electronics

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

The coming of the new tubes

✦

Why is radio in the red?

✦

Receiver design for the pentode

✦

Variable-area sound-picture recording

✦

Automatic record changers

✦

Cabinet design

A McGRAW-HILL PUBLICATION

Price 35 Cents

APRIL 1931

Announcing . . .

TWO IMPORTANT

THE NEW VARIABLE-MU PRINCIPLE

New in Design . . . Advanced in Principle . . . Efficient in Performance

Every set manufacturer, every radio engineer, the entire trade, will be vitally interested in this newest invention—the Arcturus Type 551 Variable-Mu Tube.

Seldom, in the rapidly changing radio industry, has one tube embodied so many advantages and presented to set manufacturers such splendid merchandising and economic possibilities for 1931 receivers—with practically no changes in existing circuits.

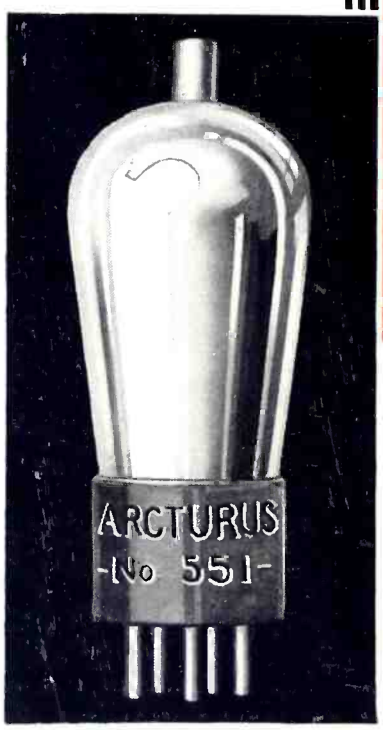
By shaping the plate current-grid voltage characteristic so as to minimize the higher order curvature over an extended range of control grid voltage, the Type 551

1. Divides cross-talk by a factor of several hundred and eliminates modulation distortion and receiver "hiss";
2. Eliminates distortion of signals from high-power stations caused by the non-linear relation between the r.f. output voltage and the r.f. input voltage;
3. Minimizes hum in a-c receivers due to modulation of the carrier by low-frequency hum voltages inadvertently present in the control grid circuit;
4. Obviates the use of antenna potentiometers, local-long distance switches, double pre-selectors, etc.

These features are of important significance to manufacturers in designing 1931 sets where production costs and performance are paramount considerations.

A special technical bulletin on the Arcturus Type 551 Variable-Mu Tube will be sent upon request.

Licensed under patent applications of Boonton Research Corporation.



Arcturus' quick-action is another feature of the 551.

ARCT

"The TUBE with the

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electronics

A McGRAW-HILL PUBLICATION

New York, April, 1931

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

Get together - - -

Standardize and Simplify

UNPRECEDENTED activity in tube designers' laboratories brings up again the question of standardization of tubes, and simplification of lines.

For example, there have just been announcements of two types of screen-grid tubes (of the variable-mu or exponential type) designed to overcome overloading distortion and cross-talk. These tubes differ in characteristics, though performing the same service. They require different circuits and different apparatus. They will probably not be interchangeable with complete success. Such duplication involving not only manufacturers of sets and tubes, but the whole trade and the final consumer as well, should not be permitted.

There should be but one such tube.

IN the interest of simplicity of design, distribution and use, tube types should be kept to a minimum, a fact long recognized and actively pursued by the industry. If several tubes to perform identical functions are developed, experienced set engineers should have the opportunity of choosing which tube should be announced and manufactured. For commercial expediency or pressure to dictate premature announcement of tubes would be to vitiate all the past efforts toward standardization.

IN the present case or in that of automobile tubes or other new developments, such widely divergent functions as technical design and consumer use demand that but a single tube with a single type number be produced. Such a tube will be the one which furnishes the set owner with a better radio receiver.

Service must be the prime consideration.

When new tubes are to be brought out, it is the responsibility of all concerned to *get together, standardize and simplify.*

THE NEW TUBES—

Output pentodes — **"Permanent" tubes**
Variable-mu's — **Built-in tubes**
Exponential tubes — **Shock-proof tubes**
Special tubes — **Horizontal tubes**
Automobile types

SPRING is the season of germination and of "growing things," and certainly the Spring of 1931 has been a period of hectic germination of ideas, and of helter-skelter growth of new schemes in the field of radio tubes. Meanwhile, the rest of the radio industry stands by and wonders. "What next?"

Pentodes, variable-mu's, exponential tubes, special tubes, permanent tubes, built-in tubes, shock-proof tubes, horizontal tubes, automobile tubes—these are some of the new or resurrected ideas which are right now budding into physical form, along with the buds on the trees outside the designers' laboratories.

For one thing the output pentode* has in 1931 landed with both feet. This is a tube supplying from 2 to 4 watts of undistorted (relatively speaking) power output. (The r.f. pentode touted a year ago as a great advance, has apparently died of inanition.) Already reports indicate that several manufacturers will have sets at the June Trade Show employing the power pentode. The slowness with which this tube has come into commercial use has been fortunate. Time and freedom from pressure have enabled set and tube engineers to study unhurriedly the pentode. The results of such research will be apparent soon. Undoubtedly the power pentode will find its way into many small and some special sets. Perhaps in large receivers it may become of economic importance as well. As the season hurries toward the June Trade Show, new pentodes will make their appearance.

Variable-mu or exponential tubes

Announcement of two types of screen-grid tubes designed to overcome hum modulation, cross-talk, and other forms of overloading distortion, has put the industry into a funk of uncertainty, and at the time of writing (April 1) the industry remains in its fog, not knowing which tube to build its new set around, complicated as the picture is by tube distribution, relative advantages of the two types, and other embarassing uncertainties.

These tubes, differing in characteristics though designed to serve the same purpose, represent the same unfortunate lack of get-together-before-spilling-the-beans that has faced the industry in the past. No doubt set manufacturers will take matters into their own hands and settle which tube (if either) they use.

It is certain that the variable-mu idea will be one of 1931's big technical advances, that receivers using both pentode and variable-mu tubes will be shouting for their place in the sun at the Trade Show. Both represent important technical advances for particular tasks.

*See *Electronics* for May, 1930, "The Two Pentodes."

This year some tube manufacturers report a tendency on the part of the set makers to call for "special tubes" designed to fit particular requirements, and therefore to be *non-interchangeable* with any other tubes for use in these makes of sets. If this tendency makes progress the Smith radio set will require Smithotrons, the Brown set will require Brownotrons, and the distracted dealer will have to have a shelf stock like a shoe store, to supply all the varied demands of the neighborhood trade for special-named 'trons and 'odes. One tube manufacturer reported ten different special tubes under development in his laboratory at the behest of set-makers who want to tie up their customers "body and soul" each with their own special brand of equipment.

"Special tubes" for each make of sets

In England the idea of special tubes has been given much greater development than has so far been accorded this idea in mass-production America, the home of interchangable standard parts. In the British Isles, the tube situation has gotten into about the same condition as the safety-razor business in the United States. In fact, "over there" receivers are made and sold without particular effort to make a profit on sets, the proprietor keeping his eye primarily on his "special valve" market. Sets he is willing to sell at a loss, even,—if thereby he can create a renewable and renewing demand for his own particular brand of valves, without which, of course, the sets in the public's hands will not be operable.

How far the "special tube" situation will go in the American market during the next twelve months, remains a question, but the trend will be intently watched by manufacturers who want to keep a closer control over their sets and their renewals. Meanwhile the distributors and dealers regard such a tendency with unconcealed alarm. Not only will the trade have to carry a greatly increased number of unit types of tubes, but the objective toward which the industry had been working *"A complete tube assortment for any set, always within easy reach,"* will be shattered and knocked skyhigh. No longer will Mr. Surburbanite be able to put on his hat and pick up a 243 handily in his neighborhood Radio Shoppe which is accommodatingly still open at 10 p.m. Instead, his wailing family will have to go radio-less to bed, while a string is tied around father's finger to remind him to "try to stop in downtown tomorrow" and get the missing tube at the place he bought his radio!

No attempt can be made to conceal the disappointment which has been felt in the replacement market for tubes during the past year. It had been expected that tubes would accommodatingly burn out or "go blooey" right on schedule after 1,000 hours or one calendar year of use! But not so. Instead tubes faithfully hang on and hang on, until 2,000 hours and 3,000 hours are not exceptional, and some tubes exceed 4,000 and 5,000 hours. "Tubes are too long-lived" is the consensus of complaint everywhere in the trade.

Certain manufacturers have therefore been giving

A rush of new ideas and new designs for 1931

thought and study to the problem of so improving their product as to make such longevity uniform and assured. They reason that this should be a comparatively easy matter. Unlike incandescent lamps, radio tubes do not have to be burned at any particular intensity or minimum high temperature. Thermal efficiency may be dropped, with very little concern when the electricity cost is only 3 to 10 cents per kw-hr. But at such lower temperatures the life possibilities become tremendous. It is then only a question of supplying sufficient electron-producing material to last throughout the presumable life of the radio set—and this average receiver-set life has been variously estimated at 3 to 5 years.

Proposals have been considered to build such long-life tubes right into the set as integral parts thereof, like the transformers or condensers. The cost of both bases and sockets would be saved, and the user would be guaranteed against tube trouble for a definite time. Automatically, too, the question of selling sets "less tubes" would be answered.

But most important of all would be the public's response to announcements that the new Umpty-ump Stenostat was offered "complete, ready to run," and with "nothing to burn out."

"No tube replacements!"

Backers of the idea feel that the rush to buy such a "permanent-tube" set would be so conclusive and overwhelming, that all producers would sooner or later be forced into line and the replaceable tube would become a "pre-1931 memory."

Shock-proof tubes for shipping in sets

Meanwhile the practice of shipping radio sets with tubes in place finds increasing favor in many quarters. There is strong influence at work among the set manufacturers to have sets priced and sold complete with tubes. If such tubes can be shipped right in the sets as they leave the factory, packing problems are simplified, tube mix-ups are prevented, and the customer gets his set in the exact condition it left the factory test.

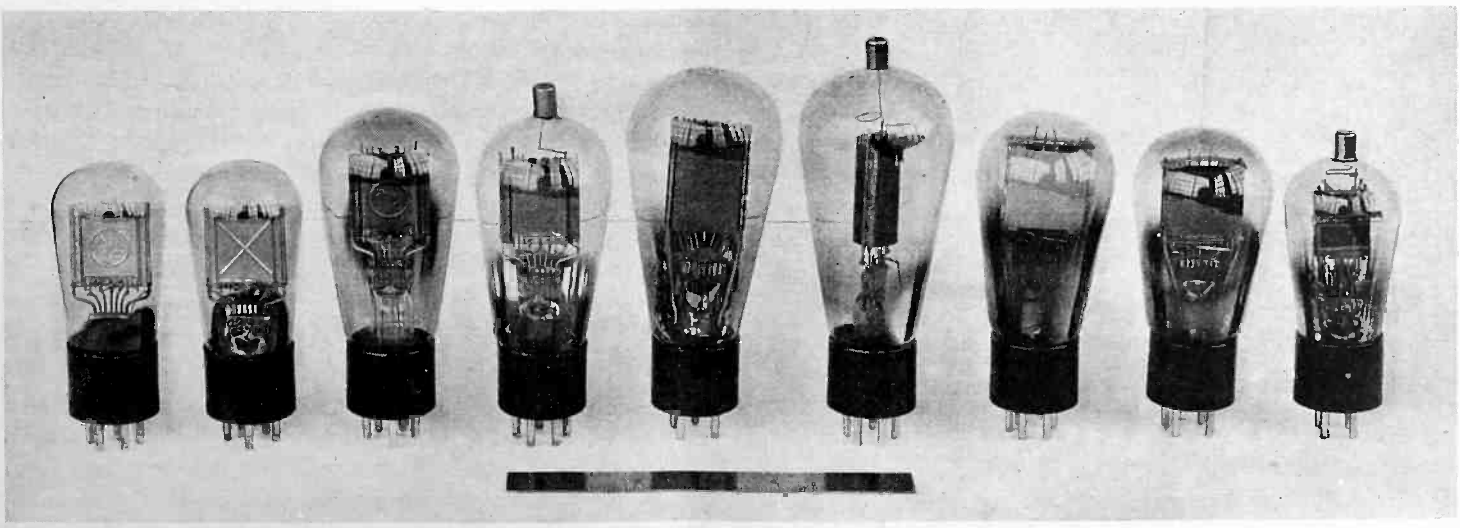
Manufacturing attention is therefore being given to developing greater mechanical strength and sturdiness in the tube structure so that the tube will withstand the buffeting and shocks of freight shipment. Already great progress has been made in this direction, and it seems likely that the once-fragile tube will soon be as shock-proof as any element in the set.

Such a development may automatically crush the vicious habit of some set manufacturers buying from tube manufacturers duplicate complements of tubes, part of which they either sell at a profit or, for good will, give them to their jobbers, at a longer discount than the jobbers can get by their own trade arrangements.

Horizontal-burning tubes for perpendicular chasses

The aesthetic determination of some 1931 set designers to stand normally horizontal chasses perpendicularly "on their beam ends" has led to some unexpected complications in tube operation and considerable thought as to their proper structural design of filament spans. With tubes mounted horizontally in these new vertical sets, the filament loops tend to hang down in catenary fashion, at times completely changing the spacing clearances and characteristics which prevail when vertical. And since the tube elements are mounted in their bases without definite orientation in regard to the pins or without regard to the plane in which the filament might droop if inserted in its socket horizontally, it follows that sometimes the filament merely droops in its own plane and at others moves closer to or further away from the grid which surrounds it.

Tendency to mount tubes in other than vertical position may impose new restrictions on tube manufacturers. They will be forced to so place filament and element structure with respect to base pins that the filament will hang in such a plane that if it sags, tube characteristics will not change. [*Continued on page 614*]



A number of experimental "output pentodes" recently produced by American tube manufacturers

Design problems of

Power pentodes for radio receivers

By B. V. K. FRENCH

United American Bosch Corp.

THE power output type of pentode is a five electrode tube consisting of a cathode, three grids and a plate. In structure it is a power type screen-grid tube with an auxiliary grid positioned between the screen and the plate, connected internally to the cathode or filament for the purpose of inhibiting the flow of secondary electrons from the plate to the screen. The various elements will be called in order, cathode, control grid, screen-grid, cathode-grid, and plate. These elements are shown in the "exploded" view of an American pentode—the Arcturus Type PZ, Fig. 1.

Advantages and limitations

In the usual three element output tube high output is not compatible with high amplification. For this reason the amplification constant of triodes for power amplification is usually of the order of three to eight. This reduced amplification factor works a hardship on the designer of a broadcast receiver because the trend toward high signal voltage detection and a reduction of the number of component parts in receivers has left insufficient margin of audio amplification after detection. With either the 27 or 24 type tube used as a plate rectifier it is impossible to bring the power tubes to overload with low percentages of modulation unless at least three hundred volts is used as detector plate voltage.

The pentode on the other hand, is not limited in this regard. It is possible to construct this type of tube with amplification factors exceeding a hundred and with power output comparable with triodes of the same size. Since the transconductance remains about the same order of magnitude as in a triode of equivalent size, the plate resistance measured at the operating point is of the order of fifty thousand ohms. This set of operating parameters results in a high value of power sensitivity. Two methods of rating the power sensitivity of an output tube have been proposed; that by Stuart Ballantine[1] allows comparison of output systems on a basis which is comparable with measurements on other stages of the receiver. Comparing the familiar type 245 with a 2.5-watt pentode, the power sensitivities expressed as the ratio of the square root of the power output in watts to the r.m.s. grid voltage become 0.0358 for the 245 and 0.1326 for the pentode.

This four-fold increase in power sensitivity makes possible a reduction in necessary amplification in other parts of the receiver and in the case of midget design would allow a reduction in the number of tubes. The advantage thus gained makes possible simplifications in the reduction of size of power supply equipment and dimensions of the receiver chassis.

Another advantage of the pentode lies in its increased power efficiency. The power dissipation of the grids and the plate in a pentode are usually about 70 per cent of the plate dissipation of the equivalent triode of the same power output. While this slight advantage is not of extreme importance in receivers operated from power lines, it is of interest in considering battery and automobile receivers.

The power pentode does not come out of a comparison with the triode unscathed. Its structure is complicated and the problems of proper alignment of the various grids in manufacture together with the difficulty of proper exhaust may present a serious problem. The shrinkage is likely to be high in early stages of manufacture and may reflect itself in a disproportionate list price.

The triode is still the unrivaled tube for distortionless amplification. The pentode output contains a small amount of harmonic distortion even when operating under the best conditions. This distortion however, is not objectionable when the load conditions and operating points are properly chosen. If attention is not paid to the peculiar conditions under which it must work the harmonic distortion may become serious. This is especially true if the rise in impedance of the loud speaker with frequency is neglected in the design of the output coupling device.

▼

POWER pentode tubes present new engineering problems and interesting technical possibilities. This non-mathematical article dealing with practical matters should interest all set and tube engineers, coming at the beginning of a season in which the pentode will become of commercial importance.

▼

Design of the output coupling device

The fundamental difference between the triode and the pentode lies in the shape of the curves expressing the relation between the plate current and the plate voltage at various control grid biases. In the pentode the high-voltage grid or screen has characteristics with respect to the control grid which are very similar to the plate characteristics of a triode. In this case, however, most of the electron flow passes through the openings in the screen and becomes plate current. As the plate is at a sufficiently high voltage to collect all of these electrons the plate current represents a saturation current and is practically independent of the plate voltage over most of the characteristic.

A considerable amount of valuable data necessary in the design of the output transformer can be obtained by simple graphical methods. (References Nos. 2 and 3.) The familiar expedient of drawing load lines on the plate conductance curves is used as a starting point. In Fig. 2 is shown the relation between plate current and plate voltage in a pentode now commercially available. The slope of a line in volts per ampere drawn through the operating point defines the value of the resistance load referred to the plate circuit. This is the resistance or impedance of the speaker times the square of the turns ratio. The point of intersection of these load lines with the plate current curves for various grid biases gives the instantaneous plate voltage and current. By plotting these plate current points as a function of grid voltage for various loads the dynamic transconductance curve, Fig. 3, may be obtained. From these two characteristics the power output and harmonic content of the tube for various grid swings and output load resistances can be determined to a degree of approximation sufficient for the purpose of preliminary analysis.

If the dynamic curve shown in Fig. 3 is examined critically it will be seen that a load resistance between 6,000 and 8,000 ohms lies closest to a straight line representing distortionless amplification. The deviation of the curve from a straight line for any particular load resistance is a measure of the harmonic content. In a sinusoidal wave in which the harmonics are in phase with the fundamental the effect of combined second and third harmonic components is to cause the wave to become peaked on the negative half of the wave and flattened on the positive half, these being referred to the grid voltage. For the calculation of second and third harmonic contents the following expressions may be used:

Second harmonic content in per cent fundamental

$$\frac{\frac{1}{2}\,(I.Max. + I.Min.) - I_0}{I.Max. - I.Min.} \times 100 \text{ per cent}$$

The effect of odd harmonic components is to distort the shape of the wave without causing assymetry and

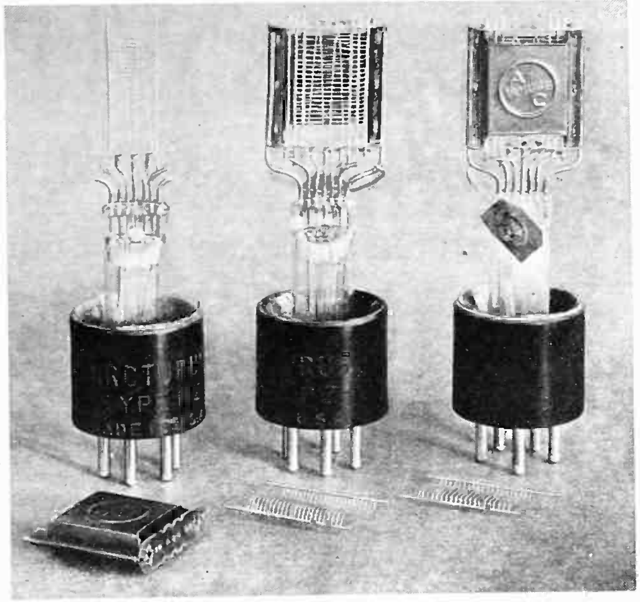


Fig. 1—Exploded view of power output pentode

an approximation of the third harmonic content may be obtained by considering the curvature of the dynamic curve, Figure 3, to the right of the operating point because the amount of curvature to the left of the operating point is always less. If the current at half the operating bias is designated as I_1 an approximate expression for the third harmonic is

$$\frac{I_1 - \frac{1}{2}\,(I.Max. + I_0)}{I.Max. - I_0}$$

When the harmonic content is low the above formulae hold to a degree useful for preliminary design in the absence of elaborate harmonic analysis apparatus.

If the data of Fig. 3 are analyzed by these equations for the condition of a peak signal equal to the bias the following results are obtained.

Load R	Second Harmonic %	Third Harmonic %	Watts Output
4,000	3.9	3.8	2.15
6,000	1.7	5.4	2.60
8,000	1.7	6.7	2.8
10,000	5.5	8.0	2.77
12,000	10.9	9.0	2.62
16,000	17.8	9.3	2.40

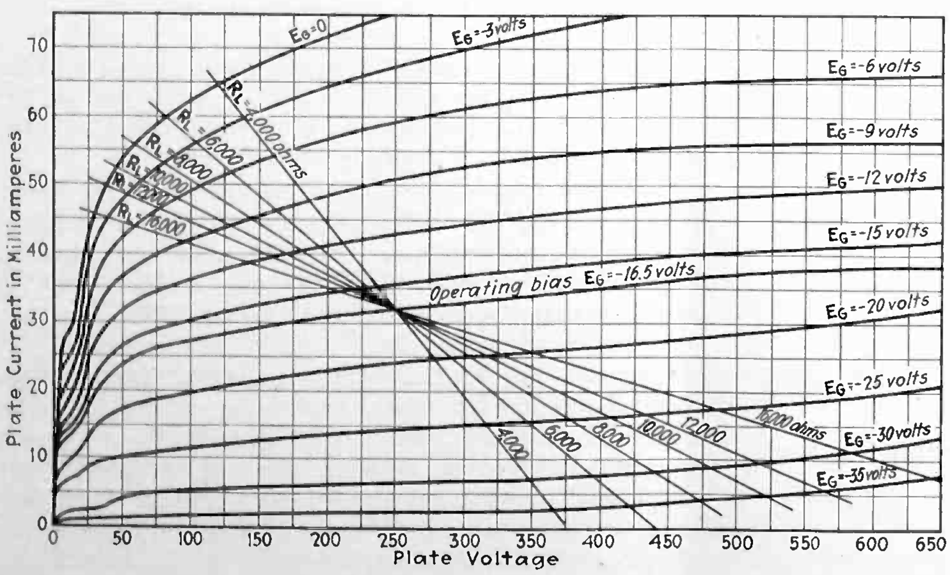


Fig. 2—Plate characteristic of pentode showing load lines for various load resistances

Since the plate resistance of this pentode is 38,000 ohms at the operating point, the first interesting conclusion to be drawn from the above table is that when dealing with pentodes and the optimum load resistance is much less than the tube resistance. This is apparently at variance with the usual requirements of triodes that the load resistance for maximum u.p.o. shall be $2R_p$. The distinction is not significant, however, but arises from the fact that the triode has practically constant plate resistance over the entire range of operation, while in the case of the pentode the resistance varies widely. If the load resistance is made twice the plate resistance at the positive end of the grid swing rather than at the usual operating point the rule holds for the pentode as well.[4] Consequently as the grid swing is restricted the positive end

[Continued on page 614]

WHY IS THE RADIO

Despite gross volume of $500,000,000 last year, few manufacturers made net profit unless also in other lines outside of radio

A CAREFUL survey of the 155 firms in the set manufacturing field by the editors of *Electronics* reveals the appalling fact that with but two or three exceptions these firms did not make a profit on their radio business during the past year, if we exclude the concerns having other operations outside of radio. In a number of instances where other lines of manufacturing were carried on, profitable operations were reported for the year, but in these cases it would be impossible to analyze fairly the loadings of administration and overhead expense, hence the true picture of their radio situation, taken alone, would be difficult to ascertain.

Looked at in any way, from a net-profit standpoint, the situation in which radio manufacturers find themselves is a serious one. It is the subject of discussion wherever radio men meet, and the many angles it assumes have been threshed over in countless arguments and conferences. Many different philosophies of underlying causes and suggested avenues of escape into improved conditions for 1931, have been formulated by radio leaders, and these views have been called upon in drafting up this summary now before the reader.

Let us put down the various causes which radio men and economic students have assigned for the predicament in which radio finds itself. These are, (above):

▼

SOME "WAYS OUT" FOR THE RADIO INDUSTRY IN 1931

Statistical control of production.

More uniform factory production throughout year.

Purchase of ready-made parts where economic.

Diversification of production outside radio.

Price schedules that compensate all factors in the merchandising chain.

Opening up new territories by increase of broadcast power and "synchronizing."

Promotion of public appreciation for broadcasting.

▲

1. The general economic depression.
2. Overproduction of radio sets.
3. The licensing situation.
4. The coming of the midget.
5. Failure of distribution machinery.
6. Apathy toward broadcasting.
7. The approach of saturation.

Obviously the background for the present radio business situation is furnished by the general economic slump, with its effect on employment, buying power and general business activity.

Overproduction is still a besetting problem in radio manufacturing, even though executives have cut their active production period to a few months or weeks. Radio is carrying the load of a factory capacity *ten or twelve times any production* the trade can possibly absorb. Plants can be operated only a short period out of the year, operators have to be trained for weeks, work at full production only a short time, and are then laid off.

Certainly the whole production situation in radio should be thoroughly reorganized to put the industry on a sound basis.

Licensing agreements, patent structure

Critics of the present licensing agreements within the radio industry, declare that these licenses are a principal cause of manufacturers making no profits. While royalty payments range from $7\frac{1}{2}$ per cent of gross sales to as high as a total of 12 per cent for additional royalties paid other licensing groups, this amount, it is pointed out, comes from licensees in competition with the same products manufactured by the patent-holding companies. This, in addition to strong competition from newcomers to the field producing equipment on more favorable licensing terms, has resulted in an unsatisfactory arrangement within the industry as a whole, it is asserted.

The situation is made even more unbalanced because some manufacturing groups, it is charged, do not pay the same royalty or any royalty to certain patent-holding groups.

Licensees at present are also restricted to radio equipment for home use. Prevention of initiative in developing markets for amplifiers and associated equipment in the industrial and other fields is thus a serious check on diversification of products and markets badly needed, according to the complaint.

Licensees are also restricted from the export field. Here, individual initiative in obtaining outlets for radio equipment abroad is eliminated. The benefit of present foreign patent-pool agreements, which is the basis of this restriction, based upon possible competition from imports, is more than offset by the loss in continuous production that a healthy export outlet would help maintain. American manufacturers can more than hold their

INDUSTRY IN THE RED?

own in competition with foreign radio apparatus.

For a good share of the 1931 situation sans profits, undoubtedly the coming of the midget is to blame. The public was ready to purchase such sets and the radio engineer was equipped to design them long before radio sales departments would admit the "midget idea" was more than a passing fancy on the part of the public. Meanwhile some eighty new manufacturers broke into the radio field using the midget as an entering wedge. Other older makers considered midgets only as a preliminary step to selling console models. In some cases the midgets were so priced that they offered only doubtful profits to their makers. So between large consoles that did not sell, and midgets that sold without profit, there was little chance for these manufacturers to make money during 1930.

