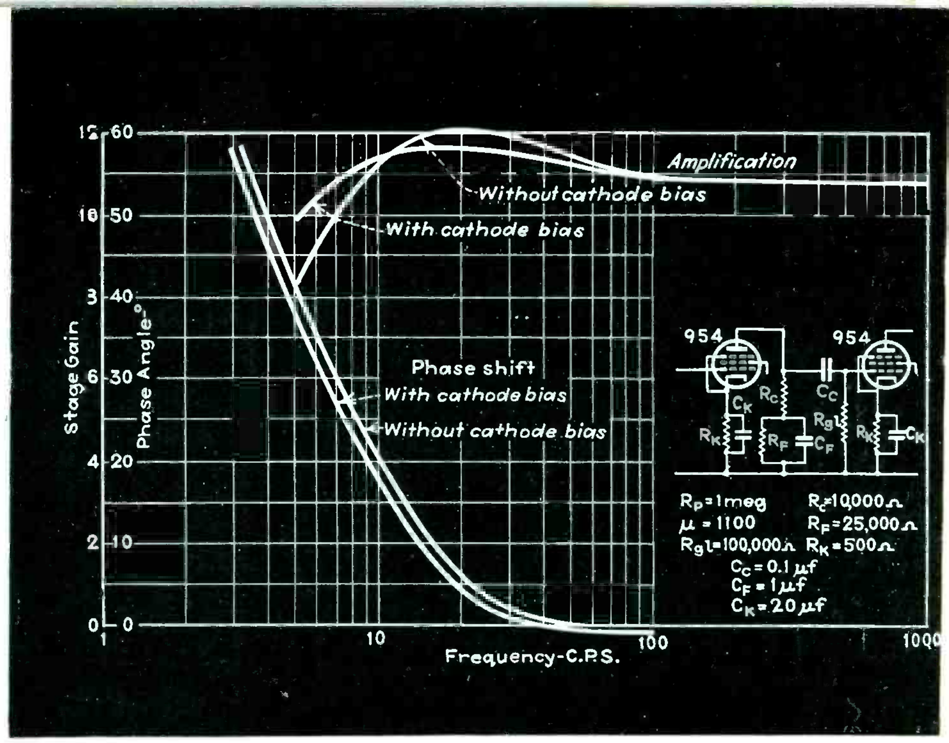
Low Frequency Correction

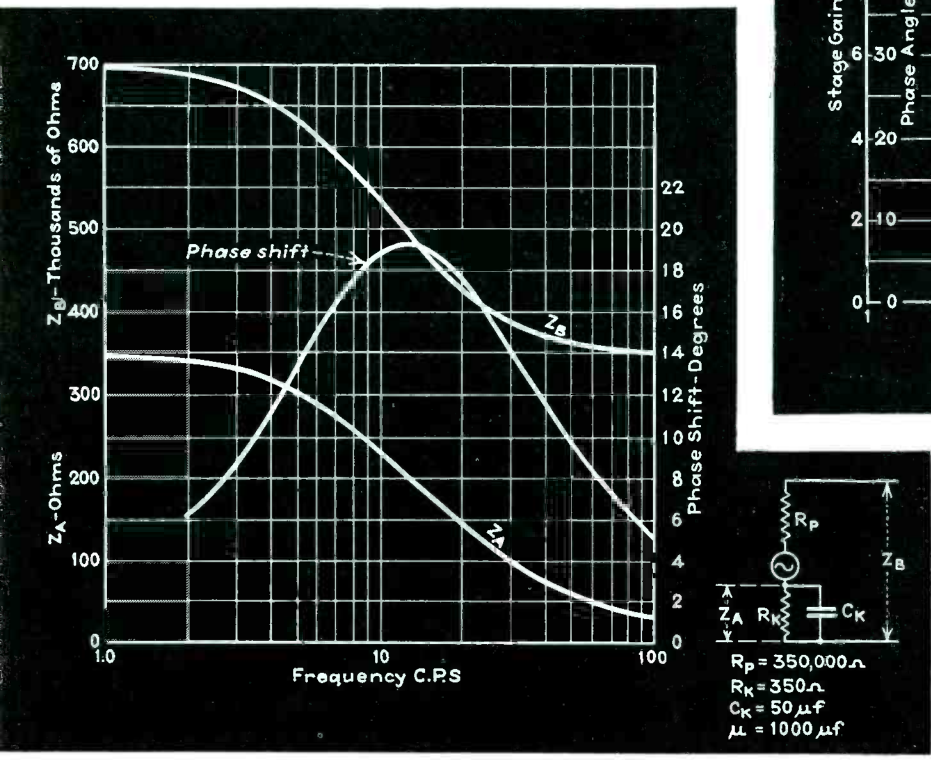
In the equivalent circuit of Figure 1 (b), R_{gl} is usually much larger than R_c. To satisfy the high frequency requirements, R_c must not be very large or the shunting capacitances will make the combined impedance excessively low. If the value of R_c could be automatically increased at the lower frequencies without affecting operation at other frequencies, the amplification would tend to remain at a higher value for much lower frequencies.

One of the simplest and most effective of the methods for holding up the amplification at low frequencies is shown in Fig. 3 (a) with equivalent circuit as shown in Fig. 3 (b). A resistor, R_F, shunted with a condenser, C_F, comprises the network whose impedance rises with a de-

Fig. 6—(below) Impedance relationships due to cathode bias

Fig. 7—(right) Effect of cathode bias on low frequency response of stage employing 954 tubes





$$b = \left[\frac{1}{\omega T_F}\left\{\frac{R_p}{R_c} + \left(1+\frac{R_F}{R_c}\right)\left(1+\frac{R_p}{R_{gl}}\right)\right\} + \frac{R_p+R_c}{\omega T\, R_c}\right]$$

$$T'_F = T_F \frac{R_c}{R_c + R_F}$$

$$T_F = C_F R_F$$

$$T = C_c R_{gl}$$

crease in frequency. At the intermediate and high frequencies, C_F is essentially a short circuit, effectively taking R_F out of the circuit. At the low frequencies, the reactance of C_F increases causing the total anode load impedance, and therefore the amplification, to increase. Probably one of the most important effects of the correction network R_F-C_F is that the phase shift is negative and in the proper direction to correct for phase shift due to the coupling condenser. Another advantage of this correction network is that it operates as a decoupling filter, helping to remove the power supply ripple from the voltage applied to the tube. Too much must not be expected of R_F and C_F in this regard, however, for the decoupling effect will be small for frequencies lower than the point where correction begins to take place. If additional de-coupling is needed, the effect of another filter upon the amplifier response will be negligible as long as the time constant of the added filter is selected so that the impedance is negligible at the lowest frequency to be amplified.

Figure 4 shows the phase shift and amplification characteristics of a television amplifier using the type 954 acorn tube which was used in the discussion of high frequency amplification. (*Electronics*, January, 1938, page 16). A plate resistor of 10,000 ohms and a time constant of $R_{gl}\,C_c$ equal to 0.01 is used, both with and without correction. The correction network consists of a resistor R_F = 25,000 ohms and C_F = 1.0 microfarad. A tremendous improvement of phase shift, an important item, is obtained. The calculation of the corrected curve of Fig. 4 is very laborious at best. O. E. Keall[1] has analyzed the whole problem very well and presented a graphical method by which close approximations to the actual response and phase shift curves may be obtained relatively easily after a working knowledge of his methods is obtained. Based upon the equivalent circuit of Fig. 3 (b), Keall shows that the voltage developed across the grid leak resistor R_{gl} is:

$$e_o = \mu e_g \frac{\left(\frac{1}{a - jb}\right)}{\left(\frac{1}{1 - j\frac{1}{\omega T'_F}}\right)} \qquad (3)$$

where:

$$a = 1 + \frac{R_p}{R_c} + \frac{R_p}{R_{gl}} - \frac{1}{\omega T\, T_F}\left(1 + \frac{R_p+R_F}{R_c}\right)$$

Effect of Cathode Bias

Placing a resistor in the cathode circuit of an R-C coupled amplifier is a common method of biasing the tube by virtue of the plate current flowing through it. The cathode is made more positive than the grid by the amount of voltage drop in the bias resistor, R_k. To prevent degenerative feedback, caused by the a-c signal component of the plate current also applying a voltage to the grid, a large condenser is shunted across R_k, thus providing essentially a short circuit for the a-c, yet still producing a d-c bias voltage. Of course at the low frequency end of the band to be amplified, the reactance of this cathode capacitance, C_k, becomes large. At sufficiently low frequencies, then, the effect of R_k in the circuit is quite pronounced.

In Figure 5 (a) is shown the schematic diagram of a simple amplifier with a cathode resistor R_k, not by-passed. Figure 5 (b) shows the equivalent circuit of this same amplifier in which E_o is the voltage of the equivalent generator which is the product of the voltage between grid and cathode of the tube and the mu of the tube. This voltage is the customary μe_g reduced by the drop in R_k or,

$$E_o = \mu\,(e_g - iR_k) \qquad (4)$$

By Kirchoff's law we find:

$$E_o = i\,(R_p + R_c + R_k) \qquad (5)$$

By equating (4) and (5) and solving for i we get:

$$i = \frac{\mu e_g}{R_c + R_p + R_k\,(\mu + 1)} \qquad (6)$$

In other words, at the low frequencies where the by-pass condenser C_k is ineffective we find that the resistance of the plate circuit has been increased by the amount μR_k.

This may easily result in a 100 per cent increase of apparent internal impedance of the tube, reducing amplification accordingly. Fig. 6 shows impedance and phase shift relations in a typical screen-grid amplifier. It will be noticed that the phase shift due to the cathode bias is in a direction that will correct for the phase shift due to the coupling condenser. Z_a is zero at the higher frequencies because the reactance of the condenser C_k approaches zero, and approaches some steady state value equal to R_k in the region where the reactance of C_k approaches infinity. Utilizing the $(\mu + 1)$ factor, we obtain Z_b, the apparent internal impedance of the tube. This increases at the point where the reactance of C_k begins to take effect and flattens off at a value about twice its normal plate resistance. While this will affect amplification, a more important factor than amplification at the low frequencies in television frequency amplifiers is that of phase shift, and cathode bias improves that. Figure 7 shows an improvement of both amplitude and phase distortions of the low frequency corrected amplifier of Fig. 4.

It is appropriate here to mention a method used[4] to eliminate the necessity of the large cathode bypass condensers. With electrolytic condensers available, its technical value is doubtful, but constructional and economic factors might dictate its use. Figure 8 shows a schematic diagram of an R-C coupled amplifier using this scheme. The resistor R_1 has a much higher resistance than R_k (100,000 ohms for example). As the grid-leak, R_{gl}, is connected to one end of R_1, only a portion of the degenerative voltage due to the a-c voltage drop across R_k is fed back to the grid. In effect, C_1 and R_1 act as a potentiometer across R_k and the degenerative voltage fed back to the grid is proportional to $\dfrac{1}{\dfrac{\omega C_1}{R_1}}$. It is obvious that a much smaller condenser C_1 can be used for a given loss in amplification and phase shift. The leakage in electrolytic condensers makes their use undesirable for C_1, as this would upset the bias conditions.

General Design Considerations

Time Constant: The time constant T, as discussed in connection with Eq. (2), has certain limits. Experience has indicated[1] that values of T over 0.01 are unsafe to use. This limits the amount of low frequency response that can be obtained by using large values of coupling condenser or grid-leak resistor. The input resistance of the tube limits the value of grid-leak resistor which can be placed in parallel with it. Large values of coupling condenser result in bulky condensers whose stray capacitance limit the high frequency response. The phase shift and attenuation characteristics of amplifiers having a $T = 0.01$ do require correction, necessitating the use of correction circuits similar to those described. This value of T will also avoid difficulties due to blocking of the grid.

Push Pull: The use of the push-pull circuit for wide band television amplifiers offers some attractive advantages[2], and the low and high frequency correction methods just discussed are entirely applicable. When many stages of amplification are used, as is necessary when only a low gain per stage can be utilized as in television amplifiers, the possibility of oscillation must always be faced. A certain amount of feedback voltage is always present due to common de-coupling elements. One of the greatest advantages of the push-pull Class-A tubes is that the instantaneous sum of plate and screen-grid currents of the pair of tubes is essentially constant. This constancy gives little feedback voltage to cause oscillation and is a good contribution toward stability. By careful matching of the tubes, it is possible even to eliminate the cathode by-pass condenser and plate and screen-grid decoupling condensers.

The use of push-pull triodes for output tubes has been popular in this type of circuit due to their low distortion and good power output.

References

[1] Keall, Correction Circuits For Amplifiers *Marconi Review* No. 54, May-June, 1935, page 15.

[2] Nagy, The Design of Vision-Frequency Amplifiers *Television and Short Wave World* (London) March, 1937, page 160: May, 1937, page 279.

[3] Walker, The Design of High-Definition Amplifiers *Television And Short Wave World* (London) November, 1935, page 672: March, 1936, page 151.

[4] Congreve, Automatic Grid Bias in Television Receivers *Television and Short Wave World* (London) March, 1936, page 167.

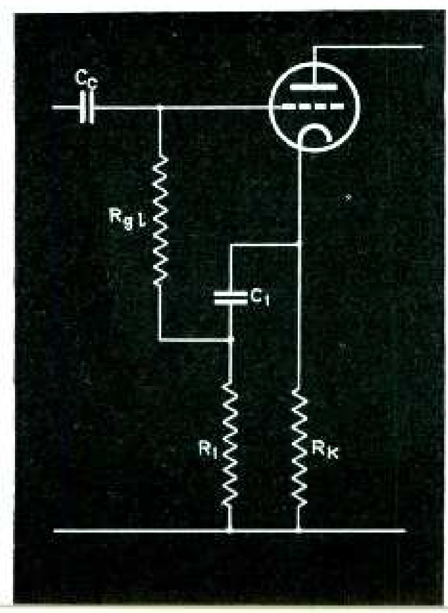


Fig. 8—Partial cathode bias connection

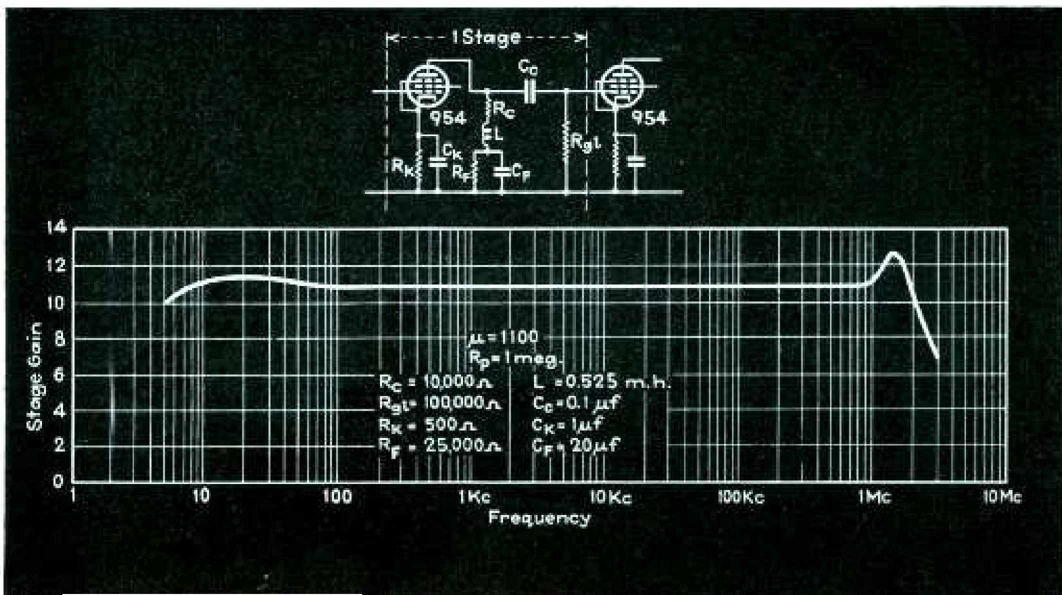


Fig. 9—Calculated over-all response of amplifier, including plate circuit correction and cathode bias

