AUGUST, 1936

Radio Engineering

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VOL. XVI NO. 8

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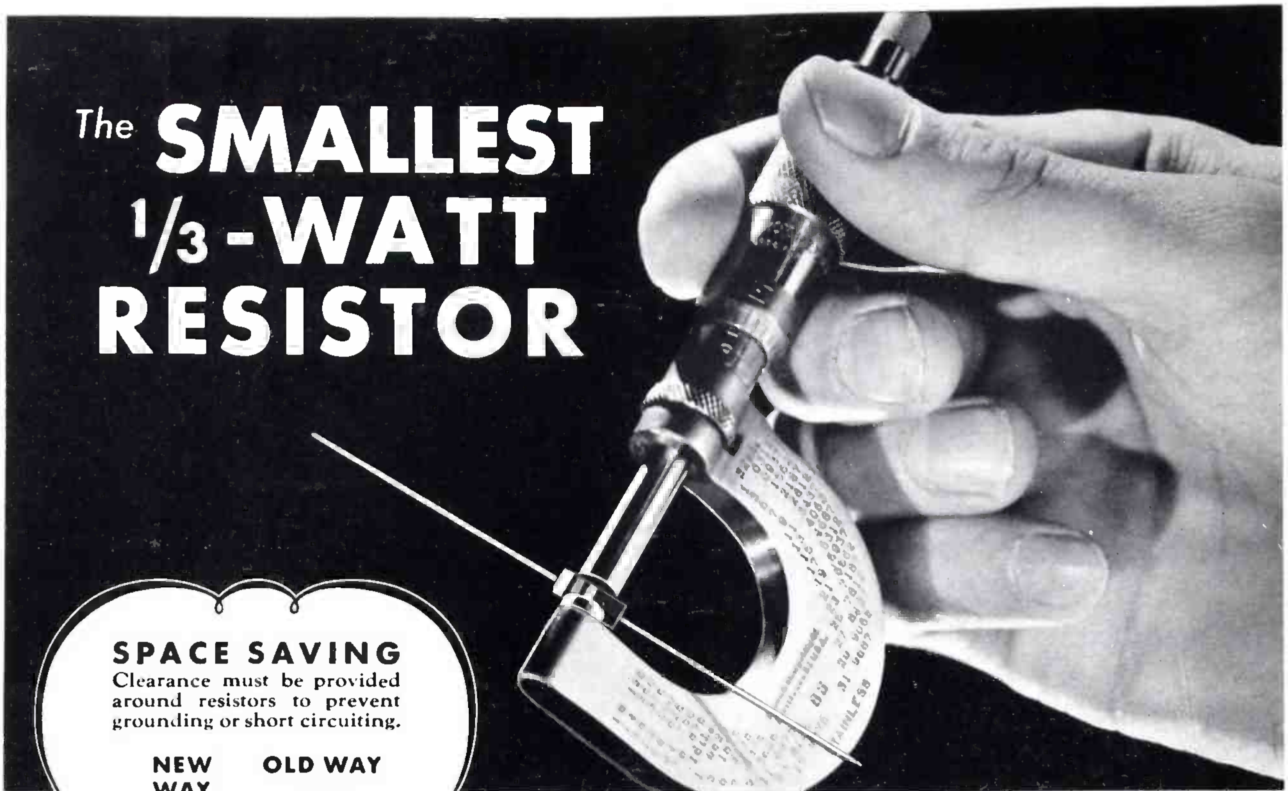
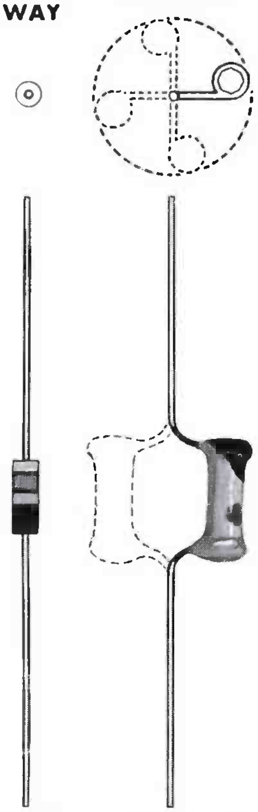
es Mgr. ________	Pur. Agt. ________

The Journal of the
Radio and Allied Industries

The SMALLEST 1/3-WATT RESISTOR



SPACE SAVING
Clearance must be provided around resistors to prevent grounding or short circuiting.



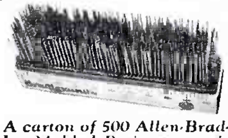
Type E resistors, with leads attached longitudinally to the center of the resistor, cannot swing out of line and cause accidental grounding or short circuits. No special care is needed in placing the resistor.

Old style resistors, with leads attached radially to ends of resistor, can swing around a wide circle. Special care must be taken when soldering to install resistor in correct position.

Easily Mounted in Small Sets
Cuts Your Chassis Assembly Cost

The new Allen-Bradley Type E solid molded resistor, with straight line leads, is the smallest 1/3-watt resistor on the market!

It is so tiny that it can be tucked into the smallest under-chassis spaces, but electrical and mechanical safety factors are as high as ever. Specially tempered leads eliminate sharp bends that cause lead breakage. The absence of externally connected leads further reduces the bulkiness of the type E resistor unit.



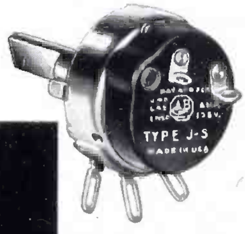
A carton of 500 Allen-Bradley Molded Resistors, ready for the assembly line.

Another novel feature is the indexed carton which holds 500 resistors in neat and convenient order for the assembly line. The resistor leads are always straight—there is no tangling—no fumbling—no delays. A quick inventory of resistors can be noted from the graduated scale on the carton. The color-coding is visible in all positions.

Modernize your production methods and improve your receivers by standardizing on this Allen-Bradley molded resistor.

Allen-Bradley Company
126 W. Greenfield Ave. Milwaukee, Wis.

ALLEN-BRADLEY
RADIO RESISTORS



Standardize on Type J Bradleyometers—made with or without line switch—for volume and tone control.

RADIO ENGINEERING

REG. U. S. PATENT OFFICE

W. W. WALTZ • Editor

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FEATURES

DEPARTMENTS

VOL. XVI — *Member Audit Bureau of Circulations* — NO. 8

COVER ILLUSTRATION

FIVE-METER TRANSCEPTORS IN PRODUCTION AT THE PLANT OF THE TRANSFORMER CORPORATION OF AMERICA

PUBLISHED MONTHLY by the

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Editorial

IN THIS ISSUE

WE'D LIKE TO know, too, just when television is going to "break." In the meantime, there are some ideas from outside of the radio industry which may be of interest to our readers. These ideas, by an engineer who is well acquainted with the technique of communication sciences as applied to amusements—i.e., radio broadcasting and sound pictures—are based upon what might be called long-range observation. Their author is by no means an authority on television, but we believe that his comments are entirely pertinent now that television demonstrations seem to be the order of the day.

This month's chart reminds us that it is about time to scrap the idea of designating the harmonic content of amplifier outputs, and the ripple-voltage content of a filtered d-c supply, in percent. Decibels below the fundamental mean considerably more, and serve to bring everything within the same standards. The fundamental of a filter's output can very well be the full-load d-c voltage delivered by the system.

We never gave any serious thought to the question of low- and high-power signal generators, either. Apparently there is more to the idea than appears at first glance. The discussion of this angle of the broad subject of signal generators is, we believe, timely.

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TELEVISION

JUST BEFORE THIS issue went to press we were privileged to see Philco's version of television. Lack of time prevents a detailed description this month, but we will have more on this and other television systems in an early issue.

From one point of view, the hesitancy about releasing television is understandable —there have been too many "duds" in the past. But from what we have seen of television in the past few months, it is our guess that the public would go for it in a big way. It may be crude, but there is a noticeable improvement, one might almost say from day to day.

However, this restraint is admirable. No doubt, the engineers are quite anxious to perfect this latest means of communication, but hesitate to do so at public expense. So, despite the racket raised by some publications which profess to see "corners" in television, and the market being hogged by one or two big corporations, there is evidently to be an orderly release of television data, when it is ready, *in the engineers' opinion*, and not before.

• • •

NEXT MONTH

THE ISSUE OF RADIO ENGINEERING, known as the Annual Buyers' Directory will make its appearance. Built around the idea of providing a ready reference to manufacturers and suppliers of all the raw materials and component parts which enter into the manufacture of receivers and kindred equipment, this Directory has come to be recognized as an indispensable adjunct to engineering files.

In view of the importance of this special issue, RADIO ENGINEERING will be pleased to send copies to interested persons whose names are not now on the mailing lists. Our readers will be conferring a favor by sending us the names, official positions, and addresses of their associates who are not regular recipients of this publication.

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IRE CONVENTION PAPERS

WITH THE ANNUAL Rochester fall meeting of the IRE only three months off, it seems pertinent to bring up the subject of convention papers.

There must have been quite a few cases of hurt feelings following the annual convention in Cleveland last May; in any event we have heard plenty of remarks about "RCA and Bell Labs conventions." On the face of things, such remarks are ridiculous to the extreme.

Upon checking with the IRE, we find that many invitations to contribute papers are sent out into the industry, but the responses are few. We don't know, although we'd like to, just why it is that engineers seem to dislike writing; the fact remains that getting an engineer to sit down and transfer his thoughts and ideas to paper is something like trying to start a cold motor—it takes lots of patience, and sometimes priming.

However, it isn't this type of engineer to whom we were referring above. There may have been an unintentional oversight on the part of the IRE committee which sent the invitations, but lack of an invitation shouldn't prevent anyone with a good idea from sending it in for consideration.

RADIO ENGINEERING

FOR AUGUST, 1936

HOW WILL TELEVISION AFFECT THE RADIO INDUSTRY?

From a Source Outside the Industry Come These Pertinent Comments on What the Public May Demand. The Author Is Well Acquainted with the Amusement Game, Especially from the Technical Viewpoint.

IT IS MUCH easier to assert that television will revolutionize the radio receiver industry than to trace in detail the changes that may be expected. No powers of prophecy are needed to predict a hectic few years in which the making and losing of fortunes—and of jobs—will be commonplace. Likewise, it is thoroughly safe to state that a large market in antenna kits will develop, and certain other evolutions, outlined below, come well within the limits of reasonable probability.

Other phases of television development remain matters of guesswork, or at best of balancing chances that involve very large elements of uncertainty.

ANTENNA KITS

One of the few fairly certain things about television is that it will operate on ultra-high frequencies. Bandwidth per station must be estimated, even for poor quality pictures, in hundreds of kc instead of 10 or 16 kc, and there is of course no room for such bands in the lower ranges of the spectrum. Likewise, existing wire facilities are not adapted to the transmission of television signals, and the cost of modifying them to meet the requirements of transmitting motion pictures indicates that the first television addressed to the public will be delivered via the ether. If the ether performs satisfactory work (as tests already completed show that it may) there is no reason to suppose that more expensive wire transmission will ever be used.

Transmission in the quasi-optical band, however, certainly requires tuned antennas for satisfactory results, even with sound, and the requirements of pictures are, as will be seen, more exacting. Hence plug-in-the-wall antennas and bell wire tied to bed springs will be ancient history when television is an established fact, and every receiver, wherever located, will require a carefully designed, properly manufactured short-wave antenna.

If precedent counts for anything in the radio industry, it may also be safely assumed that varieties of antennae will compete for public favor, with rapid obsolescence of older models, until experience on a wide scale has demonstrated which type is best for any given type of location, after which obsolescence will proceed at a less rapid rate, and the antenna kit industry settle down to predictable production per year.

The necessity for special television antennas lies partly in the nature of the frequencies that must be used, and partly in the fact that appeal is made to the eye rather than to the ear. This latter point also bears upon many other television problems, both those that can be envisaged now and others that will arise in the future—and constitutes, in fact, one of the central considerations of all television work.

RELATIVE REQUIREMENTS OF EYE AND EAR

It is a fact of common observation that defects in appeal to the ear, such as acoustic distortion, fading, extraneous noise, etc., produce only *psychological* dissatisfaction. Excessive volume is the only exception to this statement. Defective appeal to the eye, however, such as blurring, poor detail, flicker, extraneous flashes or dark spots, produces both *physical* and *psychological* dissatisfaction, and in addition to displeasing the mind, strains and hurts the eye, creating actual physical pain. In consequence forms of distortion that are perfectly tolerable in radio sound reception would represent an impossible barrier to television. Not only more perfect antenna systems for reception, but more carefully engineered equipment throughout, will be required for the new development. This is one of the "safe" predictions.

HOW NEAR IS TELEVISION?

One of the most clouded of all questions is that which asks when television will be ready. The obvious answer is that television has been "ready" for ten years, and that acceptance waits upon the public. The question of when television will become an industry merely raises the related question: "How perfect must it be before the public will accept it?"

It was possible to buy Nipkow scanning disc equipment ten years ago, apparatus capable of transmitting and receiving reasonably clear and bright pictures ranging in size from a postage stamp to a postal card. Such equipment can still often be found, covered with dust, in the cellars of the larger radio stores.

The buying public did not think it good enough. The attempt to make television grow, as radio grew, from crude and sometimes home-made beginnings, simply did not appeal to public fancy. Is anyone in the audience ready to state what the public will fancy, and why?

Television has been improved steadily to date. Ingenious modifications have been made in the Nipkow scanner, systems of lenses and prisms have been developed to take its place; new departures have been made in the flying spot, the iconoscope and the cathode-ray tube. Pictures are larger, brighter and clearer. Modern radio circuits have made possible increased detail and lower distortion. Enormous sums have been expended to achieve these results. But is the public satisfied to spend money for them? That remains to be seen.

Five potent obstacles still stand against public acceptance.

1. *Demand for high quality*: The living-room group calls for a picture that all members can view without unseemly crowding, peering or eye-strain —that is, a picture comparable in size to the home movie, and therefore larger than is readily available today, if good detail is to be included. Detail again must be more than tolerable; it must be appealing if advertisers are to pay the cost of programs. Lastly, extraneous disturbances, static, man-made static and similar spots and flashes will not be tolerated if they exist to the degree of straining the eye and causing pain.

2. *Difficulties of transmission by wire or ether*: To avoid these disturbances both ether- and wire-borne transmission must be shielded from external electric and magnetic effects of all kinds. The peculiar type of fading experienced on the quasi-optical bands must be overcome by installation of large numbers of transmitting stations, involving capital investment of very large proportions.

3. *Increased cost to advertisers*: It has been estimated that Hollywood's entire output of pictures per year would not suffice television for a month. That calculation is doubtless exaggerated, since television is useless as "background" and demands undivided attention. In consequence it may be expected that 18-hour service would be rare, at least at first, visual programs being confined to favorable hours, with mere sound during the greater part of the day. Even so, the cost to the advertiser would be considerably in excess of present radio costs, allowing for "sets," scenery, costumes, and talent that not only sounds but looks well. Is that much advertising money available?

4. *Competition of facsimile*: The desire of the advertiser to pay for television may be complicated by the fact that facsimile, still-picture transmission, is available to him at infinitely less cost, anytime anyone wants to broadcast it and the public wants to buy receivers to tune it in.

Facsimile also provides a handy index to picture quality. Its problems are almost infinitely simpler than those of television, yet radio-transmitted pictures in the newspapers do not inspire great confidence in the quality of radio vision, still or moving, that will be available in the near future.

5. *Resistance of the moving picture industry*: A capital investment of some several billion dollars sees in television (as in anything that may keep people in their homes) a potential threat to its own welfare. Through the enormous royalties it pays for sound recording to the very industry most likely to produce television, Hollywood holds a formidable weapon, and is further developing colored pictures to provide more drastic competition if and when the added cost of color in studio and theatre seems to be necessary for self-defense.

None of these five points, bearing upon public acceptance of television, may be as formidable as first glance might indicate.

Even high quality is not imperative in the case of "spot news" such as ball games, fights, election campaigns and similar activities. The public will tolerate any bad quality in such connection. It now buys many thousands of $20 "ringside" seats and carries its own binoculars to them.

Difficulties of transmission involving definite eye-strain will doubtless be tolerated in connection with television programs of that type. Newspaper editors who know their business print radio photographs.

The advertiser, or some advertisers, may find the cost of television programs worthwhile, and in this connection it is noteworthy that the advertising industry was prepared a few years back to finance the production of moving pictures carrying sales copy and that development was prevented only by vigorous resistance in Hollywood.

Facsimile is relatively "dead" for spot news that will doubtless provide the earliest and most important of visual programs.

Lastly, the motion-picture industry regarded radio, ten years ago, as a potential threat of high calibre (still does) and never was able to do anything successful about it.

RECEIVER CONSTRUCTION

A number of details of television receivers also fall within the province of reasonable certainties, irrespective of which type of reception mechanism may be used.

Thus, it is undoubtedly safe to say that any receiver whatever will carry at least three distinct electrical systems—one the audio receiver, substantially identical with the present-day radio; one the system for receiving, tuning, amplifying and reproducing the television picture, and one the synchronization system. The mere bulk of equipment involved indicates that for some years at least, if not forever, the midget or mantel-type equipment is very definitely out with reference both to size and to cost.

Still another factor, inherent in the nature of the living-room circle, must of necessity operate to increase the size and bulk of the receiving equipment. The living-room circle will not gather to peer into a peep-hole in a darkened box. Yet even the brilliance of home movies and the greater brilliance of theatre movies require a darkened room. The living-room will refuse to be darkened. Switching out the lights for the showing of home movies once on occasion is a different matter, from the point of view of family routine, to maintaining a permanently dusky enclosure in which television programs are to be received night after night, or equipping windows with light-proof curtains to receive spot-news television during the day. Nothing of the sort is conceivably consistent with the ordinary mechanism of life in apartments or the average small home. The darkened area in which the picture is shown must be located within the cabinet of the television receiver, and that cabinet must be so wide that the observers seated comfortably in their chairs at different viewing angles can look within the darkened recess without straining their necks. The television cabinet, equipped with an opening of suitable width, must likewise be sufficiently deep to maintain twilight recess in a well-lit room, and that with a minimum of rearrangement of the lamps in the room.