Another charge frequently brought up is that the distribution machinery broke down and failed to move the merchandise. Certainly the figures show that the *number* of receivers sold did not dip so much below 1929—only 14 per cent. But dollar volume fell off fully 45 per cent. Evidently the distribution machinery was not adapted to the new kind of load which the latter half of 1930 threw on it. If that distribution machine is to function in the future it must be overhauled and reshaped to handle an even larger volume in number of units while the unit value of the sets reduces to half or less of preceding prices per individual sets.

THE SOURCES OF "RED INK" IN RADIO'S 1930 LEDGER?

1. **The general economic depression.**
2. **Overproduction of radio sets.**
3. **The licensing situation, patents, etc.**
4. **The coming of "the midget idea."**
5. **Inadequacy of distribution machinery.**
6. **Public apathy toward broadcasting.**
7. **The approach of receiver saturation.**

Probably the public is more sensible of the general group of causes which fall under the head of "apathy toward broadcasting" than to any other of those here discussed, outside of the general business situation. There is no question that members of the public are too often nowadays heard to express themselves as "fed up on radio," and as rebellious against "too much advertising on the air." Great features come and go on the radio programs, yet make all too little impression on the radio audience which seems sated with the feast of riches it has enjoyed during recent years, all without cost. While many small broadcasting stations have been grossly guilty of the charge of a continuous advertising barrage, there is evidence in plenty that the great stations and great networks have held their advertising hours well in hand, and that the percentage of advertising, compared with total hours of service on the air, is only a few per cent.

In some quarters there is a feeling that with half of the homes of the North American continent now equipped with radio sets, saturation is approaching, and that from now on, with the cream off the radio-sales situation, radio merchandising will find a rocky road ahead. This viewpoint overlooks the vast small-town and rural market, where home-electrification is rapidly coming, paving the way for more radio-set sales. It also overlooks the great amount of new territory which can be opened up with increases in broadcasting service made possible by new developments in the broadcasting art.

Statistical control of production

But it will not do merely to conduct an autopsy on 1930's misfortunes and miscarriages. The mishaps of the season that is behind us can be analyzed to good account only if we can learn how to apply these lessons to the season ahead. What are the constructive purposes which should animate the radio industry and trade during 1931?

The whole problem of production should be carefully studied, and reduced to dependable statistical information which can serve as a basis for adjusting factory schedules in the light of definite knowledge. An industry which has information about itself can intelligently control its processes, can avoid the pitfalls of excess manufacture, and can escape the later penalties of "dumping," price-cuts and general demoralization of manufacturer, jobber and retailer.

A way must be found out of the present schedule of intense production peaks during a few weeks out of the year, followed by long shutdowns when the plant lies idle and workers are laid off. Factory programs must be set out so that economical manufacture can be produced without excessive overhead of factory capacity (capacity now many times that needed if production were spread out more nearly over the entire year). In some cases this may mean a complete rearrangement of factory processes, perhaps eliminating long production lines and regrouping the same operations into smaller units which can be more carefully supervised, and rapidly checked against errors and faults. In the opinions of some production managers, marked savings would be made in this way.

An allied situation is that of purchasing parts and accessories "outside," from makers specializing in these items, rather than attempting to manufacture within the factory parts which can be produced better and more cheaply by specialists. A full discussion of the present trend toward purchase of integral parts, and away from complete manufacture, appears on later pages of this issue.

Diversification into lines outside radio

It is significant that better operating returns are invariably reported by radio manufacturers having outside non-radio lines than by concerns doing an exclusive radio business, with all of radio's seasonal winter demand and summer slack. The combination business has a chance to operate at a more *even* load-factor throughout the year, and overhead can be spread over more than the single radio department. Outlets and distribution connections developed in one line can often be utilized in another. And the lesson of diversification—whether with electric refrigerators and appliances, automobile accessories, or entertainment devices—can be applied to advantage all the way down the distribution trail, through wholesalers and distributors, to the retail dealers. For to the last-named retail merchants, such widening of merchandise lines becomes practically a necessity if sufficient volume is to be built up to create a profitable business.

Price schedules that produce compensation for all

Much complaint has been heard concerning price schedules, particularly on some of the newer sets. Starting out with long discounts to the dealer, these have usually been sacrificed early in the game, and the resulting net price structure has left few resting places for profits for wholesaler or dealer. List prices have in too many cases been mere fictions.

In tubes, the nominal factory-cost multiplier has been eight and ten times, instead of the common four times in corresponding fields, but such list prices so figured have lasted as such only until the first mail-order catalog could be printed.

Much could be written on the subject of price schedules, but when all is said and done, *radio merchandise must be so priced* and *discounts so set up that every factor in the merchandising chain that performs a distribution function will get paid for it.*

Opening up new territories for radio sales

Fear has been expressed that radio is approaching saturation. This may be true in certain cities and populous areas, where, it can be admitted, the ratio of sets to homes exceeds 60 per cent. But there are still tremendous territories—taking in thousands of small towns, villages and settlements, and millions of farms—which are yet unserved by even one or two good programs of sufficient field strength to make radio listening a pleasure and the purchase of radio sets desirable.

High-power broadcasting for all clear-channel stations when granted by the Federal Radio Commission, will greatly improve radio reception over present unserved areas, and open up new territories for selling radio sets. Past experience has shown that when power of stations has been increased, local sales of sets has invariably mounted. General adoption of "synchronizing" or operation of many stations on the same channel, now the subject of important experiments, is bound to multiply the usefulness of existing channels and greatly increase the areas served, with consequent increased demand for sets.

Little attempt has been made as yet to merchandise the "two-or-more-set" idea. Lack of originality of set design, and lack of ingenuity in sales efforts on the part of dealers are contributory factors to lack of as wide sales as desired.

Reclaiming public interest in broadcasting

The old original thrill of listening to radio broadcasting is in some respects passing. The public must now be stimulated to turn to the wonderful things on its receiving-set dials. Features of world-wide interest and uncounted cost are too often missed, because insufficient notice or attention is given.

The theatrical business has long appropriated a high percentage of its gross to publicity and to advertising its offerings. Radio has already learned much showmanship from the stage and the movies; perhaps its next needed lesson is in the fine art of ballyhoo—simply "shooing the public in" to witness the *free wonders inside the tent.* This is a service which must be undertaken by all hands concerned—broadcasters, manufacturers, jobbers and dealers.

The picture of the radio industry and its troubles and dilemmas, is a complex one. The radio problem has many sides, and can be attacked from many angles. Some of radio's outstanding difficulties have been discussed in the foregoing. No single situation or solution offers the answer sought for. The industry's task in pulling out of the present situation and back to "business normalcy," and then into the manifest destiny of the radio art, will be:

(1) A matter of "clearing the interference away," at many points along the line, and

(2) Getting the now widely separated branches of radio broadcasting and the radio industry and trade to realize their common needs and pull together to the common prosperity of all.

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ENGINEERING, DISTRIBUTION, AND PROFITS

RADIO engineering has advanced at an unprecedented rate. The dramatic progress in the efficiency of production of radio receivers has far outstripped the efficiency of distribution. Until the radio executive can find means of coordinating engineering and distribution so that supply and demand may be closer together there can be little hope of profit for most radio companies.

H. B. RICHMOND,
General Radio Company,
Past-President, Radio Manufacturers Association.

Electron tubes in industrial service

By W. R. G. BAKER [1]
A. S. FITZGERALD [2]
and C. F. WHITNEY [3]

SOME insight into what the Thyratron tube can do was discussed in January *Electronics;* the following descriptions are illustrative of further Thyratron, and other electron tube applications:

The parallel inverter, shown in Fig. 1, is a device for obtaining a.c. output from a d.c. input, which is definitely related in frequency and phase to the a.c. grid excitation. The grids, normally biased negatively, are excited so that one is positive when the other is negative. During the positive half-cycle of grid excitation, tube *A* will conduct while the anode of tube *B* is at line potential. During the negative half-cycle tube *B* will conduct, thus lowering its anode voltage to the tube drop. Since the tubes are tied together by the capacitor *C*, the anode voltage of *A* will go negative because the capacitor cannot discharge immediately. If the circuit constants are such that the existing ions can diffuse before the anode voltage becomes positive, the grid of tube *A* will resume control. Similarly if the grid of tube *B* is made positive and that of tube *A* negative, the current will again shift tubes. The circuit is started and stopped by switching the d.c. source. The wave form of this type of inverter tends to be rectangular but may approximate a sine wave with suitable circuit constants.

The circuit in Fig. 2 shows the parallel inverter arranged for self-excitation instead of being driven. The circuit will invert at the frequency determined by the constants of the circuit when the line switch is closed. The circuit is stopped by switching the d.c. supply.

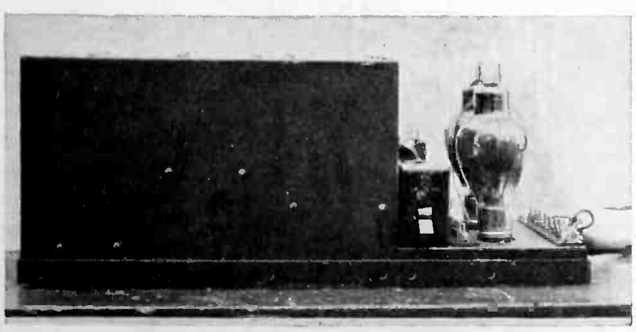


Fig. 3—This inverter supplies 150 watts, 60 cycles from a 115-volt d.c source for refrigerators, radios, etc.

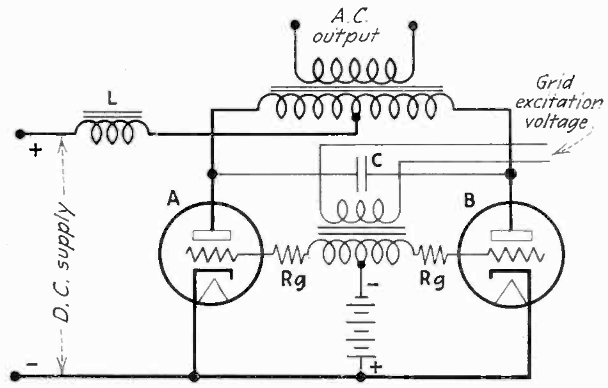


Fig. 1—An inverter circuit for supplying a.c. from a d.c. source

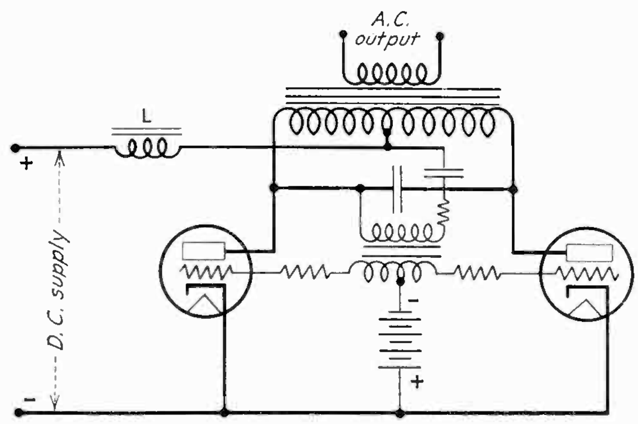


Fig. 2—Self-excited inverter. Output frequency determined by the circuit constants

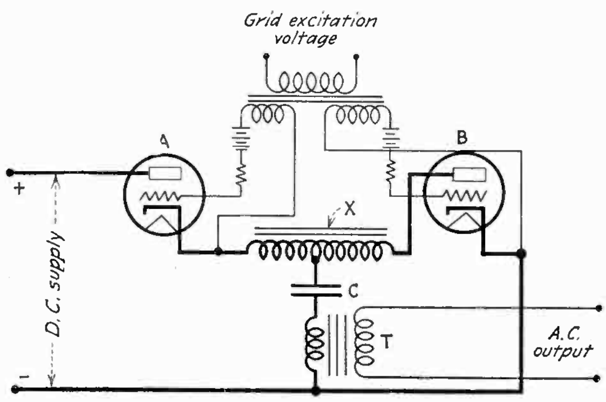


Fig. 4—Separately excited series type inverter circuit

These circuits may be used to supply a.c. power from a d.c. source or to supply frequencies higher than 60 cycles as frequently desired for special purposes.

Fig. 4 shows a circuit for a separately excited series type inverter which may be used as a source of a.c. from d.c. supply, or as a high output amplifier to reproduce phase and frequency. The grids of the tubes are excited so that one is positive when the other is negative. Bias batteries keep the grids normally negative. If a d.c. voltage is applied to the plate of tube *A*, when its grid is positive current will flow through the tube, half of the reactor *X*, capacitor *C*, and the primary of the load transformer *T*. When *C* becomes charged the current stops. In the next half-cycle of excitation the capacitor discharges through the other half of the reactor *X*, tube *B*, and the load transformer *T*, thus furnishing the load with an alternating current.

[1]Vice-president in charge of manufacturing, RCA Victor Company.
[2]Engineering department, RCA Victor Company.
[3]Radio department, General Electric Company.

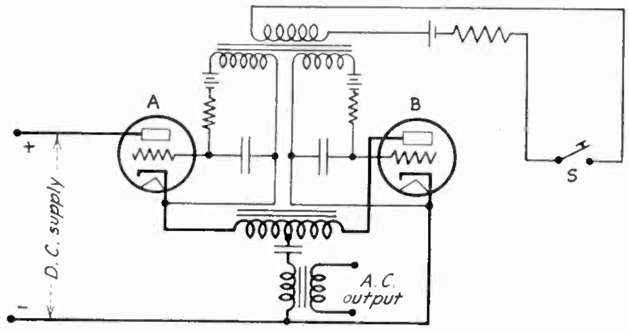


Fig. 5—Self-excited inverter for working into loads of low resistance

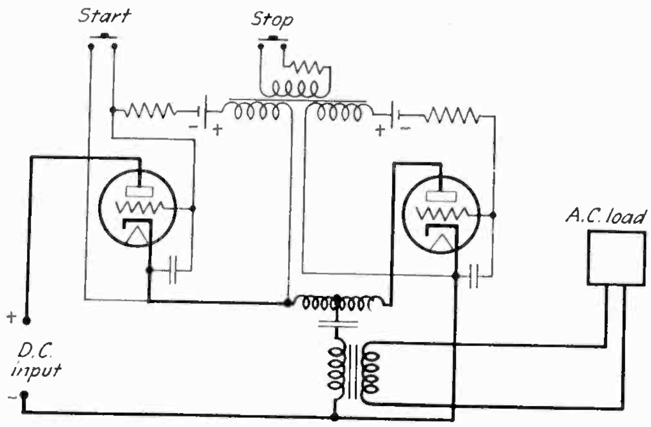


Fig. 6—Rush-button or impulse control of inverter

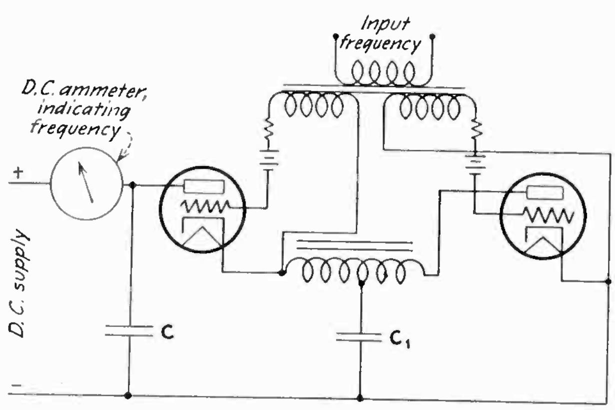


Fig. 7—Thyratrons for use as a frequency indicator

In Fig. 5 is shown a self-excited inverter circuit having a special control feature. In this circuit the grid excitation is obtained by means of the mutual inductance between the two windings of the grid transformer. This permits the inverter to operate into loads of low resistance. The operation of the inverter may be stopped and started by removing or restoring the grid transformer coupling. This can be done by means of the switch *S*, shown in the diagram, without switching the d.c. supply.

The circuit shown in Fig. 6 is similar to the one in Fig. 5 but is arranged for impulse or push-button control. When the "start" button is pressed the inverter will commence oscillation and the load will be energized. It will continue to operate until the "stop" button is pressed, which causes the inverter to stop oscillating, and no further action will occur until the "start" button is again pressed. No switching means in the d.c. power supply circuit are necessary.

The circuit shown in Fig. 7 employing two Thyratrons, may be used as a frequency indicator. It furnishes a direct current which is proportional to the *frequency* of the voltage applied to the grids of the tubes and within limits independent of the grid *voltage*. The device operates on the series type inverter principle.

A time-delay relay

The circuit shown in Fig. 8 was designed to give a definite time delay device to operate over a time range of 30 minutes. To obtain the desired characteristic, the four-element vacuum tube was brought into use. The plate current of a screen-grid tube is practically independent of plate voltage; it is determined by the voltages on the control and screen-grids as long as the plate voltage is above the screen voltage. As the plate voltage is reduced below the screen voltage, the plate current falls off rapidly.

The circuit in Fig. 8 utilizes this characteristic. The a.c. supply is rectified and divided by the potentiometer to give the proper voltages on the two grids, and the remainder is applied to the capacitor *C*. When switch *S* is opened, the capacitor *C* discharges at a constant rate through resistor *R* and the plate filament circuit of the Pliotron. The discharge current gives a drop across *R* which controls the Thyratron. The time is directly proportional to the voltage to which the capacitor is charged and the value of the capacity.

The time delay between the opening of the switch *S* and the operation of the Thyratron is directly proportional to the charging voltage applied to the capacitor. The obvious way to control the timing is by means of a potentiometer controlling this voltage. The potentiometer may then be calibrated directly in time. The time error with voltage change is very small over a given range.

Electron tube telemetering system

For transmitting instrument readings over long distances, the varying frequency principle has a distinct advantage because a frequency indication is substantially independent, so far as accuracy is concerned, of variations in the resistance or transmitting quality of the line over which the signal is sent.

To carry this system into effect it is necessary to

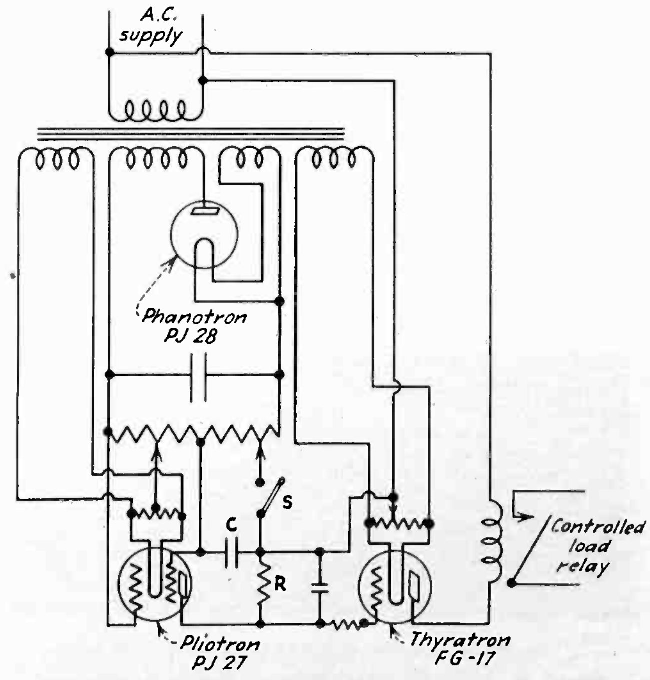


Fig. 8—Time-delay relay using screen-grid tube and Thyratron

generate a frequency definitely related to the reading of the instrument which is to be telemetered. This frequency is transmitted to the instrument which is to be telemetered. This frequency is transmitted to the dispatcher's office or remote station, where a device, operated by frequency will give a deflection proportional to the reading of the transmitting instrument. In such systems the totalizing of loads at two or more different stations is almost invariably required and any frequency telemetering system should be capable of accomplishing this.

The electro-mechanical system shown on the left of Fig. 9 has a contact mounted upon the pointer of the transmitting meter which cooperates with two contacts fixed on a co-axial follower element driven by a motor. The follower controls a variable resistance and automatically adjusts itself to the position of the pointer. The resistance controls the speed of a motor-alternator. Thus the frequency generated depends upon the instrument reading.

This frequency is transmitted over a special pilot wire to the remote station where it is arranged to drive a small synchronous motor. This synchronous motor drives a d.c. generator. The voltage of this generator, if the field be kept constant, will clearly be proportional to the frequency. Thus it will be definitely related to the pointer position of the transmitting instrument. A d.c. voltmeter may therefore be connected to this generator and its deflection will be a function of the reading of the transmitting meter.

Transmitting meters at two different remote stations are shown, the readings being telemetered to a third location. The load at each station is indicated by the voltmeter reading, the voltage of the respective d.c. generator and the total load is shown by a third voltmeter reading the sum of the two d.c. voltages.

The operation of the electron tube system is as follows: A small condenser is mounted on the movement of the meter of which the reading is to be transmitted. This condenser controls the frequency of a beat oscillator. The beat frequency is proportional to the deflection of the meter. The condenser is light and of small dimensions and may be mounted on the movement of any type of meter ordinarily employed in power distribution systems without interfering with its accuracy.

The frequency might be transmitted by pilot wires if desired. In the diagram it is shown transmitted by means of carrier current. The beat frequency modulates a carrier wave, the usual master oscillator power amplifier and modulator connections being shown.

At the receiving station the carrier is detected and the de-modulated beat frequency is amplified and connected to a Thyratron frequency indicating circuit shown in Fig. 7. This furnishes a direct current exactly proportional to the beat frequency and thus also proportional to the deflection of the meter. Thus a simple d.c. current measuring instrument connected to the circuit such as shown in Fig. 7 gives an indication of the reading of the remote meter. Any number of readings may readily be totalized by adding together by means of an additional d.c. instrument the sum of the d.c. current furnished by the several circuits of Fig. 7.

It will be noted that the electron tube scheme eliminates all moving parts other than the meter movements at the two ends. It also avoids the use of rotating machines which have to be kept in synchronism. This feature of the electro-mechanical system is not without certain practical difficulties.

By the use of electron tubes another feature of interest is obtained. In the left-hand diagram it will be noted that a special pilot wire must be used to transmit the frequency signal. This is avoided in the tube system by transmitting the beat frequency over the high-voltage power circuit by means of carrier current. Electron tubes are further employed for the generation and reception of carrier current.

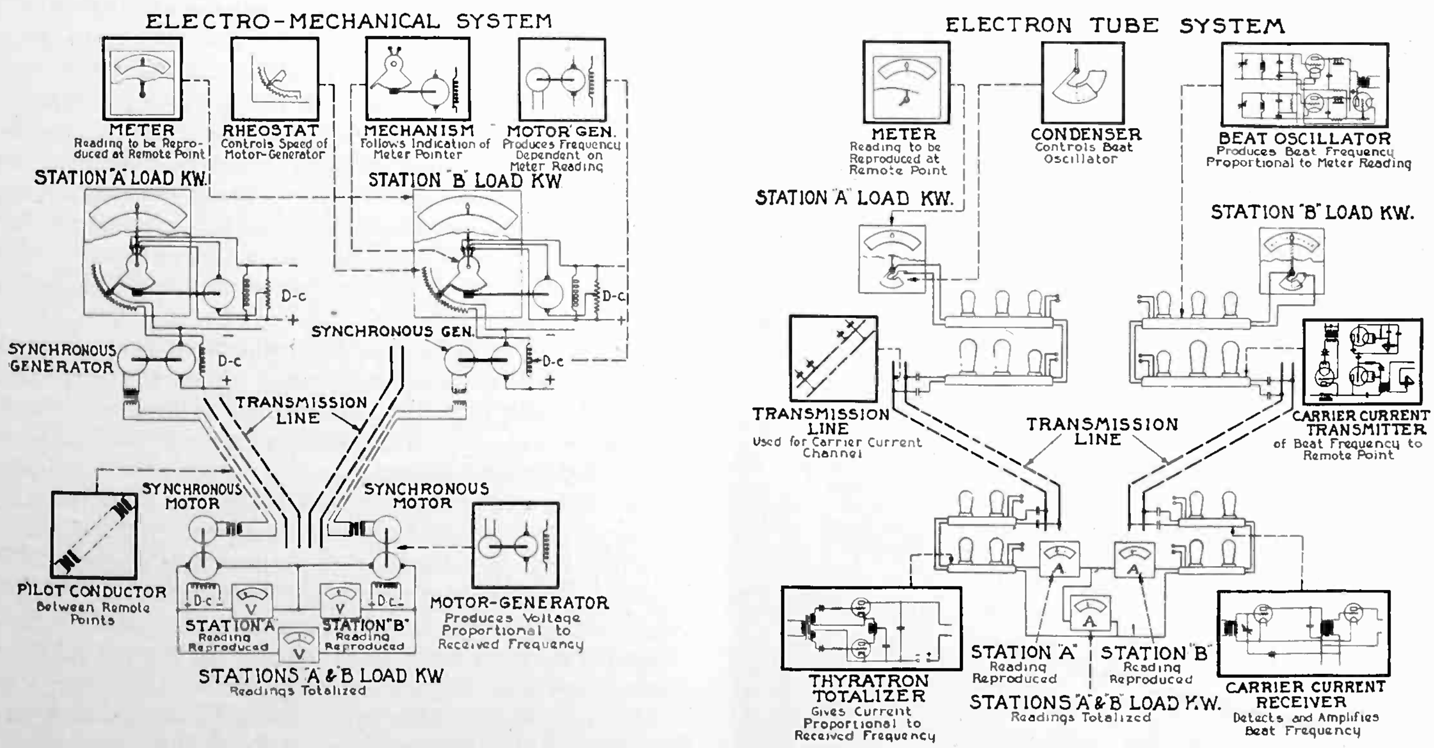
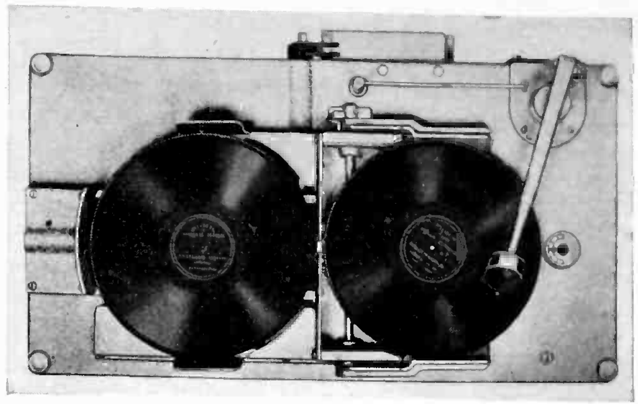


Fig. 9—Electron tube telemetering and totalizing system, variable frequency method

Developments in automatic record changers



Capehart model (18-H) will play ten to fourteen 10-inch records, both sides (20-28 selections), continuously without refilling magazine

By FRANKLIN S. IRBY

Associate Editor, "Electronics"

DURING 1930, a total of 155,400 radio-phonograph combinations, with a sales value of $34,188,000 were sold. The number of automatic record changers included in this total is estimated at 15,600. The development of home-recording devices in connection with radio-phonograph combinations did not appreciably change the outlets or totals sales for this equipment. The drop in sales of radio-phonographs in 1930 from the total of 238,000 units sold in 1929, cannot be attributed to a lack of the public's interest in phonograph records as a source of entertainment, but was due to the same economic factors that affected the whole radio industry.

A study of the average price trend alone for radio receivers during the past three years would indicate a rather uncertain outlook for radio-phonograph combinations as to volume sales, if this were the only factor to be considered. Fortunately, there are others pointing to a more optimistic outlook for such combination units during the coming year. The most important is the automatic feature which is now being more widely recognized as a medium for exploitation.