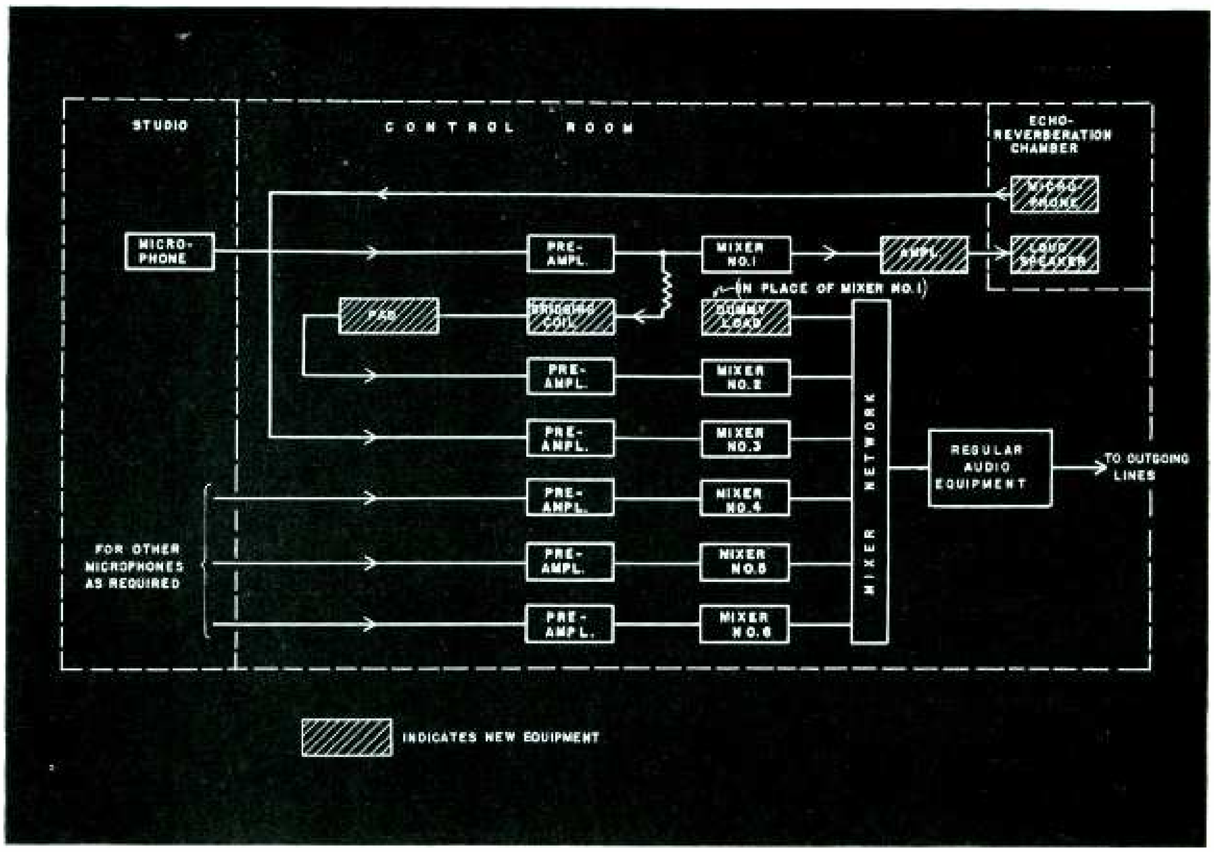


FIG. 1 Fool-proof method of adding reverberation chamber to high level mixing audio equipment

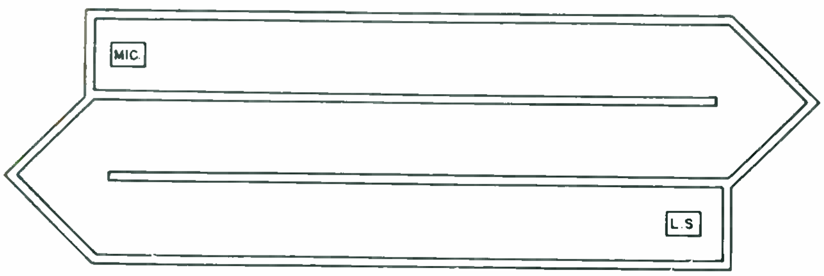


FIG. 2 Labyrinth-like arrangements of echo reverberation chamber

Reverberation

PRODUCTION of programs for broadcasting purposes often requires the creation of reverberant effects, just as in the case of motion picture recordings. (See *Electronics*, January 1938, p. 15). In addition, echo effects are frequently required.

In the design of facilities for creating these effects, it is essential that the difference between "reverberation" and "echo" be recognized. Reverberation is generally obtained by employing a "live" room while echos, on the other hand, require the introduction of a time lag into the program circuit.

The effects that are required in broadcasting are often a combination of these two characteristics. This combined result may be obtained by employing a long tube (for time delay) leading into a live room (for reverberation). A loudspeaker is placed at the far end of the tube and a microphone is placed in the reverberation chamber.

Control over the "degree" of the echo may be obtained by employing tubes of various lengths. It is also possible to devise means of introducing the loudspeaker into a long tube at various points along its length. Such an arrangement obviates the need for more than one tube, provided a combination effect, consisting of simultaneous echos of various time delays, is not desired. An echo-reverberation unit, therefore, may consist of a live room with one or more tubes of various lengths leading into the room.

Both the tubes and the room must be hard surfaced on the inside to obtain the desired effect. In addition, sound isolation treatment must be used to prevent the introduction of undesired extraneous sounds into the chamber. This treatment also avoids disturbances to adjacent areas by the sounds being reproduced within the tube and chamber.

Control over the degree of reverberation is obtained by adjustment of the volume level of the reproducing loudspeaker. Combinations of loudspeaker level and pick-up microphone-channel output level permit a wide range of dramatic effects to be obtained. An alternate method of obtaining these effects is the use of

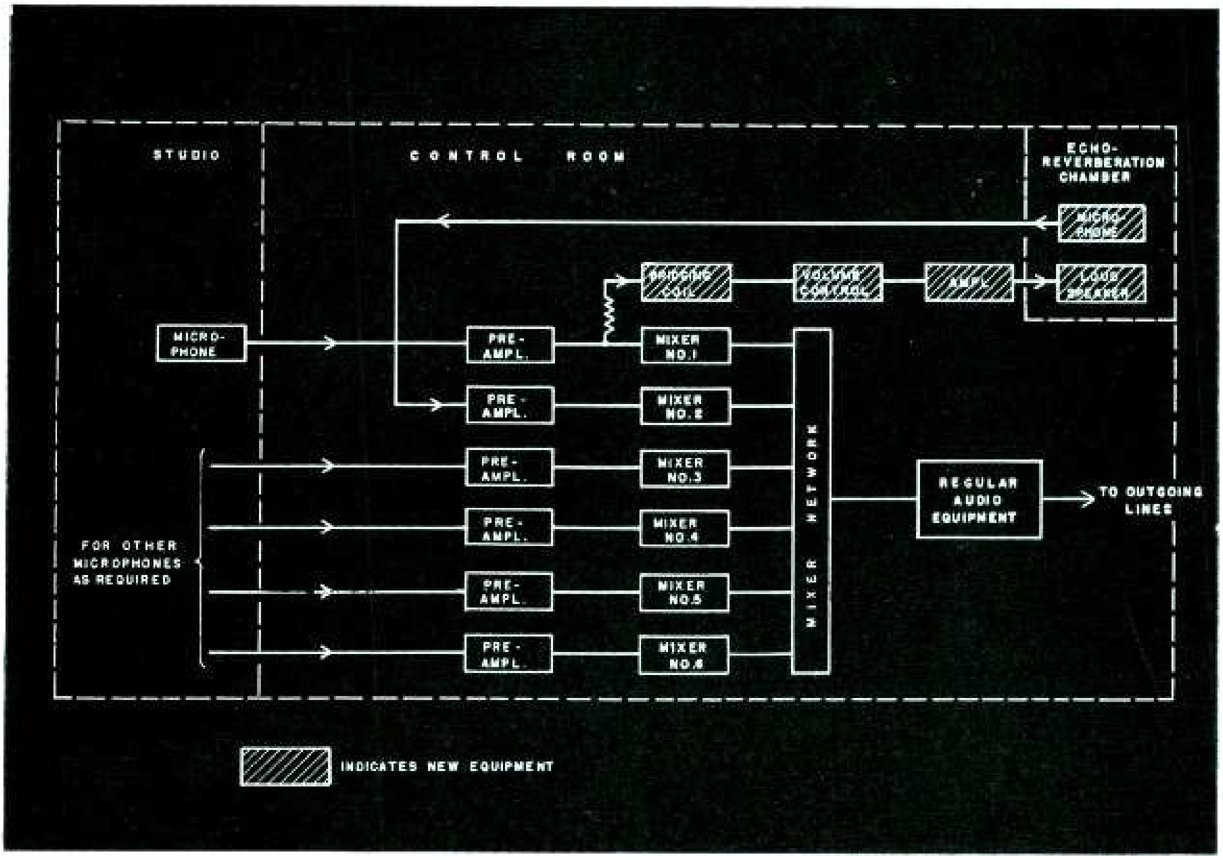


FIG. 3 Simpler method of adding reverberation chamber involving only two mixing channels

Control in Broadcasting

By
HOWARD A. CHINN
Columbia Broadcasting System, Inc.

a labyrinth-like arrangement such as shown on Fig. 2. The walls, ceiling and floor of the chamber should be hard surfaced and the dimensions determined by the effects desired. The arrangement results in an echo-reverberation chamber that is economical to install and to operate.

The high-level mixing audio equipment that is standard in modern broadcasting studios lends itself readily to the addition of reverberation channel facilities. Figure 1 illustrates a method that is simple and yet fool-proof. One of the existing mixers (No. 1) is used for reverberation channel input control. Still another mixer (No. 2) controls the original, unchanged, sound pickup while a third (No. 3) is used as the reverberation channel output control. Adjustment of mixers Nos. 2 and 3 results in any desired admixture of the original with the reverberant and delayed sound. Mixer No. 1 controls the loudspeaker level in the reverberation chamber and consequently provides still further influence over the resulting effect.

A disadvantage of the above arrangement is the fact that it utilizes three of the studio microphone channels. Furthermore, one mixer must be disconnected from the mixer network and a dummy load resistor substituted in its place. An arrangement that overcomes these drawbacks is shown in Fig. 3. This circuit involves only two of the regular mixer channels. The reverberation chamber input volume control, in this case, is added to the existing facilities, external to the regular mixer console. One of the regular mixers (No. 1) then controls the direct, unchanged pick-up while a second (No. 2) controls the amount of reverberant sound which is being added to the channel.

This arrangement has a possible objection since, by improper adjustment of the various volume controls and circuit gains, an electro-acoustical feedback circuit can be created. In practice, however, there is little difficulty in designing and operating this circuit in such a way as effectively to guard against this possibility.

The labyrinth-type of reverberation chamber, together with the last mentioned circuit arrangement, has been successfully used by the Columbia Broadcasting System for several years. The range of effects that can be achieved by placing the microphone and loudspeaker at various points in the labyrinth and by the addition of portable acoustical treatment, baffles, etc., satisfies practically every demand made of these facilities.

NEW BOOKS

Fernsehen

By FRITZ SCHROTER with 8 television experts. (*Julius Springer, Berlin. 260 pages, 228 illustrations, 1937. Price, 21 RM clothbound.*)

THIS BOOK is a collection of eight lectures, given by eight different German experts well known in the arts of television and electron optics. These lectures were held late in 1936 for engineers who wished to become acquainted with the problems of television. The subject matter is divided as follows:

"Development and Status of the Television Art," by Dr. F. Banneitz, "Fundamentals, Possibilities of and Limitations in Television Transmission," by Dr. F. Schroter. Care was exercised to present the matter explicitly. Simple mathematical equations are cited wherever necessary. "Mechanical Scanning Systems and Synchronization", by Dr. R. Möller. It may be surprising to American readers that mechanical scanning systems are also treated. This was believed justified because of the excellent results obtained with such apparatus, which is being further developed in Germany. "Electron Optics", by Dr. E. Brücke. This chapter gives an introduction into a calculation of electron paths, and deals with different types of electron lenses and particularly properties of electron-optical systems. It also briefly treats electron-optical characteristics in electronic image pick-up tubes and in cathode-ray tubes.

"Cathode Ray Tubes in Television", by Dr. M. Knoll. This chapter deals with pick-up and receiver tubes employing cathode-ray scanning. The Farnsworth Dissector and the Iconoscope are described. Electron gun structures are discussed, as well as electron lenses and their defects, which become evident in the shape of the scanning spot. "Television Broadcasting", by W. Buschbeck. This chapter deals with power problems, neutralization, modulation of television transmitters, as well as propagation of wide-band modulated carriers along coaxial lines. "Television Reception", by M. von Ardenne. This chapter deals with the composite television signal, field strength and noise level in ultra short-wave transmission, problems of television reception, methods of coupling, final stages in receivers, discrimination between picture and synchronizing impulses, as well as a thorough treatise of Kipp oscillations and mathematical investigation thereof. An abstract of the latter matter was published in *Electronics* recently. "Projection of Television Images for Theatre Use," by Prof. Dr. A. Karolus.

No mention is made of methods of producing synchronizing and blanking impulses for interlaced scanning and their superposition upon the video signal. This is a book well adapted to convey thorough knowledge and understanding of the problems of television to engineers and experienced amateurs. The book is well equipped with illustrations and diagrams of good quality.

R.F.W.

WOR TESTS FACSIMILE

Two-column facsimile newspaper received in the preliminary tests of the Finch system, made on WOR's 50-kw. transmitter. A regular schedule on eight meter waves is contemplated, using 100 watts

Kinetic Theory of Gases

By EARLE H. KENNARD, *Professor of Physics, Cornell University (McGraw-Hill Book Co., New York, 1938. Price, $5.00, 483 pages, 94 illustrations.)*

AS THE LATEST addition to the International Series in Physics, Professor Kennard's book is a substantial treatment of the kinetic theory of gases from the modern point of view, contains a survey of kinetic theory as it exists at the present time, offers introductory chapters on wave mechanics and statistical mechanics. The text is designed to serve both as a textbook for students and as a reference book for the experimental physicist or research engineer. Throughout, the physicist's, rather than the engineer's point of view is maintained, although in the field of electronics, the physicist-engineer distinction is likely to be decidedly blurred.

The statement on the jacket cover, that the book contains an introduction to the kinetic theory of gases, can hardly be interpreted to indicate suitability as an elementary first course text in the subject; one does not jump into statistical mechanics without some preparation. The work is on a level suitable for junior, senior, or graduate students in physics or engineering who have had a thorough foundation in college physics and mathematics. And to one who is no longer awed by triple integrals or partial derivatives, the book is most enjoyable reading. It is definitely out of the ordinary in its logical and orderly presentation, easy flowing style, and completeness. For these reasons, the volume should have considerable appeal as a textbook. For use as a reference work, the book could have been considerably improved had the index been made more complete and detailed; the table of contents is actually more extensive than the index.

Despite the author's modest claim that the book is not intended to be exhaustive, it seems likely that few readers of *Electronics* will find essential subjects omitted or inadequately treated. Relatively few references to periodical literature are given, but the treatment is sufficiently complete as not to require them. Perhaps the scope of the text may be judged best from the chapter headings: elements of the kinetic theory of gases; distribution law for molecular velocities; general motion and spatial distribution of molecules; viscosity, thermal conduction, and diffusion; equation of state; energy, entropy, and specific heats; fluctuations; properties of gases at low densities; statistical mechanics; wave mechanics or gases; and electric and magnetic properties of gases.—B.D.

Experimental Radio

(Fourth Edition)

By R. R. RAMSEY. (*196 pages, price $2.75. Ramsey Publishing Company, Bloomington, Indiana.*)

SINCE 1923 Professor Ramsey has been regularly bringing out new editions of his volume of experiments for students in radio theory and practice. This fourth edition is a companion and laboratory guide to his text, "Fundamentals of Radio" which is also time-tested. In addition to methods for measuring all the useful circuit constants there is some constructional material which will aid the school with insufficient means for purchasing complete equipment. The author calls particular attention to experiments which he says tend to prove that closely coupled circuits do not produce two frequencies and on the modulation experiments which prove that the addition of two frequencies do not produce combinational frequencies.—K.H.

(Other book reviews are on page 36.)

its of the complaint has no alternative but to drop the articles under litigation—even though the patent under which he is threatened may later be declared invalid.

Permeability Tuning

(*Continued from page* 13)

is not constant over the frequency range covered by each coil in this particular design, but this can be controlled to a great extent by proper selection of core material. However, the variation in overall set sensitivity is quite small as shown by the curves of Fig. 4. For this reason no attempt has been made to design for constant Q by the method outlined above. These data (Fig. 4) were taken with the antenna tuning capacity adjusted at each frequency for perfect tracking. Additional curves of Fig. 4 show the loss of sensitivity due to mistracking when the antenna coil is tuned with the predetermined capacity for optimum tracking of all coils. These curves show a loss of less than 2 db due to improper tracking. It is quite probable that this can be improved, but at the present time has been considered adequate for all practical purposes.

The sensitivity curves of Fig. 4 were taken with an intermediate frequency and audio system whose input to converter grid at 262 kc. was 82.4 db. The selectivity at 100 times resonant input was 29.5 kc. and at 1000 times was 40.2 kc. The image ratio with the circuit of Fig. 3 varies from 40 at 600 kc. to 22 at 1400 kc. This, however, can be improved to approximately 96 at 600 kc. and 27 at 1400 kc. by the use of the Hazeltine capacity coupled antenna circuit as illustrated in Fig. 5. A slight loss of sensitivity results but this can be improved by other means.