Hence, the mere bulk required by the electrical apparatus for television, substantial though that may be in comparison with the present-day midget or mantel receiver, may perhaps be considered a minor matter as compared with the bulk required for the proper showing of a picture, the size of which must be sufficient to satisfy the average family in their customary comfort, and the location of which must be within a deep and semi-dark recess. Television would thus appear to offer substantial opportunities to cabinet manufacturers; on the other hand the cost of their operations may prove a substantial factor in limiting the growth of the new industry on a popular price scale.

RECEIVER CIRCUITS

The obvious and inevitable location

of television broadcast in bands of the order of 30 megacycles or higher (probably much higher) places the design of television receivers in the class of ultra-short-wave amateur and communication receivers with relatively little use of material for coils and condensers, but correspondingly rigid requirements in constructional trivia of placement of parts, wiring arrangements and grounding. Picture reception, of course, imposes circuit requirements not found in sound reception, in that the band width per signal must be hundreds and possibly thousands of kilocycles in place of a mere 10 or 15 kc as in the case of sound.

The requirement for wide bandwidth is accompanied by the requirement of minimum separation, made necessary by the quasi-optical character of the waves used and the resulting multiplicity of stations needed for adequate coverage of a given area. The radio-frequency tuning circuits of the television receiver must admit a band hundreds (if not thousands) of kc in width without frequency discrimination that will be apparent in the picture, and yet cut off sharply at both ends in order to accommodate a maximum number of stations in the ether range available.

The television i-f circuit must be tuned for equal width of band, and with cut-off sharp enough to prevent cross-talk blurring the picture, much less tolerable psychologically than a background of cross-talk in a sound program. As television transmitting stations multiply in number it may conceivably become necessary to mount the oscillator circuit, and possibly even the r-f and i-f circuits, in temperature controlled chambers to reduce cross-talk by minimizing frequency drift.

(*Crystal filters in the i-f stages may be the answer to the requisite of broad-band response with sharp cut-off at the marginal frequencies. Temperature controlled chambers for portions of the circuits, while they might seem desirable at first thought, would add materially to the bulk and complexity of the system. Research might develop a means whereby positive and negative temperature co-efficients are made to off-set each other. In so far as oscillator circuits are concerned, there is enough known at the present time to insure a high degree of stability in these circuits irrespective of fluctuations of circuit elements.*—EDITOR.)

Requirements for reception are, of course, reasonably clear in these elementary matters, but requirements as to synchronization are more vague at present, since a number of methods of synchronizing are possible and undergoing active development. Quite possibly power-line frequency will be used, especially if the experience on a large scale should confirm the current impression that a large number of short-range transmitting stations will be required. In that case, each station (except in border-line locations) can count upon "listeners" and itself being powered by the same electric plant, and any line frequency drift experienced being common to both. That condition would simplify matters at the transmitting end, no doubt, but complicate them for the receiver manufacturer, who would presently be advertising trick adjustments and compensators for the benefit of users who might want to tune in stations not tied to their own power lines.*

The broadcasting and reception of a third and separate signal (in addition to picture and to sound), provides a ready method of securing synchronization, but adds to the crowding of the ether. Still another method is to interleave synchronizing impulses between pictures or even between the lines of pictures, separating them at the receiving end by means of a low-frequency filter. This procedure helps the receiver manufacturer in that it requires only another circuit in the receiver, instead of an entirely separate tuner operating on a distinct but related band, and conserves frequency range. It has operated satisfactorily in practice. But in this and in most details of television construction, patent considerations may complicate procedure.

POWER SUPPLY CIRCUITS

Most radio receivers made today, even quite good ones, present the listener with a residue of 60-cycle hum that in midget models sometimes rises to the level of definite noise without being too seriously objectionable. The ear simply rejects what it doesn't want to hear. That is a natural function of the hearing mechanism, the purpose of which is to choose, out of a multitude of background sounds always present, those for which attention is desirable. The eye works otherwise, its function being to focus, resolve and clarify the meaning of an image. But a constant distortion, such as a sixty-cycle background to a television picture, is troublesome only for a moment, and automatically ignored as soon as its presence ceases to be a problem. This reaction can readily be checked at the movies. Take a rear seat and watch half the picture. Move up front. The "grain" of the picture apparent from a front seat will be seriously annoying for a very short while, and then be forgotten altogether.

This fortunate courtesy of the eye will minimize power supply problems, but not eliminate them. Any ripple or background distortion that hides a significant detail of the picture causes the eye to perform additional work in attempting to clarify what it wishes to see, and is therefore painful.

Similarly, those television engineers who report that static or man-made static is not disturbing in a television image because the observer can always glance away (while there is no corresponding protection for the ear in the case of sound disturbances) have forgotten that the eye will not glance away from anything it wants to see. Watching a routine signal transmitted for the thousandth time in the course of laboratory tests is a different matter from watching the world's series. In the latter case the eye will quite unconsciously cling to the distortion and try to sort it out, and at the end of ten minutes of the process the observer will have a first-class headache.

THE REPRODUCING MECHANISM

The mere bulk and weight of the reproducing mechanism is still one of the least predictable things about television receivers, in view of the number of rival systems now being pushed to completion. It is reasonably safe to say that television will be transmitted via ether because existing wires can't handle it, and rewiring the country would be somewhat of a job. It is safe to say that television will be transmitted on the highest frequencies because they are best adapted to it, and there is no room for it elsewhere anyhow. From these two apparent facts a number of deductions as to receiver requirements are obvious and permissible. But how the amplified signal is to be re-converted into light depends, at present, upon the race for perfection in which different mechanisms are involved—and upon the patent office.

The flying spot method is perhaps the least bulky, and the cathode-ray tube the most. Yet this statement is not wholly true since the flying spot requires bulk in the way of unobstructed space between its source and the viewing screen. The cathode-ray tube will certainly have to be larger than the type used at present in oscilloscopes since several persons located at comfortable distances cannot comfortably view the details of an image confined to so small a cross section. The illumination of the cathode-ray tube, as at present used, is also unsatisfactory both as to intensity and as to color. The simplicity of cathode-ray reproduction may to a degree be off-set by these limitations, and leave scope for competition by other means. The flying spot and translucent screen will offer satisfactory illumination and color tone. Whether detail will be equally satisfactory remains (so far as this writer knows) to be seen.

*This point is open to question in view of the almost universal tie-up of electric power distribution systems.—EDITOR.

SIGNAL GENERATORS: HIGH

by MALCOLM FERRIS*

THE TRANSMITTER ENGINEER may well be amused at the above title, since in a signal generator "high power" may mean perhaps a quarter of a watt, while "low power" may refer to a milliwatt or so. These terms, however, have real significance to an instrument designer, and to the receiver engineer who realizes that a signal generator is his most important laboratory tool and wishes to become familiar with its capabilities and its limitations. In order to generate a known voltage for use in testing radio receivers, we begin by allowing a known current to flow through a known resistance which is inserted in the antenna circuit of the receiver, thus impressing the voltage at the desired point. The amount of resistance inserted is of vital importance to the receiver engineer, for it can affect the operation of his circuits to a large degree. He does not ordinarily care much about the magnitude of the current, but that is of great importance to the signal generator designer, for it affects directly the complexity and therefore the cost of the instrument. It is the purpose of this article to show the manner in which these and other practical considerations affect the design and performance of signal generators.

The simplified circuit shown on the left of Fig. 1 contains the essential parts used in the vast majority of standard signal generators in commercial use today. Current, measured by thermo-element E, flows through the known resistance R, which is inserted in the dummy antenna circuit of the receiver under test.

Fig. 1 is much simplified to direct attention to certain basic principles; in an actual instrument there are usually complications present, which do not, however, alter the basic principles. Fig. 2 is drawn to indicate two of the complications frequently round. At (a) in Fig. 2 is shown an attenuator, so constructed that the current flowing in different parts of the circuit follows desired relations. As frequently built, I_2 is one tenth I_1, I_3 is one tenth I_2, etc., so that I_4 in the figure would be 1/1000 of I_1. This introduces no basic difference; it merely makes the current flowing through resistance R a definite fraction of that measured by the thermo-element, and so makes it easier to produce small output voltages with reasonable values of resistance R.

*President, Ferris Instrument Corp., Boonton, N. J.

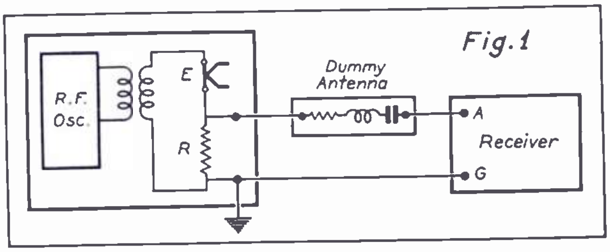


Fig. 1

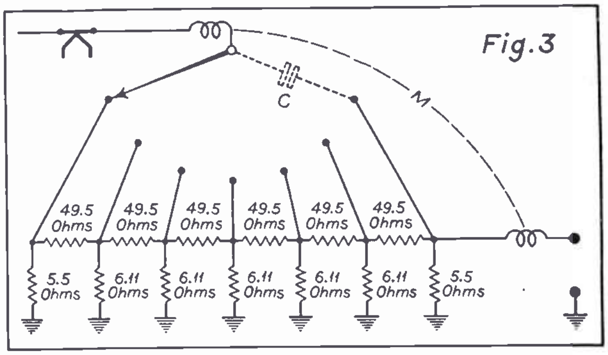


Fig. 3

At (b) in Fig. 2 is shown another variation. Instead of measuring the current I_1 with a thermo-element, a vacuum tube voltmeter is used to measure the voltage across the initial resistor. The final output voltage is determined by current I_4 through resistor R, as before.

Remembering that the complications shown in Fig. 2 and many variations of them do not affect the basic principles, let us return to Fig. 1 and consider resistor R. The output voltage obtained is simply the IR drop in this resistor. Keeping this in mind, let us see what current would be required in this resistor for one volt output:

With R = 1 ohm, current required is one ampere, and the power is 1.0 watt.

With R = 5 ohms, current required is 200 milliamperes, and the power is .2 watt

With R = 10 ohms, current required is 100 milliamperes, and the power is .1 watt

With R = 100 ohms, current required is 10 milliamperes, and the power is .01 watt

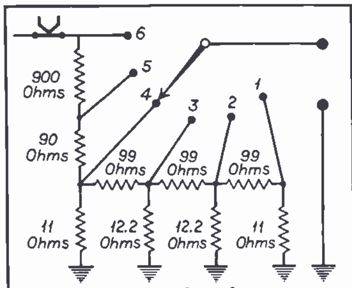
With R = 1000 ohms, current required is 1 milliampere, and the power is .001 watt

In other words, if we must have high output, and still keep a low output resistance, we must have heavy current and high power. For his own convenience, the writer has been in the habit of classifying signal generators as "high power" or "low power," and considers those having a maximum current in the attenuator of over 50 milliamperes as "high power" while those having maximum attenuator current under 5 milliamperes are considered as "low power." Those with attenuator current between 5 and 50 milliamperes might well be classed as "medium power."

From the user's point of view, a reasonably low output resistance (not over 10 or 20 ohms) is to be preferred, as it can be inserted in the usual dummy antenna

OR LOW POWER?

A Seldom-Considered Point in the Selection and Use of Standard Signal Generators



Point	Output Microvolts	Resistance
1	10	10 Ohms
2	100	10 "
3	1000	10 "
4	10,000	10 "
5	100,000	100 "
6	1,000,000	1000 "

Fig. 4

circuit without causing appreciable error; at the same time voltage up to one-half volt or one volt is often wanted. This would seem to indicate that "high power" generators would be required. Actually, probably the majority of such instruments in use are of the "low power" classification, and there is very good reason for this. A "high power" signal generator is much more expensive to construct than one of "low power," and as the latter can be made at a much lower price, while still being suitable for many types of service, it is quite generally used in the majority of cases. The "high power" instruments are generally used for more exacting service, and as a result instruments of this type are likely to have other expensive features, as well as the high output across low resistance.

Fig. 3 is drawn to indicate some of the reasons why "high power" generators are more expensive to build. The capacity C and the mutual inductance M, indicated in the dotted lines in this figure, are not intentionally placed in the circuit, but are undesirable elements which must be reduced to extremely low values by carefully arranged shielding.

Assuming that the voltage at the switch, as shown in Fig. 3, is one-half volt, and the maximum voltage which we can allow the stray capacity C to introduce in the output circuit is one-tenth microvolt, then the capacity C must have a reactance of at least 5,000,000 ohms. That is, if the highest frequency to be used is 20 megacycles, capacity C must be less than one five-hundredth of a micromicrofarad (1/500 uufd). This obviously can not be done on a single normal switch, but by using a very carefully shielded switch, or a switch divided into several sections, shielded from each other, it can be accomplished.

The undesired mutual inductance is much more troublesome. If the maximum current is 100 milliamperes, and the maximum voltage which can be introduced into the output circuit is one-tenth microvolt, the mutual reactance must not exceed one-millionth of an ohm. If the highest frequency is to be twenty megacycles, this means the mutual inductance must not exceed one one hundred and twenty-millionth of a microhenry. Such values are obtainable, but they require very careful shielding construction.

If the current input to the attenuator is reduced to one milliampere, the permissible mutual inductance can be one hundred times as great. In practice, this means that the problem of shielding the attenuator is very much simpler, and that it can be built much more economically. This is a reason why many "low power" generators with one milliampere in the attenuator are in quite common use.

With an attenuator current of one milliampere, the maximum voltage obtainable across ten ohms is 10,000 microvolts. More output than this is desirable in most cases, and accordingly most low powered signal generators use an arrangement similar to that indicated in Fig. 4. In this arrangement taps 1, 2, 3 and 4, giving output voltages of 10, 100, 1000 and 10,000 microvolts, each have a resistance of ten ohms; point 5, giving an output of 100,000 microvolts has a resistance of 100 ohms, and point 6, giving one volt output, has an output resistance of 1000 ohms. (The circuit in Fig. 4, while quite similar to that employed in many commercial instruments, is somewhat simplified, to direct attention to the principles involved. For instance, no variable elements are shown, and the output is only in fixed steps, with no provision for intermediate values between these steps.)

Of special interest to the user is the question "What limitations does an arrangement similar to that of Fig. 4 place on the usefulness of the instrument?" In other words, can a low power instrument be used for most purposes, or is it necessary to have one of high power? This question is so important that it will be considered in some detail.

The most important single use of a signal generator is for measuring the sensitivity of a completed radio re-

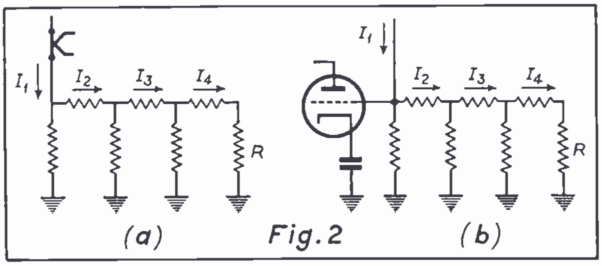


Fig. 2

ceiver. For this measurement, the signal generator output is inserted in the dummy antenna circuit, as shown in Fig. 1. Practically all sensitivity measurements are made at 1000 microvolts or less, and practically all good low power signal generators have low output resistance at this point.

Another important use of signal generators is for measuring selectivity of a complete receiver. For this measurement, the signal generator output is inserted in the dummy antenna circuit, as for sensitivity measurement, and sensitivity is measured. Then measurements are taken at a number of points either side of resonance. the signal generator output being increased as it is operated farther from the resonant point, to obtain the same receiver output, and the usual form of selectivity curve is plotted. The 1933 Report of the Standards Committee of the IRE recommends that measurements be made at least every ten kilocycles up to 100 kilocycles off resonance, or until the signal generator output is 10,000 times that at resonance, or until it is one volt. whichever is reached first.

To do this would require an output as high as one volt in some cases. The circuit of Fig. 4 shows an output resistance of 1000 ohms when one volt output is obtained, and this could not be inserted in the usual dummy antenna circuit without causing prohibitive errors. Hence. we must conclude that a low power signal generator of this type cannot be used for selectivity measurements, except within certain limitations.

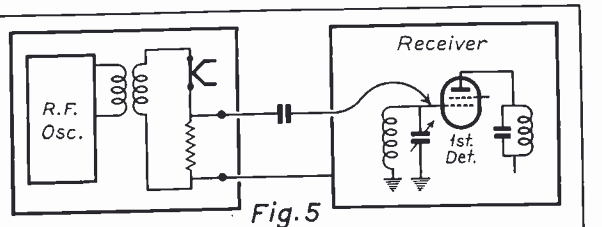


Fig. 5

In looking at Fig. 4, we see we could obtain an output up to 10,000 microvolts with an output resistance of ten ohms. In working with a receiver with ten microvolt sensitivity, this would allow the curve to be carried out to 1000 times the resonant value, which is far enough for many purposes, though not quite as complete as specified by the I R E Standards.

One caution in this connection: Fig. 4 is for illustration only, and actual low power signal generators differ somewhat from this figure. Consequently, it is necessary in using a particular instrument to find out exactly what the output resistance is for various output voltages, and use only those output voltages for which the resistance is not too high.

It was mentioned above that a 100 ohm output resistance could not be inserted in the usual dummy antenna circuit without prohibitive errors. Many actual generators have intermediate values of resistance, often 20, 50 or 100 ohms. Some of these resistances can be inserted in dummy antenna circuits without causing serious error, but this will have to be checked in each particular case before it can be considered safe to use the higher resistance point.