A new recognition for these units is also being found in country clubs, hotel lobbies, steamships, pavilions, bowling alleys, poolrooms, etc., where reliance on the radio alone for a continuous source of musical entertainment is not practical. Record changers of the earlier types are not new to this field, but sales have been restricted due to the former high prices of such equipment.

The addition of an automatic record-changing feature to a radio creates an immediate impression of superiority over machines not so equipped, so that tone quality, selectivity, etc., are taken somewhat for granted in comparison to other units. This appears to be the buyer's reaction to equipment now available. Up to the present, however, sales of such equipment have been limited to a class market. This is due to the high price of such combination units in comparison to a radio receiver alone.

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WITH 4,500,000 obsolete radio sets in homes, the replacement buyer will look with a discriminating eye for some *important additional feature* before parting with his present set. This feature may be the automatic record-changing unit.

▲

Additional features for new radios

With the development of radio sets at the crossroads as to future design from a price viewpoint, the opportunity for popularizing automatic record-changing units in the better class of such equipment, has an excellent chance for success. The liquidation of development costs, and larger production, has now made available record-changing equipment that might well be incorporated in radios for a much wider market. An important factor that might also be considered is the replacement of some 4,500,000 obsolete sets now in the hands of the public. It is true that first purchasers of present-day radios look with favor on the cheaper units, but a percentage of the replacement buyers will look with discrimination for some *important additional feature* before parting with their present sets. That additional feature must stand out, and might well be the automatic record-changing unit.

The owner of an antiquated radio set is only going to part with his present equipment when the new sales appeal also fits into his idea of effortless entertainment. Over a period of years, radio has trained the public to accept the luxury of automatic music. One need only to tune in a station and sit and listen. It eliminated the necessity of jumping up every few minutes to change a record, which is present in non-automatic record-changing units. This may partially account for the smaller percentage of sales of radio-phonograph combinations in comparison to the total sales of sets during the past two years. However, it must be admitted that the price range has been a guiding influence in mass consumption during this period. The introduction of the midget set has been an important factor in this regard.

With better stabilized economic conditions, it is believed that a steady development and demand for radios combining the automatic record-changing feature will thrive. It has been said that the mass of the public owning cars selling for more than $1,000 were originally Ford owners. This may be analogous to the replacement set business which is now in the offing, representing many millions of obsolete radios. A demand on the part of the public for something more than a cabinet with a minimum-priced radio, will offer an opportunity for greatly increased sales of automatics. This will allow an increase in the unit sale price of radios and a larger margin of profit on every unit.

Minimum number of records required

Record-changing equipment at present available will handle up to 10, and in some units, up to 24 records. Ten records have now been generally accepted as the minimum number to furnish the desired continuous program for automatic changers.

A record changer made by the Allen-Hough Carryola Company will handle ten 10-in. or eight 12-in. records, playing on one side only. The motor supplied with this unit is a shaded pole induction type with an integral governor manufactured by General Industries Company. It is designed for operation on a 110-volt, 60-cycle current, furnishing 15 inch-ounces torque at 80 r.p.m.

Any standard pick-up can be furnished either terminating in leads, or through tip jacks, or with volume control on record-changer with tip jacks for input to amplifier. Provision is made for repeating any record by manually lifting the arm carrying records. Rejection of a record is accomplished by moving pick-up to end of record. This machine can also be provided with switch for operation with coin-operated mechanism.

Capehart introduces two models

The Capehart Corporation has brought out two models of record-changers. One model, designated 10-12C, will handle ten 10-in. or ten 12-in. records playing on one side only, and a second model (18-H) designed to handle ten to fourteen 10-in. records, playing on both sides. This latter instrument will thus play 20 to 28 selections continuously without further attention. These units have also been combined in eight different cabinets, some with the record-changer unit only and others complete with radio.

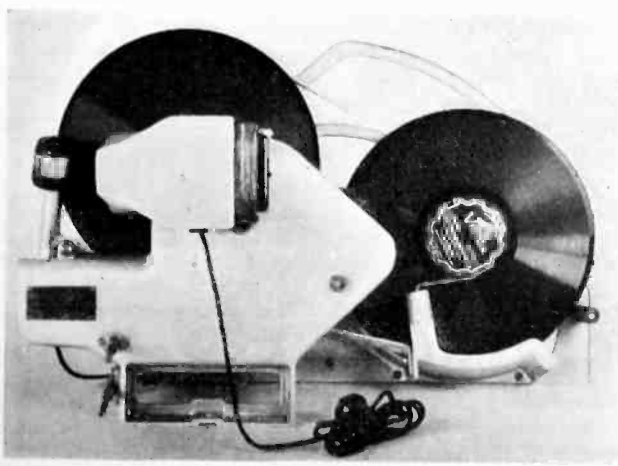
In the 10-12C model, the last record repeats until the records are re-stacked or the master switch is shut off. Any record can be repeated by raising the record magazine to a perpendicular position. The chassis is also equipped with a reject and record-unloading lever. The master switch for starting the mechanism and a volume control are mounted in the right front corner of the mounting plate. No oiling is required on this unit, except for the turntable motor. Other principal moving parts that would require oiling, have oil-less bushings installed. This unit, while designed to accommodate the Capehart pick-up, will also accommodate any of the standard types by special adaptations furnished.

A unique feature of the pick-up connections is the method of eliminating needle scratch during record-changing operations. The leads from the pick-up are carried to two terminals mounted on the trip switch plate on the underside, and are so arranged with the cut-out switch that when the pick-up reaches the stop groove of a record, the pick-up is cut off from the amplifier. No needle scratch is thus transmitted while the pick-up is in the change groove, and before it is lifted off the record.

Junior model (10-12 C) record changer brought out by the Capehart Corporation, requiring small space

Record changer designed by Allen-Hough Carryola Company, handles up to ten records

Compact record changer handling ten records designed by Electromatic Record Changer Corp.



Record changer designed to play records in vertical position made by Hardray, Inc., N. Y. C.

This unit is also designed so that with a double-throw master switch, provided at some convenient location, when it is desired to shut off the phonograph, it will finish out the record partly played and return the tone-arm to the extreme outside or open position. This will allow records to be changed without touching tone-arm by hand. It is accomplished by having a special switch mounted on the cam shaft, which automatically stops the machine in the wide open position.

When it is desired to repeat any particular record which is being played, the magazine arm can be raised and it will then keep repeating the record on the turntable until the current is shut off or the magazine arm is placed in the operating position again.

The Electromatic Record Changer Corporation, Chicago, has developed a rather compact unit which will handle ten 10-in. records. It repeats any record when desired, and has a record rejector permitting change of any selection if desired. The motor of this unit is suspended on an adjustable sub-base below the mounting plate. The time required for record change is given as five seconds. With this unit is also included pick-up, volume control and starting switch.

The White Engineering Corporation has also developed a rather compact unit that will handle twelve 10-in. or nine 12-in. records. All controls are on the face of the cabinet; it is thus not necessary to raise top of cabinet after loading to control operations. A reject button on the front of the cabinet, will, when pressed, reject record playing and start another one if desired. A repeat knob is also provided for repeating any record in the magazine. In order to eliminate slippage when 12 records are stacked on turntable, the records are held together under pressure by means of a record arm in such a way that the top record, on which the pick-up rests, can not slip and thus vary its speed relative to turntable.

A feature of the record changer made by Hardray, Inc., is the vertical position of the records while playing. Twenty 10-in. records of any make can be played continuously in this machine without reloading magazine. This unit allows freedom in cabinet design in that a standard open top type of cabinet, a closed top cabinet with a side loading door or a front opening door may be used.

This record changer has a single control knob which when pushed starts the machine. If a record is playing and one does not want to wait until it finishes, pushing this knob will reject the record. Turning the same knob to the right changes the operation to repeat the record being played, and turning it to the left, returns it to the normal record-changing operation.

Among some of the record-changing units which are sold only complete with cabinet, is one designed by the Western Electric Piano Company, Chicago, Ill. This instrument will handle up to 15 records, playing both sides. It is also provided with remote control. An interesting use has been made of this unit in connection with a centralized radio control cabinet designed by the same company. Phonograph record programs can be

[*continued on page 612*]

Specifications for automatic phonograph record changers

Manufacturer	Model number	Driving motor*	Number records handled	Speed regulation	Turntable drive	Time required record change	Record-changer dimensions inches	Type of pick-up	Special Features
Allen-Hough Carryola Co. Milwaukee, Wis.	Models 4, 5	General Industries Co. commercial voltages available	Ten 10 in. or eight 12 in.	Governor built into motor	Rubber friction disk	15 seconds	Length $13\frac{3}{4}$, width $14\frac{3}{8}$, ht. above mtg. $9\frac{1}{2}$, ht. below mtg. $3\frac{7}{8}$	Any standard type furnished	Has repeat mechanism. Repeats last record until stopped.
The Capehart Corp. Fort Wayne, Ind.	10-12 C	Shaded pole induction type	Ten 10 in or ten 12 in.	Governor on motor	Friction disk	18 seconds	Length $14\frac{1}{4}$, width $14\frac{1}{4}$, ht. above mtg. $7\frac{3}{16}$, ht. below mtg. $3\frac{7}{8}$	Capehart or special as required	Record reject and unloading lever. Can repeat any record. Cabinet models also available.
do.	18-H	1/30 H.P. split phase change motor. Friction driven turntable motor	Ten to fourteen 10 in. play both sides	Governor on motor	Friction disk	20 seconds	Length $27\frac{1}{2}$, width $14\frac{3}{4}$, ht. above mtg. 12, ht. below mtg. 7	Capehart or special as required	Device for reject and button control for remote installation. Cabinet models also available.
Electromatic Record Changer Corp. 2212 South Paulina St., Chicago, Ill.	....	General Industries "Blue Flyer," special	Ten 10 in.	Governor on motor shaft	....	5 seconds	Length $19\frac{1}{2}$, width $14\frac{3}{4}$, ht. above mtg. $4\frac{3}{4}$, ht. below mtg. $4\frac{3}{4}$	Own make	Record reject mechanism. Repeats any record.
Electra Corporation 1500 North Kostner Ave., Chicago, Ill.	....	Two motors used disc and changer	Twenty-four 10 in. play both sides	Mechanical governor	Direct drive	7 seconds	Length $27\frac{1}{2}$, height 25, depth $14\frac{1}{2}$	Own make	Two cabinet models available, unit also sold separately.
Hardray Inc. 644 Broadway, New York, N. Y.	....	General Industries "Green Flyer"	Twenty 10 in.	....	Friction disk clutch	11 seconds	Length 22, width $11\frac{1}{2}$, height 14	Webster type 4-C.	Records played in upright position. Chassis aluminum casting. Weight 22 lb.
White Engineering Corp. 32nd and Arch Sts., Philadelphia, Pa.	*Phonomatic*	General Industries	Twelve 10 in. or nine 12 in.	Mechanical governor	Silent worm gear	12 seconds	Length $13\frac{3}{4}$, width 14, height 9	Webster high impedance	Record reject button. Repeat any record desired. Controls on face of cabinet.

* 110 volt 60 cycle; Turntable speed 78 r.p.m. unless otherwise specified.

Effects of optical slits in

Variable area sound recording

By JOHN P. LIVADARY

Technical Sound Director,
Columbia Pictures Corp., Hollywood, Calif.

IN THE case of variable area recording a constant intensity exciting lamp is used, the light of which is focused upon a tiny mirror cemented on a loop of molybdenum ribbon free to vibrate in a magnetic field under the action of an electric force. The voice currents pass through this loop or vibrator, causing the ribbon and mirror to vibrate and reflect the image of the light upon an optical slit of fixed dimensions which is focused sharply on the moving film. The vibrator is so adjusted that without any voice currents through it the beam of light covers one-half of the optical slit. Full modulation of the film is attained when the light reflected from the vibrator mirror alternately covers and exposes the full length of the slit.

Practical limitations in slit width

As one can readily visualize, the action of the vibrator is such that the wave form of the voice currents is actually traced upon the moving film. However, the physical dimensions of the slit and practical limitations in obtaining an infinitesimal focus on the film introduce a certain amount of distortion. This distortion as well as the normal frequency characteristic obtainable by this type of recording is discussed in this paper.

Figure 1 will serve to illustrate how a true sinusoidal wave would register on film by this method. The upper half of the cycle is flattened out by an amount equal to the width of the slit and the lower half never reaches its true minimum, stopping at the point of intersection of the two displaced sine waves. This result may be explained as follows: When a beam is moving in the direction $O-Y$, the left edge of the slit becomes the recording edge, assuming that the motion of the film is to the left. As the beam reaches its maximum position and starts moving down, the right edge becomes the recording edge and effectively the wave is displaced along the X axis by an amount equivalent to the width of the slit. Similarly, the minimum point of the lower half cycle cannot be reached because at the time the beam assumes the minimum position on the slit there is a point on the film in the middle of the slit which has already received its exposure as it entered the optical field, when the beam of light was above its minimum position. Therefore, the minimum exposure of the lower half cycle is effectively less than its true minimum value, particularly so on high frequencies.

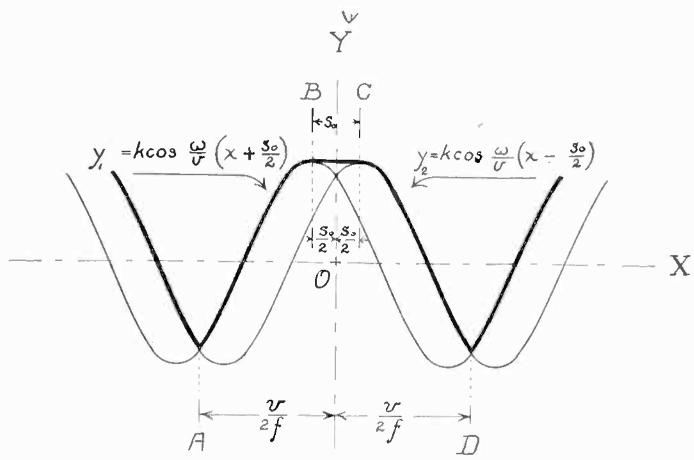


Fig. 1—Illustrates how a true sinusoidal wave is recorded on the film with oscillograph in variable area recording

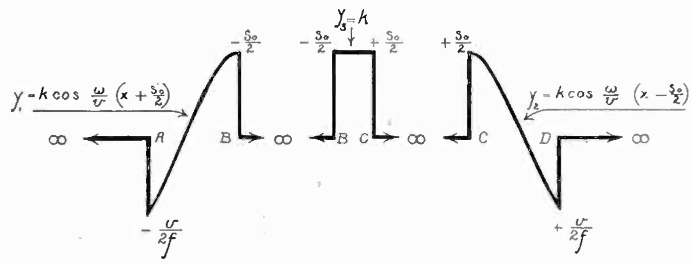


Fig. 2—Typical sinusoidal wave is broken up into three component parts for analysis

THIS is the second article of a series of three dealing with the effects of optical slits in the three fundamental different systems of sound recording. The analyses presented are general and may be applied to any of the widely used sound systems.

Mathematical analysis offered

In the following discussion a mathematical expression will be derived to represent the upper envelope of the two sine waves, outlined in Fig. 1 by a heavy line. This envelope represents the complex wave form recorded upon the film whose fundamental and harmonics will be studied and computed. For the purpose of analysis we will break up the wave form under study in three parts. One part will start at point A and end at point B, assuming the values of sine curve No. 1, between these points. The second part will be constant and equal to

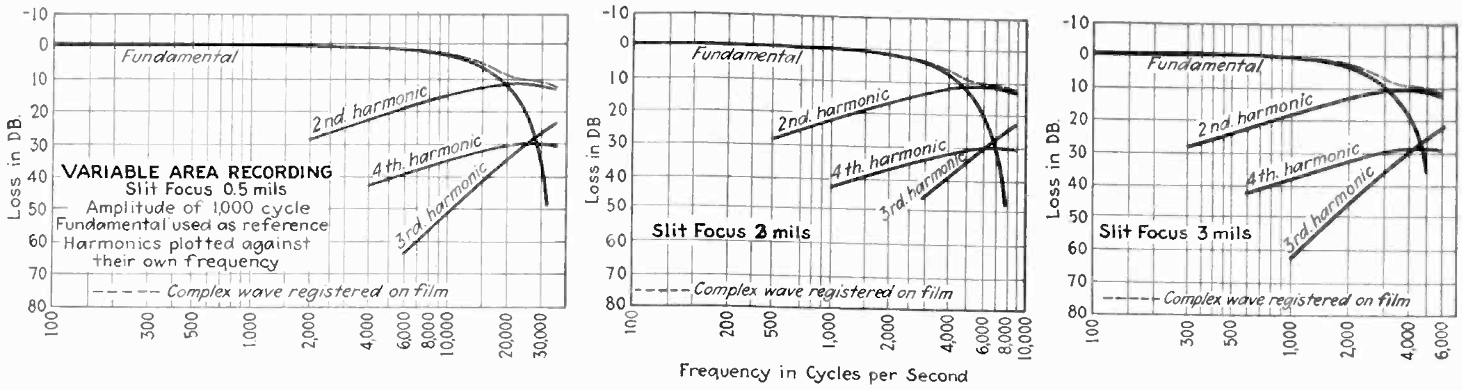


Fig. 3—(a) (b) and (c) Presents data of Table I in graphical form which indicates level in decibels relative to 1,000 cycle wave of the fundamental, 2nd, 3rd and 4th harmonic components

the maximum amplitude of the sine wave for a distance equal to the width of the slit. The third part will be similar to the first part but it will hold only for points between C and D and will use the expression of sine wave No. 2. All these curves are assumed to be zero beyond the points within which they are defined, as illustrated in Fig. 2.

The coordinate axes are chosen through the middle of the slit in order to simplify the expression, by making the figure symmetrical in respect to the Y axis. The following symbols will be used:

wave to be recorded $= k \cos \omega t$,
slit width $= s_o$,
film velocity $= v$; $\omega = 2\pi f$,
frequency of recorded wave $= f$,
wave length upon the film $= v/f$,
distance on the film $= x$,
time $= t = x/v$.

The edge of the light beam covering the optical slit is assumed to be perpendicular to the slit.

The equations of the three curves to be analyzed are as follows:

$$\text{Curve No. 1 } Y_1 = k \cos \omega \left(t + \frac{s_o}{2v}\right) \quad (1)$$

between $-\frac{s_o}{2v}$ and $-\frac{\pi}{\omega}$

$$\text{Curve No. 2 } Y_2 = k \quad (2)$$

between $\frac{s_o}{2v}$ and $-\frac{s_o}{2v}$

$$\text{Curve No. 3 } Y_3 = k \cos \omega \left(t - \frac{s_o}{2v}\right) \quad (3)$$

between $\frac{\pi}{\omega}$ and $\frac{s_o}{2v}$

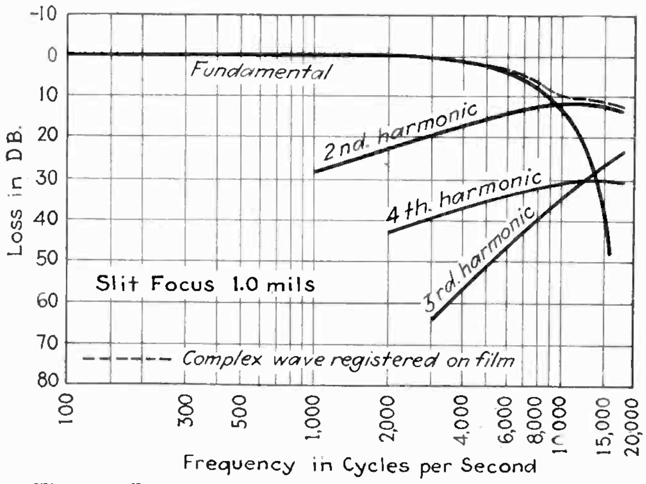


Fig. 4—Data from Table I plotted in graphical form for slit of one mil width

It is now assumed that the equation for the heavy line of Fig. 1 may be expressed as

$$Y = \sum_{n=o}^{n=\infty} \left\{ A_n \cos n\omega t + B_n \sin n\omega t \right\} \quad (4)$$

Where

$$A_n = \frac{\omega}{\pi}\int_{-\frac{\pi}{\omega}}^{-\frac{s_o}{2v}} Y_1 \cos n\omega t \, dt + \frac{\omega}{\pi}\int_{-\frac{s_o}{2v}}^{\frac{s_o}{2v}} Y_2 \cos n\omega t \, dt + \frac{\omega}{\pi}\int_{\frac{s_o}{2v}}^{\frac{\pi}{\omega}} Y_3 \cos n\omega t \, dt \quad (5)$$

and

$$B_n = \frac{\omega}{\pi}\int_{-\frac{\pi}{\omega}}^{-\frac{s_o}{2v}} Y_1 \sin n\omega t \, dt + \frac{\omega}{\pi}\int_{-\frac{s_o}{2v}}^{\frac{s_o}{2v}} Y_2 \sin n\omega t \, dt + \frac{\omega}{\pi}\int_{\frac{s_o}{2v}}^{\frac{\pi}{\omega}} Y_3 \sin n\omega t \, dt \quad (6)$$

Substituting the values of Y_1, Y_2 and Y_3 as given by equations (1), (2) and (3) in (5) and (6), and carrying out the indicated integration we find that

$$A_n = -\frac{2k}{\pi(n^2-1)}\left[\sin\left(\frac{\omega s_o}{2v} + n\pi\right) + \frac{1}{n}\sin\frac{n\omega s_o}{2v}\right] \quad (7)$$

and

$$B_n = 0. \quad (8)$$

From (7) we obtain the following values for the first four coefficients for the series (4):

$$A_0 = \frac{k}{\pi}\left[\sin\frac{\omega s_o}{2v} + \frac{\omega s_o}{4v}\right]$$

$$A_1 = \frac{k}{\pi}\left[\sin\frac{\omega s_o}{2v} + \left(\pi - \frac{\omega s_o}{2v}\right)\cos\frac{\omega s_o}{2v}\right]$$

$$A_2 = -\frac{2k}{3\pi}\left[\sin\frac{\omega s_o}{2v} + \tfrac{1}{2}\sin\frac{\omega s_o}{v}\right]$$

$$A_3 = \frac{k}{4\pi}\left[\sin\frac{\omega s_o}{2v} - \tfrac{1}{3}\sin\frac{3\omega s_o}{2v}\right]$$

$$A_4 = -\frac{2k}{15\pi}\left[\sin\frac{\omega s_o}{2v} + \tfrac{1}{4}\sin\frac{2\omega s_o}{v}\right]$$

It will be noted that the series (4) contains a constant term, A_o, which indicates that the line of symmetry of the recorded wave of Fig. 1 is displaced above the axis OX. The amount of this displacement is a function of the fundamental frequency of the recorded wave, and is given by the expression for A_o.

Table I indicates the levels in decibels, relative to a 1,000 cycle wave, of the fundamental, second, third and fourth harmonic components of the recorded wave for various impressed vibrator frequencies and for several values of the effective optical slit width at the film. Fig. 3, (a), (b) (c) and Fig. 4 contain the data of Table I in graphical form.

Table I.—Level in decibels referred to 1,000 cycle fundamental

	Fundamental				2nd Harmonic				3rd Harmonic				4th Harmonic			
Freq.	S= .5	S=1.0	S=2.0	S=3.0	S= .5	S=1.0	S=2.0	S=3.0	S= .5	S=1.0	S=2.0	S=3.0	S= .5	S=1.0	S=2.0	S=3.0
100	.....	.....	.....	—1.08	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
150	.....	.....	—.45	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
300	.....	—.11	.....	.....	.....	.....	.....	28.0	.....	.....	.....	.....	.....	.....	.....	.....
500	.....	—.09	—.34	—.80	.....	.....	28.2	.....	.....	.....	.....	.....	.....	.....	.....	.....
600	—.02	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	42.5
1,000	0	0	0	0	.....	28.5	22.3	18.2	.....	.....	.....	62.8	.....	.....	42.6	37.1
2,000	.09	.34	1.56	3.20	28.6	22.6	16.4	12.9	.....	.....	.....	45.1	.....	42.6	36.5	32.8
3,000	.26	.97	3.83	8.85	.....	19.2	13.6	10.7	.....	63.8	54.8	36.3	.....	.....	33.5	.....
4,000	.43	1.86	7.67	18.1	22.7	16.9	11.9	10.1	.....	.....	.....	29.9	42.7	36.8	31.6	29.2
5,000	.75	2.86	12.1	35.6	.....	15.2	11.0	.....	.....	.....	.....	25.3	.....	.....	30.5	.....
6,000	1.06	4.17	18.8	∝	19.3	13.9	10.8	12.3	63.9	46.1	30.6	22.1	.....	33.8	29.9	29.4
7,000	1.44	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
8,000	1.99	7.70	47.2	.....	17.0	12.2	11.8	.....	.....	.....	.....	.....	36.9	31.9	29.8	.....
9,000	2.41	9.9	∝	.....	.....	11.7	12.9	.....	54.4	37.3	22.8	.....	.....	.....	30.1	.....
10,000	2.95	12.4	.....	.....	15.3	11.3	.....	.....	.....	.....	.....	.....	.....	30.8	.....	.....
12,000	4.26	19.1	.....	.....	14.0	11.1	.....	.....	46.2	30.9	.....	.....	33.9	30.2	.....	.....
16,000	7.71	47.5	.....	.....	12.3	12.1	.....	.....	.....	26.0	.....	.....	32.0	30.1	.....	.....
18,000	9.91	∝	.....	.....	11.8	13.3	.....	.....	37.4	23.1	.....	.....	.....	30.4	.....	.....
20,000	12.5	.....	.....	.....	11.4	.....	.....	.....	.....	.....	.....	.....	30.9	.....	.....	.....
24,000	19.2	.....	.....	.....	11.2	.....	.....	.....	31.0	.....	.....	.....	30.3	.....	.....	.....
30,000	36.7	.....	.....	.....	.....	.....	.....	.....	26.4	.....	.....	.....	.....	.....	.....	.....
32,000	47.6	.....	.....	.....	12.2	.....	.....	.....	.....	.....	.....	.....	30.2	.....	.....	.....
36,000	∝	.....	.....	.....	13.4	.....	.....	.....	23.2	.....	.....	.....	30.5	.....	.....	.....

Notes: Negative numbers indicate levels higher than level at 1,000 cycles.
Levels of harmonics are also referred to 1,000 cycle fundamental and are tabulated against *their own frequency*.
S = slit focus on film in mils.

Example: Under 2nd. Harmonic S = .5, 13.4 is the level below the 1,000 cycle fundamental, of the second harmonic whose frequency is 36,000 cycles. This harmonic, however, was generated from the 18,000 cycle fundamental.

Table II indicates the percentage of second harmonic tone present in the recorded wave on film for several values of fundamental frequency, column two indicating the percentage as given by the ratio of second harmonic amplitude to fundamental amplitude and column four indicating the percentage as given by the ratio of second harmonic amplitude to root-mean-square amplitude of the recorded wave. Calculations are based on an effective slit width of 0.5 mils.

Important features of variable area recording

Of the many interesting features encountered in a study of variable area recording, the following are perhaps of the greatest importance: First, it is fundamentally impossible to record a tone on the film if the effective optical slit width at the film is equal to or greater than the wavelength of the tone on the film. Second, while it is impossible to record a 9,000 c.p.s. tone on the film if an effective slit width of 2 mils is used, it is still possible to obtain a 9,000 cycle tone during reproduction from a 2-mil recording, providing a fundamental frequency of 4,500 c.p.s. was recorded. Third, no phase distortion is obtained in variable area recording due to the optical slit employed.