It would be well to say in passing that with a similar system designed for an intermediate frequency of 456 kc. and using the antenna circuit of Fig. 5. image ratios of from 350 at 600 kc. to 70 at 1400 kc. were attained. Also with an intermediate frequency system whose selectivity at 100 and 1000 times resonant input was 22.5 and 38 kc. respectively, the overall selectivity was 29.5 kc. at 600 kc. and 26.5 kc. at 1400 kc. at 1000 times.

Since the frequency stability of the system depends upon the stability of the oscillator circuit, and the coil assembly has been designed with this idea in mind, it should be noted that the principal cause of drift remaining is condensers C_1 and C_2. For this reason they should be of the low drift type. The stability of the condensers associated with the antenna circuit is not quite so important, since mistuning to the extent of approximately $3\frac{1}{2}\%$ of the total resonant capacity will only cause a loss of sensitivity in the order of about 2 db. However, condensers with a relatively low drift characteristic are to be recommended where economic reasons do not prohibit their use.

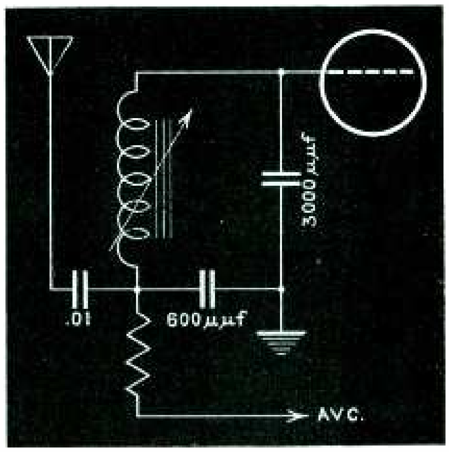


Fig. 5—Use of capacity coupled antenna circuit

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Patent Reform

(*Continued from page* 11)

competition by efficient business units which are sufficiently capable to offset the royalty differential in favor of the patentee. There might also be a provision providing price fixing of patented articles.

It would also be preferable to limit liability for infringement to the infringing manufacturer himself. To hold the seller and buyer of the infringing merchandise responsible leads to abuses which should be abated. Often the owner of a patent, which may later be declared invalid, will sue jobbers and dealers handling competitive and supposedly infringing articles. The dealer or jobber, who knows nothing about the merits of the complaint has no alternative but to drop the articles under litigation—even though the patent under which he is threatened may later be declared invalid.

Nuisance Patents

The conception of invention discussed here will go far to eliminate the nuisance patent useful only to the holder as a means for decreasing the value of a more important or more practical patent. This type of invention often consists of a bright idea reduced to a pencil scrawl. A striking example is a group of patents issued during the world war which described the use of a combination of several kinds of tubes for an industrial control device. Tubes as diagrammed were not then generally available, their characteristics were not thoroughly known. The circuit was then unworkable. Yet these patents could prove to be a serious stumbling block to any worker in that particular field during the life of the patent.

The lack of workability of the circuits might have been proved in court. No one, however, should be compelled to go to the expense and delay caused by an important patent suit in addition to the considerable time and expense of development work.

It is the consensus that patent rights were created to encourage industry by vesting valuable property rights in the patentee. But it is worth pointing out that an inventor's right to exclusive use of his invention is not an inherent right like that of a playwright in his play.

The playwright may establish a copyright if he chooses to do so but he has definite rights under common law even if he does not take advantage of the copyright law. It appears that the inventor has no such rights under our common law. If he cannot defray the cost of a patent application and particularly if he cannot pay the patent fees his invention can be used by anybody.

It follows that a patent is a privilege granted by society to the inventor for its benefit and incidentally the benefit of the inventor. Because of this society may fix the conditions under which the inventor is invested with his special rights.

(*Continued on page* 36)

Patent Reform

(*Continued from page* 34)

This is not in accordance with the popular belief that the inventor has automatically some rights in his invention. The framers of our patent statute probably had something of this sort in mind. American patent law goes further than any other in an attempt to protect the original inventor. To do so was the obvious intention of the legislators. Unfortunately it does not produce the effect desired by them.

An improved law should be formulated which will protect the inventor and benefit society; which will clearly describe the invention; which will make it possible easily to test the validity of the patent; which will make a patent quite a bit more than a pompous document which really may prove to be, in the long run, only an expense to the inventor.

NEW BOOKS

La Moderna Supereterodina

By D. E. RAVALICO. (*390 pages, 210 illustrations, circuits, tables, appendices, etc. 1938. Price 20 lira. Ulrico Hoepli, Milan.*)

UNFORTUNATELY this reviewer does not read Italian, for this looks like a most interesting book on the modern superhet. There are chapters on the basic theory of the wave-changer, on the input circuits, on frequency conversion, on intermediate frequency amplifiers, detectors, volume control, on automatic frequency and selectivity control, etc., etc. It is paper bound and printed on good stock. It seems to be the sort of pocket-size book that engineers frequently wish American publishers would bring out, something the publishers never do.

Electron and Nuclear Physics

By J. BARTON HOAG, *Assistant Professor of Physics, University of Chicago. D. Van Nostrand Co., Inc., New York, 1938. Price, $4.00, 502 pages, 263 illustrations.*

SINCE THE first edition of this book appeared in 1929 (under the simpler title "Electron Physics") a vast amount of research into the properties of particles other than electrons has been undertaken. The new edition has been expanded to include this material, which is grouped in a section called "Nuclear Physics".

The book differs from the many others available with similar titles, in that it is concerned almost exclusively with *experimental techniques* underlying the present concepts of the atomic and sub-atomic world. The classic experiments, (such as the oil-drop and more modern X-ray grating methods of determining the charge on the electron) are described, and simpler experiments which the student may perform to illustrate the principles, are also provided. From this point of view the book qualifies as a laboratory manual, but it is more than that—it is a thorough and up-to-date review of the experimental background of modern microscopic physics. Used in conjunction with a good theoretical text, it should give the student, or engineer, a solid foundation in the field.—D.G.F.

PHOTO-RELAY ASSEMBLIES

Each of these rod-like structures is a complete phototube relay, containing the phototube, amplifier tube and auxiliary components, designed by the Electronic Control Corp. of Detroit

Air-Cooled Transmitting Tubes

RCA Manufacturing Co., Inc., Harrison, N. J. (Price $0.25, 192 pages)

TECHNICAL MANUAL, TT3, does for the Radiotron line of air-cooled transmitting tubes what technical manuals RC-13 and TS-2 have already done in providing technical information on receiving tubes and cathode ray tubes, respectively.

Line drawings of the tubes, socket connections, ratings for the various recommended types of service, and characteristic curves are provided for each transmitting tube. In addition, considerable general and design information is provided in various sections under the headings, general vacuum tube considerations, generic tube types, transmitting tube installation, transmitting tube application, technical description by tube types, transmitting tube ratings, transmitter design considerations, formulas useful in radio work, transmitting tube charts, rectifiers and filters, and a section on schematic wiring diagrams.—B.D.

Electrical Occupations for Boys

By LEE M. KLINEFELTER. (*E. P. Dutton & Co. 227 pages. Price, $2.00.*)

A SURVEY of vocational opportunities for boys in the electrical field written in narrative style. A boy and his father visit various kinds of electrical work. The battery man, the power plant, the movie operator, the wireless operator, radio service, electric welding—all are considered from the boy's standpoint. It should show a boy what kind of work these people do, and should tend to orient him in the direction he might ultimately wish to travel.

Sprinkle's Conversion Formulas

By LELAND W. SPRINKLE. *P. Blakiston's Sons & Co., Philadelphia, 1938. Price, $1.25, 122 pages.*

WITH SOFT LEATHER cover, this small volume (4¼" by 6¾") fits into one's pocket easily and provides a wide range of conversion factors from one system of measurements to another. An alphabetical arrangement of material is used, which contributes to the ease of using this book. Conversion factors for changing length, area, pressure, heat, volume, liquid measure, velocity, weight, mass, etc. from one system of measurements directly into another are given. Calculations are made to greater precision than will ordinarily be required; many conversions are exact, while others are calculated to seven significant figures.

Temperature and other conversions of purely scientific interest are omitted, and the electrical conversions are not nearly so complete and extensive as certain other listings. But the book provides useful information to anyone who wants to know, for example, how many cubic millimeters there are in a hogshead.—B.D.

P. S.—The answer is 238,482,400, to seven significant figures.

TUBES AT WORK

A Method of Periodical Sound Reproduction

BY T. KORN
The State Institute of Telecommunications, Warsaw, Poland

OF ALL THE methods of high fidelity sound recording, the photographic method allows for the greatest number of reproductions without noticeable reduction in sound quality. However, even this number is not unlimited. With the standard system of noiseless recording, the sound-on-film can be reproduced by means of ordinary theatrical apparatus about a hundred times only; thereafter the noise level increases above the tolerable amount. This number of reproductions is in many cases not sufficient. Recently, it was found necessary for several purposes, to develop equipment for periodical sound reproduction, in which the sound must be reproduced several million times, without any destruction to the film on which it is recorded. It is quite obvious that the usual system of reproduction by means of ordinary apparatus could not be applied in this case.

The method of sound reproduction developed by the author produces a quality of the sound practically equal to that obtained from talking pictures. The second advantage of this method is that the registering of the sound can be carried out on ordinary film recording equipment. Moreover, the new method allows for a very simple and inexpensive construction.

Full details of this method have been described in the July 1937 issue of *E.N.T.* Germany.

The general principles of the method are shown on Fig. 1. The film with sound recorded on it, is placed on a metal drum with a mirrorlike polished surface, film being placed with the emulsion toward the polished surface. The reproduction of the sound is obtained in the following way: The lamp *L* throws by means of the ordinary optical system *O*, as used in the theatrical apparatus, a slit of light on the surface of the drum, at a certain angle α. The light reflected on the mirror surface falls on the photoelectric cell.

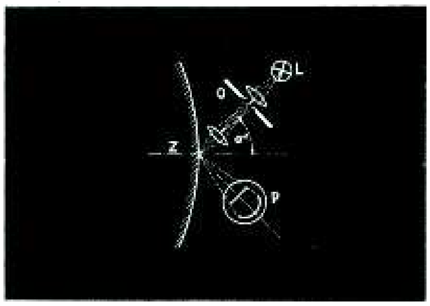

Fig. 1—Principles of sound reproduction from the mirrorlike drum. L—exciting lamp, O—optical system, Z—the mirrorlike drum, P—photoelectric cell.

The mathematical principles of this sound reproducing system differ from those commonly known in the theory of talking pictures. This is due to the fact, that in the new method the light passes twice through the photographic emulsion and not perpendicular to it. In consequence the absorption of light is much greater than in the ordinary method based on the principle of light passing only once through the film. It has been proved experimentally, that at the angle $\alpha = 40°$, the density of the film in the new method is thus increased about 2.5 times. To obtain best results it is necessary to develop the film, which is going to be reproduced by this method, with γ about 2.5 times smaller than the normal sound film. This condition being respected, both systems of "variable density" as well as "variable width" can be used.

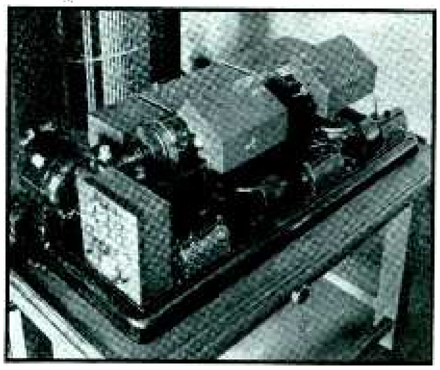

Fig. 3—Telephone speaking clocks.

By proper development of the film, the loss in the intensity of the sound in the new method, in comparison with the reproduction of ordinary sound film, will come up to few db. only, and this is due to absorbtion of light by surface of the mirror and of the celluloid. That loss, however, may be considered as negligible.

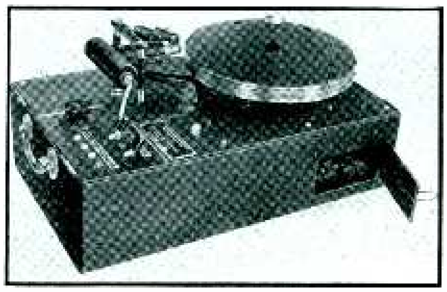

Fig. 4—Apparatus for broadcasting station signal reproduction.

Linear distortions

The new method, by using the ordinary theatrical optical system, causes a slight increase in the linear distortions. This is due to the fact, that the slit of light on the film is a bit wider, as the light does not fall on the film perpendicularly to it. The Fig. 2 shows the calculated frequency response curves for the ordinary and the new method of reproduction, using the same optical system. With the film developed properly, i.e., keeping $\gamma = 1/2.5\gamma_n$ where γ_n is the normal positive slope, non-linear distortions are not visibly greater than in ordinary sound films.

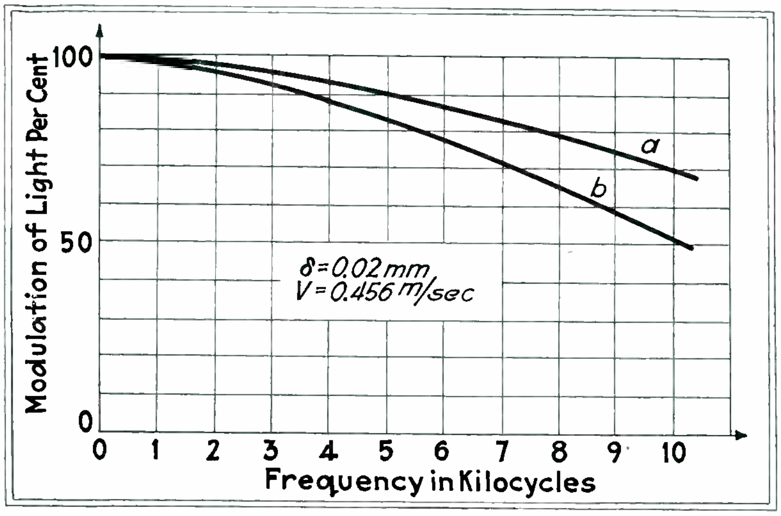

Fig. 2—Frequency response curves obtained with the—(a) ordinary and new (b) method.

(*Continued on page* 40)

Tubes At Work

(*Continued from page* 38)

The method described above has many practical applications of great commercial value. Speaking telephone clocks, indicating the exact time to the telephone subscribers (Fig. 3), installed at the telephone exchanges, are main practical applications of this method. These speaking clocks are a great success with the general public, wherever they are installed. In certain Telephone Exchanges in Europe the income brought in by these clocks amounts to 15% of the total revenue. Another installations of this kind are the speaking barometers, giving to the subscribers, on a call, a short weather forecast consisting of ten words. The barometers are also installed at the Telephone Exchange and should be established firstly in the harbor and mountain districts, where they would be certainly in constant demand. The apparatus for reproducing the broadcasting station signals during the intervals in the programme, were also constructed on this principle, Fig. 4. Similar apparatus connected directly to a loud speaker may be used for publicity purposes, like announcing advertisements, in automatic selling of newspapers, cigarettes, etc.