This check can very easily be made. For instance, assume that, with the attenuator of Fig. 4, we are making a measurement on point 4, which is 10 ohms resistance, and we want to know whether we can use point 5, which has 100 ohms resistance, without causing serious error. We can easily put 90 ohms in series with the dummy antenna, and observe how much difference in receiver output it causes. If the difference is slight, we can safely use the higher resistance point, with this particular receiver and dummy antenna, and at this particular frequency. This check must be made separately for each frequency.

Another limitation that applies to many low power signal generators, though it is not directly due to their being low powered, is that their tuning condensers have scales with such short scale length that the small differences of frequency required for selectivity measurements cannot be read with any accuracy. Special scale spreading arrangements, to make possible reading small frequency differences, are usually provided on high power signal generators. Although sometimes provided on low power instruments, in the majority of cases they are omitted. However, by operating at intermediate frequency, it is often possible to obtain a selectivity curve of the intermediate amplifier of a receiver, even on a signal generator whose tuning condenser scale does not permit close readings of frequency, since at the lower frequency the scale is better spread out. While this is not the same as the overall selectivity of the complete receiver, it is often quite close to it, and may give sufficient information for many purposes.

Signal generators are frequently used for other purposes than the measurement of completed receivers. One of the most common types of measurement involves measuring the sensitivity at some particular point in a receiver, usually at the grid of a particular tube, as indicated in the diagram of Fig. 5, which shows the output of the signal generator connected through a blocking condenser to the first detector grid of a superheterodyne receiver. Such a connection can be used to measure selectivity of the intermediate-frequency amplifier, as mentioned above.

For such use, at broadcast and lower frequencies, an output resistance as high as 1000 ohms can be used without appreciable error. At higher frequencies, such a high output resistance is not usable, for even the unavoidable capacity in the circuit and leads would effectively short circuit such a high resistance. For instance, at 20 megacycles, a lead capacity of 100 micromicrofarads would have an impedance of only 85 ohms, and this in parallel with a 1000 ohm output resistance would cause plenty of trouble.

An output tap like point 6, of Fig. 4, giving one volt across 1000 ohms is sometimes provided in low power generators, and is often useful if restricted to uses such as shown in Fig. 5, at broadcast and lower frequencies. More often, this point is omitted in low power instruments, because it cannot be used at higher frequencies, and cannot be inserted in the usual dummy antenna circuit, and attempts to so use it by engineers who do not understand its limitations may give misleading results. Thus, in low power instruments it is customary to find the maximum output voltage limited to 100,000 microvolts (0.1 volt) appearing across a resistance of 50 to 100 ohms.

Measurement of automatic volume control characteristics of a receiver usually requires a voltage up to one volt or more, introduced directly into the dummy antenna circuit. For such measurements, a high power generator is obviously necessary.

To sum up: A high power signal generator has a number of advantages over a low power instrument, and can be used for a number of purposes for which a low power instrument is not suitable. Low power generators are, however, much more economical, and if used for sensitivity measurements and other work within their limitations, may be found suited for a considerable part of the work for which a signal generator is needed.

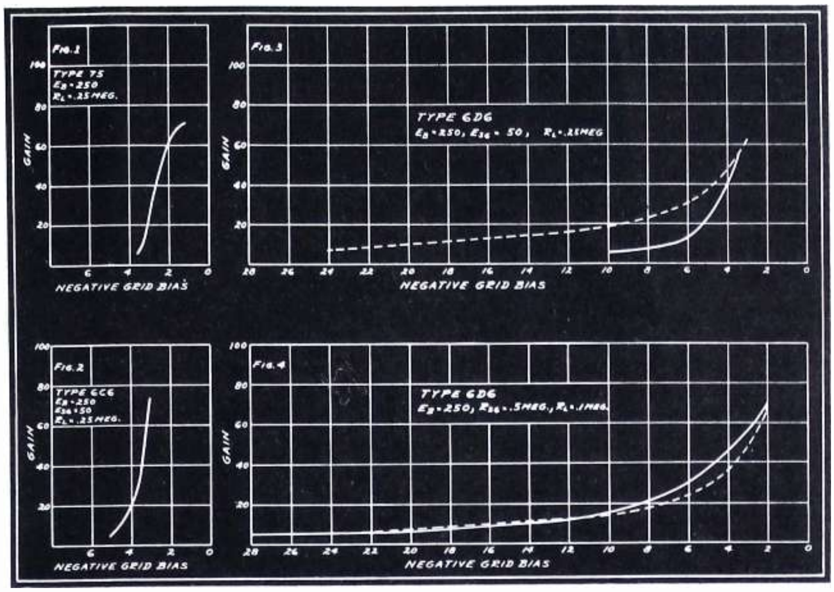
A-F VOLUME CONTROL*

THE CONVENTIONAL METHOD of controlling the output voltage of a resistance-coupled a-f amplifier, by varying the input signal voltage, effectively serves, in most instances, for "gain control" or more properly "volume control." However, special applications of a-f amplifiers sometimes bring with them the need for true gain control. An example of such application is found in the case of extension of avc to the audio amplifier of a receiver.

In a receiver having the d-c voltage developed in the diode detector, applied as a bias to the grids of the several preceding high-frequency stages, a commercially satisfactory avc system results. General design considerations sometimes make it impractical to apply avc voltage to more than one preceding amplifier stage. Under such circumstances, the avc performance obtained leaves much to be desired.

While the idea of applying avc voltage to the audio amplifier, as well as to the r-f and i-f stages, is by no means new, little use has been made of it. Apparently, it is generally believed that "over control" will result. Unquestionably, such "over control" can occur with certain arrangements. However, if the audio amplifier is arranged so that its gain varies inversely with the applied audio signal level, "over control" will not result. As the avc voltage obtained from a simple diode detector is for all practical purposes proportional to the audio signal level, the d-c output of the diode constitutes a convenient means for suitably varying the audio gain. An extremely close approximation of the audio gain varying inversely with the applied negative grid bias can be obtained by proper selection of tube type and operating conditions for same, as a resistance-coupled audio amplifier.

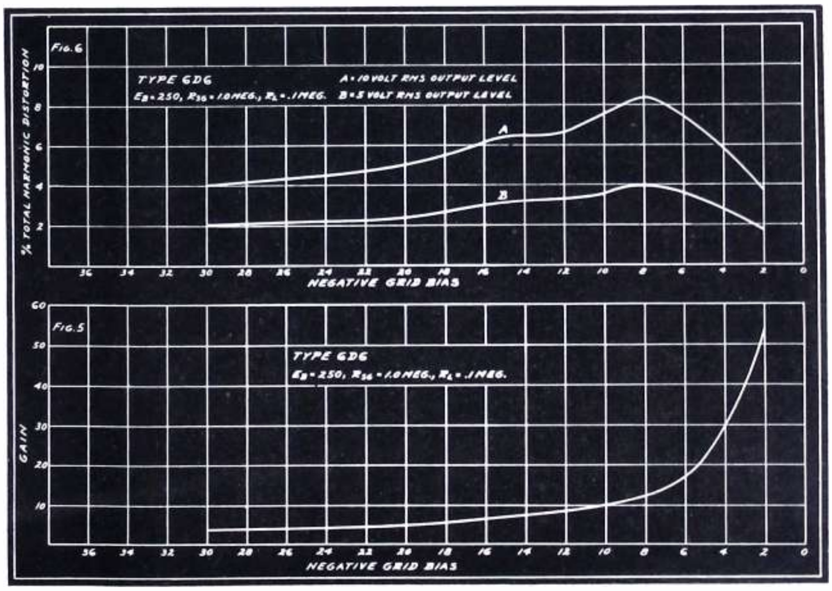
In Figs. 1 and 2 are shown the relation between negative grid bias and gain for a triode, type 75, and a sharp cut-off pentode, type 6C6. Fig. 3 gives the same relation for a remote cut-off pentode, type 6D6. The operating conditions, as regards the plate load resistor and screen voltage, are normal. The dotted-line curve in Fig. 3 depicts the gain varying inversely with the grid bias. Fortunately, the use of a series screen dropping resistor not only is an economical method of securing the screen voltage, but also it is one which tends to make a remote cut-off pentode even more remote in cut-off. The grid bias-gain characteristic of the remote cut-off pentode can be altered within reasonable limits by proper choice of the plate resistor and the screen dropping resistor. In Fig. 4, the bias-gain characteristic is shown, when series resistors are chosen, to closely approximate a curve where the gain varies inversely with the bias.



Even closer approximation can be obtained through the use of a higher series screen resistor as shown in Fig. 5. Utilization of this audio amplifier, in conjunction with a receiver, by the application of avc voltage to the control grid, would result in a receiver having a flat avc characteristic.

In an amplifier, such as described in Figs. 4 and 5, the maximum undistorted output is curtailed simultaneously with

(Continued on page 31)



*Data furnished by National Union Laboratories.

MAKING THE SURVEY

by H. V. WENGER, JR.*

AFTER THE RADIO manufacturer is convinced of the value of making a plant survey, it is necessary that a definite plan of procedure be laid out. In order that the survey will be of the most possible value, it is necessary that it be as comprehensive as possible. Graphic surveys are made for the purpose of obtaining information which is valuable in improving the operation of the plant by reducing waste, improving performance, lowering costs and bettering the product. In general they have to do with four elements which enter into the cost of a product, namely, condition of equipment, power used, employees' time and handling of equipment.

The plan of procedure should first be to list every piece of power-using equipment. It will then be necessary to determine just how long the meters should be left on each piece of equipment. Some records will be for a period of only a few hours, others for a matter of days and still others for several weeks. The time of each record and the chart speed will depend upon how the load fluctuates and how long it takes to complete each load cycle.

POWER CONTRACT

Before starting the survey it will be well for the electrician running the tests to familiarize himself with the details of the power contract between the company and the manufacturing plant. It is essential to know the power load on which the present demand charge was figured and the charge per kilowatt of demand. Equally important is the penalty that the plant has been paying for poor power factor and the bonus that is available for high power factor. A study of the power bills for one year will furnish this information. From these bills it is possible to determine at just what period of the year the load was heaviest and how the load at the time of the survey compares with the load of the plant under maximum production. Without this information, the recommendations of the plant electrician may be unreasonable when compared with the actual conditions.

The order of the day is "research." Many of the radio firms spent the spare time afforded by the depression in refining and developing new products. The value of this research has already become a reality in many plants which are feeling once more the pulse of good times.

Research, however, does not have to be confined to the development of new products. Research spent on the proper productive methods and most efficient use of power offers the wide-awake manufacturer dividends that will equal and often exceed those derived from the development of new products.

CHOICE OF INSTRUMENTS

The selection of the instruments to be used in the plant survey has been covered in the preceding article. The most important instrument, of course, is the portable recording wattmeter. This instrument should preferably be suited for operation on either alternating or direct current, and provided with potential ranges so that it can be used on 110, 220 and 440 volt circuits without potential transformers.

The self-contained range of the wattmeter is very limited and can be greatly enlarged by the use of current and potential transformers when measuring alternating current and shunts when measuring direct current. The current transformers are available with as many as nine or ten primary ranges so that with only one pair of portable transformers, three-phase loads up to nearly 1000 amperes can be measured. A careful study of the direct-current loads should be made before selecting shunts, since a separate shunt is necessary for each different current range.

Recording instruments are available with several different types of chart drives. The advantages of the strip type chart with a clock providing five or six chart speeds per hour and per minute greatly out-weigh the other combinations that are available. The chart speed may be usually changed from minute feeds to hourly feeds and vice versa by the shifting of a small lever on the side of the clock. In certain types of survey work it is desirable to have chart speeds in inches per second. This can often be provided by purchasing an external motor drive which drives the chart mechanism only when second feeds are employed. The recorder also usually offers the choice of an eight-day spring clock or a synchronous motor clock. The spring driven clock is preferable for a portable instrument, since synchronous current is not always available where the test is being made.

In addition to the graphic wattmeter, the survey equipment should include a power-factor recorder, a voltmeter and an ammeter. The power-factor meter should be suitable for operation on 3-phase circuits. Power factor is seldom measured on loads of less than 15 hp, since smaller loads are so small in relation to the total load that their individual power factor is of little consequence. It is safe to say that all motors over 15 hp are three-phase. A three-phase power-factor instrument cannot be used on single-phase circuits.

The graphic voltmeter becomes a valuable piece of equipment for measuring the voltage coming into the plant and the drop at the end of the different feeders throughout the plant. It is quite important that the voltage be correct for both lighting and motors. The maximum life of an incandescent lamp requires the maintenance of a constant voltage of the proper value. A supply voltage of only two volts above rating on the lamps reduces their life 21%, while a voltage only four volts below rating reduces the illumination furnished by the lamp 15%.

Economy and continuous operation of an industrial plant require that the voltage of the supply circuit be maintained uniformly at the proper value. The ability of the heavily loaded motors

*The Esterline-Angus Co., Indianapolis, Ind.

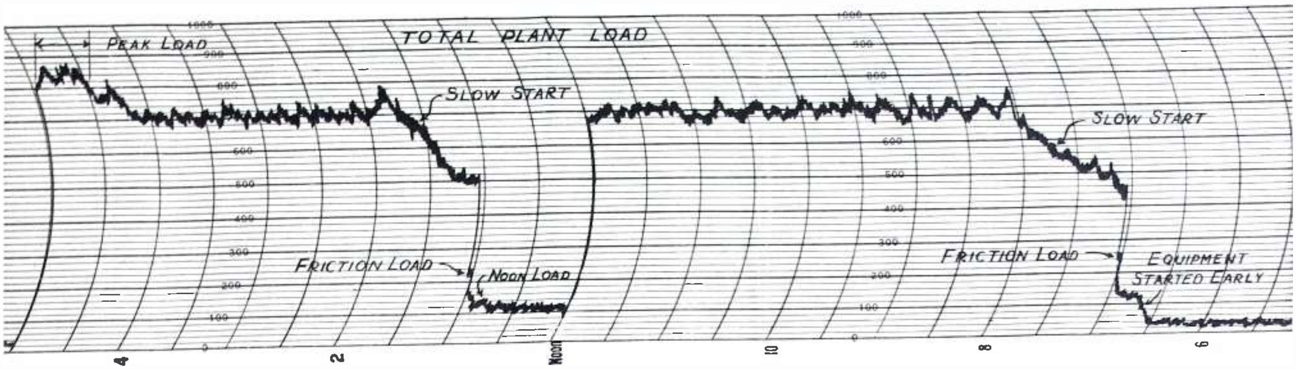


Chart of total plant load for one day. The delays following the morning and noon starting times are quite evident.

to start their loads and carry them continuously without overheating depends upon the voltage being kept at the proper value. The starting torque of induction motors drops off approximately as the square of the reduction in voltage. A motor that is carrying all of the load it can handle at the proper voltage will quickly overheat if the voltage is appreciably lowered.

The ammeter's place in a graphic meter survey is evident when its uses are considered. Feeder lines throughout the plant carry power, but the important thing in determining their adequacy is the current that they are carrying, and it is here that the ammeter comes in. From an ampere record it is possible to choose the proper fuse sizes for each load and to set the circuit breakers. Circuit breakers can be set to different trip currents by adjusting a small dial provided for that purpose. These settings are not accurately calibrated and further means should be taken to set the trip current at the proper value. A graphic ammeter on the line will show exactly at what value the circuit breaker is opening. Proper settings of the circuit breakers is very important, for too high a setting may cause the equipment to be damaged, and too low a setting will cause needless and time-wasting shutdowns due to the circuit breakers opening before the current has reached a dangerous value.

TOTAL LOAD

Assuming that the necessary survey equipment has been provided, the circuits traced and the motors located and classified, let us see how engineers propose to use the data which graphic instruments make available. Beginning with the main power circuit, the wattmeter, the power factor meter and the voltmeter are connected to record the total load. Since total load will vary from day to day, it will be advisable to leave these instruments on the incoming line for at least a week so that the minimum and maxium load can be determined.

It will be interesting to note from the record obtained just what the maximum load is in kilowatts, how the load varies for different days and different hours of the day, how the power factor varies with the load, and how the voltage drops as the load increases. These records properly interpreted offer a host of information that will be valuable in cutting down high power bills.

DEMAND PEAKS

Study of the records taken from these instruments will show that on one particular day the power peak was higher than on any of the other days. This peak constitutes the demand of the factory on the utility for the period of the test, and it is on such a peak as this that the actual demand charge is being figured by the power company. The comparison of the demand period on the chart and the actual demand peak on which the power company has based its rate, shows how nearly the load at the time of the survey approaches the maximum load at peak conditions. It is important that this relation be kept in mind when studying the records so that the estimation of the savings to be made will be reasonable.

The accompanying chart was an actual record taken in a manufacturing plant. The wattmeter was connected into the main circuit and the record shows the power used during one working day. In this particular chart it will be noticed that the peak power load was just before quitting time. This chart was taken in the winter time and it began to get dark about four o'clock, with the result that a heavy lighting load was added to the power load. However the lighting load was not large enough to represent the peak shown on the chart and further investigation showed that rattlers in the foundry department were being operated at the end of the day, causing their load to overlap the lighting load. As shown by

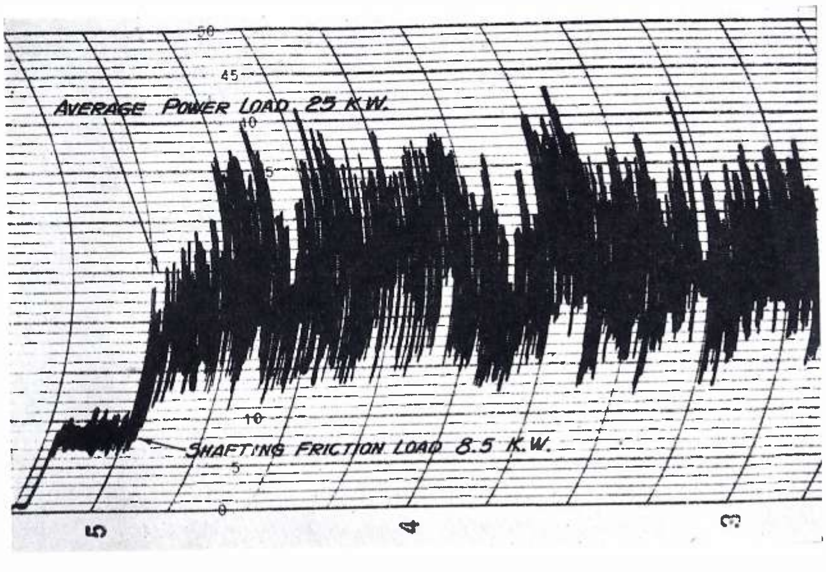


Chart showing departmental friction and peak loads.

the chart, this load added 56 kilowatts to the demand. The operation of these rattlers at times other than when the load is at a peak would make a corresponding reduction in the maximum demand and the charges for the month.