If we were to record a constant level frequency film by this method covering a range from 0 to 18,000 c.p.s. using a slit focus of 1 mil, and should then reproduce this film through a perfect sound projector the result would be as follows:

Up to 3,000 c.p.s. we would obtain a pure tone, the slit harmonics being 20 or more db. below the fundamental. From 3,000 c.p.s. on, the level of the second harmonic would gradually become audible, boosting the apparent level of the higher frequencies. At the cut-off frequency of the slit we would detect an 18,000 cycle tone at a level only 13.3 db. below fundamental, but made up entirely of 94.4 per cent second harmonic and 5.6 per cent higher harmonics.

Naturally, this is a hypothetical case because it is hardly practicable to record commercially frequencies beyond 9,000 c.p.s., particularly so as most commercial sound projectors cut off between 4,500 and 6,000 c.p.s. However, it will serve to illustrate how the effect of harmonics becomes prominent at the high end of the recording characteristic.

Incidentally, an analysis of this sort assumes that the vibrator resonant frequency lies beyond the range of frequencies considered, and further does not account for any irregularities in the optical system used with this type of recording. Although the recording slit frequency characteristic is of fundamental importance, the overall characteristic of a recording system depends on many other important factors as well. We will have occasion to speak of these factors after we have studied the characteristic of a slit of varying dimensions which will be published in a subsequent issue of *Electronics*.

Table II.—Relation of 2nd harmonic to recorded frequencies at S=0.5

Freq.	Attenuation of Fundamental	2nd Harmonic in Per Cent of its Fund. Frequency	Apparent Attenuation of Recorded Frequencies	2nd Harmonic % Present in Recorded Frequencies
1000	0	3.7	0	....
2000	.09	7.4	.09	3.7
3000	.26	11.2	.26	....
4000	.43	14.9	.40	7.6
5000	.75	18.4	.70	....
6000	1.06	22.4	1.0	12.2
7000	1.44	....	1.3	....
8000	1.99	30.1	1.7	17.5
9000	2.41	33.9	2.0	....
10000	2.95	37.6	2.4	24.0
12000	4.26	45.2	3.8	30.9
16000	7.71	59.7	6.4	50.1
18000	9.91	66.7	7.8	62.8
20000	12.5	....	9.0	....
24000	19.2	....	10.5	92.2
30000	36.7	....	11.0	....
32000	47.6	....	11.9	96.6
36000	∝	....	12.9	94.4

Notes; S = slit focus in mils. The effect of higher order of harmonics is not considered.
Examples—Under column 3, 18.4 per cent is the amplitude ratio of the second harmonic to its 5000 cycle fundamental.
Under column 5, 94.4 is the per cent of second harmonic in a 36,000 cycle tone recorded on film.

Greater simplification suggested in

Designing the radio cabinet

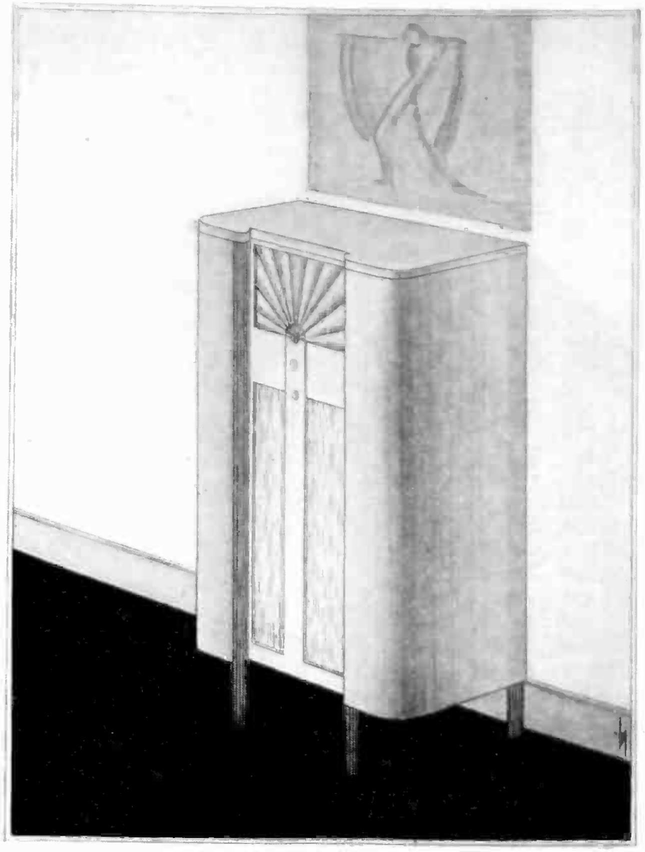


Fig. 1—Suggestion for radio cabinet with decorative treatment reduced to its simplest form

By PHILIP FRANCISCO

Consulting Designer, New York City

SINCE radio began to represent in the American home a source of recreation and information, manufacturers and radio engineers have been devoting their energies to perfect an instrument which would function more adequately from the technical point of view, endeavoring to produce a greater degree of clarity and more purity of tone. In the growth of the industry, it is quite natural that the primary function of the radio should first demand careful consideration of its engineering features. However, with the growing perfection of these technical qualities more care is being given to the exterior design of the cabinet, in order that the radio may become adaptable as a harmonious piece of furniture in the home.

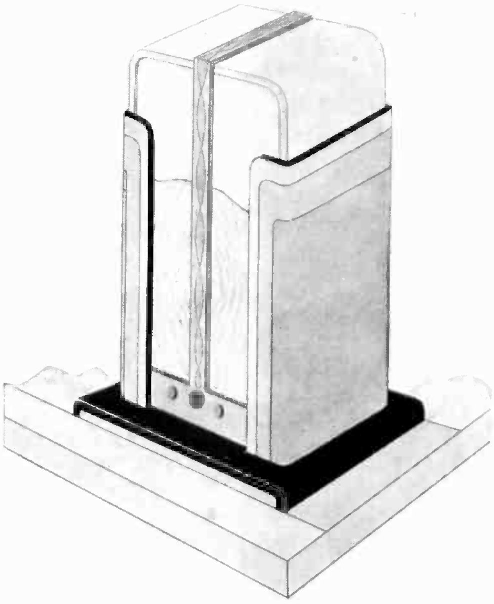


Fig. 2—Midget cabinet with less concealing of constructive forms

From the first metal cases, ornamented with gilt, which contained the more primitive radios, to the present cabinets of wood, which are so often over-elaborate "period" reproductions, relatively few radios have been carefully planned from the standpoint of proper adaptability to the various types of interiors in which they should become consistent pieces of furniture.

A growing furniture-consciousness has arisen over the country, due to the interest brought about through the influence of the American Wing of Colonial and Early American furniture at the Metropolitan Museum of Art in New York, and by the advent of a new style in furniture which became apparent at the time of the Exposition of Decorative Arts in Paris, 1925. The realization of this vast interest in furniture, and of the value effected by a well-designed radio cabinet, is causing many manufacturers to consider the factors which will make their products better conform to the demand of the buying public.

Since cost of production must be kept reasonably low, it is obvious that cabinets produced in volume cannot express the fine handicraft which was often lavished on the furniture of more leisurely days, when cabinet makers worked for months over single details; but it should be remembered that a public which begins to discriminate, does not necessarily prefer the machine-made "period-reproduction" which has no reference to the purpose of the radio.

What, then, should the radio cabinet embody? What factors should be considered from the viewpoint of the designer who seeks to give to the manufacturer projects which will produce greater sales volume and still represent dignified design quality?

Furniture—a visible symbol of its function

If furniture is considered with utility as its basis, the purpose of a chair, as an example, is to permit one to be seated comfortably; the purpose of a desk, whether it be from the era of Louis XIV of from the Victorian age, is to provide space and surface necessary for writing and studying. The purpose of a screen is to be a temporary partition, behind which some area of a room may be hidden. However, the accurate function of a piece of furniture does not presuppose a fine design. A chair, by the character of its design, is formal or informal. It may be stern, as was the high, straight-backed Gothic chair, or it may be pleasantly inviting due to the comfort suggested by low, full curves. The angular metal desk may savor of the office and cannot easily fit into a quiet, livable room. Therefore, all furniture, in consequence of its design, should not only fulfill its function, but also denote suitability to its environment.

The radio has as its function the accurate transmission of sound. The material used in the cabinet should therefore not obscure or muffle the tone. All furniture is a visible symbol of its function. The fireplace of past generations was a symbol of unified family life. It provided not only light and heat, but was also the center of the family group where social intercourse took place. Today, particularly in large cities, family life is less unified—each member often having widely varied interests; hence the fireplace today has lost to a great extent this symbolism, although it remains in many homes, and is installed in apartments where steam heat and electricity are taken for granted. In certain respects, the radio replaces the symbol of the fireplace, providing for the modern family of differing interests the type of entertainment each desires.

It is apparent, that the radio is essentially a modern instrument, but there are relatively few homes with thoroughly modern interiors into which a cabinet might be placed, designed with the austere beauty of the straight line and the simplicity of the flat plane which characterizes good modern furniture. Such a cabinet, although it may be of excellent contemporary design, becomes strained and "self-conscious" when placed with antique furniture. One cannot expect the public to throw aside at once its inherited furniture (no matter how mediocre), hence the radio, in the majority of cases, must become adaptable to the spirit of the past without losing its modern precision and significance.

More natural "finish" stressed

The few fine examples of the contemporary style (those pieces which represent an effort on the part of sincere designers to produce furniture, simply and distinctive, with the materials which the age provides), are unfortunately rare and difficult to acquire. Since the market has been flooded by such a multitude of harsh, bizarre, exotic pieces unsuited to any dignified interior, it is thus to be expected that the public is reverting more generally to the past for the motifs of "period" and Colonial masters.

A possible solution, then, for the designer, is to compose radio cabinets with sincere modern principles in mind; ones of accurate function, economy of cost, suitability of materials, simplicity of construction, precision of line, and dignity of fine proportions. Then, one should adopt classic motifs when necessary, in harmony with these present day principles.

The first sketch, Fig. 1, is a suggestion for a combined radio and phonograph cabinet, or may be used for radio only, which, for volume production, might be adaptable to the home whose furniture is given careful consideration. The function of this cabinet is to clothe the mechanics of the instrument in suitable materials. Wood remains the most practical substance for this use; birch, maple, walnut and the various veneers are the best suited. It is suggested to manufacturers that as to "finish" for radio cabinets, a clean surface retaining as much as possible the natural qualities of the wood, is greatly to be preferred to the specious psuedo-antique finish which is brought about rather obviously in two or three hours under modern construction. If a simple finish is applied instead of disguising the newness of the wood, the cabinet would seem more genuine.

The motifs of the design in Fig. 1 are classic, but have been reduced to the simplest forms, in order that the carving may be easily and quickly cut by machine. The supporting forms are simplifications of the classic column often used in Colonial times. The wings of the cabinet, in the top section of which space is provided for records, are plain in surface and finish, providing a foil for the carving in the front panel. Throughout the design, the vertical line is stressed, therefore, the cloth covering the loud speaker in the lower section should be in light vertical pleats. This cabinet is not designed to represent a piece of furniture of any period in the past, but rather to be consistent with old pieces, remaining a definite modern radio.

The sketch in Fig. 2 is considered for those who find space saving necessary, and who prefer the less expensive radio. The "midget" has been found practical to the consumer, and is easily adaptable to the many small apartments in thickly-populated districts of the country. These

[*continued on page 612*]

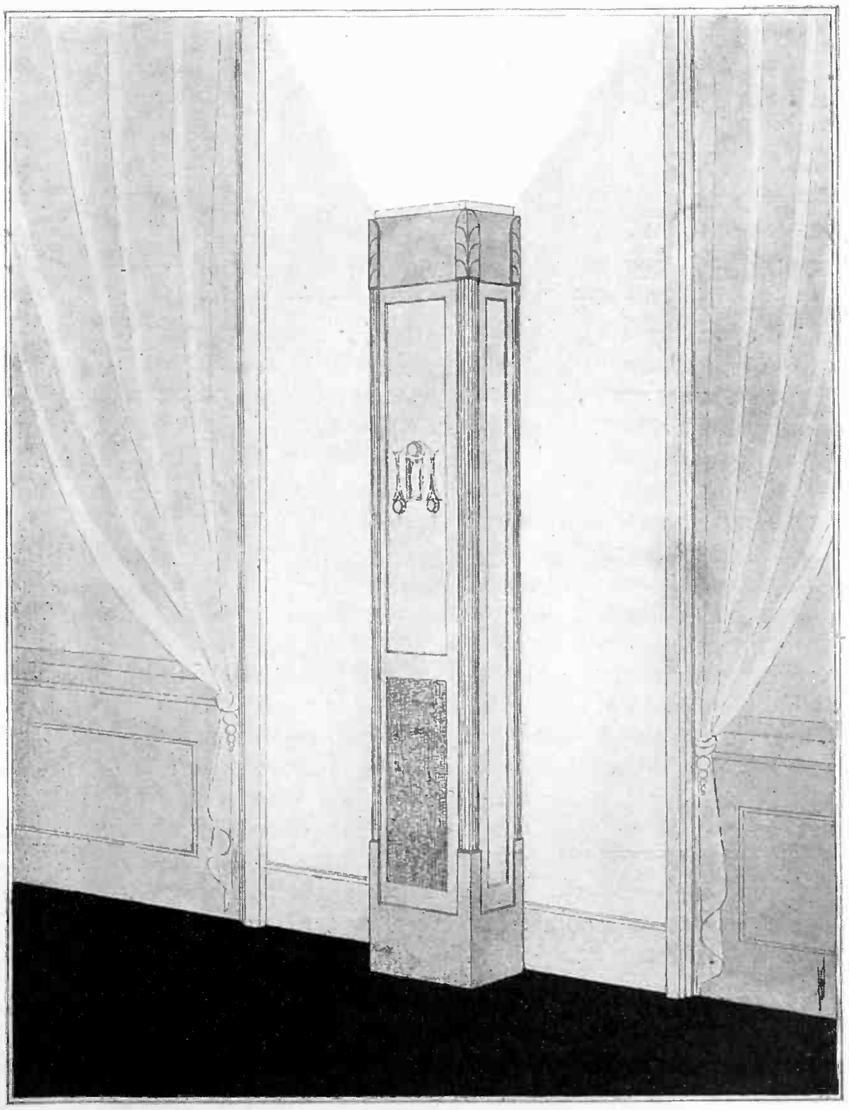


Fig. 3—Cabinet designed with a high-wattage lamp in top which furnishes an indirect lighting source

Tabulation showing percentage of parts purchased by individual set manufacturers

Manufacturer No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Sockets	...	100	100	100	100	90	10	100	...	...	...	100	100	100	100	100	100	100	100	...
Cabinets	...	100	100	...	100	20	70	...	100	100	100	100	25	...	...	100	...	100	...	100
A. F. transformers	40	...	...	...	100	...	100	...	...	...	...	...	...	...	100	...	...	50	...	...
A. F. chokes	...	...	...	...	100	...	100	...	...	...	...	...	...	...	100	...	...	25	...	...
Tuning coils	100	20	...	...	...	...	...	...	...	...	...	...	100	...	...	...	...	...	...	...
Tuning condensers	...	100	100	10	100	100	...	100	...	...	75	100	100	...	100	...	100	100	...	100
R. F. chokes	...	15	100	...	100	...	...	...	...	...	50	...	100	40	...	...	...	...	...	...
Bypass condensers	...	100	100	100	100	100	...	...	...	100	100	100	100	...	100	...	100	100	100	50
Filter condensers	...	100	100	100	100	...	30	...	...	...	100	100	100	...	100	...	100	100	100	50
Filter chokes	40	10	...	...	100	...	100	...	...	...	...	...	...	...	100	...	...	15	...	...
Power transformer	100	...	100	...	100	100	100	...	...	...	...	...	100	...	100	...	...	15	...	...
Fixed resistors	90	100	100	80	100	100	100	100	50	100	100	100	100	40	100	100	100	100	100	75
Variable resistors	100	100	100	80	100	100	100	100	...	100	50	100	100	100	100	100	100	100	100	100
Loud speakers	...	20	100	60	100	...	...	100	...	...	75	100	100	...	100	...	25	90	100	...

Buying habits of radio set manufacturers

WHETHER to buy from other manufacturers or to make in his own plant the components for assembly into his receiver is a question that assails every radio manufacturer during the production season. Buying habits of manufacturers differ and for an individual manufacturer differ from season to season. At the present time, as a result of a survey conducted by *Electronics* into the purchasing policies of 20 major companies it seems that there is a trend toward buying parts rather than making them.

It cannot be said whether this trend, if indeed it is such, is due a feeling that technical instability of the industry causing sudden changes of models makes it uneconomical for a manufacturer to build his own parts, or whether experience is proving that a specialty manufacturer can make a given product cheaper than a set assembler. It seems reasonable that as components manufacturers get other outlets for their products so they can work the year round, they can operate with greater efficiency and hence greater economy than an assembler who works only a few months. A transformer manufacturer for example makes units for radios, for sound pictures, for neon signs, and for other purposes. Condenser manufacturers find the power correction problem an additional outlet for their products.

Tables of data presented herewith contrast in so far as possible a similar survey conducted a year ago. Then about 62 per cent of components used by 14 major companies were built by the set manufacturer. Now the proportion is about fifty-fifty. The 20 manufacturers whose data are included in these tables do not include makers of midget receivers alone, who almost invariably buy rather than build. Nor does the table include such special parts not used by all manufacturers as phonograph turntables, motors, record changers, pickups, etc. Such manufacturers as use these items invariably buy them.

Of all components it is interesting to note how small a proportion of variable and fixed resistors is made by set manufacturers. Cabinets, of course, are largely bought. A change in the tendency of manufacturers toward making their own tuning coils seems apparent, no coils being purchased by the 14 leading manufacturers in 1929 while in 1930 several manufacturers bought all and some bought part of their coils.

Whether to buy or build depends not so much on relative cost to the assembler as it does upon the ability to make rapid model changes or to prevent a large surplus stock from building up.

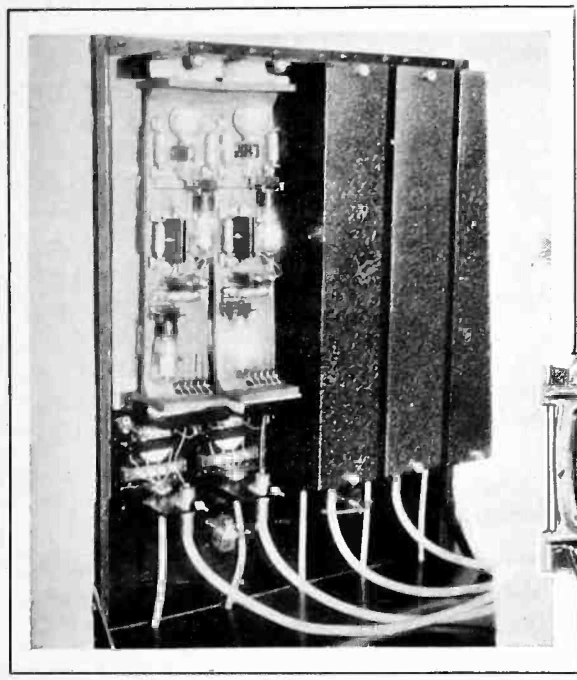
Percentage of Manufacturers who bought components

	1929		1930	
	Bought All	Bought Part	Bought All	Bought Part
Sockets	29	7	65	15
Cabinets	57	29	50	15
A. F. transformers	14	0	15	10
A. F. chokes	..	..	15	5
R. F. coils	0	0	10	5
Tuning condensers	36	14	55	10
R. F. chokes	7	0	15	15
Bypass condensers	50	7	65	5
Filter condensers	36	7	55	10
Filter chokes	29	0	20	15
Power transformers	29	0	35	5
Fixed resistors	57	29	75	20
Variable resistors	64	0	85	15
Loud speakers	29	7	35	26

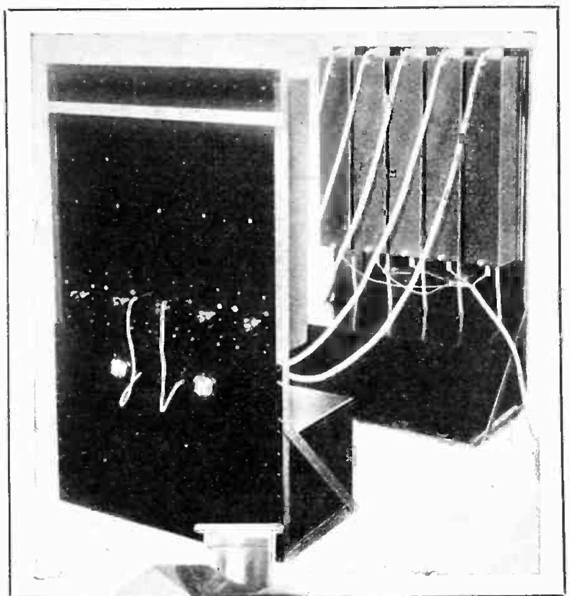
Purchasing policies of 20 radio manufacturers

Manufacturer No.	Percentage of Parts Bought	Percentage of Parts Made	Manufacturer No.	Percentage of Parts Bought	Percentage of Parts Made
1	34	66	13	73	27
2	55	45	14	20	80
3	72	28	15	79	21
4	38	62	16	29	71
5	93	7	17	45	55
6	48	52	18	64	36
7	51	49	19	43	57
8	36	64	20	34	66
9	11	89	Average	48.6	51.4
10	29	71	Average of 14 manufacturers in 1929	38	62
11	47	53			
12	64	36			

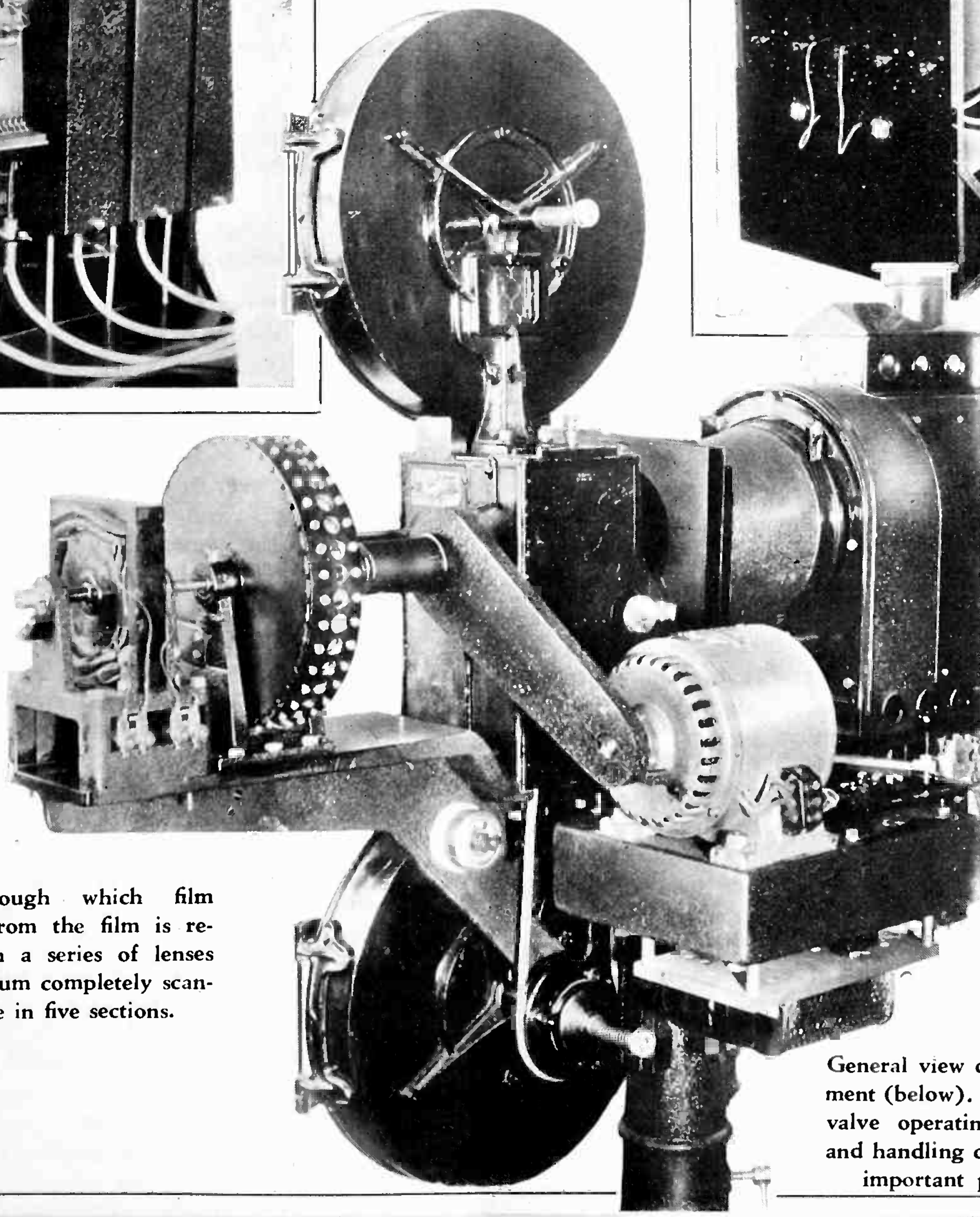
Signs of television progress abroad



Details of five-channel system developed by "His Majesty's Voice" engineers in England. Above is the photocell amplifier equipment, two amplifiers for each of five photocells

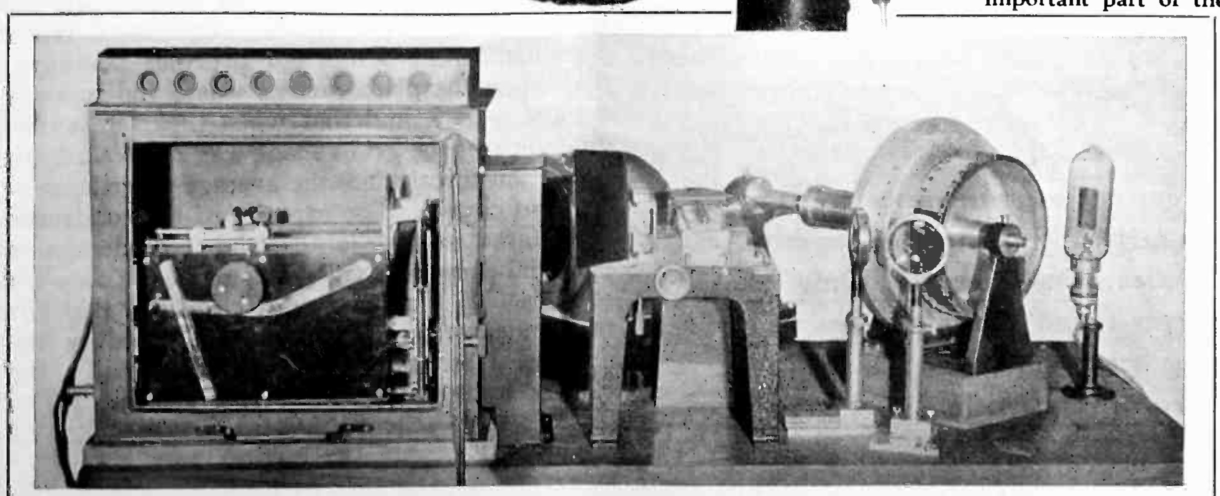


Complete view of photocell containers and racks housing the photocell amplifiers. There is one photocell for each of the five channels, and two tubes for each amplifier circuit



Projector through which film passes; light from the film is reflected through a series of lenses mounted on drum completely scanning picture in five sections.