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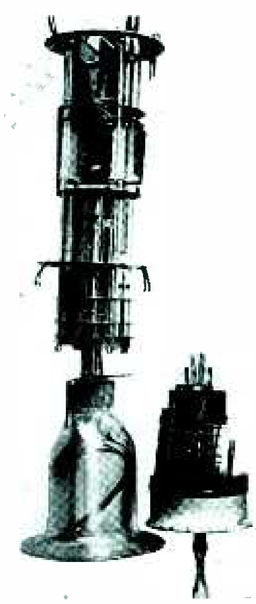
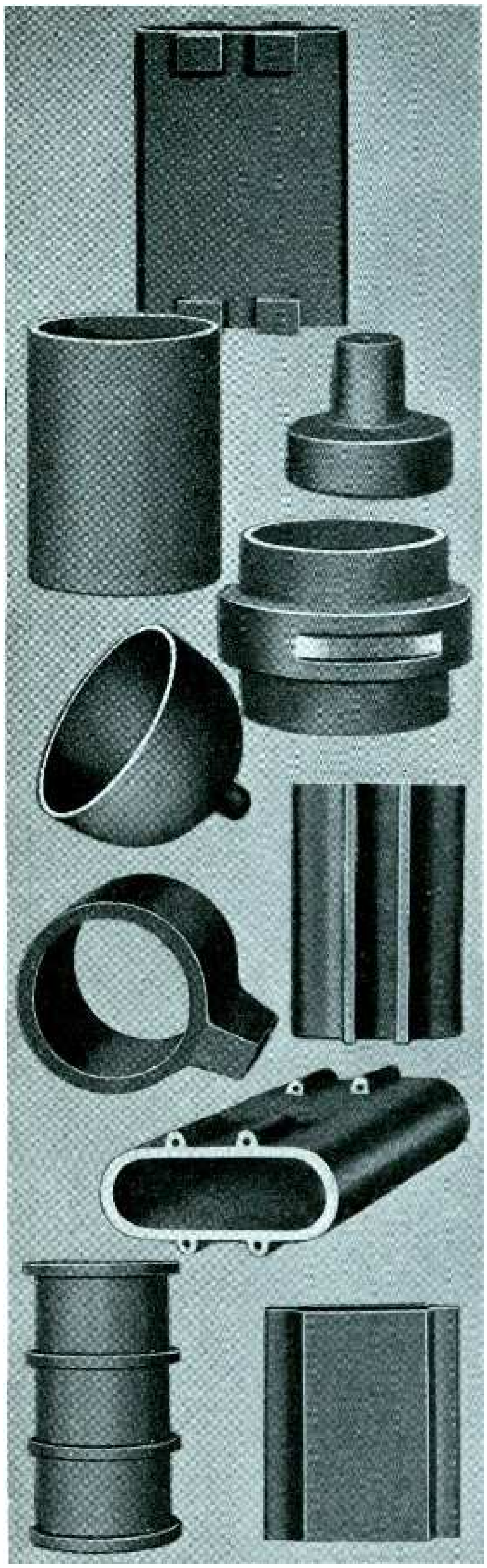
NEW CATHODE-RAY TUBE MOUNT



The small structure at the right is a new form of electron gun developed by the von Ardenne Laboratories, using a circular metal-to-glass seal. The new mount replaces the older one shown at the left



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6 MINIMIZE bulb darkening and insulator leakage.
7 IMPROVE degassing qualities.
8 DECREASE gas troubles.
9 ENHANCE tube appearance.
10 PROVIDE precise anode dimensions.
11 PRODUCE uniform tube characteristics.
12 RETAIN original dimensions in service.
13 MAINTAIN normal tube characteristics.
14 ALLOW wide latitude of anode design.

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5806

Multiplying the Range of a Vacuum Tube Voltmeter

By Gerald R. Chinski

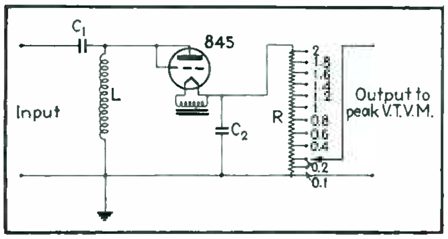
The radio transmitter engineer is often faced with the desirability of knowing, with reasonable accuracy, the peak value of certain rather large radio and audio frequency potentials, say 200 to 1,000 or more volts.

This is particularly true at KXYZ where a twenty-four hour service schedule is maintained with a single basic transmitter, forcing "trouble shooting" and maintenance to be performed in the shortest possible time.

Among the measuring equipment at this station is a commercial vacuum tube voltmeter of 100 volts maximum range. The general utility of this instrument has been excellent so it was decided to extend this range by means of an external voltage divider. This performed satisfactorily for low frequencies but was no good on radio frequencies because the divider was not sufficiently free of reactive effects.

A separate peak vacuum tube voltmeter was set up using inverted plate and grid connections as described by Terman and others. This worked satisfactorily but called for a large plate biasing supply voltage and also a grid voltage equal to plate voltage divided by the amplification constant of the tube.

It then became apparent that if it were possible to rectify the voltage under measurement without incurring other difficulties, it could then be divided in any ratio without being troubled with reactive effects in the divider. This ratio could then be indicated on the v-t voltmeter.



Circuit of high-voltage vacuum tube voltmeter

The arrangement adopted appears in the accompanying diagram.

A type 845 tube is used in this particular case as a diode rectifier. With the plate and grid tied together, it has a plate to filament capacitance of 8 $\mu\mu$fd. and resistance of about 300 ohms. This tube was selected because of the low plate-filament resistance and also the capacitance did not seem too high for the usual radio frequency circuits. Then, too, the insulation qualities are more than satisfactory, and finally because it was already available.

A value of two million ohms was selected for the load resister-voltage divider *R* because it did not seem probable that it would reflect any conse-

should be pointed out that no combination of C_1L should be used which is at or near reasonance with the frequency being measured. It should at all times be possible to bridge the rectifier input, with or without C_1L, across a circuit without any noticeable detuning or disturbing effects.

The divider should be well supported and highly insulated, for example, on ceramic standoff insulators. Also the tube socket is mounted on standoff insulators as well as C_1 to keep down stray capacities. The input circuit is connected by the shortest possible route and the wires are arranged as much in the clear as circumstances will allow.

The filament heating transformer must have high insulation between primary and secondary. It should be checked for any possible leakage before using. This is best done with a high voltage and a sensitive meter.

This device has been used at KXYZ for measuring grid excitation voltages, various tank voltages and concentric line voltages and the results have been very satisfactory. Checks with a cathode ray oscilloscope used as a voltmeter have agreed nicely. One kw. linear amplifier peak tank voltages have been measured as high as 1820 volts from ground to each side of push pull stage. This is equivalent to measuring the full peak tank voltage of 3,640 volts.

Naturally, since the whole set-up gives an indication of peak voltage only, it is of no value directly in determining r-m-s values unless the source is known to be sinusoidal or substantially so. In many applications, however, the source will be sinusoidal. When this is known the r-m-s value will be 0.707 × peak value.

• • •

Theater Sound Reproducing System Standards

By JOHN K. HILLIARD
M-G-M. Studios, Culver City, Calif.

SINCE THE INCEPTION of recorded sound to motion pictures, there has been a continual improvement in the quality of sound recording and sound reproduction by extending the volume range to produce greater dramatic effect. Improvements in amplifiers permit a wider volume range, and the theater reproducing apparatus must consequently be capable of transmitting this increased range to the theater patrons.

Some of the recent developments in reproducing equipment include: the introduction of new designs in horns which give far better quality than was formerly possible, and a more even and adequate distribution of sound throughout the theater auditorium; improvements in the film running mechanism which have reduced flutter to a minimum; and increased amplifier power, which will adequately reproduce without distortion the wider power

ranges now being recorded on the film.

It is recognized in the studios that until such time as all theaters are fitted with modern equipment, methods must be adopted which allow the wider volume range films to be reproduced to their best advantage in those theaters having equipment capable of this reproduction but which do not penalize those theaters fitted with reproducing equipment not capable of handling the wider volume range.

Film has an output limited by the dimensions of the track. The maximum volume range, i.e., the range from the faintest to the loudest sound which can

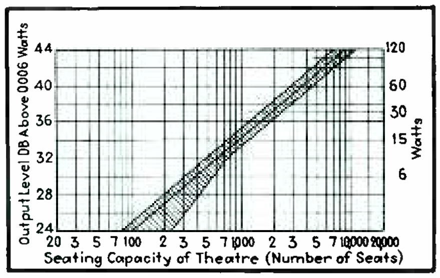


Chart for determining required sound levels

be satisfactorily reproduced, is limited by the volume range between surface noise and the total track sound output.

During the past year several of the major companies have, in a limited number of releases, made available to the theaters two general types of prints: one type being the "regular" release print with the ordinary volume

ISOLATED LOUD-SPEAKER

This suspension frame is used in the sound testing rooms of Siemens and Halske to obtain loudspeaker response measurements free from interference effects due to reflections. Note the extensive absorption treatment on the walls

BOOK REVIEWS

(*Continued from page 36*)

Principles of Electric and Magnetic Measurements

By P. Vigoureux and C. E. Webb, *both of the National Physical Laboratory, England. Prentice-Hall, Inc., New York. Price, $5.00, 392 pages, 197 illustrations.*

This is a "solid" book in the best English tradition. It treats fundamentals from a fundamental point of view, and while simply written is not "simplified". The first part, "Electricity" contains chapters on units, on action between charges, on magnets and magnetic fields, heating action of currents, the potentiometer, conductor networks, electrolysis, induction, thermionic tubes, radio frequencies, and electric charges in fields.

The second part "Magnetism" contains two chapters on magnetic measurements, including testing magnetic materials, magnetostriction, the Barkhausen effect, etc. While containing three chapters on electronic technique, the principle value to the reader of *Electronics* should be its coordination of the electronic methods with the broader fields of measurements in general. The omission of all references to the literature, stated by the authors to be intentional in the interest of easy reading, seems to this reviewer to detract from the work, but the treatment of most of the material is sufficiently detailed so that further study will not be necessary. The book is recommended.—D.G.F.

Mehrgitter-Elektronenrohren

By Dr. M. J. O. Strutt. *Published by Julius Springer, Berlin, 1937. Price RM 12.60, 131 pages.*

This book *Modern Multigrid Electron Tubes*, deals with the construction, operation, and characteristics of multigrid electron tubes used in modern radio receivers. It is the first of two columes; the second, which is to deal with the electrophysical principles of such tubes, is scheduled to appear this spring. The author is a member of the laboratory of the Philips Incandescent Lamp works in Eindhoven, Holland. He is well known for his original work and papers on this and other subjects.

The present volume is divided into three equal sections, the respective headings being "High-Frequency Amplifier Tubes," "Mixer Tubes" and "Tubes for Low-Frequency Amplification." The first section contains brief descriptions of the internal structures of typical modern glass and metal h-f amplifier tubes; an explanation of the operation of triodes, tetrodes, and pentodes; and a discussion of the fundamental properties of such tubes. The relation of the tube characteristics to the amplification of h-f signals, to the control of this amplification, and to the attendant distortion phenomena represented by modulation-rise and cross-modulation is described in detail. In addition, this section includes brief descriptions of the measurement of the important tube parameters; the disturbances which are encountered in the operation of amplifier tubes; the operation of hexodes as controlled amplifiers; the principles of operation of secondary-emission multipliers, beam tubes, and cascaded tubes (e.g., a hexode connected so that the first and second grids form a triode, and the third and fourth grids and plate form a tetrode); and the operation of tetrodes and pentodes as grid detectors and as plate detectors.

The second section contains an explanation of the principles of frequency conversion and the underlying theory of the process; a discussion of the operation of tetrodes, pentodes, hexodes, and octodes as mixers; and descriptions of the construction of several types of mixer tubes. The calculation of the conversion transconductance, the distortion, and the spurious signals which represent the by-products of the frequency conversion process is discussed in detail. The author also describes the measurement of tube admittances, conversion transconductance, distortion, and spurious signal response; discusses the space-charge-coupling phenomenon encountered in the octode type of mixer, and the d-c grid current due to electron transit-time, which is observed in hexode and heptode mixers at high frequencies; describes the frequency-drifting which is characteristic of the self-oscillating type of mixer, and mentions some of the practical difficulties encountered in the operation of the mixer tubes.

The third section contains a discussion of audio-frequency amplification, calculation and measurement of power output and distortion, the causes of distortion and various means for its minimization; operation of tubes as class A, B, and A/B amplifiers; and the effect of reactive loads. The author mentions such practical difficulties as microphonics, grid emission, and the hysteresis phenomena resulting from the impinging of electrons upon insulator surfaces within the tube.

A short appendix contains the numerical application of Bessel functions in tube calculations, a bibliography of 227 references to the international literature dealing with this subject, and an index. The book is paper-covered, but the printing and 128 figures are excellent.

The book bridges the gap existing between available general textbooks, in which the treatment of multigrid tubes is usually inadequate, and the voluminous and scattered papers dealing specifically with multigrid tubes. The book is well written and the large amount of material is organized in good fashion. Several criticisms may be mentioned. In his discussions the author frequently represents the plate current of a tube in terms of the control-grid voltage by means of a series of exponential terms, and indeed shows by actual illustration that this can be done accurately by only a few terms of such a series; nowhere, however, is indicated the process by which one may obtain such a series from a given transfer characteristic. A short appendix illustrating this process by a numerical example, or a reference to a text such as Steinmetz's "Engineering Mathematics" where this is done, would have been useful. Again, the μ-h-f behavior of amplifier and mixer tubes is treated in a rather descriptive manner.

In view of the importance of this subject, a more thorough and quantitative treatment would have been desirable. Another matter which is too briefly dealt with, is the important subject of fluctuation noise in amplifier and mixer tubes. Aside from such minor criticisms, the reviewer feels that the book constitutes a fine and up-to-date treatment of the subject. It is to be hoped that an English translation or equivalent will be made available soon.—B.S.

Pocket Databook

Raytheon Production Corp., Newton Mass. (Price $0.25, 192 pages)

This data book has been prepared to furnish the chief technical data on the complete line of Raytheon radio receiving tubes. By far the largest part of the book is devoted to outline dimensions, socket connections, ratings for various classes of operation and the more useful static curves. But the data book also contains a considerable amount of general information on the theory, operation, and practical use of tubes. Among the more important and more unusual subjects treated are sections on the fundamental characteristics of radio tubes, tube applications and circuits, conversion curves for determining the power output at other than rated voltages, design curves for resistance coupled amplifiers, tests of receiving tubes, and a list of interchangeable types of tubes.—B.D.

THE ELECTRON ART

Design, manufacture, test, and operation of high power triodes described in paper before the I. E. E. in London

Power Tubes

IN THE JANUARY, 1937, issue of *Electronics*, a paper on "Modern Receiving Valves: Design and Manufacture," was reviewed in this department, and judging from the mail inquiries received concerning it, created quite a bit of interest. A companion paper from the engineering staff of the M. O. Valve Co., of Wembley, England, was read before the Institution of Electrical Engineers in London on March 30. The title of this paper. is "High Power Valves: Construction, Testing and Operation."* It is expected that this paper will be published in the *Journal of the Institution of Electrical Engineers* within the next several months.

The first part of the paper is devoted to the constructional principles used in high power tubes. In the construction of large power tubes detailed attention must be given to the differential thermal expansion of the various elements making up the tube. This is especially important in the case of glass-to-metal seals. Throughout the range of temperatures to which the tube is subjected during its exhaust and operating life, the thermal expansion of the glass and metal must be sufficiently alike so as to preclude the possibility of strain being set up in the completed tube. This consideration requires special attention since the glass envelope or bulb is an important structural factor, for in one way or another all of the other parts are mounted upon it.

* *Electronics* does not have copies of this paper available for distribution. For additional information, readers should communicate with the Secretary, The Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London W. C. 2, England.

Copper of good ordinary quality with low content of volatile impurities is used as the material for the anode or plate. To prevent fine leaks, exposure of the "end-grain" of the drawn or rolled metal is avoided. Considerable expansion is noted when the plates are heated. The authors report that for an anode 21-in. long, the expansion at the baking temperature of 400° C. is 0.14 in. and that at the full load operating temperature of about 130° C. the expansion is 0.034 in.

Differential thermal expansion of materials having various thermal coefficients is the principal constructional difficulty in making the grids. Unless the grid structure is designed as to avoid strains such differential expansions set up strains leading to progressive distortion, due to the different rates of heating by radiation and bombardment. Low-μ tubes are constructed with a grid of parallel wires, while high-μ are built with a spiral of suitable pitch in addition to the parallel rods.

The largest tubes constructed to date require an emission current of 166 amperes, throughout a tube life of approximately 10,000 hours. In order to supply this emission requirement, approximately 50 sq. in. of incandescent tungsten must be provided. The filament assembly in this case is made from a number of filament wires 1.15 millimeters in diameter and the total filament power is 22 kw.

The principal mechanical factors governing the design of these multiple cathode systems, are that in coming up to incandescent, the longitudinal expansion of the filaments wires is 4 millimeters in a total length of 350 millimeters, and that the magnetic forces between these individual filament switch carry current of approximately 60 amperes tend to distor the filament structure appreciably.

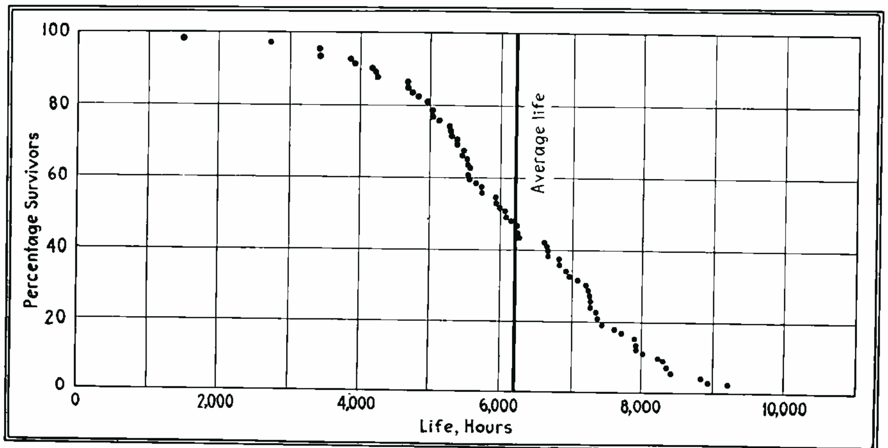


Fig. 1—Mortality curves of a set of high power triodes operated at constant filament voltage. With constant filament voltage, the curve is considerably more spread than when tubes are operated at constant emission

The general principle followed in the exhaust schedule of high power tubes is similar to that employed in low power receiving tubes, in that each part of the tube is subjected while on the exhaust pump to conditions more severe than it will ever be expected to meet in operation. The exhaust schedule differs from that of receiving tubes in that the plate is not necessarily bombarded and in that tube types which have a bright emitting filament do not make use of any getter.