LABOR LOSSES

Further investigation of the chart taken on the total load will show how long it takes after the whistle blows for the men to get all of the machinery in operation. In the illustration it took 30 minutes for the plant to reach full production in the morning and fifteen minutes after the noon hour. The engineers estimated that the loss of productive time represented by this chart amounted to about $100 per day or $30,000 annually. No one knew how long this condition had existed, and it would probably be going on today had not this survey been made. The inefficiencies which the chart shows cover the whole range of human and mechanical deficiencies, but the majority are chargeable to the company rather than to the employees. For example, in many cases the delays are due to an uneven flow of materials from one operation to the next, which accounts for the fact that delays are greatest when the production is heaviest. A careful study of this condition will usually show the engineer the weak spots in his production scheme.

Oftentimes delays are due to workmen waiting to obtain tools or to return them to the tool cribs. Doubling the tool room force and allowing workmen to hold tools until the job is completed eliminates most of this lost time. It is necessary to schedule accurately the labor and materials and to see that the schedule is maintained; perhaps time clocks should be moved, so that workmen ring in after changing their clothes; materials should be rerouted and improvements made in the method of assigning jobs. Each case should be taken individually and a search made for the real cause of the delay, and then schemes devised for overcoming these delays.

POWER FACTOR

Low power factor is a luxury that not many plants can afford. Most power companies penalize the manufacturer for loads with a power factor of less than 80% and often offer a bonus for power factor above this value. A record chart from a power factor meter attached in the main line will show the average power factor of that plant and its relation with the kilowatt load. Usually the power factor chart will show just as plainly as the wattmeter chart when the load was turned on and off. Before the plant starts in the morning the power factor chart will be reading nearly unity, and as the load picks up, the power factor will continue to go down until at maximum load it will be in the neighborhood of 50-60%. A certain amount of this power factor can be raised by careful rearrangement and selection of the motors throughout the plant. The remaining power factor can be corrected either by the installation of synchronous motors on certain steady loads which are adapted to this type of drive, or by installing capacitor equipment.

There is an economical limit to the amount of power factor correction that is advisable. The amount of corrective equipment advisable can easily be determined from a graphic power factor record of the total load. This record shows just how much capacity is needed to bring the average power factor up to the power company's requirements for a bonus.

DEPARTMENTAL LOADS

After sufficient records have been obtained on the incoming power line, the recorders should be connected to record the load of the different departments. The graphic instruments should be left on each departmental circuit long enough to determine the true load curve of the department. Each record should cover a period of at least a week. The record should show on which days the peak load occurred and the reason for this peak; the lost time in getting the department started in the morning; the power factor of the departmental load; the friction loss; and the noon and night load.

FRICTION LOAD

The friction load will depend somewhat upon the type of power drive that is employed in the department. If the whole department is driven by one motor connected to a line shaft, the friction load can be easily determined merely by leaving the shaft running a few minutes after quitting time. If the department is powered by individual motors it will be necessary to turn on every motor after the shop has closed down and take a record of the power necessary to run the machinery idling.

The chart illustrated shows that in one particular plant a record of the friction load showed that of the twenty-five kw required by the department, eight and one-half kw was used to overcome friction and windage. This means that one-third of this department's power bill was going to overcome friction and only two-thirds was doing productive work. This is not an uncommon situation and only goes to illustrate the necessity of reducing friction losses to a minimum. Wherever power is used, there is going to be a friction loss, and the user cannot expect to rid himself of this item entirely. However much of this loss is unnecessary, and any savings made will become material when figured over the period of a year or more. Oftentimes the lineshafts are mounted on cross members of the roof structure of the building, which have settled slightly since the shaft was installed and the shaft is now out of line. Other unnecessary losses may be due to poor bearings, old belting, defective clutches and slipping pulleys.

The power load of the department during periods when production has ceased, such as at the noon hour and after working hours, will often be alarming. Men are naturally careless and unless they are constantly reminded, they will leave lights and small machinery running during the noon hour and sometimes after qutting time. When the men realize that their carelessness shows up on a permanent record that will demand an explanation this carelessness will cease.

SURVEY OF INDIVIDUAL MOTORS

After the total load and the departmental loads have been studied, the electrician is prepared to go ahead with the survey of the individual motors. A record should be obtained for each motor in the plant and it would be well to arrange the work by departments so that the multitude of records obtained will not be confusing. Each record should have the make of the motor, the rating as to voltage, amperes, speed and hp. In addition it is important that the location of the motor be given, as well as the current transformer ratio and potential tap used on the test. Often filing cards are made out for each motor so that the test data may be compiled in a logical form and easily referred to on future tests.

The majority of the motors in the plant will be of the induction type and will vary in size from fractional hp up to those rated at 50 and 100 hp. These motors may be operated at various potentials and it is very important that the electrician study the name plate on the motor before connecting the meter. It is always safest to carry a small indicating voltmeter to determine the voltage on which the motor is operating before connecting the graphic instruments. This will usually save many rather embarrassing moments. Just as a loaded gun never kills anyone—it is always an "unloaded gun"—so it is with graphic instruments; meters will always be burned up by a line which the electrician was sure was 110 volts instead of 220.

The amount of current that the wattmeter and ammeter will be required to carry can be figured from the nameplate data. However, it is always best practice to hook the instrument up using a current transformer ratio which is sure to be too high. After noting how far the pen goes across scale, the proper current ratio can be chosen. Oftentimes, utility wattmeters which operate on either a-c or d-c have current coils that are capable of carrying several times the standard five amperes. When using such an instrument the range can be doubled, or increased even greater, by a simple connection scheme. For example, if the instrument is to be used on a 110 volt line and 10 amperes are flowing through the circuit, which is twice the rated current of the self-contained instrument, then ordinarily current transformers would need to be used. However, if the potential connections are plugged into the 220 taps, the potential flowing through the armatures is only half of what it previously was, and the instrument will come to full scale at 2 kw instead of 1 kw If the 110 line is plugged into the 500 volt tap, then the instrument will come to full scale 5 kw and 25 amperes will be flowing through the current coils. It is important to note that this hook-up can only be employed with a utility instrument being used on ac. The reason for this is evident; dc instruments are calibrated for a 100 millivolt drop across the current circuit and in order to keep the resistance down, it is necessary to use heavy wire in the current coils. An a-c wattmeter does not need such heavy current coils and will only carry the rated 5 amperes.

CORRECT MOTOR SIZE

The first thing demanded of a graphic wattmeter connected to a motor in the plant is the amount of power being used or, should we say, the amount of work being done by the motor. It is important to know just how well fitted each motor is for the job that it has been assigned to do. When the record shows that the motor is too small for the job, there is unnecessary heating and the life of the motor is correspondingly reduced. However, the customary condition is an underloaded motor with the result that it is operating at a low power factor and a large percentage of the power is being used to overcome friction and windage. A substantial saving can be made by selecting the proper motor for the load so as to raise the power factor and decrease the power used.

Technical magazines are filled with articles shouting the virtues of group drives, individual drives, or maybe the old single-motored line shaft. All of these drives have their merits as a perusal of these articles will show; however, the selection of the most economical drive for any one particular plant requires careful study and the savings to be made as shown by pencil and paper may vanish when the installation is actually made. One of the largest savings to be made in a plant survey with graphic meters is in the determination of the most efficient drive for the different departments.

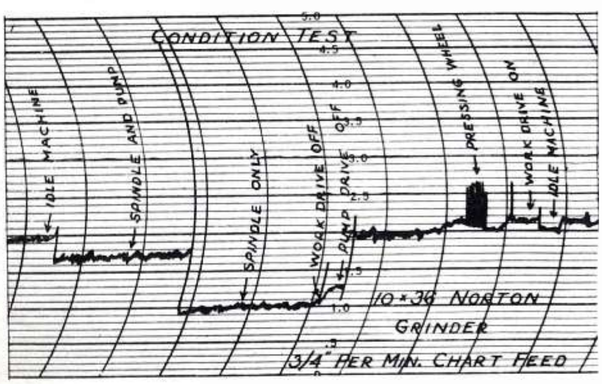
One manufacturer, having a large machine department, decided after a careful study that individual motor drive would be the most economical for his plant. The plant was driven by line shafts and countershafts before the survey was made, and he fully realized that the success of the new drive depended upon the proper selection of motors for the various machines. This presented quite a technical problem which was ingeniously solved by the clever application of a graphic wattmeter and a spare motor. The motor was mounted on a portable frame which could be moved from machine to machine. The recording wattmeter connected permanently to the motor and the unit was connected to the machinery by a belt. The record showed exactly how much power was required to drive the machine and the character of the load. The selection of the proper motor was an easy matter. The savings made by this power drive paid for the installation in less than a year.

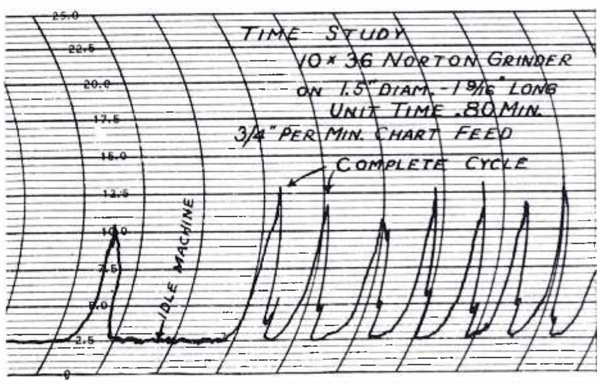
The correct motor size is only one of the many things that a survey of the individual motors will show. After the power record has been obtained, a series of friction records should be taken. First, the motor should be run idle long enough to obtain a characteristic record; next the motor and machine or machinery should be run idle, and finally the machinery run under load. Such a "condition test" is shown in the accompanying chart taken on a Norton grinder.

The idle record of the motor will quickly show up any defects in this piece of equipment. The normal idle load should just be enough power to overcome bearing friction and windage. If the idle power is high, then there are several things to look for. Perhaps the field is partially grounded and power is getting away without doing any work at all; or perhaps the bearings are defective or misaligned. In the case of the production machinery, this record will locate poor bearings, bad gears and crooked shafts. Oftentimes a frame has warped or been strained due to an overload and an abnormal amount of power is required to run the machine; the same situation may be caused by gears bottoming, or improper clearance where parts slide on one another.

Recently a plant survey showed up a piece of defective equipment that had not even been accused of being a power robber previous to the survey. The record taken on a planer in the machine shop showed that it was using far more power on the return stroke than it was on the work stroke. This called for an investigation and the machine was torn down. The bed was found to be badly warped due to manner in which the machine had been fastened to its foundation.

Another example of discovering defective machinery with a recording wattmeter, is the case of an instrument plant in the Middle West. The company purchased a stoker of the hydraulic piston type which was installed in the





Condition test and (right) time study.

boiler furnishing heat to the whole plant. A graphic wattmeter was connected to the motor of the stoker during a severe cold spell in order to find out how often the stoker operated during the day and night. On viewing the record, something else attracted attention; the motor was drawing several times its rated power on each stroke of the hydraulic piston. Investigation showed that the ways in which the piston rode expanded when they got hot and caused the piston to bind. The stoker was immediately shut down and the ways given more clearance. The whole job was completed and the stoker put in operation again before the temperature in the plant became dangerously low. Without a graphic instrument, this condition would not have been discovered until the piston froze to the ways and the motor burned up. The plant would have been without heat for at least three days and the loss due to burst pipes would probably have paid for the graphic wattmeter.

LABOR LOSSES

The records taken on production machines will show, in addition to the condition of the motor and the machine, the operation of the machine by the attendant. When the instrument is first put on the machine, the operator will feel that it is a trick to check up on his work. However, after the instrument has been taking its records for some little time and the operator is shown that the record is to test the motor and the machinery, he will get into his regular swing and the record will show just how long it is taking for each individual operation, and how much time the operator spends away from the machine. Such a time study is illustrated for a grinding operation on a Norton grinder. This will furnish information that a time study man with a stop watch could never hope to equal. The beauty of obtaining time studies in this manner is that the operator completely gets over the feeling that anyone is standing over him and the feeling that he has to fake his operations in order to keep his piece rate up.

PUNCH PRESS LOAD

The general theory of making a survey has been covered, and it would be beneficial to take several classes of loads which are present in the radio industry and analyze the value of the records that might be obtained. One of the largest users of power in the radio factory is the battery of punch presses. The method of obtaining records will depend somewhat on the type of drive that is being employed. All punch presses have flywheels which store up energy, and by means of inertia, furnish most of the power for pressing the punch through the work. If the flywheel on the punch press is too small, the motor will be called upon to furnish a great deal of power for a few seconds, and then idle until the next stroke.

Assuming that the punch presses are driven from a lineshaft, instruments should be connected to the large motor driving the shaft, along with a voltmeter and power factor meter. When the shop is idle, the friction load can be determined with the lineshaft and then on any individual shafts that can be cut off from the rest of the group, and finally for the motor itself. From a study of the friction losses, it is possible to estimate the savings that could be made by installing anti-friction bearings and re-aligning the lineshaft. The records can further be studied to determine how the motor handles its load. Do certain presses cause unreasonable peaks in the records, and what is the maximum and minimum load for the day?

If the punch presses are driven by individual motors a far more comprehensive survey can be made. Punch presses demand a motor which has fairly variable speed regulation. A motor that will hold its speed regardless of the load, will use an undue amount of power in trying to keep the speed up when the punch enters the work. A motor with variable speed characteristics will slow down momentarily when the punch enters the die and allow the flywheel to do the work, which of course is the more economical method. The graphic record will show just how the individual motors are handling their load, and whether the presses have enough flywheel weight. In addition to determining the friction in the machine, a graphic record will also show the condition of the dies and the care that has been taken in setting up the machine. If the set-up man has not been careful in aligning the dies and the punch does not enter straight, a noticeable increase in power consumption will appear on the record.

One manufacturer having a large punch press department insisted that each machine be set up with the aid of a graphic instrument. The dies were adjusted until the record showed the smallest power consumption, and this indicated that the dies were properly set. The result was a saving in set-up time, and also a marked increase in the life of the dies.

SCREW MACHINE DEPARTMENT

Another large user of power is the screw machine department. Screw machines operate automatically and one operator will have charge of five or six machines. The result is that the machines keep running as long as the parts produced will pass the inspection. When a machine is shut down for retooling every effort is made to get it back in production, and it is impossible to tell the condition of the moving parts until a machine breaks down, then of course it is too late. Screw machines are built to stand a certain definite amount of stress, and anything over this will cause trouble. Jobs that do not use the full capacity of the machine represent a loss in time and money. By studying the operation of the different machines it is possible to enlighten the production department as to the capacity of the machines and the portion of the capacity which is being used. This was described in more detail in the preceding article.

It is often an advantage to group screw machines so that four or five machines may be operated from one motor. The character of the machines is such that the load is heavy for a few seconds and then completely off, while the next tool is coming into place. With four or five of these machines grouped together, it is possible to average these cycles so that the load will be quite steady and the motor can operate at its maximum efficiency. Graphic records will show at all times the success of the group drive which is being employed.

LIGHTING

The radio factory usually has a large group of employees and each employee requires a definite number of lumens of light in order to do his best work. A survey with a graphic voltmeter and a photometer will enable the management to make large savings in the bill for electricity and lamp bulbs. A careful survey of the voltage at which different lamps are operating, and the illumination which they are producing, will enable the engineer to master the lighting problem. Oftentimes lighting circuits have been hurriedly installed, and additions made with no regard for the load on the line. The result will be a material drop in the line voltage at the end of the line. The reduced line voltage causes a marked decrease in the illumination provided by the lamp, with the result that many more lamps are needed than would be necessary if the voltage were kept up. The remedy is usually the installation of heavier wires and a carefully controlled load.

A wattmeter on the lighting load will show many interesting things which would not be anticipated when the instrument is first hooked up. The record will often show sizeable lighting loads at noon when the workers are out to lunch and in the evening when the sweepers and nightwatchmen are the only one in the plant. One firm found that the light load steadily increased in the evenings until after midnight,

(Continued on page 31)

NEVER BEFORE WAS IT *so easy to buy*

NEVER before was it so easy to give excellent service—and to purchase the necessary instruments. Actually thousands of radio engineers have bought the RCA Cathode Ray Oscillograph for hard cash. Now it is offered on easy payments! This is the basic unit of swift, accurate service. In aligning, it makes use of the unique double-image method, showing a symmetrical curve, regardless of shape of top. Also useful in checking distortion, intermittent operation, transmitter modulation, etc. Surprisingly effective for both sets and service work.

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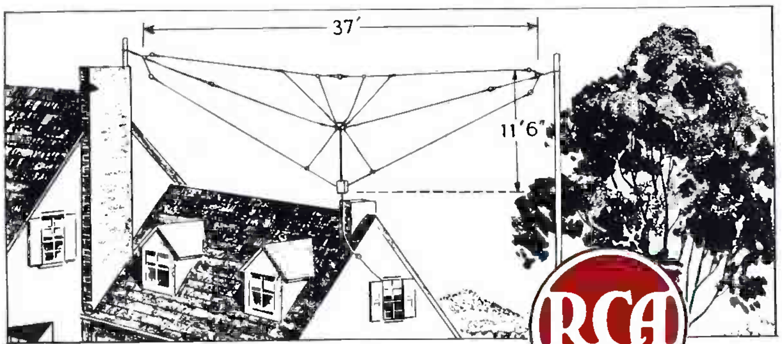

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Never before was an antenna so effective. Has proved itself out sensationally since its introduction in May. Peps up signals amazingly, and in addition reduces noise on all short waves. Even amateurs are finding it beats their usual receiving antennas! Functions as a T from 140 to 4,000 kc., multiple-doublet system above, to 23,000 kc. Kit available extending coverage to 70 megacycles, clearing up 5-meter complaints. System, $8.95; Kit, $1.50.