General view of the receiving equipment (below). A special form of light valve operating at high frequency and handling considerable light is an important part of the system



Measurement of vacuum in radio tubes

By M. D. SARBEY

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*Kemet Laboratories Company, Inc.**

THE measurement of vacuum in finished radio tubes consists in measuring the "inverse" current that flows in the grid circuit under some standard condition of operation of the radio tube. By "inverse" current is meant a current which flows in the grid circuit when the grid is negative with respect to the filament, that is, a current which flows in the sense of grid to filament in the exterior circuit. It can be demonstrated that this current originates from the ionization of the gas in the tube, and is therefore largely proportional to the gas content of the tube.

In the common types of radio tubes the magnitude of the grid current is from a few hundredths of a micro-ampere to several micro-amperes, depending on the excellence of the vacuum in the tube and the test conditions chosen. Currents of this size represent about the lower limit of sensitivity of the very best portable instruments that can conveniently be used in factories and factory laboratories.

During a research conducted at Kemet Laboratories Company, in Cleveland, to discover the "gettering" effects of metallic barium and various barium alloys, for example, barium magnesium, it was found that the vacua produced were so high, and consequently the grid currents so small, that ordinary factory laboratory methods of measurements failed to detect the currents at all. While these measurements could have been made with delicate galvanometers, these are unsuitable for use, or unavailable, in factories and factory laboratories, and the method described here was developed to fill this need.

▼

GAS current measurements are usually fraught with danger to sensitive and delicate instruments. Only instruments found in the average tube factory are required in the method outlined in this article.

▲

In the usual factory practice the acceptance test for vacuum in radio tubes is made on a standard set-up for measuring the inverse grid current by means of a micro-ammeter. For a given type of tube the acceptance point is set at, say, 2 micro-amperes of inverse grid current, or "gas" current as it is sometimes called. All tubes showing a greater current are rejected. Many tubes will be recorded as having "zero" gas current. Measurement of these zero gas currents by this more sensitive method shows that these presumably perfect tubes may vary in amount of gas current by several hundred fold. It seems probable that a study of these lower ranges of gas current would reveal many illuminating facts about the performance of production machinery.

Method of measurement

Referring to the drawing herewith, T is the tube under test. B is a "B" battery or similar source of current, with a potential of, say, 90 volts. C is a "C" battery or the like with a potential of, say, 22.5 volts. P is a slide-wire potentiometer by which a variable negative bias may be put on the grid. V is a voltmeter for measuring this bias. K is a condenser of known capacity, say, 0.1 microfarad, and S is a switch for disconnecting the grid and condenser from the source of negative bias. M is a milliammeter of a few milliamperes full-scale reading.

Suppose now that T is a 201A tube and that P is set so that V shows a negative bias of 2 volts. The plate current indicated by M will then be, say, 5 milliamperes. Suppose now that P is moved until V shows a grid potential of 5 volts. M will then indicate a plate current of, say, 1 milliampere.

If we now open the switch S, those plates of the condenser which are connected to the grid (and the grid also) will be left charged to a potential of 5 volts (negative) as indicated by V just prior to opening S. The grid, being negative, will attract the ions formed in the tube by the ionization of the gas, and an inverse current will flow in the grid circuit. This current neutralizes the charge on the condenser K so that its potential drops. As the potential of the condenser and grid falls, it permits more and more plate current to flow, so that if we watch the pointer of the meter M we shall see it move gradually to higher and higher current readings.

Suppose now that with a stop-watch we start measuring the rate of increase of the plate current, and that we find that it takes 100 seconds to move from 1 milliampere to 5 milliamperes. From our previous readings we know that when the plate current was 1 milliampere the grid voltage was 5, and that when the plate current was 5 milliamperes the grid voltage was 2. We are therefore in a position to calculate the average current that flowed in the grid circuit. The capacity of the condenser K is 0.1 microfarad or 10^{-7} farads, and it discharged through a potential drop of 3 volts (from 5 to 2) in a time of 100 seconds. Q, the quantity of electricity that flowed from the condenser, is the capacity multiplied by the potential drop, of 3×10^{-7}. The average current I is the quantity divided by the time, or

$$I = \left(\frac{3 \times 10^{-7}}{100}\right)$$
$$= 3 \times 10^{-9} \text{ amperes.}$$

This current, 3 thousandths of a micro-ampere, is readily measurable by this method, but is quite beyond the sensitivity of the ordinary portable instrument.

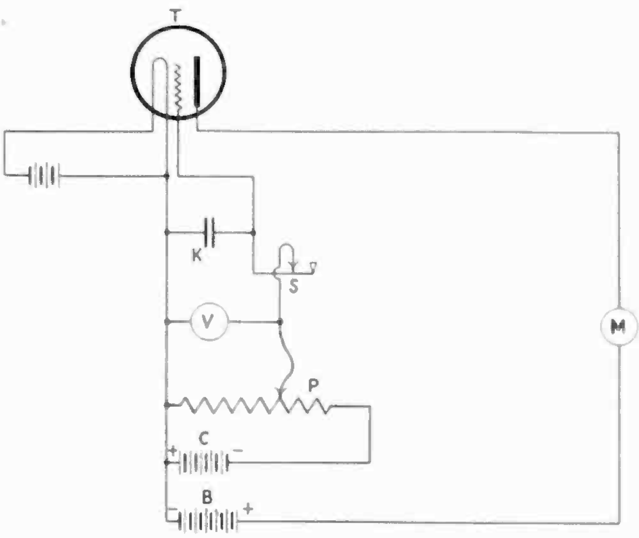
A new tube constant—the ionization factor

This current, as already stated, is a measure of the gas present in the tube. But the amount of ionization that takes place in the tube depends not only on the number of gas molecules present in the electron stream, but also on the number of electrons moving, that is, the plate current. The grid current, as we have just measured it by this (or any other) method, is therefore also proportional to the plate current, and is to that extent dependent on the conditions of measurement. It is apparent, however, that if we divide the grid current by the plate current, that is, calculate the amount of grid current that flows *per unit* of plate current, we shall get a quantity which is independent of the plate current flowing, that is, independent of the conditions of measurement and governed only by the amount of gas in the tube.

Thus, going back to the specific example previously cited, the average grid current was 3×10^{-9} amperes. The plate current was 1×10^{-3} amperes at the beginning of the test and 5×10^{-3} amperes at the end. The average plate current was therefore 3×10^{-3} amperes. The ratio of grid current to plate current was therefore

$$3 \times 10^{-9} \div 3 \times 10^{-3} \text{ or } 1 \times 10^{-6}$$

This means that the amount of gas in the tube is such that any electron current (plate current) flowing will give rise to an ionization or inverse grid current that is 10^{-6} times the plate current, or one millionth part of the plate current. This is a fundamental constant of the tube and may be called the "ionization factor." Its physical significance is that it represents the number of ions formed per electron.



Circuit diagram for measuring gas content

In the foregoing calculations "average" currents have been employed. This presupposes that the currents involved vary linearly during discharge. Actually, of course, we know that a condenser discharges not linearly but along a logarithmic curve. Accurate calculation would therefore require the use of natural logarithms. Analysis shows, however, that with the small potentials employed, the short length of the logarithmic curve used is practically a straight line and the error that results from employing averages rather than logarithms is only 1 or 2 per cent and for most purposes is negligible.

The specific numerical example previously cited can now be generalized as follows. We operate the tube at rated filament voltage and some convenient plate voltage (say rated plate voltage) the exact magnitude of which is immaterial. We set the grid voltage at some negative value E_1 and note that this gives a plate current of I_1. We then set the grid voltage at some more negative value E_2 and note that the plate current is I_2. The exact values of E_1 and E_2 are immaterial, but they may well be the extremes of the rated grid bias of the tube. E_1, however, must always be more negative than the free grid potential. With the grid voltage left at E_2 we then open the switch S and note the time that it takes for the plate current to get back to I_1. Call this time T, and let the capacity of the condenser be C farads. Then the quantity of electricity discharged is $(E_2-E_1)\,C$ and the grid current is

$$Ig = (E_2-E_1)C/T.$$

The average plate current is $\frac{I_1+I_2}{2}$, and R, the ratio of grid current to plate current, or ionization factor as we may call it, is

$$R = \frac{\frac{(E_2-E_1)C}{T}}{\frac{I_1+I_2}{2}} = \frac{2C}{T}\left(\frac{E_2-E_1}{I_2+I_1}\right)$$

As already shown, R is proportional to the amount of gas in the tube, and therefore the *greater* the value of R the *poorer* the vacuum.

It only remains now to add a few practical suggestions.

The handle of the switch S should be very well insulated. Otherwise, small moisture leaks will immediately discharge the condenser when the switch is touched by the hand, and it will be impossible to make readings. A small piece of rubber vacuum tubing slipped over the handle of an ordinary porcelain-base knife switch serves very well.

The plates of the condenser K should be very thoroughly insulated from each other. The ordinary paper-insulated condenser is not satisfactory, but a mica-insulated condenser, rated at 1,000 volts, will do very well. Such condensers are made by the Dubilier Company and doubtless by other manufacturers.

In the numerical example, a condenser of 0.1 M. F. capacity was assumed. This serves well for tubes of very high vacuum, but for tubes of poorer vacuum it is desirable to have also a condenser of 1 M.F. capacity; with such tubes, the plate current climbs so rapidly that it is impossible to time it accurately when using a small condenser.

In the interchange of information about radio tubes, the statement that a tube has a certain mutual conductance, or a certain amplification constant, defines a perfectly definite quantity the measurement of which can be reproduced anywhere. The statement that a tube has a certain gas current, however, is meaningless unless the exact conditions of measurement are given. Even then, tubes of the same type but having differing plate currents will show different gas currents although having identical vacua. Much indefiniteness could be obviated if, instead of gas current, the ratio R or the "ionization factor" as it has been called here, were used to define vacuum. Then the statement that a tube has a certain ionization factor would give standard and accurate information as to vacuum on a par with the present description of other radio tube characteristics.

*A unit of Union Carbide & Carbon Corporation.

Electrolytic condensers for radio use

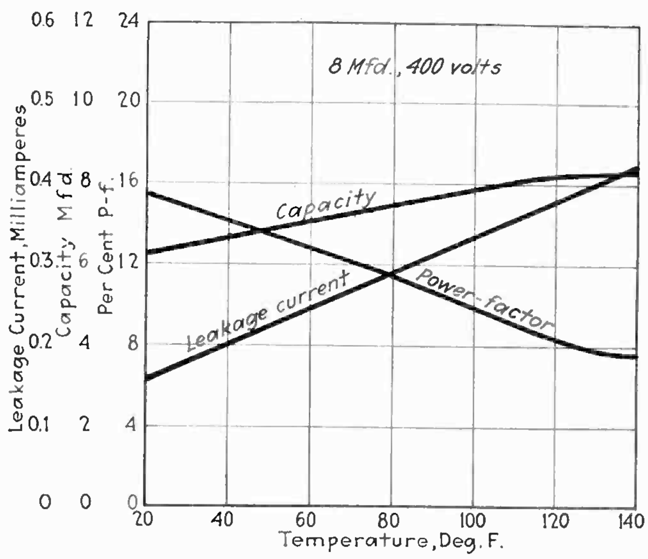
By F. W. GODSEY, JR.

THE aluminum electrolytic condenser dates back to 1853 when the peculiar behavior of an aluminum anode in an electrolytic cell was observed and commented upon by Wheatstone. Aluminum readily oxidizes when a freshly cut surface is exposed to the air, the property that keeps utensils made of aluminum clean and bright. The oxide formed adheres to the metal surface in a thin, transparent layer that is extremely tough and durable; and it is the durability and thinness of these films that make electrolytic condensers available for commercial use.

When a strip of aluminum is immersed in a suitable electrolyte and current is passed from the aluminum to the electrolyte, it is found that increasingly higher voltages are necessary to force the current through to the electrolyte as the quantity of current that has passed, or the coulombs passed, increases. This increase of resistance is such that an 8 mfd. unit with a total exposed area of 70 to 75 sq. inches of anode will increase in resistance from a few ohms to a high enough value that less than one milliampere will flow when 400 volts are applied to the anode.

The increase in electrical resistance can be ascribed to the formation on the surface of the aluminum of a very thin film of aluminum oxide, mentioned above. The thickness of this film depends upon the quantity of current passed and the voltage applied, and is almost independent of the electrolyte except that some electrolytes will allow a thicker film to be formed ultimately than others, and hence the application of a higher voltage. The effective thickness of the film is almost exactly proportional to the voltage applied after the film has grown to its normal thickness for that voltage.

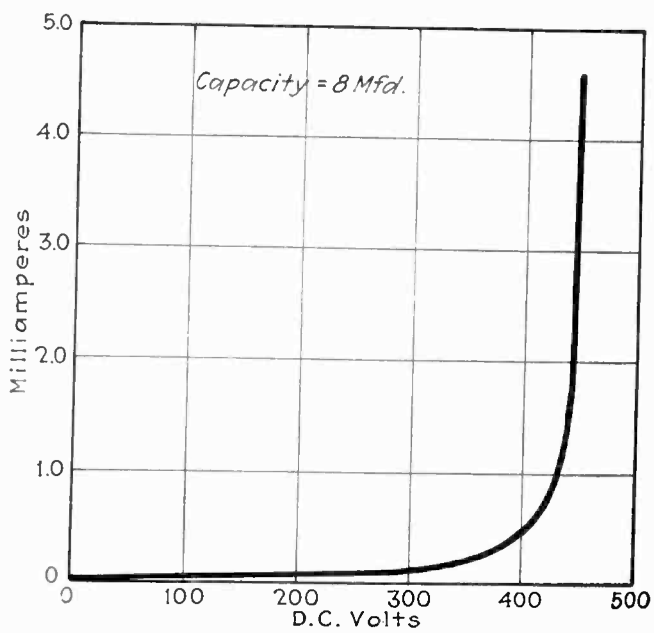
When a film has once been formed to a given voltage, it does not readily dissolve and the voltage may be lowered for some time before the thickness decreases to the new equilibrium value. The limiting voltage to which a film may be formed on an aluminum anode is controlled by the purity of the aluminum, the electrolyte used, and the temperature of the electrolyte. Usual values are between 50 and 450 volts for most electrolytes; but in some electrolytes the dissolution of the film forming material is so rapid that it can be said that there is really no film formation.



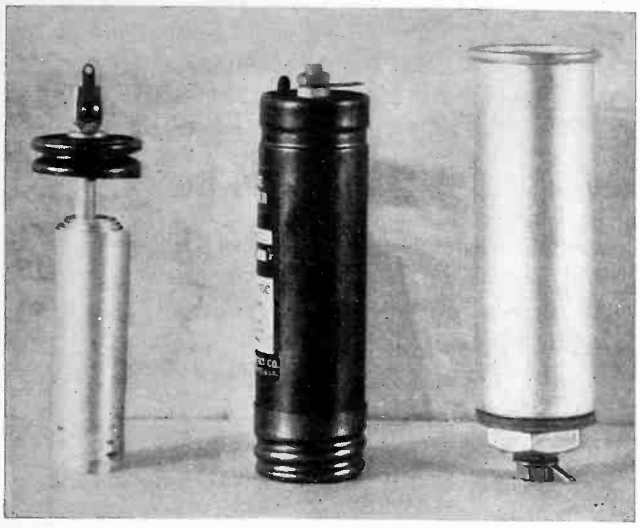
Power factor, leakage current and capacity as a function of temperature

The thickness of the film formed on the aluminum anode is found to vary from 5 x 10^{-6} to 5 x 10^{-4} cm. With such extremely thin films separating the aluminum and the electrolyte, there is a very high electrostatic capacity between the metal and the electrolyte with the oxide film acting as the dielectric. Since the thickness of the film is proportional to the formation voltage, the capacity is inversely proportional to the voltage of formation. As an example, if a condenser formed to 200 volts were reformed to 400 volts, the capacity will have been halved. Likewise, if a 400 volt condenser were operated on 200 volts, the film would gradually dissolve until the capacity were doubled. This transition from the high voltage of formation to a lower voltage is usually measured in days and weeks, while the reforming from a lower voltage to a higher may require minutes.

The capacity of a film formed to 400 volts is about 0.125 mfd. per square inch. The usual practice is to allow from 10 to 20 per cent excess capacity above the rated capacity so that about 75 square inches are required



Leakage current of electrolytic condenser (Sprague) 8 mfd. in capacity



Typical condensers showing anode construct on, upright and inverted mounting

for a unit formed to 450 volts and rated at 8 mfd. for which a strip of aluminum $2\frac{1}{2}$ in. wide by 15 in. long securely fastened to an aluminum stem or riser is wound spirally about the stem until the entire assembly fits into a $1\frac{3}{4}$ in. diameter can. Sometimes a perforated spacer of celluloid sheet is placed around the anode to safeguard against contact with the container walls.

Usually, an aluminum condenser consists of an anode of aluminum, a suitable electrolyte, and means for obtaining electrical contact to the electrolyte, generally by the use of a metal container. In most commercial condensers the electrolyte is a saturated solution of borax and boric acid in water. The container is a metal can, and can be made either of copper or of aluminum. Present practice favors the aluminum container whenever constructional difficulties do not prevent. The anode is a spirally rolled sheet of aluminum; and for the standard 8 mfd. radio filter condenser rated at 430 volts, has an exposed area of 75 square inches.

Complete units are sealed to prevent leakage of electrolyte, and the escape of gas is allowed through a soft rubber valve. This valve consists of a suitably shaped rubber nipple pierced by a pin hole. When a slight pressure is exerted on the rubber, the pin hole opens and the gas escapes.

Electrical characteristics

The life of a condenser is limited by its construction and the service in which it is used. A well designed condenser will have an almost unlimited shelf life; and in continuous use will have under normal conditions, a life of twelve to fifty years, depending upon the actual conditions. When the condenser is over-rated by the manufacturer or abused by the user the life will be greatly shortened.

After a condenser has been on the shelf for several weeks, the oxide film will be found to have lost appreciably in thickness. Therefore, when the condenser first has voltage applied, there will be an initial current surge that lasts only a few moments. In the worst cases, the film reforms almost completely in less than five minutes in a radio set. Generally less than a minute is required to completely reform the film.

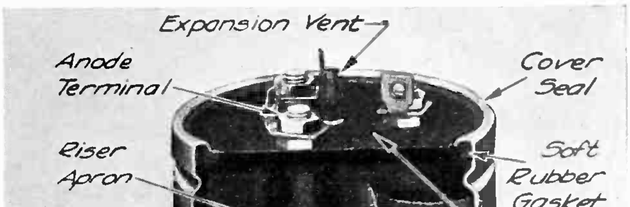
Electrolytic condensers have a poor power factor compared with paper dielectric condensers. Usually, the power factor is between 8 and 10 per cent in radio filter circuits. This high power factor must not only be considered when designing the power filters of radio sets and other applications, but should be made a consideration when estimating the operating temperature of the condenser.

High power factor is not much of a detriment in filter circuits for radio use, however, since the amplitudes of the higher harmonics in a full-wave rectifier are lower the higher the harmonic. The other consideration that must not be forgotten in calculating performance of an electrical filter is the equivalent series resistance of the condensers. Electrolytic condensers are obtainable in comparatively high capacities in very small spaces, and effects of high resistance can be overcome by increasing the values of capacity used over what would be used in a paper condenser. This is a factor which must not be forgotten when working close to the filter's limits. It is one of the points which must receive particular attention in the midget radio receivers.

Care must be used to so use electrolytic condensers that reversals of voltage across them never occur. As long as the formed anode is positive, leakage currents are negligible; but if the potential is reversed, heavy currents can flow with very little resistance to oppose them. However, it would be very unusual to find such a condition in the ordinary filter circuit for d.c. power supplies for radio use.

A very efficient filter for radio use is composed of two 30 henry chokes and a 24 mfd. condenser consisting of three 8 mfd. anodes. The voltage divider may take the customary form. For lower current requirements, it is possible to use only one choke of 40 to 60 henries, and 16 mfd. In the midget radio receiving sets, the magnetizing coil of the loudspeaker can be utilized as the choke when a dynamic speaker is used. In this case, it has been found necessary to use 12 mfd. per anode in the condensers where unusually severe operating conditions prevail. Input voltages to the filter are high for the condenser ratings, and fairly rapid deterioration of the condensers result. This abnormal condition can be readily corrected by limiting the input voltage.

Electrolytic condensers are particularly useful in filter circuits where the output ripple must be kept low with the lowest consistent cost of equipment. Voltage supply units for operating photo-electric relays, vacuum tube relays, etc., in industrial applications offer particularly advantageous opportunities for electrolytic condenser filters.



Interior construction of Amrad condenser

Simplified inductance calculation

By L. H. RUSSELL and G. B. ABRAHAM

ANYONE who has had occasion to design a set of coils for a radio receiver or transmitter has, no doubt, been impressed with the lack of a "quick and easy" method of determining the number of turns of a given size wire on a given diameter tube required to cover a certain range of frequencies when associated with a given size condenser.

It is the purpose of this article to introduce a set of curves from which it is possible to quickly determine the number of turns required for a given inductance with a minimum of calculation.

Nagaoka's formula, which is well known states that

$$L = \frac{4\ \pi^2\ a^2\ N^2}{b}\ K\ 10^{-8}\ \mu\ \text{Henrys}$$

where N is the number of turns.

K is a function of $\frac{2a}{b}$

a is the radius of the coil.

C is the length of the coil in centimeters.

This formula assumes the coil to be wound with an infinitely thin conducting tape, the edges of which touch, though electrically insulated. The correction on commercially available conductors is relatively small and may be neglected as far as practical results are concerned.

The curves shown on the following page give the inductance in microhenrys for coils wound one turn per inch for the various diameters shown. The data for these curves were obtained by substituting values for a, b, N and K in Nagaoka's formula (1) on the basis of one turn per inch. For a coil wound with N number of turns per inch, the inductance of the coil is:

$$L = L_o\ N^2\ \mu H \qquad (2)$$

where

L_o = inductance of one turn as shown on the curves.

The examples following serve to indicate how the curves can be used. A table of LC constants and one of turns per inch of various insulated wires will be useful.

Example 1—Suppose we wish a coil for use with the band 550 kc. to 1,500 kc. to be wound with No. 24 D.S.C. wire with a tuning condenser of 0.00035 MF. Usually the commercial condensers are slightly larger than their rated capacity so we will assume that a coil that will tune to 550 kc., will be sufficiently large to tune without using all the condenser.

The LC constant for 550 kc. is 0.0836 and 1,500 kc. is 0.0112.

It is generally assumed the minimum value of a condenser to be $\frac{1}{10}$ of the maximum.

As $LC = 0.0836$ max. and 0.0112 min.

Then $L = \frac{0.0836}{0.00035} = 239\ \mu H$ max. and $\frac{0.0112}{0.000035} = 320\ \mu H$ min.

From the above values it can readily be seen that a coil of 239 μH with a 0.00035 MF condenser will cover the necessary range.

The LC constant for a coil of 239 μH and the minimum condenser value (0.000035 MF) will then be

$$0.000035 \times 239 = 0.00836$$

Substituting in $LC = \left(\frac{159000}{f}\right)^2$

we obtain $f = 1{,}750\ KC$

It will not be possible to reach 1,750 kc. since we have not considered the distributed capacity of the coil. Since the distributed capacity of the coil is, in effect, a condenser in parallel with the tuning condenser, the minimum capacity of the condenser will never be realized as far as tuning is concerned. It is, therefore, safe to assume that the combination of a 0.00035 MF condenser and a coil of 239 μH will cover the range of 550 kc. to 1,500 kc.

From wire tables it is found that No. 24 D.S.C. will wind 38 turns per inch.

Therefore $L = L_o N^2$ or $L_o = \frac{L}{N^2}$ from (2)

and substituting $L_o = \frac{239}{38^2} = \frac{239}{1{,}444} = 0.1655\ \mu H$

On the curves draw a line as shown at 0.1655 μH and we find we will require a coil 1.57 inches long on a tube $2\frac{3}{4}$ inches in diameter or 2.31 inches long on a tube 2 inches in diameter, etc.

This, then, will require $(38 \times 1.57) = 60$ turns on the $2\frac{3}{4}$-inch diameter coil or $(38 \times 2.30) = 88$ turns on the 2-inch diameter coil.

Example 2—Suppose we wish to find the inductance of a coil $2\frac{1}{2}$ inches in diameter wound with 90 turns of 24 D.C.C. wire.

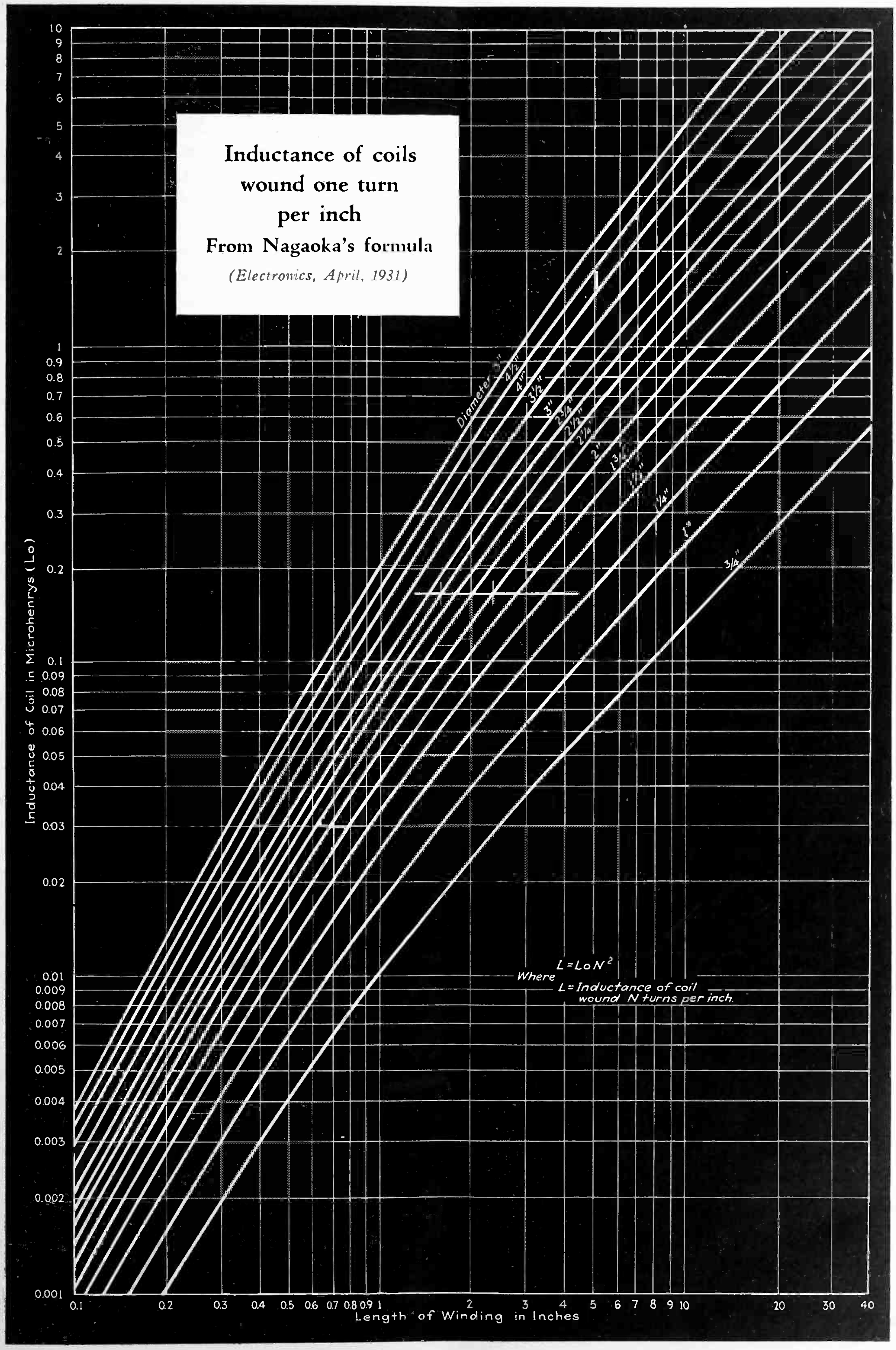
From the wire tables we find that No. 24 D.C.C. wire winds 33.6 turns per inch.