The authors point out that one of the more important factors to be considered in working out a successful exhaust schedule for power tubes is the production of a tube capable of cleaning up, if required, the largest possible amount of gas liberated in operation. Totally aside from the effects of exhaust schedule on cleaner, certain operating conditions are conducive to clean-up, notably those in which the anode current flows when the grid is negative, at any rate for part of the operating cycle. The normal operation of class B and class C amplifiers falls in this category. "Conversely, conditions in which an absorber biased beyond cut-off when inactive, and passing anode current only when the anode potential is low and the grid is at a high positive potential, are not favorable to clean-up."

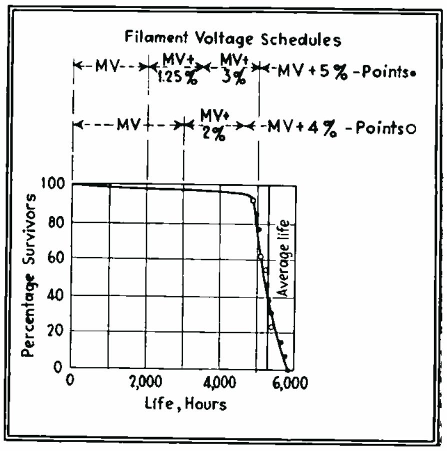
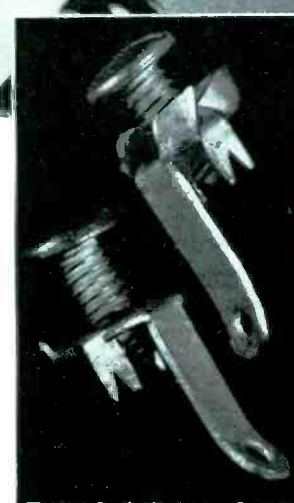


Fig. 2—Mortality curve of tubes operated at constant emission. Actul filament voltage, in terms of the manufacturer's rated voltage, is shown above the graph

Attention is given by the authors to the determination of the saturated emission current. It is pointed out that the method used in the manufacture of receiving tubes, i.e., that of providing considerable excess emission over that actually required, is wasteful and expensive, particularly in the case of tungsten filament tubes. It is impracticable in making tests, to measure the full emission from the cathode continuously, because of damage to the tube through overloading. Such emis-

(*Continued on page* 54)

STRAY WIRE ENDS CONTROLLED IN NEW CINCH BINDING POSTS



No scraggly wires when screw is tightened in the new "Cinch" collar binding post as pictured (right) at top. The new feature controls and hugs the wire to the screw, keeps it wrapped around and fastened, and it neatly provides for more than one wire at one time. The "Cinch" binding post you select is used by the most discriminating set manufacturers — everywhere. That is the most sincere endorsement. Supplied in strips as shown below, plain or with marking. From one to ten — choose the one that fits your need!

Cinch and Oak Radio Sockets are licensed under H. H. Eby socket patents

CINCH

MANUFACTURING CORP., 2335 W. VAN BUREN ST., CHICAGO
SUBSIDIARY UNITED-CARR FASTENER CORPORATION, CAMBRIDGE, MASS.

Center distance between posts is 7-16". Strips of one to six posts available in 1-16" thick Ucinite, and seven to ten posts in 3-32" thick Ucinite unless otherwise specified.

sion test may also be misleading since the end of the filament may tend to become overheated through the superposition of the space charge on the filament current. Consequently satisfactory methods of determining the saturated emission must be made by applying the filament voltage intermittently, or by determining the reduced emission at some subnormal filament temperature. For high power tubes in which the full emission may be several amperes, the method of reduced emission for normal current may be obtained by methods of extrapolation of a plotted curve.

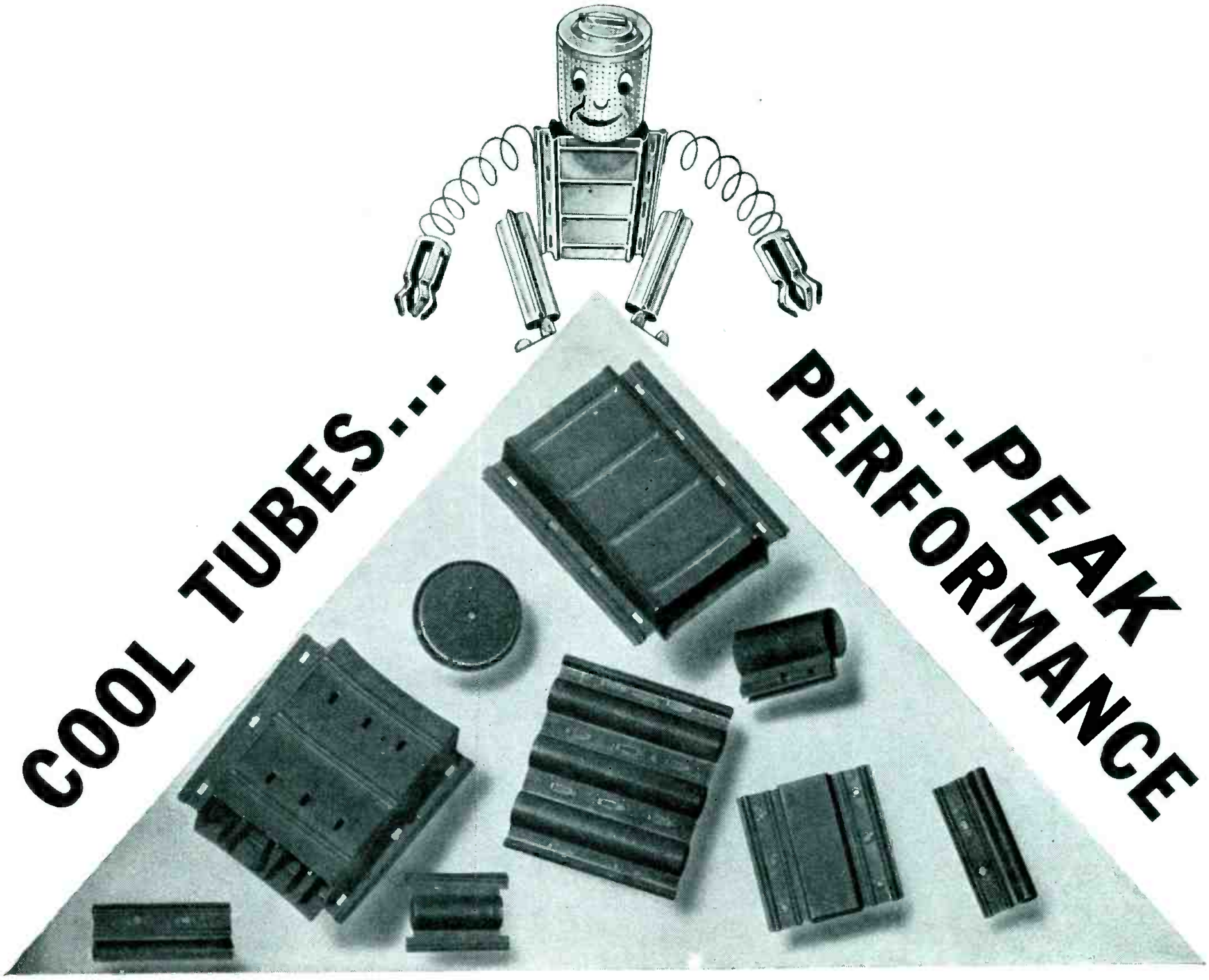
The authors point out that to obtain the static characteristics of high power tubes "is frequently just possible without undue risk to the valve, but high power plant is needed." Dynamic methods in which peak current or peak voltage recorders are used, also require considerable power equipment. The method which is used for the determination of tube characteristics makes use of a cathode ray oscillograph in which the space current characteristics are determined from low power readings. The method in which such measurements are carried out and the significance of the graphical plots which may be obtained, are considered in some detail by the authors.

The general form of the lower part of the grid voltage grid current characteristic is determined to a large extent by the amount of secondary emission. Comparatively little variation from tube to tube of any given type is found in the grid emission characteristics which indicate that the grid of a high power tube represents a clean metal surface and that the secondary emission coefficient is approximately that of the pure metal. The authors have found that the secondary emission is not uniform along the length of the grid, but is much greater from the ends which are opposite the cool ends of the filament, than from the central active region.

The authors discuss the conditions of operating voltages in currents which are conducive to conservative operation of the tube and longevity.

With regard to the life of power tubes, the authors say: "There are many possible causes of failure but filament burn-out is the only really fundamental cause. It may be delayed but cannot be prevented. The maximum life any valve can have is therefore the life of its filament, and we shall first consider the various factors which affect the life of the filament in pure tungsten operating at a temperature of about 2,500° K. Filament failure is due to gradual wastage by evaporation, and eventual overheating of the thinner points. It has been found, by examination of large numbers of burn-out filaments, that failure occurs when the diameter is reduced by 10% by evaporation. This rule holds whatever the initial diameter, and was first enunciated at the American General Electric Co. laboratories for lamp fila-

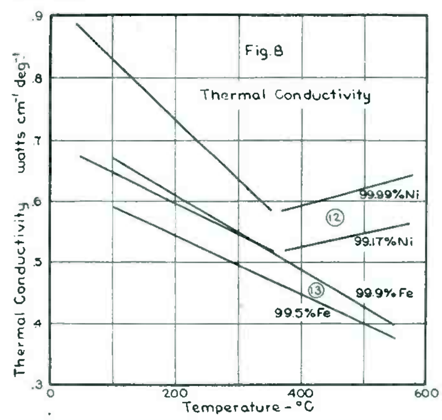
(*Continued on page* 57)

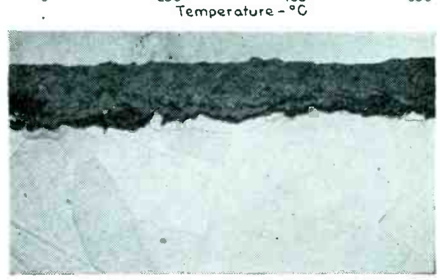


Carbonized Nickel distributes and dissipates heat uniformly and rapidly

Two important properties, rarely found in one metal, combine in Nickel to keep tube performance on a high, even plane.

Examine the accompanying chart and you'll note: First, that Nickel *conducts heat* 50% better than iron at 550° C. Thus, it distributes heat more rapidly and uniformly—keeps down local over-heating and hot spots. Glance at the other illustrations and you'll see: Second, that the coating on carbonized Nickel attaches itself firmly to the metal—and that carbonized Nickel can be drawn, stamped and spot welded without damage to the coating. The reason: Nickel catalyzes the deposition of carbon—does not form carbides and become brittle.





Micrograph of carbonized Nickel. The coating adheres tightly to the metal, and is not damaged by forming operations or by expansion of the metal at high temperatures.

Because of its tight, uniform intensely black coating, held intact during forming, carbonized Nickel *radiates heat rapidly*. That means a low, uniform plate temperature, lower back emission, improved and more uniform performance in service, greater satisfaction for the user, better reputation for the tube maker.

What Nickel does for radio tubes, Nickel and Nickel alloys can do in other applications. Write us about your metal problems. For technical information and your copy of "Nickel in the Radio Industry" write to "Electrical Research," c/o

NICKEL

THE INTERNATIONAL NICKEL COMPANY, INC., 67 WALL ST., NEW YORK, N. Y.

CONCENTRATING-

ON JUST ONE THING has put us in a position to do a better job at a better price for all users of fine small tubing—from hypodermic needles to polo mallets. If your product employs OUR product it may pay you to ask for an honest quotation from Superior Tube Co., Norristown, Penna.

★

MANUFACTURERS OF SEAMLESS AND LOCK SEAM CATHODE SLEEVES
AND SMALL SEAMLESS TUBING IN VARIOUS METALS AND ALLOYS

SUPERIOR TUBING

(*Continued from page* 54)

ments of 0.1 millimeter diameter or less.

"Knowing that a filament will burn out when evaporation reduces its diameter to 90% of its original value, we can readily and accurately calculate its life. Early life estimations for cooled anode valve filaments using tungsten evaporation figures of Jones and Langmuir gave a theoretical life of about one-half the observed average. More recent simultaneous determinations of the emission and rate of evaporation of tungsten by Reimann, using samples of tungsten from the same source as our filaments, show Jones and Langmuir's figures to be high by a factor of about 2 and the estimated life using Reimann's results is in excellent agreement with the actual lives obtained."

In general it is practice to operate the filament of water-cooled tubes at a temperature which will just satisfy the emission requirement of the circuit. Filaments are consequently rated on an emission basis, and the individual tubes are stamped with the filament voltage required to produce a certain emission current. Since a 5% increase in this voltage increases the emission by 50%, but also reduces the life of the tube to ½ of its rated value, accurate voltmeters are required in adjusting the filament temperature if the maximum life of the tube is to be obtained.

The problem as to whether the filament current or the filament voltage should be used as the determining

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TELLURIUM VAPOR LAMP

The latest vapor to be applied in electronic lamps is tellurium, with neon as a "starter." The spectral output of the lamp closely resembles sun-light. The lamp envelope is quartz, necessary to withstand the high temperature produced by the discharge. Above is Dr. N. C. Beese of Westinghouse, one of the developers of the lamp

factor in the filament temperature is discussed by the authors. Fig. 1 shows a mortality curve for 74 high-μ triodes operated at specified filament voltage in the B.B.C. regional transmitter. "This curve is for filament burn-out failures only, and is typical of cooled anode valves operated at marked volts. Some 50% of the failures occur within plus or minus 20% of the average life, a few per cent of the valves fall off at half the average life, and a few per cent survive to almost twice the average life. The average life agrees very closely with the calculated value.

"Constant filament current operation cannot be tolerated, as in that case temperature and emission increase rapidly, and the life is only about one-fifth of the constant voltage life. Constant emission is the ideal method of operation, and so far this has only been attained by increasing the filament voltage during life according to a predetermined schedule based on the results of emission tests on long life valves." The mortality curve obtained by such a method of operation is shown in Fig. 2, which is for thirteen triodes of the same type as that for which Fig. 1 is drawn. Comparison between Fig. 1 and Fig. 2 shows that the spread is much reduced, and that the extra long life tubes are eliminated. The extreme sharpness of the shoulder in Fig. 2 is partly accounted for by the fact that an increment of filament voltage comes just before this point.

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Protecting the Transmitter from Shutdown

HIGH VOLTAGE transients, and arcs in the transmitter may do appreciable damage to the transmitting equipment and result in considerable loss of revenue through the necessity of taking the station off the air until repairs are made. Protective circuits that will disable the transmitter momentarily, whenever one of these transients arcs is encountered, may be used to protect the transmitter from longer shutdown periods due to damaged equipment. With this objective in mind, the Bell Telephone Laboratories have recently developed two protective circuits which will be used to assure continuity in

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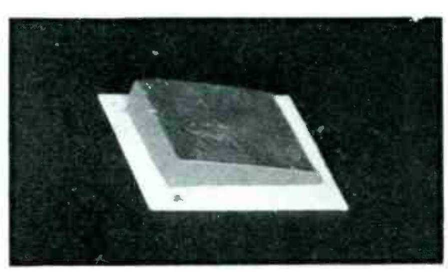
CRYSTAL FILTER



By cutting a quartz crystal in the form of a wedge, a French research investigator claims to have produced a band pass filter with sharp cut off service and to minimize damage to the apparatus.

Figs. 1 and 2 give the schematic wiring diagrams of the protective circuits developed by the Bell Telephone Laboratories. The protective circuit of Fig. 1 disables the transmitter on any disturbance occurring in the output unit circuit. Two impedances, Z_1 and Z_2 are connected respectively in the grid and plate circuits of the final power amplifier. These impedances are so adjusted that the current flowing through them is equal in magnitude and opposite in phase, so that no current will flow in the common ground connection. The common ground connection between the two impedances passes through a rectifier across which is bridged the winding of a relay. The relay can be used to cut off the carrier power supplied to the final amplifier.

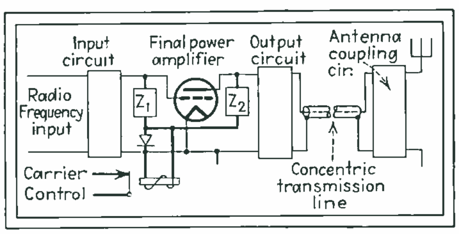


Fig. 1—Relay circuit fed by rectifier and currents through Z_1 and Z_2

If the output circuit of the final amplifier becomes untuned, due to short circuit, transient, or failure of one of the tuning elements, the impedance in the plate circuit will change, causing the radio frequency plate voltage to change in phase or amplitude or both. When this condition occurs, the currents through Z_1 and Z_2 are no longer equal and opposite so that current will flow to the ground through the relay and rectifier. The relay will then operate and remove the carrier power. When the normal condition in the final power amplifier stage is restored, the relay will release, so that carrier power may again be applied.