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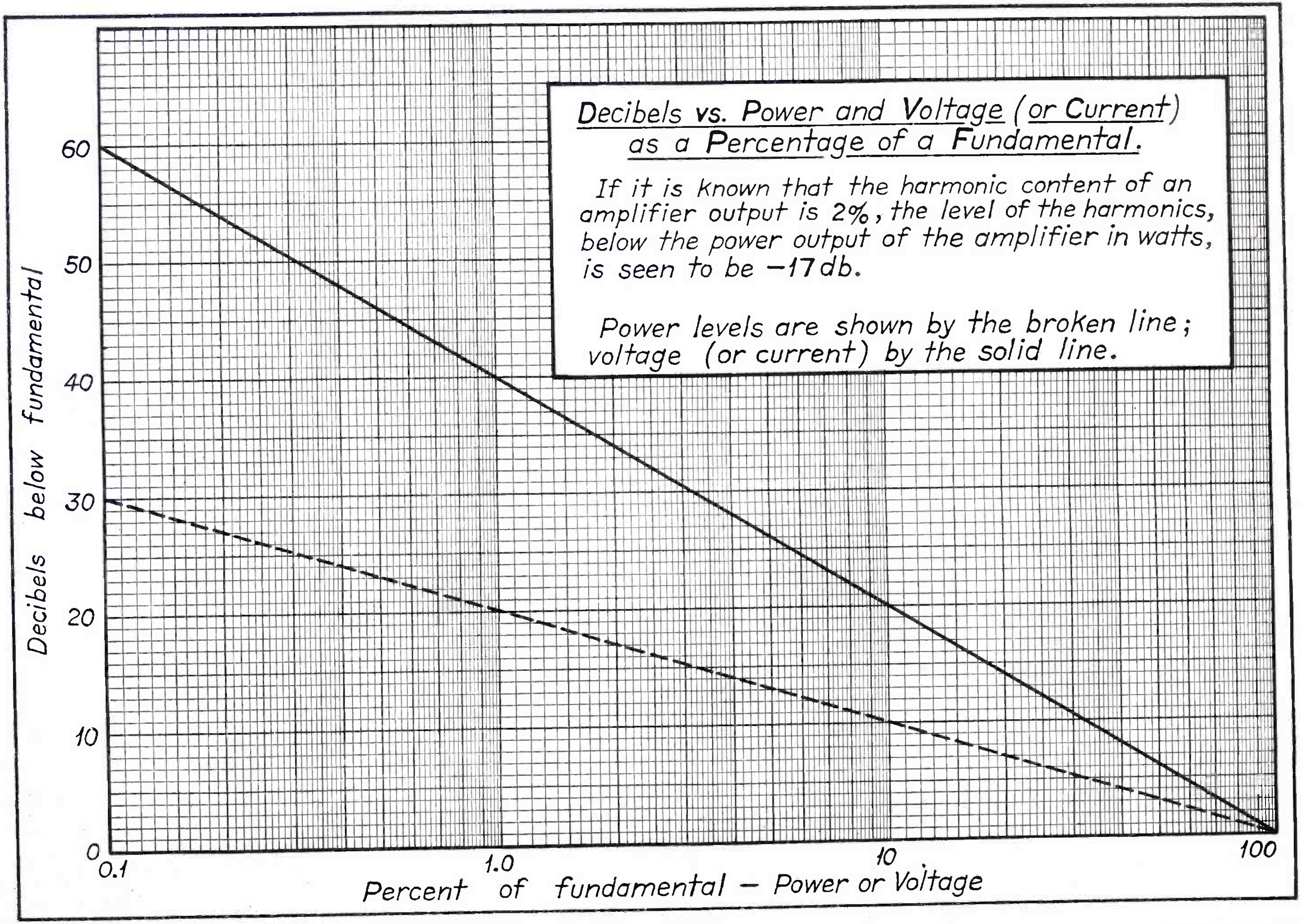

Decibels vs. Power and Voltage (or Current) as a Percentage of a Fundamental.
If it is known that the harmonic content of an amplifier output is 2%, the level of the harmonics, below the power output of the amplifier in watts, is seen to be −17 db.
Power levels are shown by the broken line; voltage (or current) by the solid line.
Decibels below fundamental
60
50
40
30
20
10
0
0.1
1.0
10
100
Percent of fundamental – Power or Voltage

NEW TUBES

THE FOLLOWING NEW tubes, with tentative characteristics as given in the tables, have been announced by the Raytheon Production Corp., Newton, Mass.

6S7G TRIPLE GRID SUPER CONTROL AMPLIFIER

Heater Rating

Heater Voltage .... 6.3 v
Heater Current .... 0.150 amp

Dimensions

Overall Length .... 4 1/2"
Maximum Diameter .... 1 9/16"

Base

Octal, 7 Pin

Pin 1—Not Connected	Pin 4—Screen
	Pin 5—Suppressor
Pin 2—Heater	Pin 7—Heater
Pin 3—Plate	Pin 8—Cathode

Cap—Control Grid

Bulb

ST-12 Grip Cap—Miniature

Interelectrode Capacitances
(With tight fitting shield)

Grid to Plate .... 0.007 max. mmfd
Input .... 4.6 mmfd
Output .... 7.8 mmfd

Operating Characteristics

Plate Voltage...	135	250	v
Screen - Grid Voltage	67.5	100	v
Grid Voltage ...	—3.0	—3.0	v
Suppressor......	Connect to cathode at socket		
Plate Current ...	3.7	8.5	ma
Screen-Grid Current	0.9	2.0	ma
Mutual Conductance	1250	1750	μmhos
Amplification Factor	850	1100	min
Grid Bias for Gm = 10	—25	—38.5	v

6D8G PENTAGRID CONVERTER

Heater Rating

Heater Voltage .... 6.3 v
Heater Current .... 0.150 amp

Dimensions

Overall Length .... 4 1/2"
Maximum Diameter .... 1 9/16"

Base

Octal, 8 Pin

Pin 1—Not Connected	Pin 5—Grid 1
	Pin 6—Grid 2
Pin 2—Heater	Pin 7—Heater
Pin 3—Plate	Pin 8—Cathode
Pin 4—Grids 3 and 5	Cap—Grid 4

Bulb

ST-12 Grip Cap—Miniature

Interelectrode Capacitances
(With tight fitting shield)

Oscillator Input .... 6.0 mmf
Oscillator Output .... 5.5 mmf
Oscillator Grid (1) to Anode (G2) .... 1.0 mmf
R-F Input .... 8.0 mmf
Mixer Output .... 11.0 mmf
Grid to Plate................ 0.3 mmf

Operating Characteristics

Plate Voltage..	135	250	v
Grid Voltage Eg2	135	250*	v
Grid Voltage Eg3-5	67.5	100	v
Grid Voltage Eg4	—3.0	—3.0	v
Oscillator Grid Gl (Leak)...	0.05	0.05	meg
Triode Gm (Egl = 0) ..	1150	1000	μmhos
Conversion Rp.	0.40	0.32	
Conversion Conductance .	325	500	
Grid Bias for Conversion Conductance = 10..	—25	—38.5	v
Cathode Current	8.0	13.0	ma

* Through a 20,000 ohm dropping resistor.

6Q6G SINGLE DIODE—HIGH-MU TRIODE

Heater Rating

Heater Voltage .... 6.3 v
Heater Current .... 0.150 amp

Dimensions

Overall Length .... 4 1/2"
Maximum Diameter .... 1 9/16"

Base

Octal, 6 Pin

Pin 1—Not connected	Pin 5—Diode Plate
Pin 2—Heater	Pin 7—Heater
Pin 3—Plate	Pin 8—Cathode

Cap—Grid

Bulb

ST-12 Grip Cap—Miniature

Interelectrode Capacitances
(With tight fitting shield)

Grid to Plate.............. 1.8 mmfd
Grid to Cathode........... 2.5 mmfd
Plate to Cathode.............5.2 mmfd

Operating Characteristics—Triode Section

Plate Voltage	135	250	v
Grid Voltage	—1.5	—3.0	v
Plate Current	0.9	1.2	ma
Mutual Conductance	1000	1050	μmhos
Amplification Factor ..	65	65	

Diode Unit

Equivalent to a single diode of a type 55 or 6B7.

6B8 DUO-DIODE PENTODE

Heater Rating

Heater Voltage .... 6.3 v
Heater Current .... 0.3 amp

Dimensions

Overall Length .... 3 1/8"
Maximum Diameter .... 1 5/16"

Base

Octal, 8 Pin

Pin 1—Shell	Pin 5—Diode Plate
Pin 2—Heater	Pin 6—Screen Grid
Pin 3—Plate	Pin 7—Heater
Pin 4—Diode Plate	Pin 8—Cathode

Suppressor Grid connected internally to Cathode.
Cap—Control Grid

Interelectrode Capacitances—Pentode

Grid to Plate.............. 0.005 mmfd
Input .... 6.0 mmfd
Output .... 9.0 mmfd

Operating Characteristics—Pentode
R-F or I-F Amplifier

Plate Voltage	250	max. v
Screen Voltage	125	max. v
Grid Voltage	—3	v
Plate Current	10.0	ma
Screen Current	2.3	ma
Plate Resistance	0.6	appx. meg
Amplification Factor.	800	appx.
Mutual Conductance.	1325	μmhos
Grid Voltage (Cut-off)	—21	appx. v

6N5 TUNING INDICATOR

Heater Rating

Heater Voltage .... 6.3 v
Heater Current .... 0.150 amp

Dimensions

Overall Length .... 4 1/8"
Maximum Diameter .... 1 9/16"

Base

Small 6 Pin

Pin 1—Heater	Pin 4—Target
Pin 2—Plate	Pin 5—Cathode
Pin 3—Grid	Pin 6—Heater

Bulb

ST-12

Operating Characteristics

Plate Supply Voltage...	135	v
Target Voltage.........	135	v
Series Triode Plate Resistor	0.25	meg
Triode Plate Current for Zero Grid Voltage....	0.5	ma
Triode Grid Voltage for Zero Degree Shadow.	—12	appx. v
Triode Grid Voltage for Ninety Degree Shadow	0	appx. v

(Continued on page 31)

THE GRAPHICAL SOLUTION OF SIMPLE PARALLEL-TUNED CIRCUITS†

by GEOFFREY BUILDER, Ph.D.

THERE DOES NOT appear to be available, at present, any particularly simple method of calculating the complex impedance of a parallel-tuned circuit. The ready solution of the impedance equation would of greater use in filter design. Moreover, plotting of the resonance curve of a parallel-tuned circuit and the full appreciation of the significance of the curves obtained would be greatly facilitated. To obtain a resonance curve corresponding to that found experimentally by measuring the ratio of voltage output across the circuit to the current flowing between the same points, without regard to phase, involves the calculation of the modulus of the impedance vector.

Zobel has used the device of conformal representation in the general cases met with in the theory of filter networks. Attention is also drawn to this device by the recent work of Bailey on the graphical solution of the equations for the propagation of waves in an ionized medium in the earth's magnetic field. Conformal representation may also be applied to the simple case of the parallel-tuned circuit and leads to interesting graphical solutions of the impedance equation.

The method to be used may be illustrated most simply by the following example:—

Let $Z = r + jx$ and $Y = g + jb$ be the complex impedance and admittance of any network. Then

$(r + jx)(g + jb) = 1$ .... (1)

It follows that

$r^2 + x^2 = r/g$ .... (2)

$r^2 + x^2 = -x/b$ .... (3)

Now (2) is the equation of a circle in the $r - x$ plane with centre on the r axis, having diameter 1/g and passing through the origin. Similarly, equation (3) is that of a circle of diameter — 1/b with centre on the x axis and passing through the origin. Choosing values of r as abscissae and those of x as ordinates, circles may be constructed for particular value of g and b, and these intersect at a point P of which the co-ordinates are the corresponding values of r and x, satisfying equation (1).

In Fig. 1, circles have been drawn for $g = 1$, $b = 1$. These intersect at a point P of which the co-ordinates are $r = 0{\cdot}5$, $x = -0{\cdot}5$. The angle which the vector OP makes with the r axis is clearly the phase angle of Z and in this case is $-\pi/4$. The length of OP is the modulus of Z. It may, therefore, be convenient to use polar co-ordinate paper for the construction of the figure if arg Z and mod Z are required. A useful chart may constructed by drawing a series of circles and marking off these circles in values of the reciprocals of their diameters. The choice of a suitable scale may be made to suit any particular purpose, but it may be noted that equation (1) may be written

$(r/A + jx/A)(Ag + jAb) = 1$ .... (4)

Thus any convenient scale multiplier may be used, providing that the inverse multiplier is applied to the components of the other factor of the equation.

Moreover, it is clear that equation (1) leads also to equations of circles in the $g - b$ plane, and these circles correspond to values of r and x. Thus the same chart may be used with either co-ordinates $r - x$ or $g - b$, as may be most convenient. In general, the chart makes the conversion of complex quantities to their reciprocals a very simple matter. This greatly simplifies the addition of impedances of arms in series and parallel connections, and is useful in the numerical calculations of the impedances of complex circuits.

Fig. 1

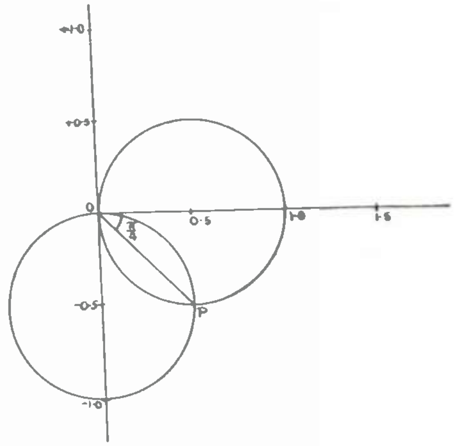
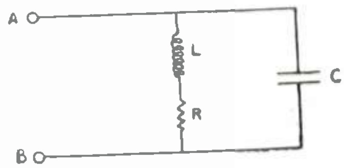


Fig. 2



With slight modification, this method is applicable to finding the complex impedance of a simple parallel-tuned circuit such as that of Fig. 2. R represents the resistance of the coil L and it is assumed that the condenser resistance is negligible. The impedance Z across the terminals AB is given by

$1/Z = j\omega C + 1/(j\omega L + R)$ .... (5)

It will be assumed that $d = R/\omega L$ is a constant, independent of frequency for any particular coil. The angular frequency of the applied emf is ω. Now equation (5) may be written

$[\omega Lg + j(\omega Lb - \omega^2/\omega_0^2)](j + d) = 1$ .... (6)

where $\omega_0^2 = 1/(LC)$.

Hence $-[\omega Lb - \omega^2/\omega_0^2] = 1/(1 + d^2)$ .... (7)

$\omega Lg = d/(1 + d^2)$

so that these quantities are constant for any one circuit. Their values may be computed when required, for any particular value of d, or values may be tabulated or graphed against values of d. Thus having obtained ωLg and $-(\omega Lb - \omega^2/\omega_0^2)$ from equation (7), the values of $-\omega Lb$ are readily found for various values of

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†Reprinted from Report No. 9 of the Radio Research Board, Council for Scientific and Industrial Research, Commonwealth of Australia.

THEORY OF THE LOUDSPEAKER
AND OF MECHANICAL OSCILLATORY SYSTEMS

Part II

by HANS RODER*

WHEN THE DIAPHRAGM of a loudspeaker is vibrating, it will generate sound waves. Electrical energy is thereby converted into mechanical energy, the latter appearing in the form of acoustical radiating energy. This energy is absorbed by the medium; it does not return to the membrane. The absorption of energy will load the diaphragm in a manner similar to the loading of a generator which works into an impedance. With an electrical radiator, electrical energy is supplied into the surrounding medium, and we attribute the ensuing energy loss to a fictitious resistance, namely, the radiation resistance. Analogously we describe the reaction which the surrounding, energy absorbing medium has upon a loudspeaker diaphragm by the introduction of a fictitious "radiation impedance."

With an electrical antenna we obtain certain directional effects, in case the dimensions of the radiator become comparable in size with one wavelength. In a very similar manner, a loudspeaker diaphragm will also display remarkable directional characteristics as soon as its diameter becomes of the order of one or more wavelengths.

In the course of this investigation, the term ρc will be required where (in approximate figures)

ρ ...... density of air $= 1.2 \,.\, 10^{-3}$ grams/cm^3

c ...... velocity of sound in air $= 3.4 . 10^4$ cm/sec

The term ρc is called the "acoustical impedance" of air; its dimension is $\frac{m}{sec}\frac{1}{cm^2}$. Its electrical analogue is the "surge impedance"

$$\sqrt{\frac{L}{C}} \text{ (dimension: ohm)}$$

ACOUSTIC RADIATION IMPEDANCE[1]

The analytical treatment of acoustical radiation involves much greater mathematical difficulties than the treatment of electrical radiation. This statement is best illustrated, when mentioning the fact that in acoustics only the case of a circular membrane located in an infinite wall has been solved. The solution of the corresponding electrical problem is known for a very large number of various radiator types.