Length of winding $= \frac{90}{33.6} = 2.68$ inches

L_o for coil 2.68 inches long $= 0.297\ \mu H$

$L = 0.297\ (33.6)^2 = 335\ \mu H$

The inductance curves presented are a graphical reproduction of Nagaoka's formula for single-layer air-core coils varying in diameter from $\frac{3}{4}$ to 5 inches and in length from $\frac{1}{10}$ to 40 inches and wound with any size wire. It has been found that the variation between the calculated and measured values of inductance do not exceed 2 per cent. Variable factors such as thickness of insulation, gauge sizes, diameter of forms, etc., may introduce variations as much as 2 per cent; however, the cumulative effect of these uncertainties is usually such, that the curves as presented are sufficiently accurate for all practical purposes.


Inductance of coils
wound one turn
per inch
From Nagaoka's formula
(Electronics, April, 1931)
Diameter 5"
4 1/2"
4"
3 1/2"
3"
2 3/4"
2 1/2"
2 1/4"
2"
1 3/4"
1 1/2"
1 1/4"
1"
3/4"
L = LoN²
Where
L = Inductance of coil
wound N turns per inch.
Inductance of Coil in Microhenrys (Lo)
Length of Winding in Inches

electronics

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O. H. CALDWELL, *Editor*

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"Mangled music"

SERIOUS injury may be done to the tone discrimination of children as well as adults in a home where an inadequate or "skimped" radio receiver permits only "mangled music," i.e. merely fragments of the rich musical treasures of modern broadcasting—to filter into the living-room or home circle.

Without parents realizing it, under such conditions children may be growing up in an atmosphere of musical distortion,—may be listening to the bob-tailed harmonies of poor or antiquated radio sets—although all around them in the night air outside, are the utterly perfect tone values of the world's greatest broadcasting stations—tone perfections which have cost millions of dollars to attain.

What good is it that the broadcasters have invested millions of dollars in improved equipment, unless the listener's own "radio ear" is capable of receiving and reproducing all of that wonderful texture of vibrations, from low notes of 40 cycles per second, up to highs and over-tones of 5,000 cycles per second?

Side-band smoke screen

KEENLY desirous of proving that mathematics cannot go wrong, engineers are frequently in the position of that army which could not see the forest for the trees. In their eagerness to rally to the defense of the side-band theory, engineers have, with great display of trigonometry and Fourier's Series, routed unbelievers—but perhaps have not remembered the old saw that where there is smoke there may be fire.

A quartz crystal may be looked on as an inductance in series with a condenser and bridged across another condenser. It is a band-pass filter, and if properly used at 175 kc. (the frequency employed in most present-day superheterodynes) will produce an attenuation of about 22 decibels at 3,500 cycles off resonance and about 40 decibels at 5,000 cycles. If, as in the Stenode receiver, an audio amplifier can be built which goes up at the same rate the crystal circuit cuts down the higher audio frequencies, and if this amplifier reproduces nothing at all beyond 5,000 cycles, and if this crystal stage can be produced as cheaply as sufficient tuned stages to produce equivalent selectivity, it might be that a very compact, exceedingly selective receiver could be built in which the crystal furnishes the selectivity, and direct-coupled screen-grid tubes furnish the gain.

All of this has nothing to do with the side-band theory, and does not involve questions of "crowding stations closer together," or any of the questions on which learned gentlemen on both sides of the Atlantic have waged bitter and passionate discussions.

Time may give us a receiver using a quartz crystal; such a receiver will be made by engineers willing to let someone else fight the side-band battle.

Radiating receivers again

APPEARANCE of radiating receivers in a radio situation already overburdened with problems, seems to be a straw at which even a camel might balk. Radiating receivers were officially and publicly condemned several years ago; were made unnecessary by the introduction of the Hazeltine circuit; continued unnecessary with screen-grid tubes; are prevented by proper shielding; and seem particularly archaic now.

Radiating superheterodynes are coming in for peculiar troubles. Listeners in the vicinity of key-pounding amateurs suddenly become aware of these—to them—sources of every noise, from power-line disturbance to static. Amateurs are accused of broadly tuned transmitters; their evenings of dx-ing with South Africa or Europe are interrupted by frantic telephone calls demanding shutdown of the transmitter.

Such kicks come from owners of new unshielded radiating superheterodynes made by skimping manufacturers, or those guilty of inadequate engineering design. Sometimes in congested quarters one super owner complains of his neighbor, and apparently with cause. Such modern receivers have been known to "squeak" at distances of several hundred feet.

The answer is complete shielding; better engineering: Let nothing be undone to turn the superheterodyne into the fine receiver it has every right to be.

It must be better and cheaper

THERE is only one satisfying and convincing form of progress, and that is a periodic and discernible improvement. As time flows on and season follows season, the public looks for marks of this change. There is no strange reason why radio sets may be regarded as an exception to this general rule. Certainly some of the nationally known names in radio have registered in the public mind, yet frequently the new offerings under these names are such radical departures from what has gone before that they can hardly be recognized as members of the same family. There is a difference between change and progress. If changes are too complete they are not interpreted as improvement.

Confidence flows from a comparison of the new with the old. In radio no less than in any other line of product, there must ultimately come that continuity of development which weighs each forward step in the revealing light of this comparison. Each aspect must show the signs of betterment. There must be more performance and greater beauty and these must be accomplished with an economy that will permit a lower price. It is by stressing not the new performance but the advance over the old, not the new price but the fact that it is lower than before, that the public can be brought to believe in the progress that has been made. A better product at a lower price is lost in a sea of competition if this necessity for comparison has been forgotten.

The organless, choirless, bell-less preacherless church of 1940

WITH the coming of the electronic church bell or chimes, demonstrated March 19, by Dr. A. N. Goldsmith in New York City, the little church of the future may become chiefly a setting for various kinds of vacuum tubes and amplifiers, which will take the place of church-bell, organ, choir, and even preacher.

Already church organs are being replaced by rich-toned electronic reproducers. Using these, any country church can have the benefit of the world's greatest organists, playing by proxy through the medium of light beams and streams of electrons. In place of choir and singing, the vestrymen, through photocells, may marshal the life-like presence of metropolitan vocal stars. Even the sermon itself may be picked up by electron tubes, either from electrical transcriptions or by short-waves from some distant city pulpit.

And finally, if the deacons of these new electronic chapels demand it, the inventors can get ready an "electric eye" or photocell, which mounted on the collection plate, will automatically detect a pants-button or penny, and instantly toss it back at its donor!

The "little theater" movement

IT has been said that big improvements in industries have come about through economic necessity as well as from scientific research.

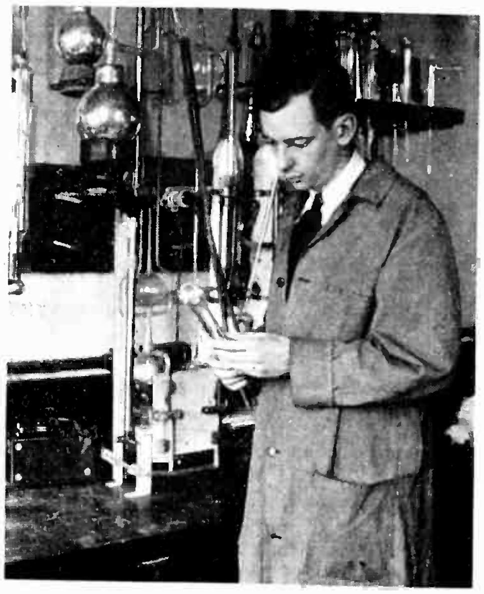
The opening in New York of a new type of theater, evolved by Translux, using rear-screen projection and other innovations to reduce overhead operating costs, may change the sound-picture industry in more ways than one. If the "little-theater" movement becomes nation-wide, the larger theaters in order to hold their present attendance against such inroads may be forced to adopt wide films and other entertainment features which will be beyond the competition of these smaller units. Even stereoscopic pictures in an acceptable form may result, as the outgrowth of scientific development forced by economic necessity. And, last but not least, interesting and far-reaching possibilities of little theaters showing gratis pictures sponsored by large manufacturers, should not be overlooked.

The march of the electronic arts

Produces glass tube thin as soap bubble

Dr. C. M. Slack, research engineer of the Westinghouse Lamp Company, received the company's $500 award for outstanding accomplishment in manufacturing methods or design of new products. The glass bubble developed is only .0002 of an inch thick, and is used as the window in a Lenard-ray tube. In manufacture, the end of the tube is worked to a definite thickness, and the bubble is made by sucking in on the opposite end, making the bubble an integral part of the tube. Although so delicate that touching will destroy them, the tubes are more practical than the metal foil windows hitherto used. The window of glass allows electrons to pass through at a lower voltage than does the metal foil window. A minimum of approximately 30,000 volts is required to pass electrons through the glass window, compared to a minimum of approximately 70,000 volts required for the metal foil window.

SUPER-THIN GLASS TUBE



Dr. C. M. Slack of the Westinghouse Lamp Company, holding one of the glass tubes which has a window thin as a soap bubble for forming end of Leonard-ray tube

Special railroad rates to R.M.A. Convention

The Radio Manufacturers Association, 32 West Randolph St., Chicago, has issued a special memorandum setting forth directions on how to obtain special railroad rates to all members attending the meeting of the Institute of Radio Engineers, June 4-6, and also the RMA Convention June 8-12, in Chicago. Detailed instructions are given concerning dates for purchasing tickets for different territories, and routes. Much trouble will be avoided if members will follow these instructions, which may be obtained by writing the Association direct.

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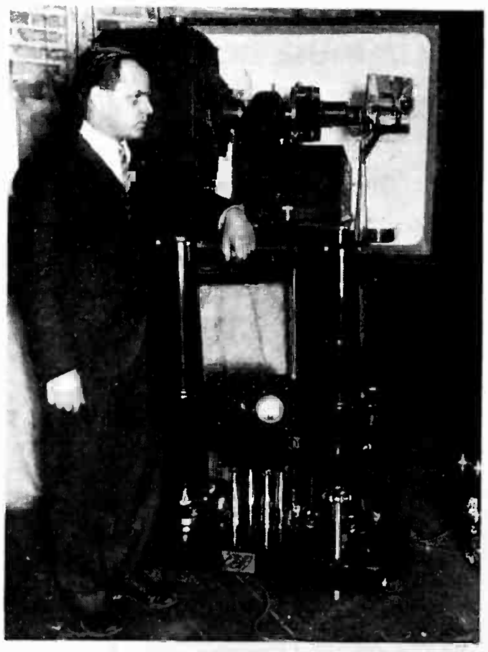
MOVIE TELEVISION SCREEN



With a projector optical system this television apparatus uses a 10-ft. screen for reproduction of the televised scene. Designed by U. S. Sanabria, Chicago, Ill.

✦

Home talkies planned by large interests

Within the next few weeks, it is expected to see RCA definitely launching its newest bid for entertainment in the home, with a 16 mm. sound-on-film movie equipment. Details of this unit are not available, but it is understood to consist of a combination radio and sound film projector in a radio cabinet of average size. Portable equipment also is expected to be made available.

General Harbord, chairman of the board of RCA, fired the first gun in the campaign in the annual statement of the corporation, with the statement that "the company is ready to begin commercial production of home talking motion picture apparatus as quickly as the necessary associated services are sufficiently developed, including a system of distribution which may eventually be able to serve 20,000,000 little theaters in the home."

Final details concerning film product supply is supposed to be holding back the launching of a strong sales and advertising campaign at present. These difficulties are expected to be ironed out in the near future. The price of this unit is believed to be under $300, with a possibility of even lowering this price in large production.

Just what position ERPI, as Western Electric's subsidiary, will take in this development, is problematical. The 10-year contract between Western Electric and RCA made in 1921, terminates in May of this year. This original contract restricted W.E. from entering the home entertainment field, except for limited sales of radio equipment. A possible re-alignment for future development is expected when this contract comes up for renewal, especially in view of the possibilities of home movies and television.

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Soviet Russia reported building a 500-kw. station

From a British source, it is learned that Soviet Russia is building a new radio broadcasting station at Noghinsk, a suburb of Moscow, which will have a power of 500,000 watts. If this report is true, it means that Russia will soon have the highest-powered broadcasting station in the world. The Soviet Government also hopes to have 11 new 100,000-watt stations, and 28 of 10,000 watts in operation before the end of 1933.

According to Amtorg, official Russia trading agency in this country, it is understood that the Soviet "Five Year Plan" contemplates having at least 60 stations in operation by that time. Amtorg reports that 47 are already built and operating, and that about 1,000,000 receiving sets are in use.

Educational subjects occupy large percentage radio time

More than 10 per cent of all radio broadcasting hours—whether the broadcasting is done by stations owned by commercial, educational or religious interests—is devoted to programs of an academic character, according to an analysis made by Federal Radio Commissioner H. A. Lafount in a recent questionnaire sent to all stations in the United States. Altogether, Commissioner Lafount found that about 35 per cent of all stations' time is consumed by programs that may be generally classified as educational.

Taking the mid-winter week of January 11-17 as typical, the Federal Radio Commission sent questionnaires to the 605 broadcasting stations licensed as of Feb. 1, 1931, asking each to indicate the hours devoted to various forms of educational matter. Replies were received from 522, or 86 per cent of all stations. The replies revealed they were on the air an aggregate of 33,785 hours during the week specified.

Of those hours, they reported 3,458 or 10.2 per cent devoted to programs featuring professional educators appearing either in studios or by remote control from colleges and schools. Included in this figure, also, were broadcasts considered educational though not necessarily by professional educators.

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Electric companies bid for interest in theater field

THE OPENING OF THE FIRST of three Trans-Lux theaters in Manhattan. on March 14, marks a new venture of RCA in the entertainment field. Trans-Lux is owned jointly by RKO Corporation and Trans-Lux Daylight Screen Corporation.

As originally planned, these "little theaters" will run a continuous program of news-reel subjects. Far-reaching possibilities lie in the development and use of advertising and sponsored pictures. Rear screen projection is used, which also lends itself to minimumn cost in initial sound installation.

In addition to the operating revenue, accruing to RCA through its interest in RKO, RCA Photophone profits in the sale of sound equipment to these units. Should this movement become nationwide, it is expected that Electrical Research Products, Inc., a subsidiary of Western Electric, will bid for its share of equipment installations. This may be accomplished by forming a new theater-operating unit or joining forces with one of the producing organizations having strong newsreel facilities. Other manufacturers of sound equipment are watching this development closely.

While the large producer-distributor organization such as Paramount, Fox, and Warners, can check-mate the release of their feature films through such outlets—unless they participate therein —the question of sponsored pictures and releases from independent producing companies may be a deciding factor in the program for these theaters.

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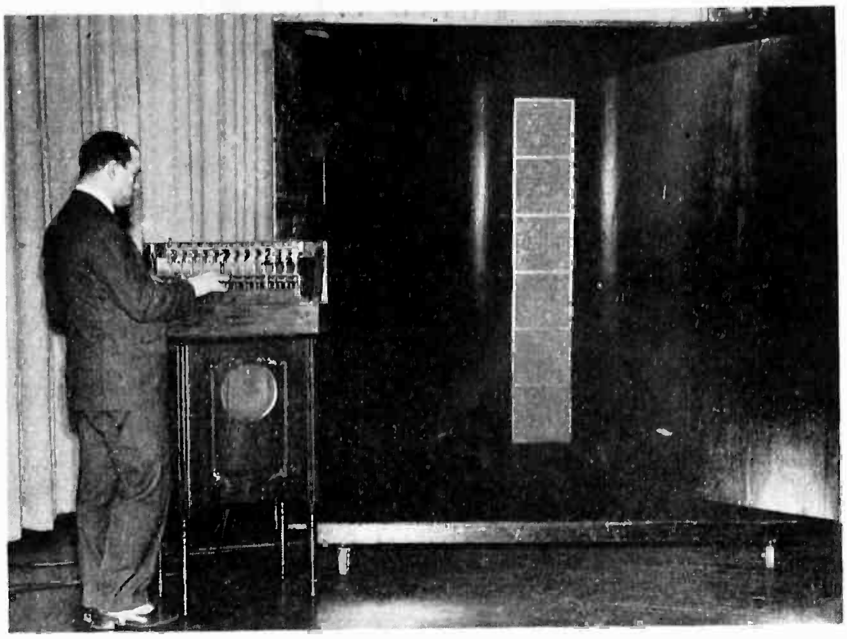
ELECTRONIC CARILLION LOUDSPEAKER



A new musical device, demonstrated by Dr. A. N. Goldsmith, consists of a series of small chimes which are struck by electric hammers mounted on the keyboard. The notes produced are amplified through this huge speaker and boom out louder than the largest church bells

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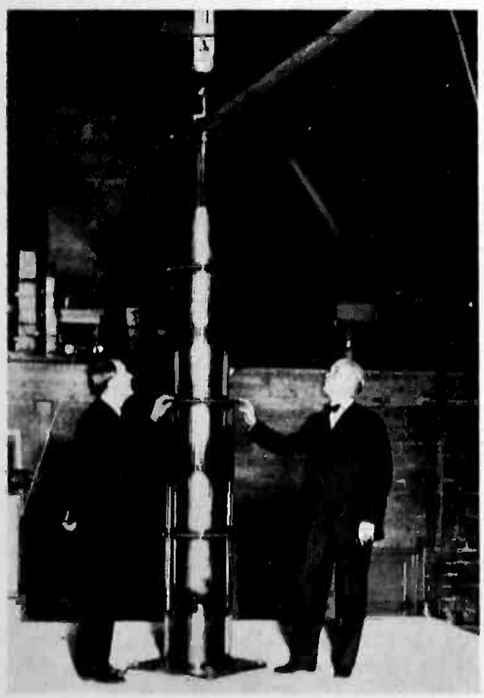
600,000-VOLT X-RAY TUBE



Dr. C. C. Lauritsen (left) and Dr. R. A. Millikan, of the California Institute of Technology, inspect their new high voltage X-ray tube

IRE expects large attendance at Chicago

THE PRESENTATION OF papers covering subjects of vital interest to the radio industry, valuable tours of modern factories, and novel entertainment will mark the Sixth Annual Convention of the Institute of Radio Engineers to be held at the Hotel Sherman, in Chicago, June 4, 5 and 6, as an outstanding gathering. Papers on the subject of acoustics and other timely topics are being arranged by the committee. Authorities on various subjects have been enlisted to present papers of timely interest before the engineers assembled.

Members of the IRE attending this convention, which assembles four days prior to the annual convention of the Radio Manufacturers' Association, will thus have an opportunity to attend both gatherings. Plans are being formulated to give the visitors an opportunity to visit Chicago industries.

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Average price of Radio Sets, 1922 to 1930

IN THE MARCH issue of *Electronics*, figures for the average unit retail price per radio set were shown, based upon the total volume of receiver-set sales each year divided by the number of radio sets (consoles and midgets).

Comparable yearly averages taken for the total sales of radio sets and phonograph-combinations were given in *Radio Retailing* for March.

In order that the two sets of yearly averages may be compared, that is, averages of "sets alone," and averages of "sets and phonograph-combinations," the two series of figures are reproduced below:

Average unit retail selling price

	1922	1923	1924	1925	1926	1927	1928	1929	1930
Receivers only (consoles and midgets)..	$50	$60	$66	$82	$114	$125	$109	$125	$82
Radio receivers and phonograph- combinations	$50	$60	$66	$82	$114	$125	$118	$133	$87

REVIEW OF ELECTRONIC LITERATURE
HERE AND ABROAD

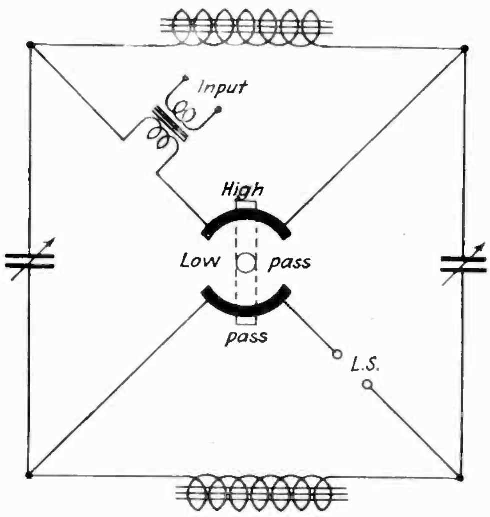
Loudspeaker research

[J. M. SCHMIERER] The conviction that the number of musical instruments will be augmented in the future by electronic devices offering new possibilities is encouraging many investigators to devote their whole attention to loudspeaker design and theory, as loudspeakers would have to be used in addition to electron tubes.

Low note response of musical instruments

Low notes of many musical instruments, the violin, for instance, are all very weak as fundamentals; the low frequencies we actually hear in instrumental music are combination tones produced by high notes. It is less important for faithful reproduction to design loudspeakers which reproduce fundamentals down to the lowest frequencies which our ear perceives as sound than it is to pay attention to the high frequencies, as the loudness of a combination tone seems to depend not so much on its own pitch but on that of the components which produce it. More or less unconsciously the instrument makers have adopted the indirect methods of getting low notes in preference to the direct methods which require the expense of too much energy, or in the case of the organ, too large dimensions. It is true that when dance music is to be rendered the direct low notes are valuable because they help to mark the rhythm. In this case the diameter of the loudspeaker should not be less than one-fourth of the wavelength in air of the lowest note desired. A simple audio-frequency filter is described which can be changed by a switch from a low-pass to a high-pass filter with the cut-off at nearly the same frequencies. It is placed between power tube and loudspeaker and should be of interest to any experimenter (two choke-coils and two sets of condensers of 0.01, 0.02, 0.03, 0.04 and 0.05 mfd. in parallel).—*Radios Helia, February, 1931.*

[H. STENZEL, RESEARCH LAB. G. E. Co., BERLIN] The author lays stress upon the necessity to indicate each time not only the frequency characteristics of a loudspeaker (pressure amplitude at different frequencies upon the normal to the diaphragm surface, or upon the axis of symmetry), but also its directive properties (pressure amplitudes at different angles). It is possible, mathematically, to deduce both characteristics from Rayleigh's well-known theorem, at least for points which are sufficiently far away from the loudspeaker diaphragm. In the case of a rigid circular membrane of 20 cm. diameter oscillating as a piston, the response is the same for all frequencies, when points upon the axis are considered, but in a direction of not quite 60 degress to the normal to the surface, the frequencies above 2,000 cycles are very weak, the pressure amplitude not being over one tenth of that of the lower notes. Some frequencies are definitely quenched. It is easy to verify this conclusion by practical tests.



A rectangular diaphragm gives similar results. This decrease with increasing angle becomes much worse when several loudspeakers in the same plane, 2 m. apart from each other, are used. When they are placed close together, one above the other, for instance, but with each speaker surface forming an angle of 30 degrees with the one below, the angular properties are improved. It is therefore natural to study speakers formed by surfaces situated in different planes, for instance, a rectangular surface folded in two, the two halves forming an angle of 90 deg. The properties of the 90-deg. cone loudspeaker may be accounted for if a diaphragm is considered formed by the three planes limiting the octant of a sphere.

Power radiation from speaker

In the second article, the questions are treated from a somewhat different point of view. The total power radiated by the rigid diaphragm into and through the hemisphere to one side of the speaker surface is calculated. It is proportional to the product of the square of the frequency by the square of the average velocity of the membrane along the normal to its plane by the radiation factor, which is itself a function of the direction (pressure amplitude in a given direction, or direction factor for the frequency in question). It is again assumed that the observations are made at such a distance from the speaker diaphragm that the lines drawn to the different surface elements of the diaphragm are parallel. Direction and radiation factor are calculated for different shapes, the diaphragm vibrating as a piston; circular, and for the first time, quadratic, rectangular (different ratios of lenth to width, but same area), elliptical diaphragms. For the same area the circular membrane has the highest radiation factor for all the longer waves. The diaphragm clamped down round its circumference and the cone are also treated. In this latter case, when the ratio of length of sideline of cone to wave-length is below one-third, the radiator factor falls to one-half when the ratio is increased from zero to one-third.—*Annalen d. Physik, January, 1931.*

Stroboscopic measurements

[B. VOIGT] Extensive experimental work applying stroboscopic methods for studying the actual motion of loudspeaker diaphragms has been published by the German Bureau of Standards (P.T.R.) The speaker used was of the electro-dynamic type and had a cone surface formed by four equal sections of convex cylindrical surfaces. It was illuminated by light from a neon tube bent backward and forward several times in the same plane. Discharges of varying audio frequencies were sent through the tube. A net of ink lines was drawn upon the diaphragm and the motion of each surface element was studied, a thin layer of varnish increasing the amount of reflected light. The motion of such a diaphragm is more complicated than might be supposed; the different points belonging to one and the same section are not necessarily in phase, and the four sections do not necessarity vibrate in the same manner. The method is applicable to all cases where sections of diaphragms turn by angles as small as 30 seconds or one minute. A number of interesting details are given suggesting applications and auxiliary devices for photoelectric cell work.—*Zeitschr. Techn. Physik, February, 1931.*

Unification in sound pictures

[WINCKEL] Short description of recent developments by Mihaly, where the photo-cell is placed beside the screen and the sound-modulated beam projected with the picture-beam. As a result it is claimed that any type of film can be used, that elaborate optical correcting devices are no longer necessary, that the sound-reproducing apparatus can be readily added to any existing projector, and that the volume control (by stopping down the projected sound-beam) is more satisfactory than present methods. Mention is also made of the apparatus developed for home use, with photographs.—*Funk Magazine, Berlin, March, 1931.*

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Broadcast intercommunications

[NESPER] Description of the European system, with map, distinguishing between pupinized special cables (Germany, Austria), other long-distance cables (England, Switzerland, Italy), and open wires (England, Scandinavia, etc.). The German Radio cable network totals some 9000 kilometers, of which a part is submarine, to avoid the Polish corridor. Frequency curves for certain of these cables are given. (Article largely based on the lecture by Höpfner, these Digests of same date, but with supplementary information and diagrams.) — *Funk Magazine, Berlin, March, 1931.*

✦

Infra-red and ultra-violet telephony

[G. GRESKY] The good qualities of present-day audio amplifiers have made it possible to revive older methods of communication over distances of one to ten miles, and in an article of nearly 20 pages the author reviews methods and results. The reception of long red waves is linked up with the improvement of the photo-cells which are being developed; a comparison between the older types, and the cells built these last few years show how the sensitivity has been extended towards the longer waves. In this respect, the copper-oxide large cell is of particular interest because it does not require an extra source of potential (these Digests, November 1930). Selenium and thallium cells (these Digests, March, 1931) show a pronounced lag, and their response is not strictly proportional to the illumination.