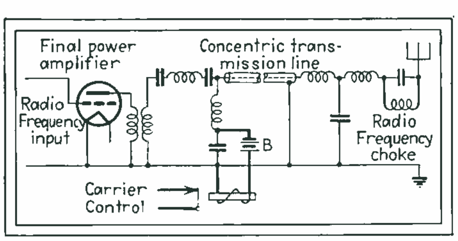
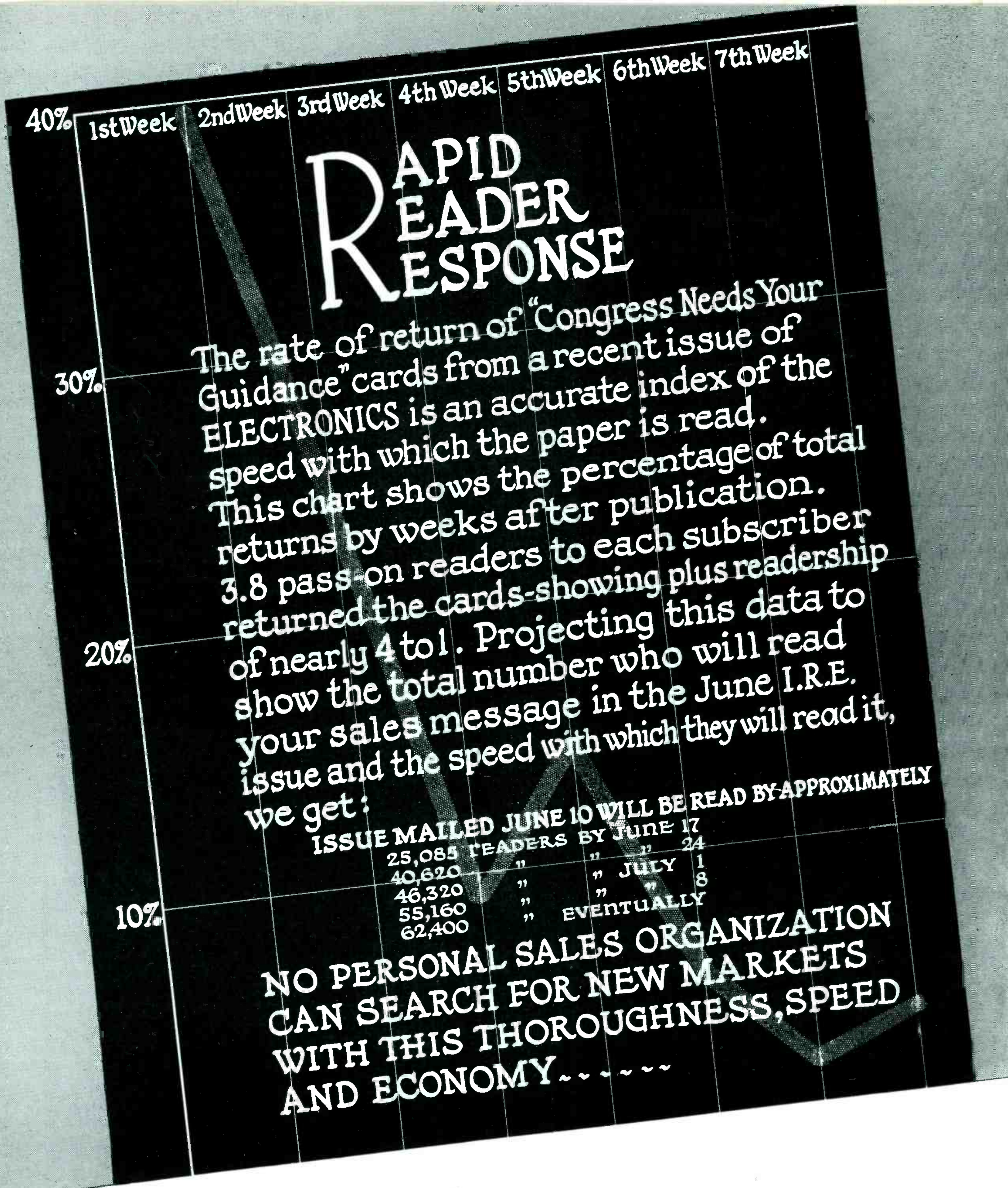


Fig. 2—Protective circuit especially suitable for use with coaxial cables

In the circuit of Fig. 2, an arc to the ground, one side of the relay is connected to ground while the other side is connected to the outgoing transmission line through a high impedance. Normally the relay contacts are closed and no current flows through the relay winding. If an arc to ground should be formed, the low impedance pass from the antenna to the ground would permit current from the battery B to flow through the relay winding, thereby opening the carrier control circuit.


40%
30%
20%
10%
1st Week
2nd Week
3rd Week
4th Week
5th Week
6th Week
7th Week
RAPID READER RESPONSE
The rate of return of "Congress Needs Your Guidance" cards from a recent issue of ELECTRONICS is an accurate index of the speed with which the paper is read. This chart shows the percentage of total returns by weeks after publication. 3.8 pass-on readers to each subscriber returned the cards-showing plus readership of nearly 4 to 1. Projecting this data to show the total number who will read your sales message in the June I.R.E. issue and the speed with which they will read it, we get:
ISSUE MAILED JUNE 10 WILL BE READ BY APPROXIMATELY
25,085 READERS BY JUNE 17
40,620 " " " 24
46,320 " " JULY 1
55,160 " " " 8
62,400 " EVENTUALLY
NO PERSONAL SALES ORGANIZATION CAN SEARCH FOR NEW MARKETS WITH THIS THOROUGHNESS, SPEED AND ECONOMY......

Relays for Tube Circuits

(*Continued from page 23*)

cuit which the contacts open and close, the voltage, current, frequency, and number of makes and breaks per unit of time. For this reason it is impossible to specify the contact area which will be satisfactory for carrying a given current, except in very general and somewhat arbitrary terms. Where currents less than 1 ampere are to be controlled, the telephone type contacts are frequently adequate, especially if the circuit is non-inductive. For currents exceeding a quarter ampere or so, large metal or carbon contacts are frequently used, although carbon has sufficiently high resistance that the voltage drop across carbon contacts is sometimes objectionable. For currents up to about 25 amperes, "mercury contacts" are widely used. The mercury contact devices consist of two (or more) wires sealed in a glass tube which also contains a small pool of mercury. These contact devices are so built that when the glass tube is tipped in one direction, the two wires present an open circuit. When the tube is tilted in another direction, the mercury runs down between the two wires, thereby closing the circuit. An advantage of mercury contacts is that they are relatively trouble free and do not require periodic cleaning, as do many types of metal contacts.

The continued successful operation of a relay device depends upon the contacts being maintained in good operating condition. Contacts should be kept in a clean condition, and may require periodic cleansing. If the relay equipment is properly designed, installed, and maintained, periodic cleaning by rubbing the surfaces of the contacts with a sheet of tough bond paper should suffice. Contacts should not be cleaned with abrasive pastes or powders, nor should these surfaces be marred (except in the most unusual cases) through the use of files, emery cloth, sandpaper, or similar abrasives. Failure to observe this precaution may result in the accumulation of particles of sand, emery, or metals (especially magnetic materials) which are left between the contacts to produce subequent trouble and annoyance. The contacts of a relay are usually situated in a fairly strong magnetic field, so that any magnetic particles between the relay contacts are especially likely to cause trouble and be difficult to remove. Another reason for avoiding the abrasion of the contact surfaces is that this abrasion is very likely to change the shape of the contact surfaces so that the current density after the abrading process is quite different from that for which the relay was initially designed.

Selection of Contacts

If possible, the choice of the contact should be made when the relay equipment is designed. If this procedure is carried out, the contacts may be designed so as to be most suitable for the intended purpose. In selecting contacts for a specific relay application, consideration should be given to the following factors:

1. Do the contacts make and break an a-c or a d-c circuit?
2. What is the magnitude of the voltage at the time at which the contacts open and close the circuit?
3. What is the magnitude of the current at the time the contacts open and close the circuit?
4. What is the normal current which the contacts must carry when closed?
5. Specify the normal frequency of operation, i.e. the number of electrical interruptions of the relay contacts per unit of time.
6. What is the rate of speed at which the contacts open and close?
7. What is the maximum permissible voltage drop across the relay contacts?
8. Specify the maximum distance at which the contacts are separated.
9. Is any method of arc extinction used? If so, what method is employed? (For example, specify whether condensers, blow-out coils, by-pass resistors, or other methods are used).
10. Specify the pressure applied to the contacts when closed.
11. State the method of opening and closing the contacts, that is, magnetic, cam operated, gravity operated, etc.
12. Specific manner in which the contacts come together, i.e. butt contacts, wiping, rolling, or rotary motion, etc.

13. Specify the mechanical and physical conditions under which the contacts are to be used. Are the contacts to be subjected to severe mechanical action, or to various corrosive fumes, gases, dust, or to coatings of oil, grease, water vapor, etc.?

14. Specify the maximum allowable temperature rise at which the relay equipment is to operate.

In connection with items 2, 3, and 4, above, if the current and voltage are varying quantities, it is conservative design to base the calculations of relay contacts upon the maximum or peak values of the current and voltage. Special attention should be given to the case in which the contacts are required to interrupt an inductive circuit.

Proper Relay Installation

To prevent inoperation of the relay device due to the accumulation of dust, dirt, grease, films of oil, or other poorly conducting foreign particles, it is preferable to install the relay equipment so that the contact surfaces are vertical, the contacts coming together in essentially a horizontal motion. This procedure is advantageous in that foreign particles will not then accumulate on the surface of the relay contacts through the action of gravity. Where the relays are to be used in an atmosphere of fumes, dust, dirt, sprays, and the like, it is desirable that the contacts be protected by enclosing them in a dust-proof chamber or container. If a container is required, it is desirable that the entire relay be enclosed and protected rather than only its contacts. Any necessary opening in this protective enclosure should be at the bottom of the enclosure and as far removed from the relay contacts as practicable.

BIBLIOGRAPHY

"Fundamentals of Vacuum Tubes," by A. E. Eastman. (Chap. VI.)

"Thermionic Vacuum Tube," by H. J. Van der Bijl. (Sec. 59.)

"Theory of Thermionic vacuum Tubes," by E. L. Chaffee.

"Electron Tubes in Industry," by Keith Henney.

"Relays in Tube Output Circuits." by E. E. George, *Electronics*, August 1937.

"Relays for Electronic Devices," *Electronics*, February 1933.

"An Electronic Voltage Relay," by J. W. Graff, *Electronics*, March 1934.

"Thermionic Delay Relays for Cathode Protection," by L. D. Miles and M, M. Morback, *Electronics*, April 1935.

"A Thermionic Time Delay Relay," by George Mucher, *Electronics*, April 1936.

"Limited Impulse and Delay Relays," by Daniel El Noble, *Electronics*, August 1936.

MANUFACTURING REVIEW

News

✦ Installation of the Lorenz instrument landing system, illustrated in the July, 1937, issue of *Electronics*, will be made at the Municipal Airport, Fort Worth, Texas. International Telephone & Telegraph Corp., parent company of C. Lorenz Company, manufacturers, announced it will be utilized extensively for training pilots in guiding the big transports to a complete runway landing entirely by radio.

✦ First of 44 Westinghouse radio range stations built for the Department of Commerce will be installed at Allentown, Pennsylvania. This apparatus is made up of transmitter unit, antenna tuning unit and coupling unit.

✦ All radio range stations are designed to operate over a temperature range of 0 degree to 50 degree Centigrade, 24 hours per day, 365 days per year.

✦ Allen B. DuMont is now located at 2 Main Ave., Passaic, N. J.

✦ Vice-President Frank E. Mason has been assigned to supervise all of NBC short-wave activity.

✦ Kenneth W. Jarvis is now Chief Engineer of Seeburg Radio Corp. of Chicago.

✦ As a recent appointment to the executive staff of United Carr Fastener Corp., Mr. Lester W. Tarr will supervise production and marketing of a new phenolic insulation. Mr. Tarr was formerly chemist with the Dupont

Company, and later general manager of Continental Diamond Fiber Co. He is a member of the American Chemical Society, American Institute of Chemical Engineers and a Fellow of the American Institute of Chemistry.

Literature

Manufacturers' literature constitutes a useful source of information. Readers who wish copies of items listed below may obtain them by writing to the manufacturers.

Voltage Regulator. Bulletin D148-71-F. For problems arising from fluctuating a-c line voltages. Raytheon Mfg. Co., Waltham, Mass.

New Ceramic Fixed Capacitors. Bulletin 20. Centralab, 900 E. Keefe Ave., Milwaukee, Wis.

Socket Instruments. Catalogue Section 43-600. 20 pages. One of several booklets on industrial applications of plug-in instruments. Westinghouse Electric & Mfg. Co., Newark, N. J.

Interval Timer. Model A. Synchronous motor driven. R. W. Cramer & Co., 67-69 Irving Place, New York City.

Multi Frequency Transmitters. Multi frequency low power transmitters suitable for aircraft. Learadio Specification folder. Lear Developments, Inc., Mineola, N. Y.

Thyratron Tubes. Bulletin No. 16. Technical data sheet. Westinghouse Electric & Mfg. Co., Bloomfield, N. J.

Glass Covered Wire. Bulletin on "Vitrotex", a glass-covered magnet wire which is fireproof and non-hygroscopic. Has high dielectric strength, and insulation resistance, and high resistance to acids, oils and corrosive vapors. Anaconda Wire & Cable Co., 25 Broadway, New York City.

Lighting Plants. A 2-page folder giving detailed electrical and mechanical specification on a-c lighting plants showing various models. D. W. Onan & Sons, 41-51 Royalston Ave., Minneapolis, Minn.

Booklets. Weston Electrical Instrument Corp., Newark, N. J. Model 721, "Photo-electric Potentiometer", technical description and applications. Model 729, "Industrial Control Relay", an aid to automatic production operation and photoelectric control purposes. "Tools For Better Seeing, 4-page form describes light measuring instruments. Model 773, a double-check tube tester. Model 776, Oscillator.

Relays. GEA-2170A. Directional distance relays. General Electric Co., Schenectady, N. Y.

Alloys. 16-page booklet, characteristics and uses of special alloys. International Nickel Co., Inc., 67 Wall St., New York City.

Color Chart Rare Gases. Listing and describing 17 colors obtainable from luminous rare gases. Linde Air Products Co., 30 East 42nd St., New York City.

Auto Antenna. Retractable, for automobile use. Hahn-McPherson Labs., Hatboro, Pa.

Bushings. Bulletin No. 104. For lead-in, transformer, and condenser service. Contains mechanical drawings, dimensions, etc. Isolantite, Inc., 233 Broadway, New York City.

Measurement. "When You Can Measure", a 32-page brochure. How electrical instruments are designed, constructed and tested. Section of book given over to voltage, resistance, time, and temperature measurements. General Electric Co., Schenectady, N. Y.

Megohmmeter. A model "DM" with a new easily readable face. Herman H. Sticht & Co., 27 Park Place, New York City.

Co-Axial Transmission Line. Bulletin gives dimensions, descriptions, illustrations. Communication Products, Inc., 245 Custer Ave., Jersey City, N. J. Bulletin No. 21 announces a new Q-Max radio frequency lacquer.

Cathode-Ray Problems. A questionnaire which when properly filled out enables their engineers to draw specifications for suitable cathode-ray equipment. Allen B. DuMont, 2 Main Ave., Passaic, N. J.

Decibel Chart. Showing the relation between voltage and power ratios in decibels. Transducer Corp., Rockefeller Plaza, New York.

Amplifiers. Catalogue No. 600-C. Thordarson Electric Mfg. Co., 500 W. Huron St., Chicago.

Tap Selector Switch. Bulletin 802. For a-c reactive circuits. Ecco High Frequency Corp., 120 West 20th St., New York City.

Microphones. Bulletins 26 and 27. American Microphone Co., D. R. Bittan Sales Co., 27 Park Place, New York City.

Stand-Off Insulators. Bulletin 103, lists wide variety of units. Isolantite, Inc., 233 Broadway, New York City.

Stop Nuts. "Elastic Stop" 1938 Catalogue. Contains 46 pages of descriptive material, 11 pages of which are devoted to aircraft fittings. Elastic Stop Nut Corp., 1001 Newark Ave., Elizabeth, N. J.

Recording Equipment. 8-page bulletin, "Fine Points In Recording". Allied Recording Products Co., 126 West St., New York City.