While a detailed computation of the radiation impedance of a circular membrane is outside the scope of this article, a brief outline of the method employed may be useful. The assumption is made that the diaphragm covers a circular opening in an infinite wall: that the medium on both sides of the wall be unlimited; and that the diaghragm proper have neither mass nor compliance. Hence, the diaphragm resembles a stiff piston or a "plunger." The surface of the diaphragm is supposed to be completely covered with small acoustic radiators, each covering an area dS and vibrating with an amplitude x_0, thereby radiating a spherical wave. It then can be computed, how much pressure the wave which is generated by the vibrating element dS_1 will exert upon a second surface element, dS_2. Integrating overall dS_1's will yield the total pressure exerted upon dS_2, and then integrating over all dS_2's, (and multiplying by $\frac{1}{4}\pi D^2$), will result in the total force with which the air is reacting upon the diaphragm. The result is (for *one* side of the piston):

$$\frac{\text{total force reacting on diaphragm}}{\text{velocity of diaphragm}} = z$$

$$= \rho c \frac{1}{4} \pi D^2 (X + j\omega Y') \text{ grams/sec} \quad \text{......... (9)}$$

where

z ...... mechanical impedance into which the force is working. The force reacting on the diaphragm is not in phase with the velocity. This is in analogy to the electrical case: the voltage drop measured at the input terminals of an electrical network is, in general, not in phase with the driving current.

D ..... diameter of diaphragm, in cm.

$$X = 1 - \frac{1}{\frac{1}{2}\alpha} J_1(\alpha) = \frac{1}{2}\left(\frac{\alpha}{2}\right)^2 - \frac{1}{2^2.3}\left(\frac{\alpha}{2}\right)^6 + \frac{1}{2^2.3^2.4}\left(\frac{\alpha}{2}\right)^6 \quad \text{............ (10)}$$

$$Y' = \frac{1}{3}\frac{4}{\pi}\frac{1}{c} D \left(1 - \frac{\alpha^2}{3.5} + \frac{\alpha^4}{3.5^2.7} - \frac{\alpha^6}{3.5^2.7^2.9} + \dots\right)$$

$$\alpha = 2\pi \frac{D}{\lambda}. \quad \text{............ (11)}$$

*Radio Receiver Engineering Section, General Electric Co., Bridgeport, Conn.

[1] I. B. Crandall, "Theory of Vibrating Systems and Sound." Secton 42.

$J_1(z)$ . . . Bessel function of the first **kind, order one,** argument z.

The functions X and Y′ are shown in Chart I as functions of D/λ. The term

$$\rho c \frac{1}{4} \pi D^2 X = r$$

has the dimension "grams/sec"; i.e., of a mechanical resistance. The term

$$\rho c \frac{1}{4} \pi D^2 Y' = m_a$$

has the dimensions of "grams." We can write

$$z = r + j\omega m_a \qquad \ldots\ldots\ldots\ldots (12)$$

The acoustical power absorbed from the piston in form of radiation is $v^2 r$, if v is the rms velocity of the piston and r is the "radiation resistance." The term $\omega m_a = Y$ is a reactance; this reactance is a function of frequency and is also shown on Chart I. The air in the immediate vicinity of the piston surface is following the vibrations of the piston, hence the mass of the air acts like loading the diaphragm with a concentrated mass m_a. The mass m_a adds to the mass of the diaphragm proper; therefore the term $\rho c \frac{1}{4} \pi D^2 Y' = m_a$ is called "accession to inertia."

We shall see later that a loudspeaker diaphragm can be considered as a stiff piston only up to a certain, rather low frequency, say 500 cycles. Consequently in most practical cases, it is sufficient to take only the first terms in the power series of (10) and (11). We then have:

$$r = \rho c \frac{1}{4} \pi D^2 \cdot \frac{1}{2} \left(\pi \frac{D}{\lambda} \right)^2 = \frac{1}{2} \frac{\rho}{c} \frac{\pi^3}{4} f^2 D^4 \frac{\text{ergsec}}{\text{cm}^2}$$

$$= \frac{1}{2} \frac{\rho}{c} \frac{\pi}{16} \omega^2 D^4 \qquad (13)$$

$$m_a = \rho c \frac{1}{4} \pi D^2 \cdot \frac{1}{3} \frac{4}{\pi} D \frac{1}{c} = \frac{1}{3} \rho D^3 \text{ grams} \ \ldots\ldots\ldots\ldots (14)$$

Equation (13) shows that the radiation resistance is proportional to the square of the frequency and to the 4th power of the diaphragm diameter. The "accession to inertia" is proportional to D^3. Equation (14) permits an interesting interpretation of m_a. $\frac{1}{3} D^3$ is the volume of a pyramid with square base whose height and base sides equal D. Consequently $m_a = \frac{1}{3} \rho D^3$ is the mass of the air contained in that pyramid, as illustrated in Fig. 5. This mass is by no means negligible. For instance, for a 10″ (25 cm) diaphragm, we have $m_a = 6.2$ grams for each side, or a total of 12.4 grams for both sides. That is almost twice the mass of an average 10″ loudspeaker diaphragm inclusive of the voice coil.

In all practical cases both sides of the diaphragm are exposed to air; hence radiation and accession to inertia take place on both sides of the diaphragm. Consequently, the right-hand sides in equations (9), (12), (13) and (14) must be multiplied by 2.

DIRECTIONAL CHARACTERISTICS OF A CIRCULAR DIAPHRAGM

The method which we shall use for computing the directional characteristic of a circular diaphragm in an infinite wall, is applicable for this case only. A corresponding solution for the case of a conical diaphragm is not known.

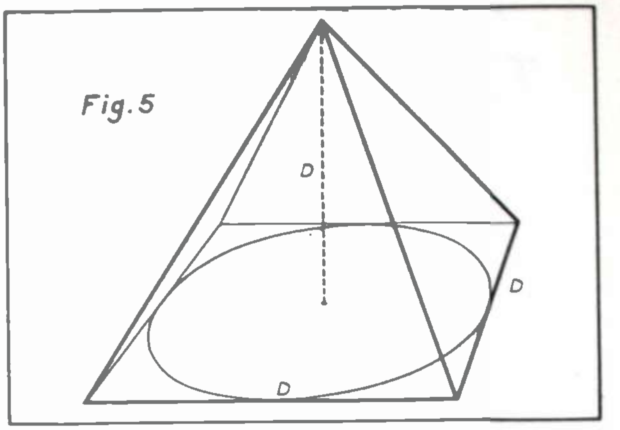


Fig. 5

As in the preceding section we assume the diaphragm to consist of a great number of small acoustic radiators, each radiating a spherical wave. The intensity of the elementary wave element is proportional to the vibrating area, thus

$$dI_r = I \text{ x } d\phi \text{ dx } \sin\omega \left(t - \frac{r_x}{c} \right)$$

where

I is a reference intensity at the membrane
c is the velocity of sound
ω is the radian freqency of the diaphragm vibration.

The significance of the remaining magnitudes can be seen from Fig. 6. The various wave elements have, for a given direction r, certain phase differences. It is convenient to measure all phase differences with reference to the radius vector r, which passes through the diaphragm center. The path difference for the directions r and r_x equals dr. Consideration of Fig. 6a yields for dr:

$$dr = r - r_x = x \cos\Theta \cos(\phi_0 - \phi).$$

By substitution

$$dI_r = I \text{ x dx } d\phi \sin\omega \left(t - \frac{1}{c} (r - x \cos\Theta \cos(\phi_0 - \phi) \right)$$

The total intensity will be obtained if we integrate over the whole surface of the diaphragm:

$$I_r = \int_{x=0}^{x=\frac{1}{2}D} \int_{\phi=0}^{\phi=2\pi} I \text{ x } \sin\left(\omega t_1 + 2\pi \frac{x}{\lambda} \cos\Theta \cos(\phi - \phi_0)\right) d\phi dx,$$

wherein we have put

$$\omega \left(t - \frac{r}{c} \right) = \omega t_1 .$$

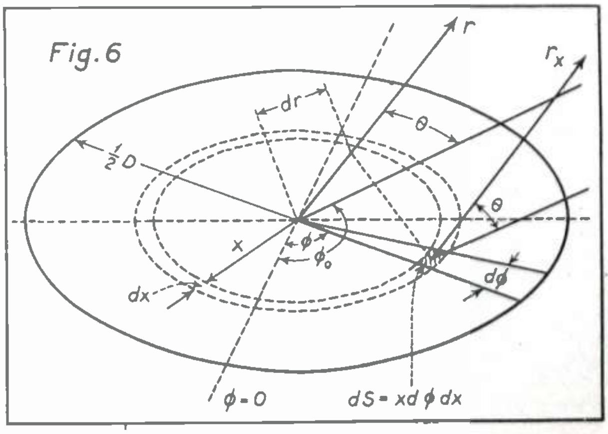
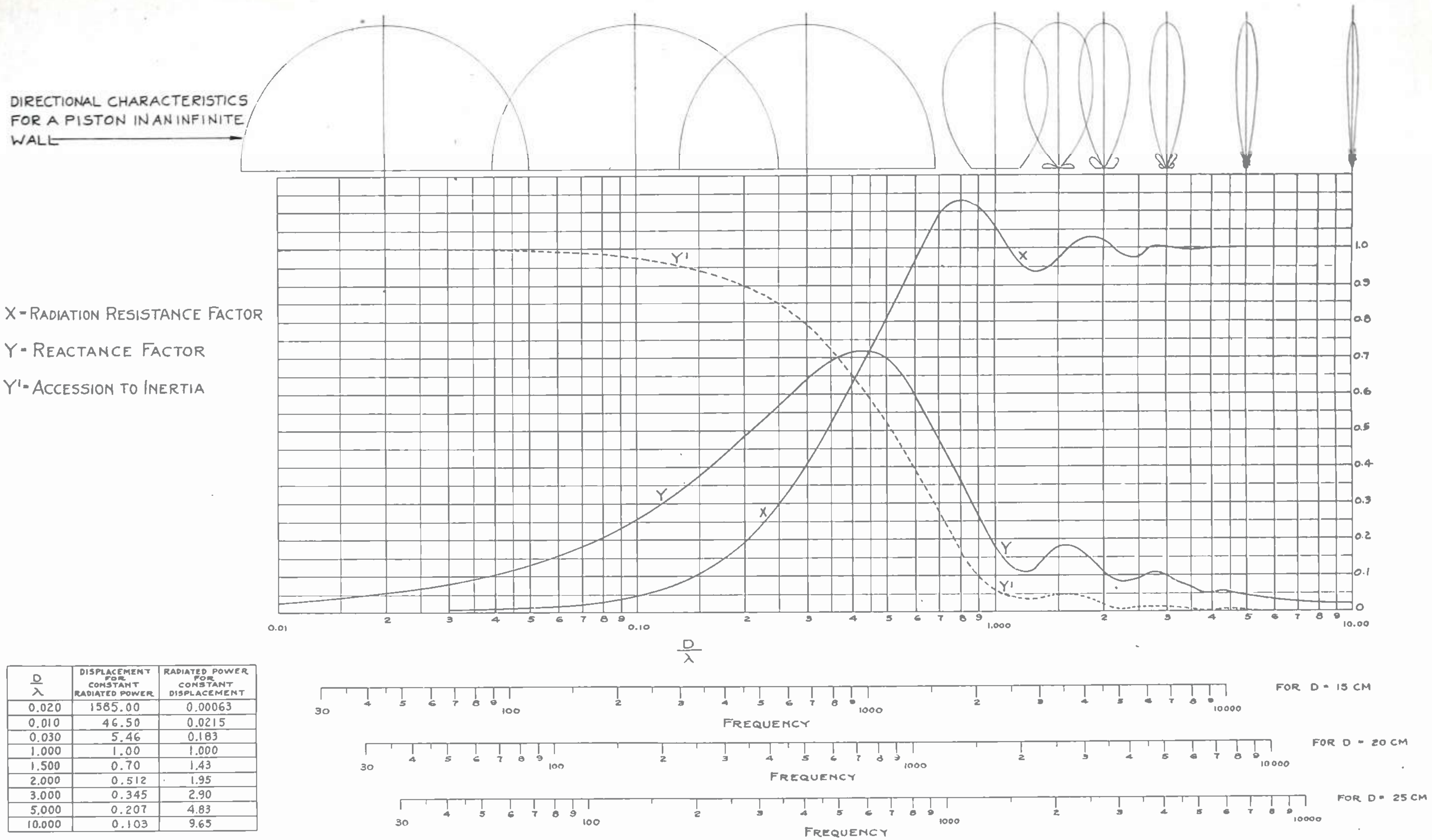


Fig. 6



D/λ	DISPLACEMENT FOR CONSTANT RADIATED POWER	RADIATED POWER FOR CONSTANT DISPLACEMENT
0.020	1585.00	0.00063
0.010	46.50	0.0215
0.030	5.46	0.183
1.000	1.00	1.000
1.500	0.70	1.43
2.000	0.512	1.95
3.000	0.345	2.90
5.000	0.207	4.83
10.000	0.103	9.65

CHART I

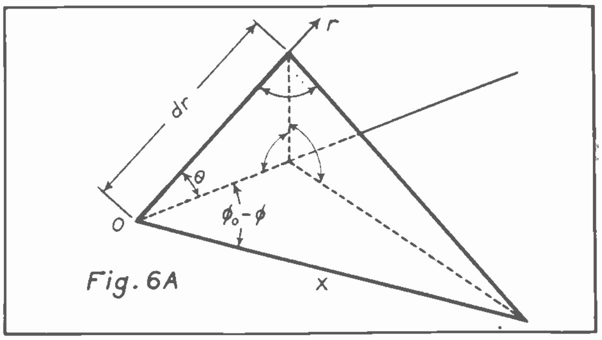


Fig. 6A

Let

$$2\pi \frac{\lambda}{\lambda} \cos\theta = 2\sqrt{y}\,.$$

We then have

$$I_r = \iint I\,x\,(\sin\omega t_1 \cos(2\sqrt{y}\cos(\phi-\phi_0)) + \cos\omega t_1 \sin 2\sqrt{y}\cos(\phi-\phi))\,d\phi dx\,.$$

From the theory of Bessel's functions, the following relations are known:

$$\cos(z\cos x) = J_0(z) - 2J_2(z)\cos 2x + 2J_4(z)\cos 4x \ldots$$
$$\sin(z\cos x) = 2J_1(z)\cos x - 2J_3(z)\cos 3x + 2J_4(z)\cos 5x \ldots$$

By using these relations for integration with reference to ϕ, we find

$$\int_0^{2\pi} \cos(2\sqrt{y}\cos(\phi-\phi_0))\,d\phi = 2\pi J_0(2\sqrt{y})\,.$$

$$\int_0^{2\pi} \sin(2\sqrt{y}\cos(\phi-\phi_0))\,d\phi = 0\,.$$

where $J_0(2\sqrt{y})$ is the zero order Bessel function, first kind, argument $2\sqrt{y}$.

We further can make use of the following simplifications:

(a) $$\left(\frac{\pi}{\lambda}\cos\theta\right)^2 x^2 = y, \quad \text{hence}$$
$$\left(\frac{\pi}{\lambda}\cos\theta\right)^2 2x dx = dy$$

(b) $$\text{for } x = \frac{1}{2}D \ldots y = y_0 = \frac{\pi^2 D^2}{4\lambda^2}\cos^2\theta$$

(c) $$J_0(2\sqrt{y}) = 1 - \frac{y}{1.1} + \frac{y^2}{1.2.1.2} - \frac{y^3}{1.2.3.1.2.3} + \ldots$$

We then obtain for I_r:

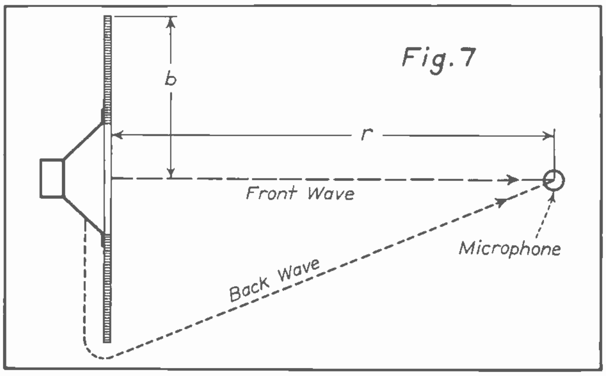


Fig. 7

$$I_r = 2\pi I \sin\omega t_1 \int_0^{y_0} \frac{\lambda^2}{2\pi^2\cos^2\theta}\left(1 - \frac{y}{1.1} + \frac{y^2}{1.2.1.2} - \frac{y^3}{1.2.3.1.2.3}\right)dy$$
$$= I\sin\omega t_1 \int_0^{y_0} \frac{\pi D^2}{4}\frac{1}{y_0}\left(1 - \frac{y}{1.1} + \frac{y^2}{1.2.1.2} - \frac{y^3}{1.2.3.1.2.3} + \ldots\right)dy$$

This can now be readily integrated. The operation yields

$$I_r = \pi\frac{D^2}{4} I \sin\omega t_1 \left(1 - \frac{1}{2}\frac{y_0}{1.1} + \frac{1}{3}\frac{y_0^2}{1.2.1.2} - \frac{1}{4}\frac{y^3}{1.2.3.1.2.3} + \ldots\right)$$

The bracketed term, however, is equal to

$$\frac{1}{\sqrt{y_0}} J_1(2\sqrt{y_0})$$

and the final result becomes

$$I_r = \pi\frac{D^2}{4}\,.\;I\sin\omega t_1 \left[\frac{1}{\frac{1}{2}\pi\frac{D}{\lambda}\cos\theta} J_1\left(\pi\frac{D}{\lambda}\cos\theta\right)\right] \ldots\ldots (15)$$

The bracketed term in (15) is the radiation characteristic of the round piston in an infinite wall. Comparing this term with equation (10) it is seen that

$$1 - X = \frac{1}{\frac{1}{2}\pi\frac{D}{\lambda}\cos\theta} J_1\left(\pi\frac{D}{\lambda}\cos\theta\right) \ldots\ldots\ldots\ldots (16)$$

if we take $\alpha = 2\pi\frac{D}{\lambda}\cos\theta$. Hence, the radiation characteristic can be determined from the attached chart by taking $1 - X$ for various values of $\pi\frac{D}{\lambda}\cos\theta$.