It is easier and more economical to produce long red waves of one ten-thousandth cm. wave-length than it is to work with ultra-short radio-waves of a few cm. length. Modulation is accomplished by two methods. Either the microphone current is superimposed, after suitable amplification, upon an arc current (carbon arc, mercury arc, Pirani glow lamp), which latter rises and drops therefore at audio frequency and causes corresponding variations in the emission of radiation. Or the emission is left constant, but a Kerr cell, or an optical system is placed in the path of the beam; the amplified audio current is applied to the Kerr cell; owing to its small size only a small amount of radiation is transmitted. At the Zeiss works the oldest method, proposed at the time by G. Bell, has found new use; the vibration of the diaphragm act upon a semi-spherical body of glass on which the beam of light from the modulated arc falls at nearly the angle of total reflection. Large variations occur in the amount of transmitted radiation when the microphone diaphragm moves.

The range covered depends upon the difference in altitude between the two stations (110 km. for 1,000 m. difference), actually moisture, fog, rain are the determining factor (see also S. H. Anderson, Penetration through fog, *Aviation*, 1930, p. 930). A convenient table is added, giving the main features of 14 methods, six of which were developed in the course of the last 3 years, and 72 references are cited. A separate section deals with devices for recording or controlling the passage of hot bodies. —*Physikalische Zeitschrift, March, 1931.*

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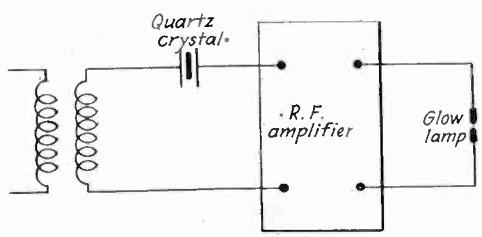
Selective amplifier for detecting side-bands

[H. STRAUBEL, LABORATORY OF BARKHAUSEN, DRESDEN] A circuit containing a quartz crystal is placed ahead of the radio-frequency amplifier; a neon glow lamp is placed at the output. When a singly modulated wave (200 kc. at 100 cycles per sec.) is tuned in, the glow lamp lights up at three wave-



lengths; at the carrier frequency, 100 cycles below and 100 cycles above the carrier frequency, showing how much more sharply crystal-controlled circuits tune in comparison to ordinary tuned radio circuits. The difference is due to the damping factor. An ordinary tuned radio circuit has a logarithmic decrement of 0.05, a crystal controlled unit, a 100 times smaller one; this latter would, of course, not do for the reception of music unless certain compensations were made. — *Physik. Zeitsch., March, 1931.*

Television transmission

[BARTHÉLÉMY] Summary of methods of scanning, especially those developed in Europe; of photo-electric cells, especially those containing potassium and argon; of the amplifier, with particular reference to the distortion introduced by stray capacities and to the use of screen-grid tubes; and of the effects of interference between ground and space waves and by atmospherics. In a second article details of the author's (new) system are promised—*L'Onde Electrique, Paris, January, (February 7), 1931.*

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Directional sending and receiving

[LOEST] Summary of methods in use, beginning with Hertz's reflectors; Braun (three vertical antennae in triangular plan); Marconi beam; Telefunken "firtree"; zig-zag forms; various loop antennae; Beverage. Elementary but convenient.—*Funk, Berlin, February 13, 20, 1931.*

✦

Recent research at the A.E.G. laboratories

[SCHW.] Special mention is made of a new loudspeaker with seven-meter horn, giving practically uniform reproduction from 100 to 7,000 cycles; of a new gramophone recording system for home use in which any good electromagnetic loudspeaker serves as microphone, being connected through a special device to the pickup terminals of any receiver, and a normal (reproducing) gramophone pickup connected to the loudspeaker terminals of this serves as a recording system; and of mercury-vapor rectifying tubes with heated cathodes, giving over 99 per cent efficiency and already produced for 300 amperes at 1,000 volts, 10 amperes at 20,000 volts, etc. These are also produced with grids for use as thyratrons (for relays or as inverters of direct to alternating current.)—*Funk, Berlin, February 16, 1931.*

✦

New television synchronizing system

[JOUGLA] Details (somewhat confused but good photographs and diagrams) of the Barthélémy method, giving synchronization to within 1/10000 second. At the transmitter, at each revolution of the disk a special photo-electric cell is illuminated for a very short period, giving a brief current of great amplitude, this being transmitted with the signals. At the receiver this current lights a special neon lamp and thus discharges a condenser parallel to it. This discharge current after amplification controls the motor driving the Nipkow disk.—*Science et la Vie, Paris, March, 1931.*

Selenium dry rectifier

[F. Noack] The rectification of alternating current by the copper oxide to lead contact is incomplete, and the performance of the rectifier changes with age and temperature. In its place pure metallic crystalline selenium welded upon a metal plate is used, the free selenium surface makes good contact with a copper disk which is pressed against it by means of an elastic flat metal cup. The three layers are placed between two copper disks which dissipate the heat. The total thickness of the whole rectifier is about 0.7 cm. its diameter 3 to 7 cm. It stands 24 volts continuously, several times the amount of other contact rectifier elements, so that an assemblage for rectifying high voltages is very compact. The reverse current is about one-fourth of the useful current. The rectifying action changes very little when the temperature is varied 100 degrees upward or downward. A graph shows the charging current, half an ampere for 6,000 hours, flowing into a storage battery.—*Zeitschrift Verein Deutscher Ingenieure, January 10, 1931.*

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Novelties in talking pictures

[Lipoug] Review of recent developments, chiefly U. S., but with a recent suggestion by Gaumont, that of using two superimposed films with coincident perforations, each of normal width and thickness, one carrying the images and the other the sound, using for this the whole width of the film. The whole of this latter film is rendered transparent to visible rays but the sound-registration is made opaque to ultra-violet (or infra-red) rays, the image film being on the other hand made completely transparent to these invisible rays. Special sources of these rays, filters, and photo-electric cells are of course used.—*Radio-électricité, Paris, March, 1931.*

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Infra-red sensitive cells

[F. Michelssen, Telefunken Laboratory] The use of extremely short radio-waves, of a fraction of one mm. in wavelength, requires quickly acting infra-red sensitive receiving tubes. As the wavelengths used are comparable in size to those of visible light, photo-sensitive alkali-metal cells may be used after suitable treatment. They seem, however, not steady enough. The sensitivity of selenium cells drops too rapidly beyond the red, for wavelengths of 1/1,000 mm. In its place the related metal tellurium was tried with good success. The main difficulty is that layers of this metal have lower resistance than those of selenium, and as the waves penetrate and change the resistance to a depth of only 5 millionths of a cm., the whole effect due to the infra-red rays will be masked if somewhat thick deposits should be used. Thin layers on glass are obtained by using tellurium, as the cathode in a discharge of reduced pressure (cathode sputtering). Films consisting of a mixture of selenium and 10 to 15 per cent of tellurium are very sensitive to wavelengths of 1/1,000 mm. By evaporating thallium sulphide in an oxygen atmosphere at 1 mm. Hg. thallofide cells with similar qualities can be manufactured. Transmission of narrow pencils of modulated infra-red waves through haze and light fog is good; but dense mountain fog at 1,150 m. altitude is just as opaque for these infra-red rays as for light. They are not suitable for signalling between aeroplanes and ground during fog.—*Zeitschrift Techn. Physik, December, 1930.*

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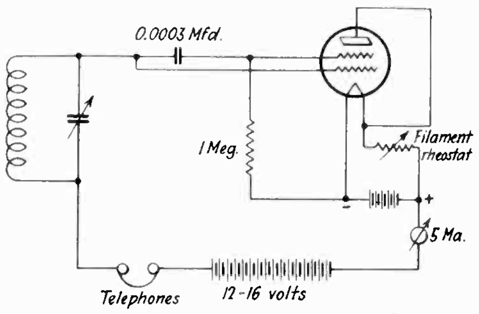
Multiple-grid tube wave-meters for short waves

[Wolf] Descriptions of the Numans-Roosenstein circuit and of an improved form (see diagram) which is stated to give frequencies far less dependant on A and B voltages than the original type. With the telephones short-circuited low A-battery voltages (2.5 volts for a 4-volt tube) give pure radio frequency



oscillations allowing of an accuracy of 0.1 to 0.2 per cent on the 40-meter band: higher A-battery voltages give radio frequency oscillations modulated at audio frequencies, the modulation frequency increasing with further increase of filament voltage. If, however, the telephones are not short-circuited it is impossible to obtain pure (unmodulated) radio frequency oscillations. The dynatron (pliodynatron) circuit is also described and practical results given.—*Funk, Berlin, February 27, 1931.*

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The glow-lamp in television

[Nentwig] Special attention is devoted to the methods of coupling the lamp to the last tube, and to the Pressler lamp in which the lighting and extinction voltages are brought very close together thanks to the use of third electrode connected through about 100,000 ohms to the positive tension.—*Funkmagazin, Berlin, February, 1931.*

Method of synchronization in television

[R. Bartheluny] Instead of sending a supplementary wave for regulating the speed of the disk, a short pulse of 1/10,000th sec. duration is emitted, say, at the beginning of each exploration, say, every 1/16 sec. This pulse acts upon a separate neon lamp in the receiver. The potential at the electrodes of this lamp is kept just below the voltage at which the lamp gives the self-interrupting, but not steady discharge. The constants of the neon tube circuit are such that these relaxation oscillations last for merely 1/16 sec. after the pulse has been received, so that a new pulse will have to restart them. The amplified pulses are made to act upon a new type of synchronous motor carrying the iron disk. The motor circuit forms part of the vacuum tube circuit amplifying the pulses. The anode current flows through one, or a series of electro-magnets E_1 which set in motion the toothed iron disk. The amplified pulses are applied to the grid, over a separate electro magnet E_2 in series with the grid. For certain positions of E_1 and E_2 the motor turns very steadily. A second method of driving it is briefly mentioned. The author has been able to receive good quality pictures of moving subjects.—*Comptes-Rendus de l'Academie, December, 1930.*

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Ancestors of the sound picture

[Teucke] Interesting historical summary, from St. George (1883) to the present day, with special reference to the methods of Schwarz (1899), Ruhmer (1900), Hochstetter (1905), Gerard (1909), and Berglund (1911); and to the synchronization methods of Gaumont and Messter (1903), with diagrams.—*Funk Magazine, Berlin, March, 1931.*

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Problem of battery receivers

[Forstmann] Study of the possibilities of reducing the load on the B batteries of a small (three or four tube) receiver, while retaining satisfactory reproduction, more especially by the use of two pentodes in push-pull and the resultant possibility of polarising their grids so heavily that the working point falls on the lower bend of the characteristic instead of the center of the straight portion thereof, without distortion resulting. The attention of manufacturers is called to the need for special pentodes of high mutual conductance and having a high "Durchgriff" between outer (third) grid and control grid: e. g. of 35 per cent while still retaining a μ of 100.—*Funk, Berlin, March 6, 1931.*

+ NEW PRODUCTS

THE MANUFACTURERS OFFER

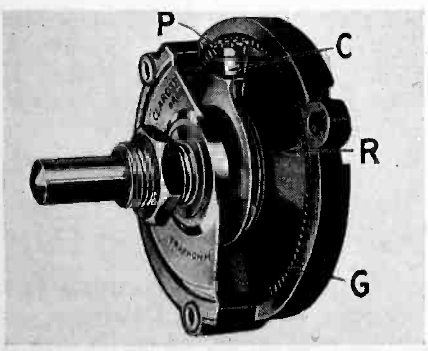
Two types of variable-mu tubes offered

Ceco Manufacturing Company, Providence, R. I., has announced two new screen-grid tubes, Types 551 and 235. These tubes are designed primarily to reduce cross modulation and distortion in radio-frequency amplifiers. The constants of the 551 are such that this tube can be used with slight changes in circuits designed for the 224. The 235, however, has distinctly different characteristics which require extensive changes in the vacuum design. Detailed characteristics of both tubes are available in Engineering Bulletin No. 7 issued by the Ceco Company and will be gladly furnished upon request. The Ceco engineering laboratories are equipped to furnish any technical information which may be desired in connection with either of the about mentioned tubes.—*Electronics, April, 1931.*

✦

Graphite element volume control

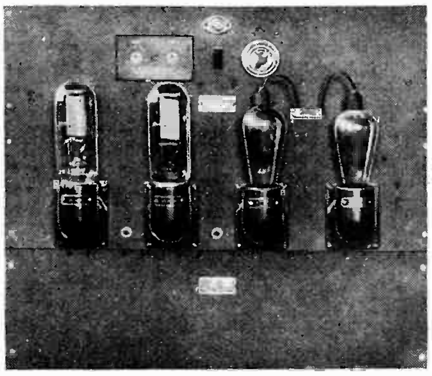
A graphite element unit that embodies a new positive rolling contact which eliminates possibility of erosion of the resistance element is one of the latest developments of the Clarostat Manufacturing Company, Inc., 285 N. 6th St., Brooklyn, N. Y. Photograph illustrates the principle by which a pure rotating motion is imparted to the contact roller



(C) by means of a small pinion (P) secured to the contact roller and engaging the gear track (G) which is moulded at the outer periphery of the resistance element (R). When a rotating motion is imparted to the contact arm by turning the knob, the roller tends to rotate in the same direction and the pinion assures this action, producing a smooth positive contact throughout the length of the resistance element. —*Electronics, April, 1931.*

Amplifier power stage panel

To meet the current need for a powerful amplifier for sound distribution systems which provides the advantages of larger units and yet conserves space, the Webster Electric Company, Racine, Wis., has developed the power stage panel illustrated. With a 56-watt output, this unit is particularly



suited to outdoor installations where considerable power is required or for permanent installations in hotels or other public places requiring great output power. The panel is known as Webster Model 6032-A and is part of the Webster line of power amplifier equipment for sound distributing systems. The unit is available as illustrated with tube guards and back covers, adapted to rack or other type of mounting.—*Electronics, April, 1931.*

✦

Exciter rectifier

Capable of replacing any storage battery unit of any type or voltage used to supply current to the exciter lamp and P.E.C. (Head) amplifier of sound-on-film equipment, is the XS rectifier recently brought out by the Forest Electric Corp., Newark, N. J. It consists of a double wound transformer with suitable taps and link connectors to enable the unit to be adjusted to local voltage variations. The a.c. from the transformer is passed through a double wave rectifier circuit, using standard rectifying tubes. The rectified current then passes through a special filter network. where it is completely filtered to smooth and noiseless direct current. A rheostat is provided in the output circuit to give accurate control of the output current. This unit is built for 110 or 220-volt a.c. supply, and is enclosed in a steel case, with toggle switch on the a.c. input. It is entirely fireproof and may be installed in the projection booth.—*Electronics, April, 1931.*

Special inductor for superheterodyne

Engineers working on the design of superheterodyne receivers can now obtain a special inductor for covering the range between 200 kc. and 150 kc. with the Type 403-C Standard-Signal generator, manufactured by the General Radio Company, Cambridge, Mass. This device makes it possible to make selectivity and sensitivity measurements on the intermediate-frequency amplifier. The new inductor, when uncalibrated, is designated Type 403-P8 and is priced at $16; when calibrated, it is designated Type 403-Q8 and is priced at $24. For information applying to additional inductors, write the company direct requesting a copy of Catalog F-X2.—*Electronics, April, 1931.*

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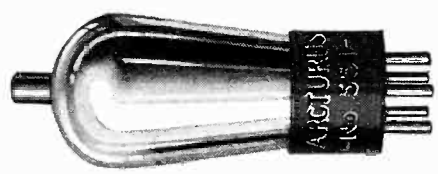
Variable-mu and power pentode tubes

Arcturus Radio Tube Company, Newark, N. J., has just issued two interesting bulletins describing in detail the Type-551 variable-mu tube and Type P-2 power output pentode which are now in production by this company.



Complete characteristics and curves are given for both tubes, including diagrams showing methods of applying control grid bias. Copies of these bulletins will gladly be furnished by writing the company direct.—*Electronics, April, 1931.*

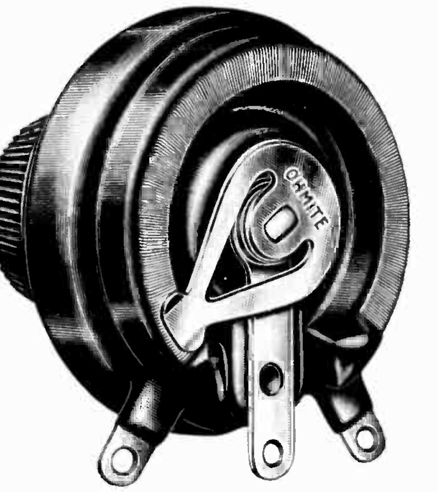
✦

Color code indicator

A color code indicator is being put out by the Erie Resistor Corporation, Erie, Pa., and will be sent gratis to those requesting same. It is a valuable aid to both the radio engineer and the user of resistors as a quick and handy guide to determine the resistance value of moulded type resistors. The indicator works both ways. It shows the standard RMA color code for any wanted resistance value and is a great help to the specification engineer in drawing up specifications in accordance with the RMA color code.—*Electronics, April, 1931.*

Porcelain core rheostat

UNIQUE IN DESIGN is the new rheostat announced by the Ohmite Manufacturing Company, 636 N. Albany Ave., Chicago, Ill. It incorporates the use of a circular porcelain core on which the resistance wire is wound, the core forming a solid non-shrinking backing for the wire. This wound core is mounted on a base also of porcelain, and the entire unit with the exception of the surface where the wiper arm makes



contact, is covered with vitreous enamel which cements the whole unit together, and serves both to protect the wire and to carry off the heat generated in the wire. Resistance values from 2 to 10,000 ohms and over can be wound on core. This unit is 2¼ inches in diameter and is arranged for one hole mounting. It can be furnished with three terminals to form potentiometers connections. This unit has a maximum rating of 50 watts. —*Electronics, April, 1931.*

✦

Series of bulletins on tubes

A NEW SERIES OF technical bulletins (Nos. 1-20) has recently been announced by the Sylvania Products Company, Emporium, Pa. Each bulletin lists average characteristics for one type of tube, presents a technical description of the tube and its uses in various set-ups, and offers a number of valuable suggestions. Copies of any or all of these bulletins will be mailed from the Sylvania factory. Send requests to W. R. Jones, sales engineer, Sylvania Products Company, Emporium, Pa.—*Electronics, April, 1931.*

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Interference locater

AN INTERFERENCE LOCATER is now marketed by the Tobe Deutschmann Corporation, Canton, Mass., consisting of four stages of r.f. and two of audio, using three shielded grid 232 tubes and three 230 tubes for detector and audio stages. The output circuit of the audio amplifier includes a transformer feeding an intensity meter through a copper oxide rectifier. This meter provides a visual indication of interference intensity or noise level. A filament meter is provided to insure operation of tubes at their proper rating. The chassis is mounted on a cast aluminum framework enclosed in a bakelite case. Accessories include portable sectional antenna constructed of a hardwood handle with split bamboo section and resonance coil, completely wired and insulated to withstand 2200 volts, separate inductive pick-up coil, and a strap for carrying locater. Weight complete, 35 lbs.—*Electronics, April, 1931.*

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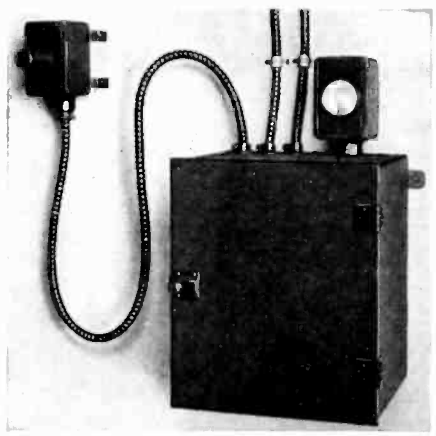
Photoelectric relay unit

ANNOUNCEMENT HAS BEEN made by the General Amplifier Company, 27 Commercial Ave., Cambridge, Mass., of a new photoelectric cell relay unit. The unit consists of a photoelectric cell in a special housing, an amplifier relay unit contained in a standard service box and 10 ft. of connecting cable. The amplifier employs two-24 tubes and one-80 tube. Ample ventilation is provided. It is designed for operation on 105-120 volt, 50-60 cycles a.c. The relay is capable of opening or closing a non-inductive circuit carrying one ampere at 110 volts. In case of larger current, an auxiliary relay should be employed. Among its



many uses are initialing operations such as stopping or starting machinery when a beam of light is intercepted, counting of delicate or freshly painted objects on conveyor belts, control of artificial illumination, etc. Bulletins describing this apparatus in detail will be furnished upon writing the Company direct.—*Electronics, April, 1931.*

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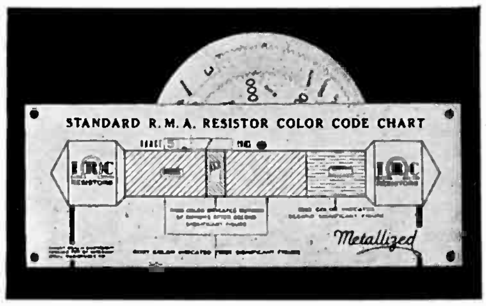
Molybdenum grid screen for radio tubes

THE NEWARK WIRE CLOTH COMPANY, 351 Verona Ave., Newark, N. J., manufacturers of wire cloth for every industrial purpose and of the "Sealedged" radio-grid screen, announces that it is now furnishing a woven wire screen made of molybdenum for use on special tubes.—*Electronics, April, 1931.*

Resistor color code chart

THE CHART SHOWN in the accompanying view has been developed by the International Resistance Company, 2006 Chestnut St., Philadelphia, Pa. This little chart and scale permits anyone involved in the use of resistors to determine immediately, knowing either



the range or color, the correct value of the unit so involved. While it is rather expensive, the company will be glad to furnish a limited supply upon request.—*Electronics, April, 1931.*

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Sound system panels

A NEW AND COMPLETE LINE of AmerTran sound system panels has just been announced by the American Transformer Company, 178 Emmet St., Newark, N. J. These panels are made for 14 different applications and may be assembled in various combinations on standard mounting racks to make up complete sound systems for every requirement. The panels have been designed to permit extreme flexibility so that standard apparatus may be supplied for every purpose. The equipment may be enlarged or reduced whenever new conditions make a change advisable, the latter being possible without loss of time and at a minimum of expense. The apparatus is mounted on solid aluminum panels of standard (19 in.) width. A 21-page booklet describing "The AmerTran Sound System" is available and will be sent gratis, provided request is on business stationery. —*Electronics, April, 1931.*

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Catalog on vulcanized fibre

THE CONTINENTAL - DIAMOND FIBRE COMPANY, Newark, Delaware, announces publication of a booklet designed to acquaint the industry with the properties of vulcanized fibre, with the manner in which it is made and how it is used. It contains a complete description of the materials now produced by this company, representing a complete line in their respective fields, and including the following products: Dilecto, Codite, Egyptian fibre, Diamond fibre, Celoron, Fibroc and Micabond. Copies of this bulletin will be gladly furnished on request.—*Electronics, April, 1931.*

A new pentode

ANTICIPATING THE EARLY appearance of simplified broadcast receivers in which the power tube of several times the usual amplification will serve to reduce the preceding amplification to a minimum, the Deforest Radio Company of Passaic, N. J., announces the Deforest 2.5 volt pentode. In general appearance this tube is not unlike the 445 power tube. Its characteristics are as follows: Filament voltage 2.5; Filament current in amperes 1.5; Plate voltage 250; Screen voltage 250; Control grid bias—16.5; Amplification factor 80; Plate resistance in ohms 35,000; Mutual conductance in micromhos 2,300; Plate current in m.a. 32.0, Screen-grid current in m.a. 6.5, base UY.—*Electronics, April, 1931.*

Bulletins on audio frequency apparatus

A SERIES OF BULLETINS has just been issued by Jenkins & Adair, Inc., 3333 Belmont Ave., Chicago, Ill., covering its complete line of amplifiers and transformers. A full description of its portable amplifier for broadcast station pickup work, and a bridging amplifier, designed primarily for audible monitoring service for broadcast, recording and laboratory use are listed in this series. These bulletins are No. 13-A and No. 14-A. Complete data on transformers, retards, gain controls, mixing controls and amplifier accessories are incorporated in Bulletin No. 1-E. Copies of bulletins may be obtained by writing the company direct.—*Electronics, April, 1931.*

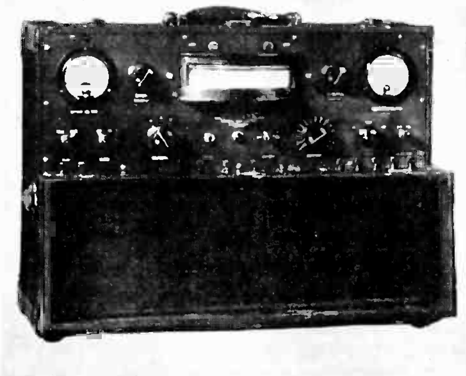
Mutual conductance meter

THE WESTON ELECTRICAL INSTRUMENT CORPORATION of Newark, N. J., has developed a new instrument for the direct measurement of the mutual conductance of all radio tubes having an amplification factor between 3.5 and 42.0, and of all screen grid-tubes. The instrument is of the copper-oxide rectifier type, with a $7\frac{1}{4}$ in. diameter case for flush mounting. A compensator mounted in a box approximately $3\frac{1}{2}$ in. x 7 in. is supplied as part of the instrument. This box is arranged for surface mounting. To measure the mutual conductance of a tube, it is necessary to apply one volt 60-cycle a.c. to the grid. The other elements of the tube are energized with a standard rated d.c. voltage, and the compensator dial is set for the value most nearly corresponding to the "Mu" of the tube under test. The mutual conductance is read direct on the scale. A circuit diagram is also furnished with each meter, to simplify the necessary connections.—*Electronics, April, 1931.*

Acoustimeter

FOR THE MEASUREMENT of sound intensities, an acoustimeter has been announced by Burgess-Parr Company, 111 West Monroe St., Chicago, Ill. It was developed by the Burgess laboratories.