Silent Gears. Engineering and design information. "Spauldite Silent Gears". Spaulding Fibre Co., 310 Wheeler St., Tonawanda, N. Y.

Plastics. "Reference For Plastics". A 40-page revised edition. A thoroughly descriptive and handsome guide book of moldable resins. Boonton Molding Co., Boonton, N. J.

Circuit Breaker Attachment. The applications for their trip attachment on Types BD and HD air circuit breakers for the protection of a-c circuits is treated in Catalog 5 of the Roller Smith Company, 233 Broadway, New York.

Multiple Frequency Generator. Model 18F signal generator. Monarch Mfg. Co., 3341 Belmont Ave., Chicago.

Flexible Shafts. Engineering Bulletin No. 38, covering subject of flexible shafts for remote control, is a 32-page illustrated booklet. S. S. White Dental Mfg. Co., 10 East 40 St., New York.

Constant Temperature. Supplementary catalogue R-13, describes a complete line of constant temperature ovens. Central Scientific Co., 1700 Irving Park Blvd., Chicago.

Lighting Plants. Showing various models and actual installations is an 8-page folder giving complete mechanical and electrical specification of a-c lighting plants. Kato Engineering Co., Mankato, Minn.

Audiphones. Hearing aids are described in a 23-page booklet, Ortho-Technic Audiphones. Miniature telephones as an aid to hearing. Western Electric Co., 195 Broadway, New York.

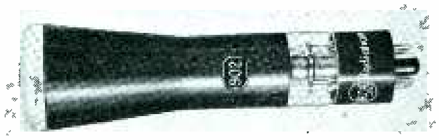
Triode-Hexode Converter. 2 pages of technical information on Sylvania Type 6K8 tube. Hygrade Sylvania Corp., Salem, Mass.

New Products

Cathode-Ray Tube

OPERATING WITH a second anode voltage as low as 400 volts and designed especially for oscillographic purposes, RCA-902 is a new high-vacuum tube recently announced. The tube has two sets of electrostatic plates for deflection of the electron beam. The luminous spot of greenish hue is produced on a screen 2 in. in diameter.

Because of its relatively low cost, small size, and its ability to produce an image at low voltages, the tube is suited for use in compact, portable, oscillographic equipment.



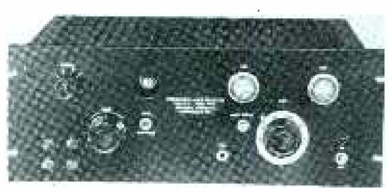
The RCA-902 will operate on voltages as high as 600 volts, and is electrically interchangeable with the RCA-913, provided the second anode supply is 400 volts or more. RCA Mfg. Co., Harrison, N. J.

Mu-Switch

IS SUITABLE for electric control circuits at a current rating of 10 amperes at 110 volts; 1200 watt non-inductive load and ½ H.P. inductive load, with less than .001 in. movement for thermostatic work. Silver contacts. Tobe Deutschmann, Canton, Mass.

Frequency-Limit Monitor

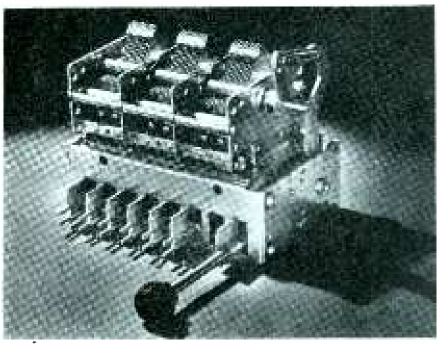
AN A-C OPERATED monitor, Type 775-A, designed for monitoring high-frequency transmitters between 1,500 kc. and 45 Mc. is a new product of General Radio Co., Cambridge, Mass.



Warning lamps indicate frequency deviation outside the predetermined limit. When the transmitter frequency exceeds this limit on the low side, one lamp lights; a similar deviation on the high side lights the other lamp. Operating limits calibrated in c.p.s. are set by a dial on the panel. The indicating system operates on the beat frequency between the transmitter and a self-contained crystal oscillator. Space is provided for mounting 4 crystals, so that 4 separate channels can be monitored.

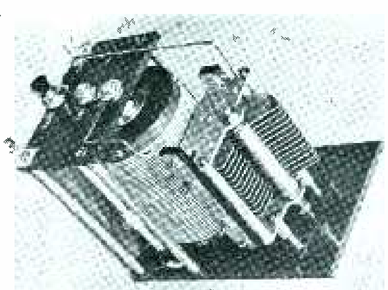
Push-Button Tuner

A PUSH-BUTTON tuner and variable condenser, complete in one unit, has been announced by General Instrument Corp., 829 Newark Ave., Elizabeth, N. J. The unit is available in 4 to 10 button frames with manual tuning. Condenser may be mounted with front or rear shaft extension.



Antenna Tuning

LEAR Developments, Inc., Roosevelt Field, Mineola, N. Y., announces a new antenna tuning system which eliminates the necessity of using relays to change from one frequency to another.



One unit is needed for each frequency or narrow band of frequencies. A single fixed antenna may be tuned to 3 or 4 different frequencies provided there is at least 20% difference between frequencies e.g., 3,000, 4,000, 5,200 kc.

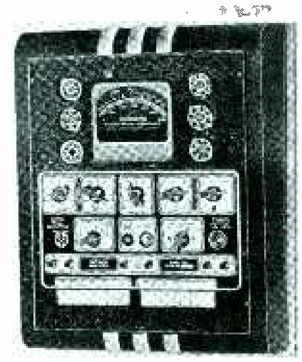
The power loss due to matching fixed antenna into transmitters is reduced by improved lead-in efficiency and the increase in antenna voltage due to these units.

Battery Charger

A COPPER OXIDE rectifier for telephone service is a new product of General Electric Co., Bridgeport, Conn. The rectifiers may be obtained in sizes from 3 to 12 amperes, and will provide a full charge for small batteries and a trickle charge for large ones. The exact charging rate is indicated by an ammeter. A built-in filter reactance promotes quiet operation while a small knob on the panel controls the transformer and provides easy adjustment of the charging rate.

Tube Tester

THE HICKOK Electrical Instrument Co., Cleveland, announces dynamic mutual conductance tube testers with square meters and having translucent, illuminated meter dials. The scale is calibrated in micromhos, and also indicates good, bad and doubtful tubes.



Other features are: checks gas content; detects both short and open elements and open suppressor grid; short tests made hot or cold.

The tester is available in either counter type or in portable type models.

Push Button Tuner

ANTENNA AND OSCILLATOR circuits designed for 456-465 kc, employing a modified Colpitts circuit with pentagrid converter 6A8-6A7. Inductance padding is provided giving 3-point alignment. The unit has 6 buttons covering 1630-945 kc. and 1070-540 kc. maximum drift of 5.9 kc. negative for 35 degree C. rise from room temperature. Dimensions 6¾ x 5 x 2½ in. List price $15.00. Aladdin Radio Industries, Inc., 466 W. Superior St., Chicago, Ill.

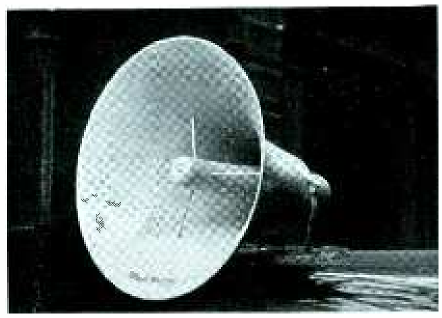
Resistance Thermometers

INDICATING RESISTANCE thermometers with a temperature range from —30° to + 250° F. has recently been announced by Wheelco Instruments Co., Chicago. For use in the air conditioning field as well as for industrial appli-

cations for low temperature readings of rooms, bulk material in bins, air ducts, etc., they can be equipped with a multiple switch for connecting up to 21 temperature bulbs located at as many different points.

Loud Speaker

A NEW TYPE of infinite baffle speaker mounting with a high frequency deflector unit concealed in back of the insignia on the speaker grill for better reproduction is a new product of Sound Systems, Inc., 6545 Carnegie Ave., Cleveland, Ohio. The deflector is a mechanical device which properly diverts the sound beams.



Polarized Condensers

MAGNAVOX ANNOUNCES introduction of Molanode capacitors for filtering and by-pass service. Magnavox states through standardization of mechanical and electrical sizes, the use of a new, finely-divided, fabricated, aluminum anode, and improved processing technique, they are able to effect many economies and thereby to offer a new standard capacitor at substantial savings over previous types.

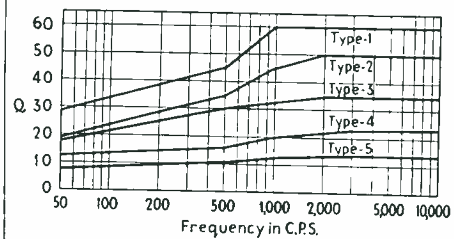
Meter

MARION Electrical Instrument Co., Manchester, N. H., announces a new line of D'Arsonval movement meters of 2% accuracy. Sealed against dust, the meters have clear reading scales, and ample torque to allow use in any position, balanced and calibrated for such use with no loss of accuracy. The pivots are set in sapphire jewels to eliminate possible friction in the movement.

One-milliampere meter movements regularly supplied with 50-millivolt drop within 2%. Meters can also be had with any millivolt drop from 50 upwards.

High Q Coils

A SERIES of five new standard high Q coils in compact form have recently been announced by Ferranti Electric, Inc., Rockefeller Plaza, New York.



These coils can be made to specification to cover the frequency range of from 50 to 10,000 cycles.

New Tubes

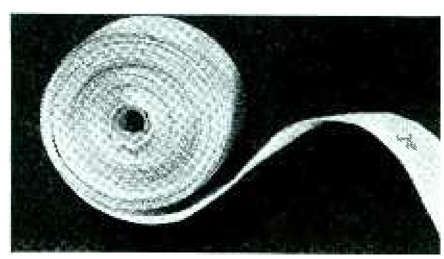
THREE NEW transmitting tubes have been announced by the Amperex Electronic Products, Inc., 79 Washington St., Brooklyn, N. Y. These are the type 270A, 251A and 279A, all of which have been approved by the FCC.

Generating Equipment

A NEW PORTABLE 500 watt plant generating standard 60-cycle, 110 volt a-c current has recently been announced by the Kato Engineering Co., Mankato, Minn.

Glass Insulating Tapes

NEW ELECTRICAL insulating tapes, woven entirely from glass yarns, have recently been developed by the Corning Glass Works, Corning, N. Y. These



tapes, with the appearance and flexibility of ordinary textiles, are intended for the insulation of coils for motors, generators, transformers, and for cables and other electrical conductors.

Enameled Resistors

A COMPLETE line of resistors having a power dissipation of from 5 to 200 watts and available as fixed, tapped, or adjustable types is announced by Lectrohm, Inc., 5133 West 25th Place, Cicero, Ill.

Audio Transformers

A NEW SERIES of midget audio frequency transformers known as the Ouncer series, having high fidelity characteristics, and available in a wide range of impedances for various classes of service, has been brought out by the United Transformer Corp., 72 Spring St., New York.

Frequency Oscillator

THE MODEL 133 beat frequency oscillator recently announced by the Clough-Brengle, Chicago, provides an output of 6 watts into a 500 ohm load. Two tuning dials are provided covering the frequency of from 15 to 15,000 cycles and 15 to 420 cycles. An output meter is provided having 4 voltage and 4 decibel scales.

Speakers

TWO NEW 3½-in. speakers are announced by the Utah Radio Products Co., Chicago. One of these is an electro-dynamic speaker having a useful frequency range of 200 to 8000 cycles with a power output of 5 watts. A similar speaker uses a permanent magnet resulting in a saving of from 3 to 6 watts.

Luminous Lamps

PRODUCTION of a new series of illuminating lamps in which ionized mercury vapor is employed to excite fluorescent phosphors deposited on the inside surface of the tubes is announced by the Lamp Division, Westinghouse El. & Mfg. Co., Bloomfield, N. J. Tubular lamps from 18 to 36 in. in length in a variety of colors are available. The efficiency is considerably greater than that of ordinary gas discharge or incandescent lamps.

Spot Welder

A DEVICE DESIGNED for soldering seam joints or spot welding and which operates from a 110-volt power line is the Thermo-Grip, recently introduced by the Ideal Commutator Dresser Co., 1631 Park Ave., Sycamore, Ill.

The OA4-G

(*Continued from page* 16)

quired to complete ionization and form a self-maintaining discharge in a cold-cathode type of tube. This may be made more clearly shown by an explanation of the operation of the tube as used with a 60-cycle supply, when a radio-frequency signal, fed onto the supply line, is used to actuate the tube.

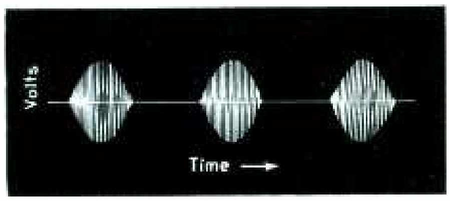


Fig. 9—Self rectifying type of signals for remote control

A typical circuit for this type of operation is shown in Fig. 6. R_1 and R_2 are potential dividers, the ratio of the resistors being so selected that for the maximum value of the line potential, the starter potential will never exceed the value required for breakdown. The magnitude of the resistors is so selected that, when the tube does break down, the current which flows in the starter circuit will be ample to complete the transfer of the discharge to the anode, but will not be enough to injure the tube. L and C is a high-Q circuit which is tuned to resonance for the frequency of the actuating r-f signal fed onto the line.

The r-f signal may be generated from an oscillator which is self-rectifying, receiving its plate voltage directly from the line, in which case it will have a wave shape somewhat as shown in Fig. 9. Since for such an oscillator each r-f group is of approximately one-half cycle duration, it is necessary that the phasing of the receiver voltage be such that the anode of the OA4-G is positive during the period that the signal is being transmitted. Due to the resonance tuning of L and C, the voltage that will appear across the inductance L will be of the same general shape as Fig. 9, but amplified by approximately the Q of the inductance. The total potential on the starter is then the sum of the instantaneous values of the 60-cycle potential (E_{R2}) and the instantaneous values of the r-f potential (E_2). This is shown in Fig. 10 for one cycle of the supply potential,

Backtalk

Pick-up Angle Again

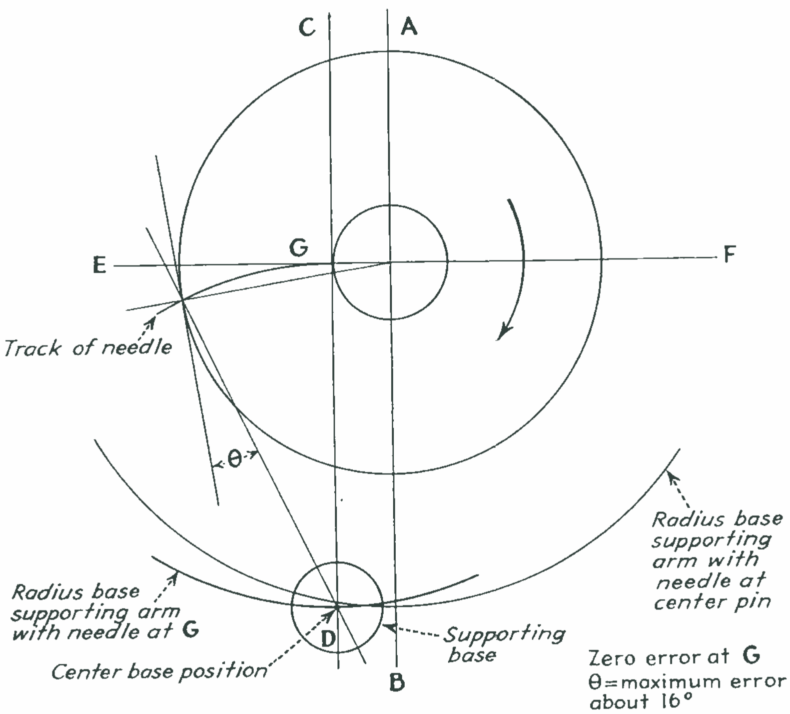
Having just acquired an RCA transcription pick-up the problem arose of positioning it right with respect to turntable. With the idea of making the needle track as nearly as possible with its axis of rotation tangent to the groove my suggestion is that a position can be found as follows:

First pick a convenient diameter AB of turntable then draw a parallel CD to this diameter tangent to innermost groove of recording to be used. EF perpendicular to AB at point of tangent G. Put needle at G with base of recording arm centered on CD.

There is then no angle between arm and groove at this point. (Any other position of head on radius of pick-up arm with needle at center pin gives same angle at outer edge of disc, and a plus or minus angle at inner groove.)

Backing off needle from center pin with base on the line CD for needle to hit G instead of center pin also somewhat reduces outside groove angle from angle it would otherwise take.

Angle will gradually increase to outside edge maximum. Correct tracking would appear to be more important at inner grooves where sound track is more compressed linearly.