If we evaluate (16) and plot the result in polar coordinates, we obtain, for low frequencies a semi-spherical radiation characteristic. As the frequency increases, the spherical wave tends to develop into a plane-parallel wave. For $\pi\frac{D}{\lambda} = 3.8$ there is zero radiation along the wall. For still higher frequencies, pronounced beam radiation begins to take place, simultaneously with the formation of smaller parasitic lobes. A number of radiation patterns is shown along the top of the attached chart for various values of $\frac{D}{\lambda}$.

With a loudspeaker diaphragm, i.e., with a diaphragm which has distributed mass and compliance, the beam effect treated above is somewhat obscured by the fact that above a certain frequency not all parts of the diaphragm move in synchronism[2]. But experience has shown that even under these conditions, a very pronounced beam effect is present at the higher frequencies.

BAFFLE EFFECTS

In the preceding section we have considered that the vibrating diaphragm be located in an infinite wall. In practice, this infinite wall has to be approximated by a baffle of finite dimensions. With any practical loudspeaker diaphragm, the waves generated at the front and back of the diaphragm are 180° out of phase. If there is no baffle at all, then the excess pressure generated at the diaphragm front will be compensated by the vacuum generated at the diaphragm back. In other words, the baffle has the purpose of separating the front and back waves which tend to cancel each other. The larger the baffle, the better it can perform this function.

When using a finite baffle, then at certain frequencies, the combined effect of front and back waves will provide addition or cancellation at the recording microphone.

This effect can be explained as follows: Calling b the average radius of the baffle and r the distance between baffle and microphone, the sound pressure at the microphone is contributed by two incident waves, the one being the direct wave, the other one being the back wave diffracted around the edge of the baffle. Assuming equal amplitudes, the intensities due to each wave are:

$$i_1 = A \sin \omega \left(t - \frac{r_1}{c} \right)$$

$$i_2 = - A \sin \omega \left(t - \frac{r_2}{c} \right)$$

r_1 and r_2 are the length of path for each wave. Since

$$r_1 = r \,,$$
$$r_2 = b + \sqrt{r^2 + b^2} \,,$$

we get for the path difference dr:

$$dr = b + \sqrt{r^2 + b^2} - r$$

[2]M. J. O. Strutt; Annalen d. Physik; Vol. 16, 129, 131.

The resulting intensity I becomes zero if the path difference dr equals an integer number of wavelengths:

$$b + \sqrt{r^2 + b^2} - r = \lambda,\ 2\lambda,\ 3\lambda \quad \text{.......................... (17)}$$

The intensity I becomes a maximum if dr equals an odd number of half wavelengths:

$$b + \sqrt{r^2 + b^2} - r = \frac{1}{2}\lambda;\ \frac{3}{2}\lambda;\ \frac{5}{2}\lambda \quad \text{.................... (18)}$$

Under practical conditions, the intensities of back and front wave at the microphone are not equal. At the higher frequencies where the loudspeaker characteristic becomes more directional, the effect of the backwave becomes negligible at the microphone. Hence in equation (17) and (18) only the values 1λ and ½λ, respectively, on the right hand are of interest. The effect is very pronounced with a round baffle, with the loudspeaker in the center.

In the following table a number of calculated and measured values are compared. f_0 indicates the frequency at which the interference dip occurs; i.e. the lowest frequency at which I (equation 17) becomes zero.

Baffle 2b	Mic. Distance r	f_0 cycles	
		Calculated	Measured
2½'	2'	684	670
2½'	3'	743	740
2½	4'	768	760
4'	3'	428	440
46 cm	122 cm	1,350	1,400

(To be continued)

THE GRAPHICAL SOLUTION OF SIMPLE PARALLEL-TUNED CIRCUITS

(Continued from page 20)

ω^2/ω_0^2, while ωLg is constant. g and b are readily computed from these values so that $Y = g + jb$ is determined. $Z = r + jx$ is then found by the method discussed in connection with equation (1). Alternatively, it may be convenient to use the equation

$$(\omega Lg + j\omega Lb)\ (r/\omega L + jx/\omega L) = 1$$

in the same way, thus obtaining directly from ωLg and $-\omega Lb$ the corresponding values of $r/\omega L$ and $x/\omega L$. It frequently happens that the variation of ωL over the range being investigated can be ignored to obtain approxivalues of Z as in the delineation of the resonance curve of a sharply tuned circuit in the neighborhood of the resonance frequency. For special cases it may be convenient to draw charts in which values of the variables are actually chosen and marked off to suit the particular problem.

This method is rigorous, subject to the assumption that d is a constant, and the numerical solution shows clearly the distinction between the conditions of resonance and zero power factor. A considerable simplification follows if this can be neglected. Equation (7) shows that for values of d less than 0.1 the values of $-(\omega Lb - W^2/\omega_0^2)$ and ωLg do not depart from unity and d, respectively, by more than 1 per cent. Neglecting R^2 in comparison with $\omega^2 L^2$, equation (5) may be written

$$\omega L/Z = j\omega^2/\omega_0^2 + 1/(j + d)$$

$$\text{i.e. } \omega L/Z = j\omega^2/\omega_0^2 + d - j$$

$$\therefore\ (r/\omega L + jx/\omega L)\ [d + j\,(\omega^2/\omega_0^2 - 1)] = 1 \quad (8)$$

Thus the method used in connection with equation (1) is directly applicable. With values of $r/\omega L$ as abscissae and of $x/\omega L$ as ordinates, circles correspond to values of d and $(\omega^2/\omega_0^2 - 1)$ respectively. Values of

$$-1/(\omega^2/\omega_0^2 - 1)$$

may be conveniently tabulated or graphed against ω/ω_0 and are applicable for all values of ω_0.

A chart, constructed as indicated in Fig. 1, has a wide range of usefulness, particularly as scale multiplication is permissible. A little ingenuity enables the construction of convenient charts for particular purposes, and for these the actual values of the variables may be marked off in the chart. A useful chart based on equation (8) is an example. Values of $r/\omega L$ are taken from zero to 150, and values of $x/\omega L$ from -150 to $+150$, i.e., for values of coil mangification from 0 to 150. Circles are also drawn for values of ω/ω_0 from 0.8 to 1.2. The use of the chart is simple. The circle corresponding to the particular value of d is chosen and its points of intersection with the circles corresponding to ω/ω_0 give the values of r/L and $x/\omega L$, or of mod $Z/\omega L$ and arg Z, if polar coordinate graph paper is used.

These methods are useful in that the phase angle, modulus, and components of an admittance or impedance are readily obtained and the charts generally indicate the physical significance of the quantities found. For example, they illustrate clearly the similarity of resonance curves of a parallel-tuned circuit for all values of ω_0 when d is the same and Z is considered in relation to ω/ω_0.

This work has been carried out in connection with the work of the Radio Research Board of the Council of Scientific and Industrial Research. The author is indebted to Professor J. P. V. Madsen, Chairman of the Board, for his continued assistance and interest in the work, and to Associate-Professor V. A. Bailey for his suggestions and criticism.

RMA NEWS

MANY NEWSPAPERS ADD SHORT-WAVE PROGRAMS; NEW FOREIGN SERVICE

More than 800 daily newspapers, including those of metropolitan centers, are now receiving the RMA service of short-wave programs and news. Foreign newspapers also are beginning publication of the expanded service of the RMA which is sending abroad weekly, through the Department of Commerce, the advance programs of all American short-wave stations. This program promotion service, ordered expanded by the RMA Board of Directors at the Association's recent convention in Chicago, now includes a comprehensive service of short-wave program material for the press of the entire world. For the information of RMA members, there is enclosed a pamphlet prepared by the RMA Service Bureau detailing the program service supplied to the American press without charge.

An increase of over 25 percent during the last year in the use by American daily newspapers of the RMA short-wave program service has been recorded. This promotion service was instituted two years ago and the short-wave programs are now an established feature of the leading American press. The new short-wave program service to foreign countries was inaugurated June 1 through cooperation of the Department of Commerce, whose commercial attaches abroad are developing its use by foreign newspapers and other foreign interests.

PRESIDENT MUTER COMPLETES RMA REORGANIZATION

Appointment by President Muter of all RMA committee chairmen followed promptly the RMA Twelfth Annual Convention at Chicago last month. The activities of RMA have proceeded without lost motion and all important functions are going forward.

The RMA Credit Committee organization was continued with reappointment by President Muter of Arthur Moss of New York City as chairman, and continuance of Ed. Metzger of New York City as vice chairman of the eastern committee, and P. C. Lenz of Chicago as vice chairman of the western committee.

Dr. W. R. G. Baker of Bridgeport is continued as chairman of the RMA Engineering Committee and of all Association engineering activities. Virgil M. Graham of Emporium, Pa., is continued as chairman of the Standards Section, and the entire engineering personnel of the Association, through various groups, is engaged upon many technical services for the industry.

A. H. Gardner of Buffalo is the new chairman of the RMA Legislative Committee. He succeeds Paul B. Klugh of Chicago who has retired from the RMA Board of Directors after many years of valuable service in connection with legislation affecting the industry.

The RMA Membership Committee also has been reorganized and enlarged. Paul V. Galvin of Chicago is the new committee chairman. A vice chairmanship for eastern activities was created and N. P. Bloom of Louisville appointed. Henry C. Forster of Chicago was appointed vice chairman of the western membership committee.

Traffic affairs continue under the chairmanship of J. C. Warner of Harrison, N. J., and O. J. Davies of Camden, N. J., as vice chairman.

Special RMA committees include the Fair Trade Practice Committee headed by E. F. McDonald, Jr., of Chicago, chairman, while James M. Skinner of Philadelphia continues as chairman of the special RMA committee on television and also of another committee in charge of the pending proceedings before the Federal Trade Commission.

RMA COMMITTEE CONSIDERS MANY MERCHANDISING PROBLEMS

Definite progress toward improvement of radio merchandising is being made through the activities of the new fair trade practice committee, of which E. F. McDonald, Jr. of Chicago is chairman, which was established at the recent RMA convention in Chicago. Chairman McDonald and his committee, including James M. Skinner of Philadelphia; E. T. Cunningham of Camden, N. J.; C. E. Wilson of Bridgeport, Conn., and F. W. Gigax of Fort Wayne, Indiana, held another meeting July 8 at the Waldorf-Astoria Hotel in New York. Production problems, including dumping, "spiffs," sales contests, inventory control and many other problems were considered by the committee and progress made toward improved merchandising practices. Another meeting of the committee will be held in August and September to secure additional data and consider further plans.

RADIO OWNERSHIP SURVEY

RMA members are being sent a recent survey regarding ownership of radio sets. This gives data by states and counties. It was prepared by the Joint Committee on Radio Research which is sponsored by the American Association of Advertising Agencies, the Association of National Advertisers, and the National Association of Broadcasters, with cooperation from some of the larger companies of RMA.

NEW ZEALAND TARIFF INCREASED

Information to RMA that New Zealand was planning to increase its tariff on radio is confirmed but the proposed higher duties will not discriminate against American radio, according to information to the RMA from the U. S. Department of State. In response to an RMA protest on behalf of American manufacturers, the State Department has advised the RMA Export Committee that "the rumor seems to be correct that a higher import duty on radio equipment is under contemplation (by New Zealand) but there is no confirmation that these duties would be applied exclusively to American merchandise." In explaining that the State Department cannot protest a general tariff increase by any government, in its letter to the RMA the State Department added:

"Naturally, the Department is concerned over any new restrictions to international trade, as these constitute a threat to the progress of world trade recovery which can be obtained only by curtailment of such restrictions. You may be sure that no effort will be spared by this Government to promote trade recovery by seeking the cooperation of other governments in its own trade program."

It is understood that the proposed general tariff increases contemplated by the new government of New Zealand are planned to protect local industry and to compensate for increased local cost of manufacture resulting from changes in New Zealand labor regulations. The New Zealand Government is reported to be leaning more and more toward a high tariff policy.

RMA AND NAB WILL STUDY PLAN FOR RADIO "FOUNDATION"

The RMA and the National Association of Broadcasters will continue efforts to develop some plan for a "Radio Industry Foundation" to provide annual awards for broadcasting achievements. The NAB held its annual convention at the Stevens Hotel, Chicago, July 6-8, and its officers held conferences with President Muter and Bond Geddes, executive vice president-general manager of RMA, on the industry award plan.

At Chicago the broadcasters had a most successful convention with a large attendance. C. W. Myers of Staton KOIN, Portland, Oregon, was elected president of the NAB, to succeed Leo J. Fitzpatrick of Station WJR, Detroit, and James W. Baldwin was reelected managing director of the Association.

MARCH, 1936, LABOR INDICES

A slight seasonal decline was reflected in the latest labor report, for March 1936, of the U. S. Department of Labor, Bureau of Labor Statistics. Radio manufacturing companies reported an increase in average hourly earnings of employees, but a small decrease in employment and payrolls.

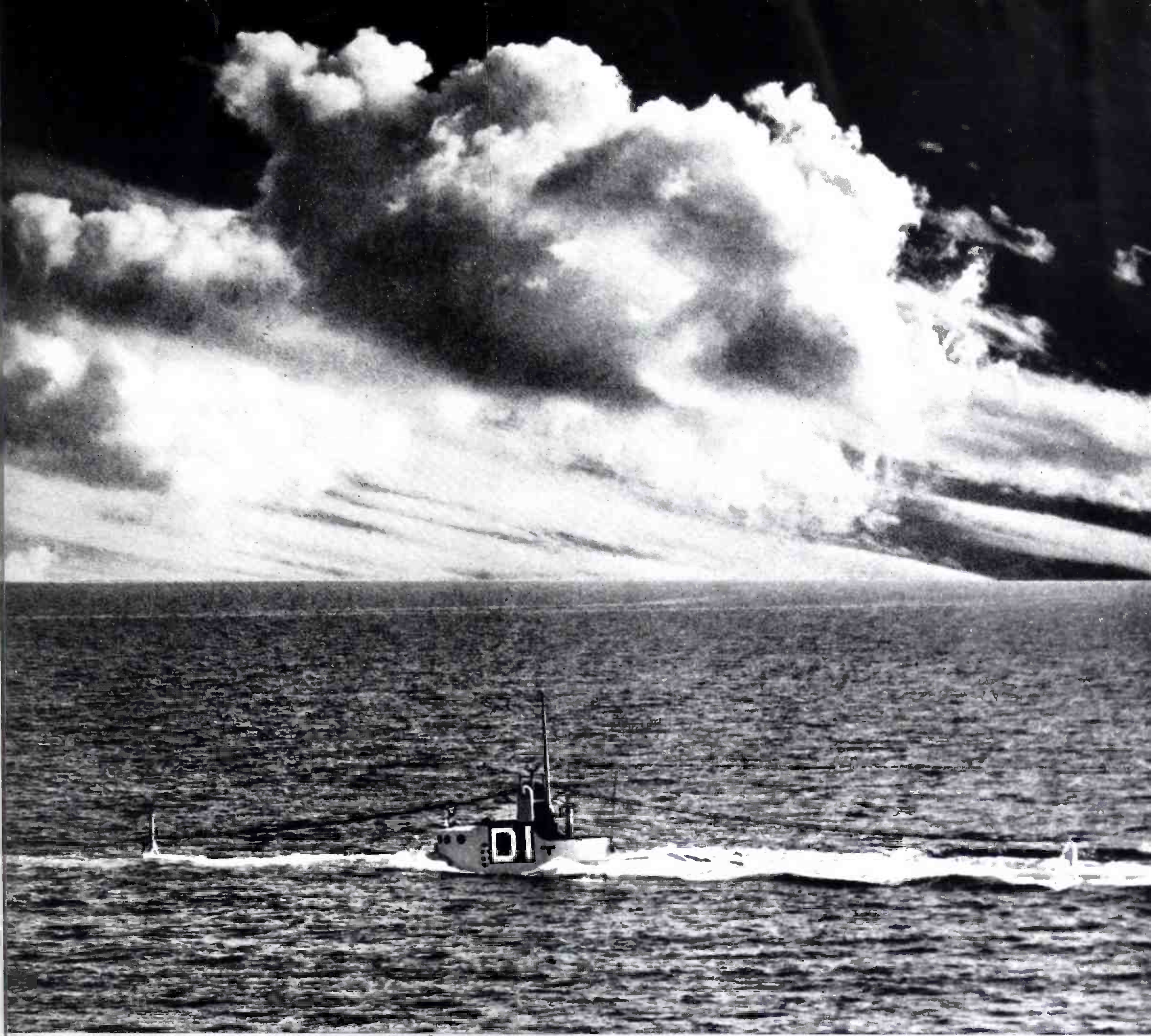
The March report of the Government showed a decrease in radio factory employment of 5.1 percent compared with the previous month of February, and a decrease of 1.5 percent from employment in March 1935. Compared with the three-year official average of 1923-25, however, the March index figure was 186.1 or 86.1 percent above the three-year average.

Radio factory payrolls in March 1936 were down 3.8 percent compared with the previous month of February, but only .9 percent below payrolls of March 1935, and the March index compared with the three-year average was 109.7 percent.

Average weekly earnings in radio factories last March were $18.23, an increase of 1.4 percent over February payrolls and .9 percent over payrolls of March 1935. Average employee hours worked per week in radio factories last March were 33.4 hours, an increase of 1.9 percent over February and 1.3 percent over March 1935.