Equipped with a specially calibrated condenser microphone, it is adapted for the measurement of air borne sounds, while with the Burgess No. 25 rigid coupled pick-up, the vibration in structural units may be located and measured. Among the problems to which the instrument has been applied are the measurement of noises caused by gears, pumps, motors and ventilating ducts, the silencing ability of automobile mufflers, window ventilators, etc., the preparation of city noise surveys, and the study of detonation in internal combustion engines. Other fields of utility are the study of loudspeaker characteristics, the investigation of the acuity of hearing, the determination of sound absorption coefficients, periods of reverberation, and other allied noise measurements. This device consists of a vacuum tube amplifier, a gain control which may be varied in steps of 5 decibels, and a sensitive indicating meter. Weight, 50 lbs.—*Electronics, April, 1931.*



Amplifying equipment

FERRANTI, INC., 130 West 42nd St., New York City, is pleased to announce that amplifying equipment is now available for numerous types of installations, completely matched and ready for immediate use. A typical voice installation for use on 110-volt, 50-60 cycle power supply, is the Ferranti Type 250-D3 rack and panel system. This includes a powerful single or double channel three-stage amplifier, using 250 type tubes in push-pull in the last stage. This amplifier has an approximate gain of 70 decibels. If used with suitable speaker equipment, it will be found adequate in most cases, for gatherings of 5,000 people or more. For outdoor work, this system has been utilized to cover large areas. A radio receiver and phonograph pick-up panels can be included in all Ferranti systems.—*Electronics, April, 1931.*

Tungsten offered in all forms

ADJUSTMENT OF certain patent restrictions now permits Fansteel Products Company, Inc., North Chicago, Ill., to sell pure Tungsten metal in all commercial forms for general purposes. This company has manufactured Tungsten since 1914, but has sold the pure metal only, in the form of finished electrical contact points. However, it has produced certain tungsten-molybdenum, tungsten-tantalum, and tungsten-copper alloys, as well as pure molybdenum, and tantalum, and is experienced in working these metals and drawing them into fine wire. This company furnishes tungsten in bars, sheets, wire and powder. Tungsten salts are also obtainable. The metal is refined from the Chinese ore (wolframite) or other basic materials, to tungsten acid, which is converted to salt and back to acid three times, in order to eliminate impurities. The pure acid, after being sampled by the laboratory, is ignited to oxide which is reduced in hydrogen furnaces to 99.95 per cent pure tungsten powder.—*Electronics, April, 1931.*

Automobile receiver tube

PRODUCTION OF A new screen-grid tube, specifically designed for automobile and d.c. district radio receiver operation has been announced by the National Union Radio Corporation, 400 Madison Ave., New York City. This tube, designated as the NY-64, is of the unipotential cathode type having 6.3 volts, 0.4 ampere filament. The manufacturer states unipotential cathode construction was chosen because of its inherent ruggedness and resultant freedom from microphonic noises and also because it is desirable that the voltage drop caused by the filaments of the tube not be subtracted from the total voltage available for the plate supply. This new NY-64 has been found to be a practical solution to the d.c. set problem.—*Electronics, April, 1931.*

Wire wound resistors

ANNOUNCEMENT THAT WIRE wound resistors are now available in either cartridge or pigtail type, has recently been made by the Lynch Manufacturing Company, 1775 Broadway, New York City. Type LW-1, cartridge and LW-4 pigtail, are made in all resistances from one ohm to 500,000 ohms. Type LW-2 cartridges are made in all resistances from 500,000 ohms to 2,500,000 ohms. Type LW-3, pigtail, is made in all resistances from 200 ohms to 100,000 ohms. Lynch precision wire wound resistors are rated one watt; tolerance plus or minus 1 per cent. Closer tolerances of $\frac{1}{2}$ or $\frac{1}{4}$ of 1 per cent can be obtained on special order if desired.—*Electronics, April, 1931.*

PATENTS

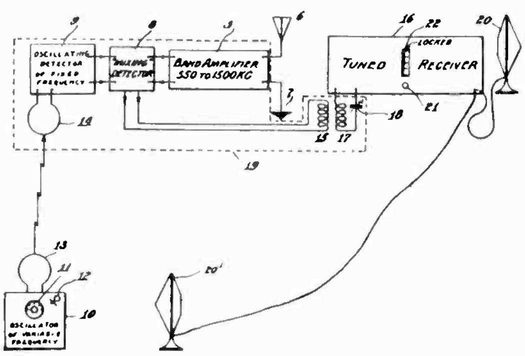
IN THE FIELD OF ELECTRONICS

A list of patents (April 3) granted by the United States Patent Office, chosen by the editors of *Electronics* for their interest to workers in the fields of the radio, visio, audio and industrial applications of the vacuum tube

Radio Circuits

Radio-frequency transformer. A transformer with variable air gap which can be used to start or stop oscillations in an amplifier. M. C. Batsel, assigned to Westinghouse E. & M. Co. No. 1,795,823.

Remote control. A method of controlling tuning and operation of a radio receiver at a distance. Bowden Washington and Wilson Aull, assigned to Remotrole Corporation. No. 1,795,269.



Receiving circuit. A method of receiving both direct and indirect radiations from a transmitter by combining the signals at two points in such a way that the signals received over one path are balanced out. while the vector sum of the signals from the other path is positive. R. K. Potter, assigned to A. T. & T. Co. No. 1,794,418.

Push-pull modulator. Low frequencies are applied to a modulator with the grids in series, high frequency is applied to the grids in parallel. In the grid circuit of one tube is an impedance for preventing the equal application of oscillatory energy to the control electrodes. Wilhelm Runge, assigned to Telefunken, Berlin. No. 1,794,645.

Heterodyne receiver. A method of using piezo-electric crystals for changing the frequency of incoming signals in a double detection receiver. Henri Chireix, Paris, France. No. 1,794,365.

High frequency receiver. Push-pull amplifier operating at high frequency. J. L. Woodworth, assigned to G. E. Co. No. 1,796,071.

Audio frequency amplifier. A coupling circuit between two tubes consists of a tapped inductance and a choke-fed direct current system. The plate of the first tube connects to the tap on the inductance, which is the input circuit of the second tube, through a condenser. The resistance of the tube, plus the resistance of the primary circuit of the transformer, is equal to the reactance of the capacity, to the reactance of the primary circuit, and to one-half the reactance of the inductance at the lowest frequency desired to transmit. R. A. Bierwirth, assigned to G. E. Co. No. 1,795,194.

Frequency modulation. A method of discriminating between amplitude and frequency modulation, and analyzing frequency modulated energy. Energy in a desired phase relation is supplied to two circuits tuned to frequencies lying either side of the oscillating frequency, and combining the output from the two circuits in an opposite phase relation. G. L. Usselman, assigned to RCA. No. 1,794,932.

Signalling system. Two triodes operated from a.c. whose grid and anode circuits are supplied in opposite phase relation. Signal current on the grid of one tube operates a relay in the final tube's output circuit. H. E. Allen, assigned to G. E. Co. No. 1,795,193.

Shortwave receiver. Transmission system, phase adjuster and detectors coupled to the phase adjusters, and an impedance at the free end of the transmission system to prevent reflection. H. O. Peterson, assigned to RCA. No. 1,794,730.

Regenerative receiver. A complicated doubly-regenerative receiver. L. Q. Slocumb, Ferguson, Mo. No. 1,794,739.

Multiplex signalling system. Several carrier waves of constant like frequency but different constant phase, are set on an antenna and at the receiving end are properly filtered, each out of the other's circuit. R. A. Weagant, assigned to RCA. No. 1,794,878.

Remote control receiver. A system whereby the proper beating frequency is supplied to a superheterodyne from a mobile oscillator. Bowden Washington, assigned to Remotrole Corp. No. 1,794,-936. Also No. 1,794,935.

Modulating system. Signal waves applied to one pair of amplifiers, and high frequency waves to another pair. Space current in one pair flows only when signal waves are applied to the other pair. R. A. Heising, assigned to W. E. Co. No. 1,795,858.

Electrostatic reproducer. A phonograph pick-up of the electrostatic type. R. H. Leffler, assigned to Carter Radio Co. No. 1,796,155.

High frequency signalling system. Suppressed carrier modulated carrier waves of the same carrier frequency are transmitted from two stations, the frequency of the carrier wave at one station is controlled by a control wave transmitted from the other station—this control wave being derived and transmitted independently of said modulated carrier wave transmission. R. E. Coram, assigned to W. E. Co. No. 1,797,284.

Interference eliminator. A method of using a vacuum tube in the antenna circuit to prevent interference. A. M. Wiehl, San Francisco, Calif. No. 1,797,307.

Multiple channel multi-phase, anti-fade transmission. A transmitting system composed of a number of distinct transmitters modulated from a common source and securing power from a given polyphase system. L. C. Young, assigned to Federal Telegraph Co. No. 1,797,746.

Photographic method of receiving radio signals. A system of transferring modulations into photographic surfaces for purposes of receiving, recording, and reproducing broadcast signals. E. E. Clements, Washington, D. C. No. 1,798,066.

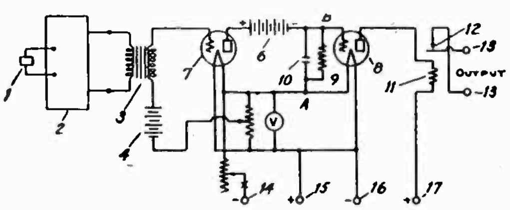
Static reducer. An electrical conductor in contact with oleo-resinous material is heated to a red heat and cooled, and when so treated has the characteristic of reducing static. C. H. Seymour, Kansas City, Mo. No. 1,797,371.

Variable inductance tuning system. Metal tubes surrounding inductance coils are varied in their relative positions to vary tuning. Louis Cohen, Washington, D. C., and August Hund, Battery Park, Md. No. 1,798,012.

R. F. Amplifier. A shunt-fed impedance coupled amplifier. E. L. Koch, assigned to Kellogg Switchboard & Supply Co. No. 1,797,988.

Electronic Applications

Watch regulation. A method of adjusting a watch with a standard. The periodic interval between ticks of the watch to be adjusted with the standard, is determined by impressing both ticks on an indicating device having a definite and adjustable time interval necessary for the recovery of the circuit after its operation. E. E. Turner, Jr., assigned to Submarine Signal Co. No. 1,794,502.



Measuring acoustical impedance. A ratio of pressure at the output end of a sound circuit to the pressure at the input when the circuit is terminated successively by the device to be tested and by two known acoustic impedances of different values measures the impedance. P. B. Flanders, assigned to B.T.L., Inc. No. 1,795,647.

Potential indicating device. A combination of a high frequency circuit, a glow discharge tube, means for rotating such tube, whereby the tube may be periodically connected to the circuit. Arthur M. Trogner, assigned to Federal Telegraph Co. No. 1,796,637.

Electrical signal recorder. Transmitted current impulse produces an electro osmotic displacement of liquid. Max Volmer, Neubalbelsberg, Germany. No. 1,796,584.

Sales device. A step-by-step system whereby customer makes a sales record, using vacuum tubes. G. H. Glade and G. H. Glade, Jr., Chicago, Ill. No. 1,796,287.

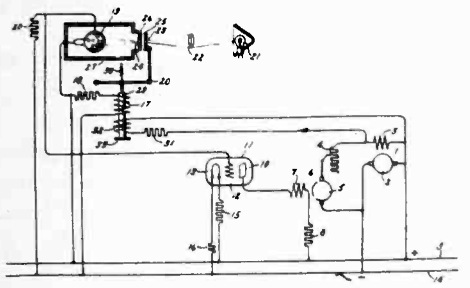
Sound recording. A frequency divider to step down the frequencies of an electrical current produced by sound. J. R. Balsley, assigned to Fox Film Corp. No. 1,794,664.

Train control. Direct current is supplied to track rails, the field of flux around the track rails picked up by a moving car, and supplied and utilized to

PATENTS—

operate safety equipment. N. D. Preston, assigned to General Railway Signal Co. No. 1,794,543.

Light regulator. A method of varying the average amount of light admitted to a light-sensitive cell. F. A. Byles, assigned to G. E. Co. No. 1,796,239.

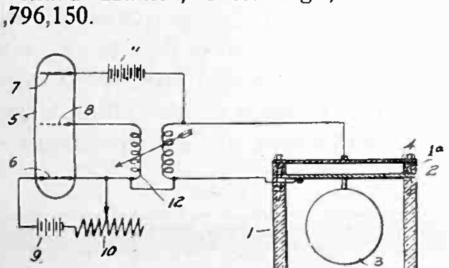


Method of damping mechanically vibrating bodies. A portion of the energy of such vibrations is converted into electrical energy. A. Meissner, assigned to Gesellschaft für Drahtlosie Telegraphie, Berlin, Germany. No. 1,794,723.

Railway traffic control system. A triode which operates only when the potential between two electrodes exceeds a certain value, depending upon the relative potential of the grid with respect to one of these electrodes has this potential changed by a capacity effect, and thereby controls the train which carries the vacuum tube apparatus. Paul H. Geiger, assigned to Union Switch & Signal Co. No. 1,797,468.

Device for determining the direction of flow of a magnetic field. A closed winding formed by several turns of conductors arranged angularly and connected in series. A resistance arranged circularly; connected to the closed winding so that corresponding points of the resistance and winding are connected, and brushes provided for effecting a contact between the two. W. A. Loth, Paris, France, assigned to Société Industrielle des Procedes W. A. Loth. No. 1,796,295.

Gravity determining device. Attraction between two bodies varies the frequency of an oscillator which can be measured for change of frequency. Richard Hamer, Pittsburgh, Pa. No. 1,796,150.



Fault-finding apparatus. A protective arrangement for an electric circuit, employing carrier current which opens the circuit whenever unfavorable conditions arise. Allan S. Fitzgerald, assigned to G. E. Co. No. 1,797,976.

Optiphone. A combination of light-sensitive devices, tone generators, and a headset so that the listener can tell which device is illuminated and in which direction the object is whose images are being projected. J. A. Clifton, Beaufort, S. C. No. 1,798,118.

Electric contact device. Two vacuum tubes arranged in a differential circuit and used to indicate when electric contacts are made and broken. F. G. Creed, and Axcel Orling, Croyden, England, assigned to Creed & Co., Ltd. No. 1,797,718.

Vacuum Tubes, Photo-Cells, Etc.

An equi-potential cathode tube. H. M. Freeman, assigned to Westinghouse E. & M. No. 1,794,950.

Triode tube construction. A method of strengthening the structure in a power tube. W. G. Wade, assigned to Westinghouse E. & M. Co. No. 1,794,933.

Filament mounting machine. Patents granted to Christian G. Blom, Eindhoven, Netherlands, assigned to G. E. Co. No. 1,795,195.

Electron emitting device. A structure designed to prevent gas ionization from detrimentally affecting a filament. J. W. Marden, assigned to Westinghouse Lamp Co. No. 1,795,730.

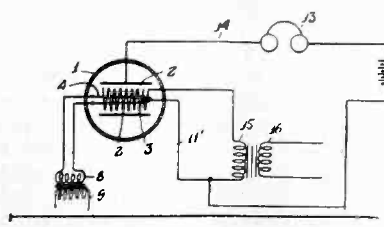
Synchronization. A method of synchronizing transmitter and receiver for facsimile transmission. E. S. Purington, assigned to John Hays Hammond, Jr. No. 1,795,616.

Picture transmission. Scanning system in which, after a complete scanning of the field, the only electrical impulses to be transmitted are those corresponding to areas of the field which have changed shades subsequent to the previous scanning. R. D. Kell, assigned to G. E. Co. No. 1,796,030.

Re-Recorder. Photo-cell and vacuum tube apparatus for copying photographically-recorded sound records. J. R. Balsley, assigned to Fox Case Corp. No. 1,795,751.

Method of preparing alkaline metals. A compound of the metals is heated in contact with a reducing agent consisting of a metal belonging to the first subgroup of the fourth column of the periodic system, said compound being of such a nature as to form a compound of the agent having a vaporizing temperature higher than the reaction temperature. J. H. DeBoer, Eindhoven, Holland., assigned to N. V. Philips. No. 1,797,131.

A.C. tube. A vacuum tube in which the filament is thick and having a low voltage drop to carry a heavy heating current, doubles back upon itself so that the magnetic field caused by the current in one leg is opposed by that in the other. Voltage temperature and magnetic effects due to cyclic changes in the a.c. supply, are neutralized. H. W. Houck, assigned to Dubilier Condenser Corp. No. 1,797,205.



Television, Etc.

Television device. A rotatable wheel, multiplicity of mirrors for receiving light arranged around the periphery of the wheel in the form of a helix, and arranged so that light reflected by the mirrors is moved in both a horizontal and vertical position. F. W. Adsit, St. Paul, Minn. No. 1,796,420.

Electro-optical transmission. A system of dividing up an object to be scanned into four channels for transmission. H. E. Ives, assigned to B.T.L., Inc. No. 1,796,931.

Motion picture film transmitter. A system for continuously moving a film to be televised at a uniform rate, and means for analyzing the picture portion. T. A. Smith, assigned to RCA. No. 1,797,378.

Framing system. A method of moving the viewing assembly bodily in a radial direction with respect to the scanning system whereby the effect of a change in the angular relation between scanning device and motive means is obtained. R. L. Davis, assigned to Westinghouse E.&M. Co. No. 1,797,259.

Sound-insulated camera. G. N. Ball, Glendale, Calif., assigned to Warner Bros. pictures. No. 1,779,653.

Modulation, Generation, Etc.

Absorption modulation. Part of the energy of alternate half cycles of high frequency waves is absorbed in accordance with the lower frequency. This absorbed energy augments modulation during absorption, and affects the variation in amplitude of the high frequency wave in an opposite sense in the remaining half cycle. E. M. Deloraine, assigned to W. E. Co., Inc. No. 1,795,714.

High frequency generator. An inductance in an envelope conductor, and another conductor mounted within the envelope and insulated for direct current, means for connecting the conductors in parallel for a.c. and for sealing d.c., through one of the conductors. H. T. Friis, assigned to B.T.L., Inc., No. 1,795,648.

Double-grid Piezo modulator. A double-grid tube has impressed on one of the grids, modulations coming from a piezo crystal which is actuated mechanically by a megaphone. On the other grid the vibrations of another quartz crystal are used to maintain frequency of modulation. A. M. Nicholson, assigned to Federal Telegraph Co. No. 1,796,117.

Piezo modulator. A method of using a piezo crystal to modulate an oscillating tube. A. M. Nicholson, assigned to Federal Telegraph Co. No. 1,796,116.

Wave suppression circuit. A method of freely transmitting modulated waves and suppressing waves of frequencies, multiples of the carrier wave source. J. F. Farrington, assigned to W. E. Co., Inc. No. 1,795,484.

Interference reducer. In a signalling system, one frequency is used for marking, and another frequency is used for spacing signals, and means are provided against interference of one with the other. J. Herman, assigned to A. T. & T. Co. No. 1,795,393.

Directional receiving system. Two parallel wave antennas spaced apart a certain distance and staggered a certain distance. R. S. Hoyt, assigned to A. T. & T. Co. No. 1,795,397.

Non-singing amplifier. A multi-stage r.f. amplifier using transformer coupling. Undesired magnetic coupling between adjacent stage transformers is prevented, and means for creating magnetic coupling between non-adjacent stages to oppose regeneration, is provided. O. O. Ceccarini, assigned to B.T.L., Inc. No. 1,795,474.

Designing the radio cabinet

[*Continued from page 591*]

apartments are often occupied by people who are beginning a home life of their own, and who are acquiring new furniture. It seems plausible, then, that the modern design is more possible here. This sketch shows less concealing of constructive forms. Access is by a removable panel in the rear. Curved edges (which may be made on a form inexpensively when produced in volume), relieve the severity of the straight line; and the three tonal gradations in the wood relieve the monotony of a flat surface. The band which begins with the dial and runs around the cabinet, is decorated with a Sheraton motif. The loud-speaker is covered, as in the previous case, by a vertically pleated cloth.

The sketch in Fig. 3 is considered from the point of view of the symbolism spoken of above. This design is perhaps most suitable to custom built sets, and indicates some of the interesting possibilities. In the top of the column is space for a high wattage lamp which gives an indirect lighting source for a large area of the room. Here is provided a source of music and light. This would be more practical in a music-room or in some large room where the radio could be used, as was the fireplace for the dominant note in the decorative scheme.

The column is decorated with classic motifs, greatly reduced and simplified with the top cut off, allowing the rays of light to continue upward. The dials and controls are used as the basis for a motif derived from Colonial furniture, thereby becoming less obvious, without being completely concealed. The loud speaker is placed in the lower section of the column.

These sketches of radio cabinets are suggestions for the solution of certain design problems. There are endless varieties which would be suitable to the environments in which the radio is becoming more and more popular. For those interested in the beauty of well-functioning machinery, one might suggest a case of transparent glass, which would make no attempt, to conceal the tubes and mechanism. Possibly the wisest use of the radio as an uncompromising modern instrument is to build it in the wall, where it is completely invisible, but to those who consider existing conditions of production and construction, the solution is more generally towards the use of a well-constructed modern radio, simplified in its gesture of compliance to past styles.

Developments in automatic record changers

[*Continued from page 586*]

arranged for playing 5, 10, 15, 20, 25, 30 minutes, or up to a full two-hour period automatically. This cabinet has distribution facilities for phonograph, radio and microphone through 21 separate loudspeaker connections.

The record-changing unit incorporated in the Stromberg-Carlson radio-phonograph combination, has several unique features. This unit is sold only complete with the radio set. It will handle from 12 to 14 of the 10-in. or 12-in. records, or a mixture of both of these sizes can be played automatically with one filling of the magazine.

Two motors are employed—one for operating the turntable, and the other for the record-shifter mechanism. Both motors are of the induction type for use on an a.c. supply. The turntable speed is controlled by a centrifugal type governor, and is positively driven through a worm-gear reduction. The complete time required for changing records averages 16 to 18 seconds. This period is to give deliberate reliable movement to the mechanism, to insure handling records in various conditions of wear or warping, without possibility of jamming or interference with the continuous operation of the mechanism.

Provisions are made in the wiring to allow remote control of motors and switching of radio set to phonograph operation when desired. Remote control is not included as regular equipment, but all the electrical and mechanical connections are made for adding remote control when desired.

Two classes of equipment may evolve

What the ultimate list price should be for radio sets combining the automatic record-changing feature, in order that volume sales to homes will result, depends on the differential between present cabinets *sans* such equipment and those having this feature. Perhaps experience only will set the limits of this differential, but a review of a limited number of dealers indicates that the complete set should list around $200 to reach a large market. This naturally means that two classes of such equipment will evolve, that selling around this figure and units selling much higher, combining additional refinements for a class market.

In spite of the fact that record-changing units have been available some time, the majority of the public still associate such equipment with custom-built sets or coin-operated devices only. Wider publicity during the coming year will develop a consciousness on the public's part of the practicability and usefulness of this equipment in the home.

PATENTS—

[*Continued from page 611*]

Miscellaneous

Filter system. A system for discriminating between currents of particular frequencies and all other currents, comprising several piezo-electric crystals corresponding to the frequencies to be discriminated against. C. H. Fetter, assigned to A. T. & T. Co. No. 1,794,889.

Amplifying system. In the plate circuit of an amplifier are several anti-resonant circuits tuned to distinct frequencies. T. H. Kinman, assigned to G. E. Co. No. 1,795,172.

Link circuit amplifier. Anti-resonant circuit in the output of one tube, and the input of the following tube are coupled together magnetically and electro-statically, by means of a link circuit, so that maximum amplification over the desired band takes place and high attenuation in frequencies outside the band. H. Whittle, and A. J. Christopher, assigned to B.T.L., Inc. No. 1,795,914.

Piezo electric filter. Electric wave filter with recurrent sections having piezo crystals to give deep attenuation characteristics and flat transmission characteristics. Lloyd Espenschied, assigned to A. T. & T. Co. No. 1,795,204.

Volume control. Variable resistance shunts the primary of interstage transformers so that smaller impedance changes are effected in the region of low volume. A. Atwater Kent, Ardsmore, Pa. No. 1,796,375.

Shortwave amplifier. Input and output circuits having only distributed capacity and inductance for amplifying short waves. G. C. Southworth, assigned to A. T. & T. Co. No. 1,796,486.

Amplifier-rectifier system. A combination of a triode amplifier of conventional design and a rectifier connected in the anode of the amplifier, so that the rectifier regulates the potential of the grid circuit of the amplifier in accordance with the space charge drop of the rectifier. E. W. Kellogg, assigned to G. E. Co. No. 1,797,985.

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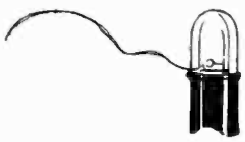

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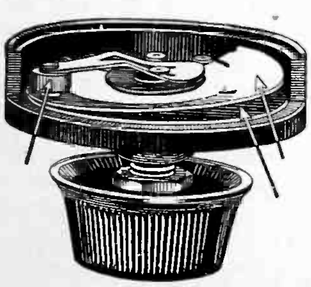

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Electronics

Power pentodes for radio receivers

[*continued from page 577*]

of the swing encounters higher plate resistances and the harmonic content for high load resistances becomes lower in magnitude. It will be seen from Fig. 3 that for low grid swings the curves for even the higher resistances are substantially straight.

Effect of loudspeaker impedance-frequency characteristic

The moving coil speaker at frequencies higher than its resonant point, usually below 100 cycles, presents to the output transformer an impedance which increases with increasing frequency. The shape of the impedance curve and proportionate rise with frequency depends upon the inductance of the moving coil and the mechanical construction of the speaker. At 4,000 cycles the impedance is from twice to four times the impedance at 400 cycles. If the moving coil is matched to the tube at low frequencies this rise in impedance will have an important bearing on the power output and fidelity at higher frequencies. If the voltage swing of the control grid is made equal to the bias and the match for maximum u.p.o. is made at low frequencies, then at the higher frequencies the output will contain serious distortion and the alternating plate voltage swings will be excessive.

In a highly selective receiver the voltage swing at the power tube grid reduces at the higher audio frequencies. This fortuitous circumstance is of considerable advantage for it allows of automatic compensation since, as was mentioned above, the optimum impedance for restricted grid swings increases. Therefore at any volume control setting which makes the grid swing less than the bias the pentode will automatically counteract sideband cutting to any desired degree, depending on the transformer turns ratio.

Tone control in the pentode output circuit

If a series circuit consisting of a suitable size condenser and variable resistance be connected across the primary of the output transformer the variation of speaker impedance and pentode efficiency with load variation may be utilized to provide tone control. The effect of the condenser is to reduce the effective load impedance at the higher frequencies. The series *R* removes the effect at lower frequencies and at the same time provides a means of varying this impedance connection network.

The actual design of the output transformer is not difficult nor is its size prohibitively large. The plate current must be taken into account and an air gap provided to give maximum inductance with the normal plate current flowing. The ratio of turns will depend upon

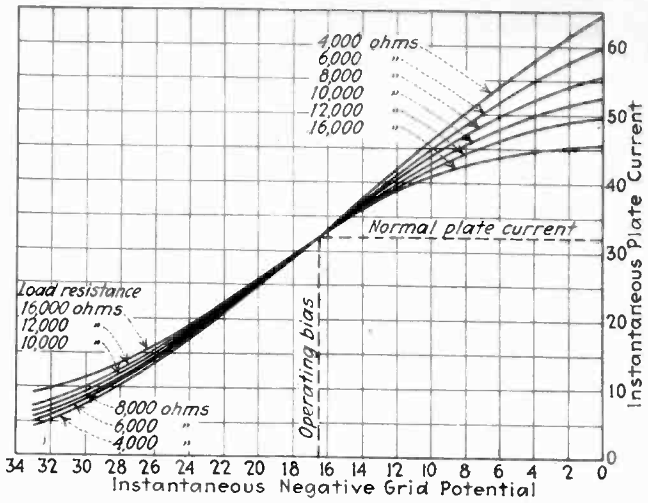

Fig. 3—Dynamic *Eg-Ip* curves obtained graphically from plate characteristic

the factors mentioned. In the curves shown here the effect of the resistance of the plate winding of the output transformer was neglected. This will shift the operating point due to the drop of effective plate voltage and also due to change in plate current caused by rectification if the plate current swings are not equal around the operating point.

Auto bias versus fixed bias

The use of a bias resistor in the cathode lead to derive a voltage from the plate current drop leads to several complications in the case of the pentode. Since the amplification factor is high the degenerative effect of audio voltage across this bias resistor is marked in effect. To eliminate this effect which results in decreased power output and loss of fidelity it is usual to bypass the resistor to audio with a condenser. The value of capacity necessary with the pentode is prohibitively large. To reach an optimum the capacitance would have to be about six microfarads. Fixed bias from some point in the "B" supply can usually be obtained by the drop across a resistor of much lower value and can be decoupled easily from the grid and plate circuits of the pentode.

Even at the risk of increasing the complication of the tube standardization problem it appears that the pentode has a place in the American tube picture.

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The new tubes

[*continued from page 575*]

Meanwhile in the field of automobile tubes, new complexities are being introduced which will give the motorist of the future dismay when he tries to replace some burned-out unit with a tube picked up on the road. Special tubes for each type of set seem to be the fashion of the future, and any dreams of interchangeable types, as standard as the bulbs in the lamps, now seen going aglimmering.

Looked at, all in all, the new tube types of 1931 show that much technical progress is being made and that advances are under way. But for a season or two as the result of the new tube element now being introduced it is apparent that considerable commercial shaking down of types and patterns will have to take place before the tube and radio-set situation returns to the happy simplicity (relative) of past seasons.