May I venture to suggest, too, that the pinch effect described in Mr. Olney's interesting article on page 23 of November *Electronics* may be perhaps minimized in acetate disc reproduction where the round-pointed needle does not bottom in the groove but rides on the sides of the V-shape trough. It can thus perhaps rise and fall somewhat to meet the condition of varying width of the track.

RICHARD GROZIER,
168 Brattle Street
Cambridge, Mass.

The OA4-G

the r-f being considerably spread out and distorted for explanation purposes.

When the starter potential reaches the value indicated by "a" in this figure, and if it could be maintained at this value or above, a self-maintaining discharge would initiate and breakdown would be completed. However, the time interval from "a" to "b" is less than the so-called ionization time for the tube. During the interval from "b" to "c", some deionization occurs, since the starter potential is below the breakdown value. Only a fraction of the ions formed

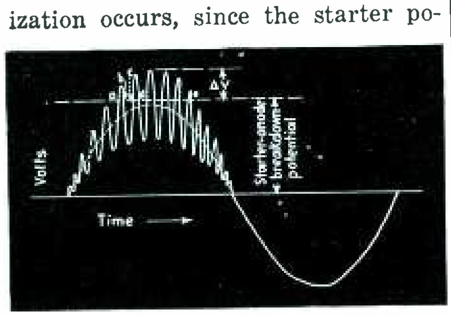


Fig. 10—Superimposition of control signals on power line frequency

during the interval "ab" are lost during the interval "bc" since there is not sufficient time for complete deionization. During the interval "cd" ionization again tends to build up, and the cycle just described repeats itself time and again. If at time "e" the resulting ionization (integrated effect of ionization and deionization over the interval "ae") is sufficient, a discharge will initiate to the anode, and current will flow until the 60-cycle supply potential falls below the tube drop of potential. During the next cycle, when the anode again becomes positive, this initiation process must again be completed if the tube is to start.

The interval "ae" is considerably longer than the normal ionization time for the tube due to the periods of deionization which occur. Because of this time requirement, the maximum peak starter potential exceeds the static value of breakdown potential by an amount Δv. For r-f signals of around 200 kc. per second, this value of overvoltage Δv may be of the order of twenty volts.

Although the foregoing description was based on control by means of an r-f actuating signal, the use of the OA4-G is not limited to this application. It may be used in any other circuit where the tube characteristics are satisfactory and the ratings are not exceeded.

British Patents

RADIO CIRCUITS

Wide band amplifier. A push-pull resistance-capacity coupled amplifier in which high frequency loss is avoided by the provision of neutralizing condensers. British Thomson-Houston Co., Ltd. No. 465,053.

Tuning system. To make easy accurate tuning the selectivity and/or AVC time constant is temporarily increased. E. K. Cole. No. 465,176.

Detector. The received modulated oscillations are supplied to two detectors having different time constants, and the outputs are so combined that in the case of simultaneous reception of two signals of different intensity the modulation of one of the signals is suppressed. Philips. No. 465,333.

Automatic tuning. A receiver is automatically brought into exact tune with a desired signal by a control potential derived by rectification from one of the receiving stages, and applied to vary the grid bias of a variable-mu tube associated with the circuit. J. Robinson. No. 465,515.

Automatic tuning. To compensate for tuning errors due to mistuning or changes in oscillator frequency, a superheterodyne receiver has two frequency changing stages; automatic frequency correction is applied to second modulator stage. Hazeltine Corp. No. 467,717.

Tuning aid. Exact tuning of a superheterodyne is facilitated by means of two rectifiers coupled to the intermediate-frequency stage, one by a highly selective coupling and the other by a circuit of lower selectivity, the latter rectifier preventing operation of the former until the receiver is a predetermined but small amount off tune. Philips. No. 467,771.

Four-grid tube. The effective input capacity of a tube is eliminated or reduced by the provision of an additional electrode, the potential of which is arranged to vary in phase with, and to the same extent as, the control grid potential. Marconi Co. No. 467,915.

Tuning system. A permeability tuned high frequency system comprising two resonant circuits gang tuned and intercoupled by an electromagnetic coupling varied with tuning so that the coupling is tightened as the frequency is reduced. Johnson Laboratories. No. 468,675.

Automatic tuning. Two highly selective circuits respectively tuned to frequencies above and below the intermediate frequency, and two broadly tuned

FIG. 1.

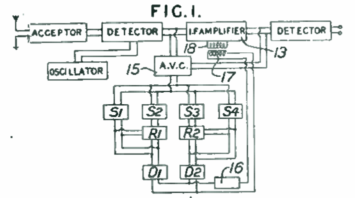


FIG. 2.

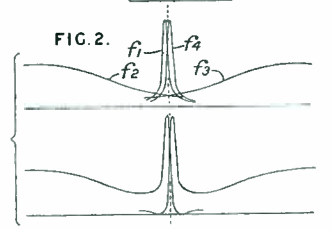
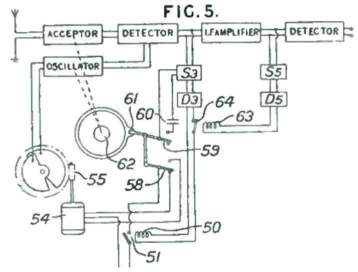


FIG. 5.



circuits having substantial response at frequencies 4 to 5 kc. on each side of the *I.F.*, the outputs of the four circuits being combined and rectified to vary the tuning of the *I-F* amplifier. J. Robinson. No. 469,077.

Signal screen. A screen composed of a conductive signal plate covered with a photo-conductive material which is coated with a substance which is a better secondary-electron emitter than the material itself. The photo-conductive material may be a sulphide or oxide of lead, thallium, mercury, cadmium, etc., or a crystalline form of selenium, sulphur, phosphorous, or iodine, while the coating material may be a borate of an alkali metal such as lithium, applied by spraying on the screen a 3 per cent aqueous solution, or metallic cessium, distilled on the screen. H. Miller. No. 465,060.

Scanning system. A film, scanned by a perforated disc, undergoes a mechanical or optical movement during scanning to produce the displacement between sets of scanning necessary for interlacing. D. S. Loewe. No. 465,184.

U. S. PATENTS
Tube Applications

Welding control. A multi-tube arrangement for automatically controlling welding current. C. J. Kopp, A. O. Smith Corp. No. 2,104,200.

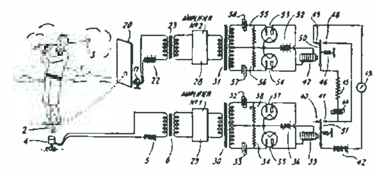
Motor control. The use of vacuum tubes for controlling the speed of a-c motors. W. R. Perry, to Reeves Pulley Co. No. 2,102,911.

Timing apparatus. An electric time indicator for use with sounding equipment comprising a condenser charged through a neon tube and a triode amplifier. L. A. M. J. Laboureur, Paris, France. No. 2,101,076.

Sorting mechanism. Apparatus for automatic separation into classes of coal and similar materials according to their electrical resistance. K. C. Appleyard, Birtley, England. No. 2,-101,381 and 2,086,060.

Sealing-off apparatus. Method involving a light-sensitive cell, etc., for automatically sealing off a vessel containing a gas under pressure greater than atmospheric. M. de Neumann, G.E.Co. No. 2,101,673.

Velocity measuring. Means of measuring time intervals involving charging



a condenser and measuring the charge by means of a ballistic galvanometer. W. v B. Roberts, RCA. No. 2,102,166.

Impulse rate meter. A condenser charge system. Benjamin Miller, Power Patents Co., Jersey City, N. J. No. 2,102,371.

Flaw detection. Apparatus for use in magnetic analysis. Theodor Zuschlag, Magnetic Analysis Corp. No. 2,102,452.

Watch testing. Apparatus for observing the instantaneous relation between the rate of operation of a device and the rate of reoccurrence of a given effect. C. J. Young, RCA. No. 2,092,039.

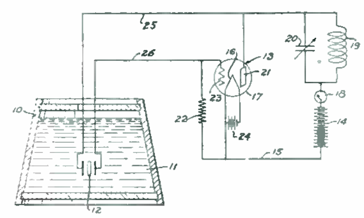
Voting system. Method by which a radio broadcast listener can push a button, thereby increasing the load on the power circuit, said load to be totalized at the broadcasting station. N. M. Hopkins, New York. No. 2,092,120.

Level control. Light sensitive means of controlling the level of liquid in a container. H. E. Brelsford, Diamond Power Specialty Corp. No. 2,091,303.

Crime detection apparatus. Use of infra red light for exposing motion picture camera so arranged that when infra red rays impinging on a light sensitive device are interrupted, the motion picture camera goes into operation. O. N. Melton, Gaffney, S. C. No. 2,086,087.

Coal separation. Apparatus for sorting coal of various sizes. No. 2,086,060 to K. C. Appleyard, England.

Liquor aging. An improved method for accelerating the artificial aging of raw fermented and distilled alcoholic



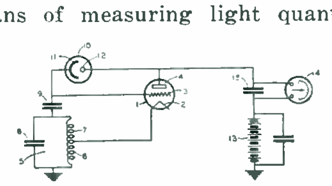
beverages by means of supersonic waves. No. 2,086,891 to J. A. Bachmann, Alameda, Calif.

Wire manufacture. Tube controlled apparatus for manufacturing coated insulated wire. Takeo Akahira, Tokyo, Japan. No. 2,103,134.

Egg tester. This patent, No. 2,102,-346, to F. L. Rivenburgh, Springfield, Ohio, has 38 claims, Claim 1 of which reads as follows: "The method of testing eggs for life activity, which comprises arousing the egg, exciting the egg by imposing an electromotive potential thereon, and determining the response upon excitation."

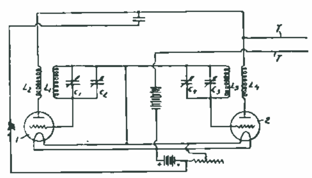
Diathermy apparatus. Two vacuum tube oscillators, etc., in an electric therepeutic machine. F. D. Webster, Federal Telegraph Co. No. 2,105,568.

Photometer. Use of a photoelectric cell with a relaxation oscillator as a means of measuring light quantities.



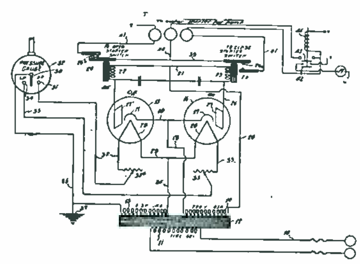
No. 2,100,755. F. H. Shepard, Jr., RCA. See No. 2,100,756 to Shepard.

Flowmeter. Apparatus for measuring the flow of fluid through a conduit comprising two variable condensers, and means for placing them in operative engagement responsive to varia-



tions in pressures at spaced points in the circuit. Isaac Bencowitz, Texas Gulf Sulphur Co. No. 2,103,741.

Switching system. A two-way system using two-element tubes in which varying pressure turns on or off the heat-

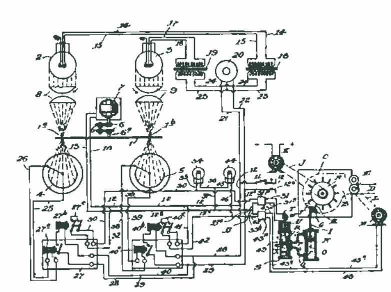


ing current to the cathode of the tube. C. N. Hardin, Sulphur, Okla. No. 2,090,531.

Control circuit. A condenser discharge system. D. E. Noble, Storrs, Conn. No. 2,090,224.

Temperature controller. A light sensitive balancing system. C. H. Wilson, Foxboro Co. Reissue No. 20,476.

Batch control. Light sensitive means for controlling a batch processing ma-



chine. C. R. Dumble, California Process Co. No. 2,086,157.

Elevator control. No. 2,096,473 to R. J. Stevens, The Express Lift Co., London.

Pressure measurement. A device for transforming pressure variations into electric variations comprising a magnetic core, a high frequency circuit so that the core undergoes high frequency changes of dimension through a magnetostriction action. Alexis Guerbilsky, Paris, France. No. 2,096,106.

Temperature measuring system. No. 2,096,323 to W. H. Gille, Minneapolis-Honeywell Regulator Co. See also No. 2,095,877 to R. D. Junkins, Bailey Meter Co. on apparatus for determining the temperature of rolls.

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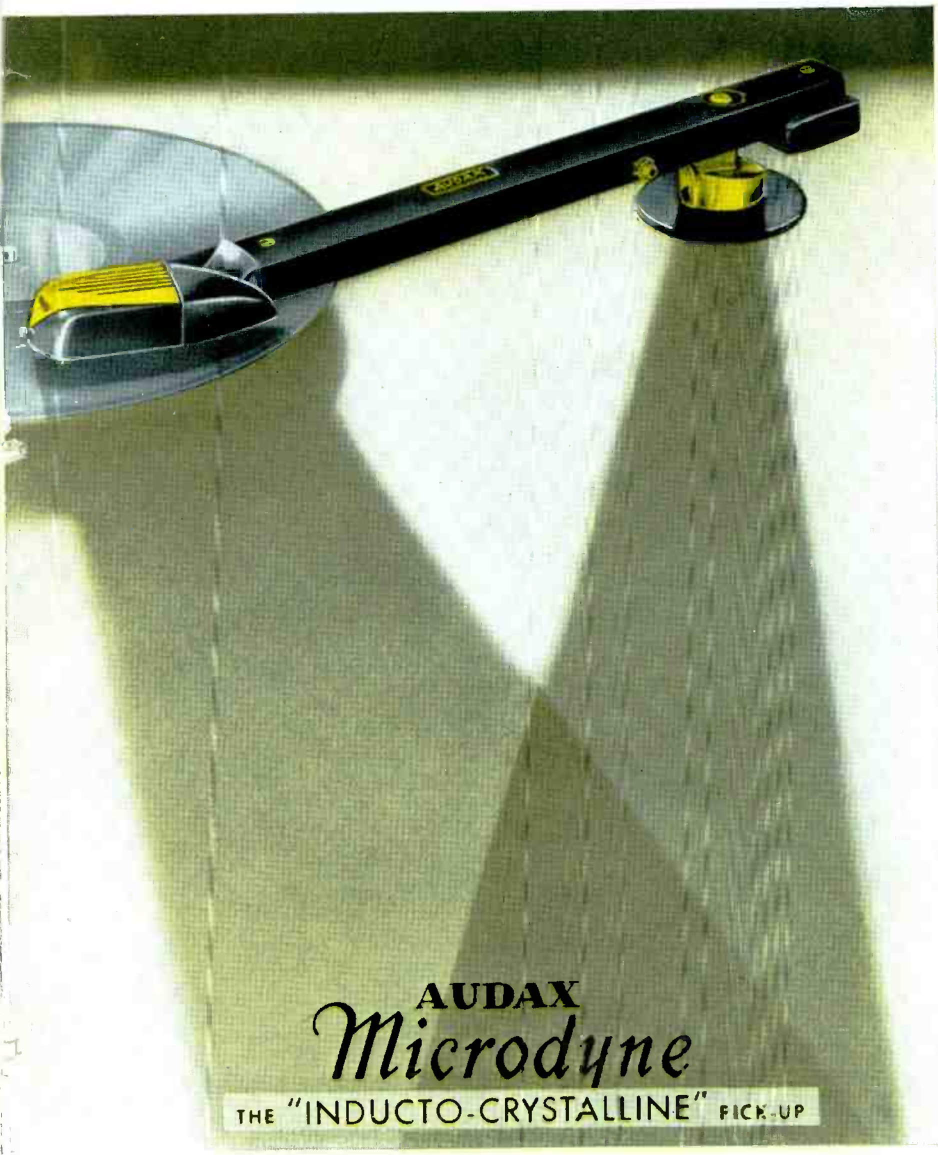

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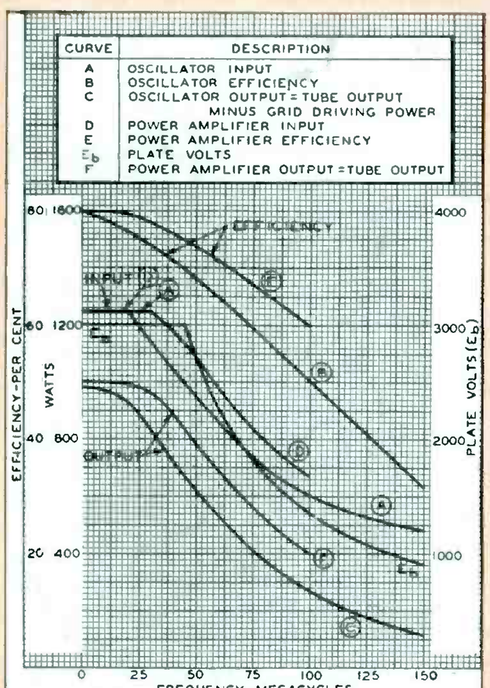

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