Average hourly earnings during March of radio factory employees were 54.7 cents,

(Continued on page 32)



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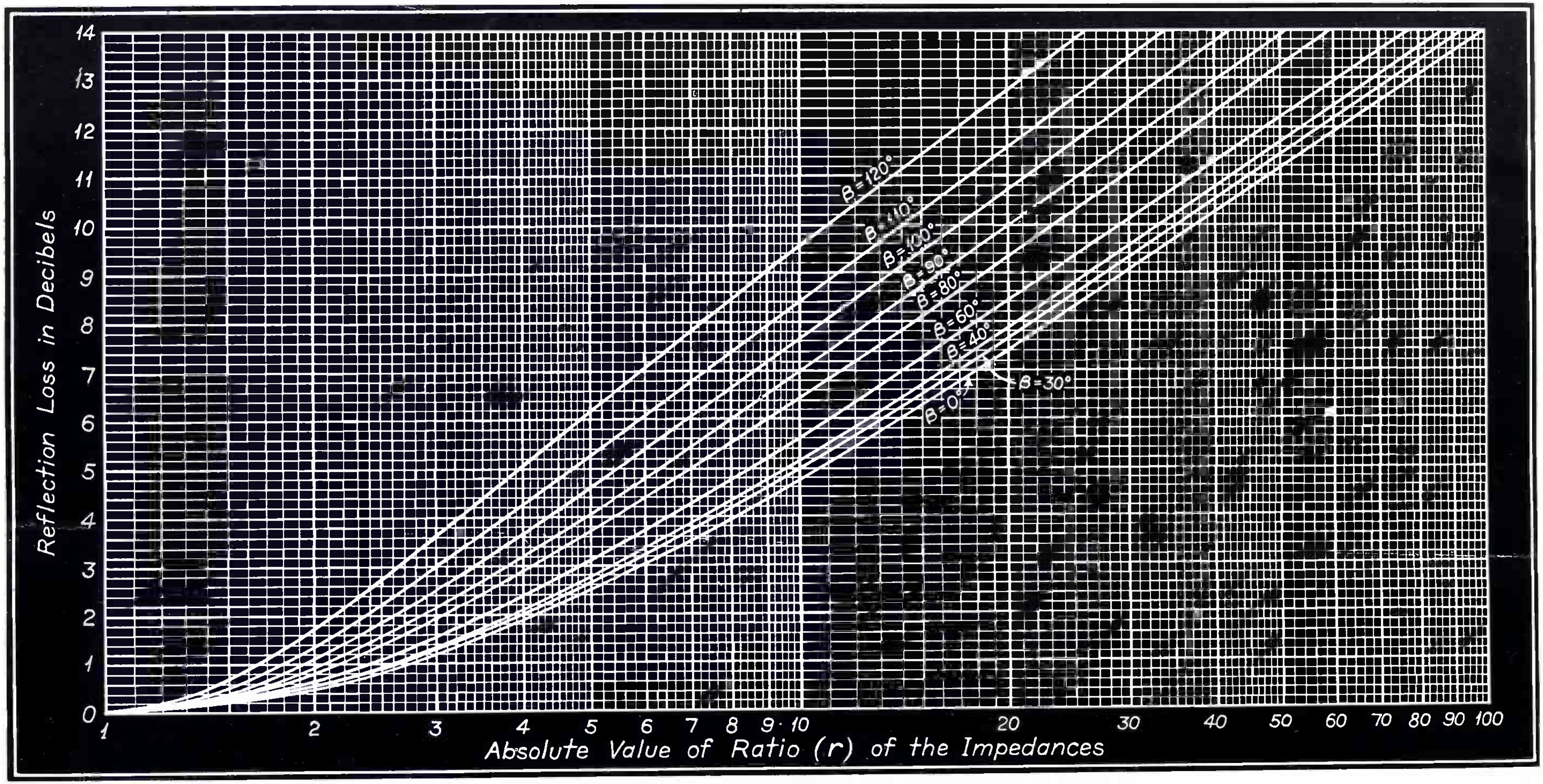

The curves show the loss, in decibels, resulting from a mis-match of circuit impedances, as, for instance, connecting a 200-ohm line to a 500-ohm amplifier input.

The chart is a plot of the equation:

$$\text{Loss (in db)} = 10 \log_{10} \left[1 + \frac{(1 - r)^2}{4r \cos^2 \frac{\beta}{2}} \right]$$

Losses for values of β not given on the chart may be found by use of this equation.

Example of the use of the chart: Assume that a circuit having an impedance of $500\underline{/-30^\circ}$ is connected to a circuit with an impedance of $4000\underline{/110^\circ}$. Adding the angles algebraically, we find $\beta = 80^\circ$. The ratio r of the absolute values of the impedances is $4000/500 = 8$. From the chart, at the intersection of $\beta = 80^\circ$ and $r = 8$, is read the loss, 5.57 db, on the left ordinate.

HIGH-FIDELITY TRANSFORMERS SHIELDING CONSIDERATIONS

THERE ARE PROBABLY an innumerable list of characteristics which are not desired in an audio transformer. Among these is the notorious tendency for the transformers—of course, reactors used in a-f circuits "enjoy" the same tendencies as transformers—to be sensitive to extraneous magnetic fields, i. e., to have hum voltages, due to the fields of power supply equipment, induced in the windings. Another is electrostatic coupling between windings which allows the transformer to pass on longitudinal signals picked up from associated apparatus. One method of taking care of the first mentioned difficulty would be to remove the sources to the next room, but this is usually not feasible, and since nothing of that sort is very satisfactory, some other way must be found.

Shielding the unit would help; this has been tried by many, but it was found that cases with walls of the order of an inch or so in thickness would be necessary, especially if the transformer was to be used at low levels.

Much has been written about the popular hum balancing type of core construction and, although this method has worked satisfactorily, there are many features in its design which must be considered if it is to be truly efficient. With this system, however, it is essential that, for exact cancellation of the field in each part of the winding, the core and coils be symmetrical in every respect—turns, physical dimensions, etc.—and the further restriction of a uniform external field must be imposed.

The final answer seems to lie in a combination of the above mentioned methods. By using a cast case of high permeability metal, with wall thickness of 1/8", along with the so-called hum balancing construction, the mutual effectiveness of the two gives the desired result. The cast case obviates difficulties due to the magnetic reluctance of the seams of a drawn case, which, even with welded seams has an appreciable reluctance.

With the cast case, the top is integral with the sides, the bottom of the case being the only separate piece. This insures a symmetrical case in which the only point of increase in reluctance is where the bottom of the case attaches; and with an appreciable contact area, aided by a ground fit, the reluctance is kept to a very low value. The symmetry of the case keeps the fields inside the case uniform at the juncture.

MERWYN HEALD,
Chief Engineer, Thordarson Electric Mfg. Co.

NEWS OF THE INDUSTRY

BRUSH DATA SHEET

The Brush Development Company, East 40th Street at Perkins Avenue, Cleveland, Ohio, is distributing its newly revised Data Sheet No. 10. This is a two-page circular on Brush crystal-operated Type A headphones. It gives a very clear and complete description of the construction of the headphone—is complete with prices, etc., of Brush Type A 2-phone headset, single phone headset and Brush lorgnette handle earphone for use by the hard-of-hearing. Copies will be sent postpaid upon request.

— RE —

UNION STEEL FOLDER

Union Drawn Steel Co., Massillon, Ohio, has an interesting folder showing some of the various products which are manufactured from their open hearth and electric furnace alloy steels.

— RE —

CONDENSER CORP. TO MOVE

From all indications, South Plainfield, New Jersey, threatens to become the new centre of the condenser industry. The Condenser Corporation of America, Jersey City, New Jersey, is another condenser manufacturer that will soon move its plant to South Plainfield. The C. C. of A. also plans to utilize increased space to accommodate fast mounting production demands.

— RE —

ZOPHAR MOVES

Zophar Mills, Inc., manufacturers of insulating compounds, waxes and varnishes, have moved from their former address. They may be addressed at their new and larger plant at 120 26th Street, Brooklyn, N. Y.

— RE —

NIPERMAG CATALOG

The Magnet Steel Division, of the Cinaudagraph Corporation, Stamford, Connecticut, has made available a catalog describing in complete detail the unusual characteristics of Nipermag, a new permanent magnet alloy.

— RE —

WARD LEONARD BULLETINS

The Ward Leonard Electric Company, Mount Vernon, New York, have just issued bulletins describing their new Vitrohm field rheostats and accessories.

Manual- and motor-drive accessories, and intermittent-duty field-discharge resistors are listed in Bulletin 60A, as well as overall and mounting dimensions, formerly given in Bulletin 60D.

Approximately fifty rheostats have been added to the listing. Bulletin 60B is arranged according to resistance values to aid in selecting the proper rheostat for the application.

To facilitate the work of purchasing. receiving and inspection departments, all Vitrohm field rheostats are listed by catalog number in Bulletin 60C, which is now combined with Bulletin 60B.

SVEA-ONICS

A series of informative bulletins, under the above title, is published by the Swedish Iron & Steel Corp., 17 Battery Place, New York, N. Y. The bulletins deal with various phases of metal treatment and should be of interest to manufacturers of vacuum tubes.

— RE —

IRE NOMINATION

L. C. F. Horle, well-known radio consulting engineer, has been nominated for the office of President of the Institute of Radio Engineers. Besides being a member of the Board of Directors of the IRE and Chairman of the IRE Standards Committee, Mr. Horle is also active in RMA, having developed the ignition radiation measuring equipment for the RMA-SAE committee, and represented the Engineering Division of the RMA at the recent FCC high-frequency allocation hearing.

— RE —

AIEE OFFICERS

Mr. A. M. MacCutcheon, Engineering Vice-President, Reliance Electric and Engineering Company, Cleveland, Ohio, was elected President of the American Institute of Electrical Engineers for the year beginning August 1, 1936, as announced at the Annual Meeting of the Institute held at Pasadena, Calif., during the Annual Summer Convention of the Institute. The other officers elected were: Vice-Presidents A. C. Stevens, Schenectady, N. Y.; O. B. Blackwell, New York, N. Y.; C. Francis Harding, Lafayette, Ind.; L. T. Blaisdell, Dallas, Tex.; C. E. Rogers, Seattle, Wash.—Directors: K. B. McEachron. Pittsfield, Mass.; C. A. Powel, East Pittsburgh, Pa.; R. W. Sorensen, Pasadena, Calif.—National Treasurer: W. I. Slichter, New York, N. Y.

— RE —

NATIONAL UNION BULLETINS

The following bulletins have been received from the National Union Laboratories, 1181 McCarter Highway, Newark, N. J.: 1F6, 1F7G Double Diode Pentode; 1B5/25S, 1H6G Twin Diode Medium Mu Triode; 1B4, 1E5G Voltage Amplifier; 1A4, 1D5G Voltage Amplifier; 1H4G, 30 Triode Voltage Amplifier; 1F4, 1F5G, 1E7G Power Output Pentode; 1J6G, 19 Twin Output Pentode; 1A6, 1C6, 1C7G, 1D7G Pentagrid Converter; Input Characteristics of Type 6A6.

— RE —

CORNELL-DUBILIER PRICES CHANGED

Leon L. A. Adelman, Sales Manager, Jobbers' Division of the Cornell-Dubilier Corporation, 4377 Bronx Boulevard, New York announces a drastic revision of list prices on their Dwarf Tiger Paper Tubular Condenser line, effective at once.

"The universal acceptance of C-D products has resulted in our having to revamp our production schedule," said Mr. Adelman. "It has been necessary to add thousands of square feet of factory space, the latest and most modern production facilities, accurate control, larger purchasing volume—all have made it possible to produce a corresponding reduction in manufacturing costs."

G-E REPORT AND APPOINTMENTS

Orders received by the General Electric Company for the second quarter of 1936 amounted to $77,398,718, compared with $55,163,014 for the second quarter of 1935, an increase of 40 percent, President Gerard Swope announced today. In the first quarter, the increase was 21 percent. The second quarter of 1936 was the best since the second quarter of 1931.

Orders received for six months amounted to $136,968,597, compared with $104,542,946 for the first six months last year, an increase of 31 percent.

G-E Supply Corporation, Richmond, Va., formerly a branch of the Baltimore district, has been made the main house in a separate sales district, it has been announced by J. L. Busey, president of the corporation. The new district comprises branches at Charlotte, N. C. and Raleigh, N. C.

The appointments of L. G. Moore, Jr., as manager of traffic appliance sales, with headquarters at the general office, Bridgeport, Conn., and J. P. McIlhenny, formerly manager of sales for the Elliott-Lewis Electrical Company, Philadelphia, as district manager of appliance sales, G-E Supply Corp., Chicago, have also been announced.

— RE —

DE VILBISS CATALOG

The DeVilbiss Company, Toledo, Ohio, announces a new catalog, "IB," covering their line of industry spray-finishing equipment. This catalog, effective July 1, replaces the former catalog "IA."

The new catalog is designed to facilitate intelligent selection of the company's many spray-finishing equipment items for industrial purposes. Complete information is given on spray guns, air compressors, air and fluid hose, exhaust systems, spray booths, exhaust fans, and other equipment. The book contains much helpful information and interesting tables to aid the finisher in the proper association of equipment with materials and finishing operations.

This company also announces the schedule of their training school for the last half of 1936. The school is open to industrial painters, master painters, automobile refinishers, and all others interested in learning the technique of spray-painting, and the use and care of spray-painting equipment.

The training period lasts for one week. Classes will start on the following dates: August 31, October 5, November 2, November 30.

— RE —

BRUNO USES PLANE

The Bruno Laboratories, Inc., microphone manufacturers, are engaged in other scientific fields as well. A Stinson monoplane has been equipped with the latest safety devices and its cabin is a veritable radio laboratory on wings. Cruising at 150 miles per hour, the plane accommodates two passengers and two pilots, and is used by the Bruno Laboratories engineers to conduct radio communication experiments and tests.

(Continued on page 32)

A-F VOLUME CONTROL

(*Continued from page* 11)

the reduction of gain. This is somewhat unfortunate, for, in many instances, the undistorted output capability should be at a maximum at times of maximum input (minimum gain). However, this need not be a serious limitation, provided the controlled stage is required to deliver only relatively small maximum output. Fig. 6 gives the percentage total harmonic distortion for several output levels as a function of grid bias. This distortion is predominantly second harmonic. At any given bias, it varies directly with the signal input.

It will be noted from Figs. 5 and 6 that the use of a remote cut-off pentode, such as a 6D6, as a gain-controlled pentode a-f amplifier following a diode detector, will deliver sufficient output, satisfactorily distortion-free, to swing the grid of the usual pentode power output stage. Proper circuit arrangements should be provided for independent application of the avc bias and audio signal to the grid of the controlled a-f amplifier. It is usually advisable that the d-c voltage applied be a fixed proportion of the diode d-c output, while, of course, for manual volume control purposes, the audio level will be subject to the will of the user.

•

MAKING THE SURVEY

(*Continued from page* 16)

at which time it went off entirely. Careful investigation showed that the sweepers were turning on the lights as they went from room to room, and turning them all off when the sweeping job was done. This was corrected simply by informing the sweepers that they were only to have lights on in the one room in which they were working.

REPORTING THE SURVEY FINDINGS

The value of the information learned in the survey will depend largely on the manner in which the material is compiled and the attention that is given the recommendations by the management. In some plants the surveys are made by one department, usually either maintenance or engineering, and the findings are made available to the other departments. Such a survey is bound to disclose some faults, short-comings and oversights of men, and it is quite important to have a set-up which will obtain results without creating friction.

Too much emphasis cannot be placed on the value of whole-hearted cooperation between the parties making the survey and the department heads and foremen. Before running any tests in any department it will be advisable to explain to the department heads and foremen, exactly what the survey is intended to disclose. If the department heads are not sold on such a survey it will be next to impossible to get any recommendations acted upon.

The report to the executives should be a summary of the findings made with the graphic instruments, and should be in such a form that it is easy to follow and the savings recommended should all be translated into terms of dollars and cents. The information should be available to all of the departments so that they may all help in bringing about the savings.

After the suggested changes have been made, in accordance with the original survey, another survey should be made to check the improvements. All of the charts should be filed so that on future tests the information is available and comparisons can be made.

•

NEW TUBES

(*Continued from page* 19)

25B6G PENTODE POWER AMPLIFIER

(*Uni-Potential Cathode Type*)

Heater Rating		
Voltage	25.0	v
Current	0.3	amp
Class A Amplifier		
(Operating Conditions and Characteristics)		
Plate Voltage	95	v
No. 2 Grid (Screen Grid) Voltage	95	v
No. 1 Grid (Control Grid) Voltage	—15	v
Plate Current	45	ma
Screen Current*	4	ma
Screen Current**	12	ma
Plate Resistance (subject to considerable variation)		
Load Resistance	2000	ohms
Mutual Conductance	4000	μmhos
Power Output (10% distortion)	1.75	watts

* No signal
** Maximum signal

In addition to the tubes listed above, these types have also been released: 6L5G, detector-amplifier triode; 1F5G, pentode output tube; 1F4, pentode output tube; RK-33, special purpose duo-triode; 1D5G, variable-mu pentode; 950, pentode output tube.

•

SORRY!

DUE TO AN unfortunate series of printers' errors, the chart page in our July issue was considerably less than accurate. The chart itself was correct, but the printed explanation of its use, and the equation from which the chart was derived—not to mention the running head—were wrong. A corrected version of this page will be found elsewhere in this issue.

NEWS OF THE INDUSTRY

(Continued from page 30)

McKIBBIN HEADS SALES PROMOTION

J. M. McKibbin has been appointed manager of a newly created Sales Promotion Department according to an announcement by N. G. Symonds, Vice President, in charge of sales, of the Westinghouse Electric and Manufacturing Company.

All apparatus sales promotion operations excepting those of the Company's merchandising department will be coordinated under the new department's management and the activities of district office sales promotion managers will be directed by Mr. McKibbin. There will be no change in the Advertising Department now under the management of R. R. Davis.

— RE —

ZOPHAR OPENS CHICAGO OFFICE

Zophar Mills, Inc., have opened an office at 21 E. Van Buren Street, Chicago, Ill., with Royal A. Stemm in charge.

— RE —

KURTZ SPEAKS AT TRIAD

On July 28, J. Kurtz, treasurer and sales manager of the Eisler Electric Corp., Union City, N. J., spoke before the Triadors club on the subject of tungsten, molybdenum and other special tube metals.

The Triadors club is comprised of a group of executives, engineers and production men of the Triad Mfg. Co., Inc., Pawtucket, R. I.

— RE —

PERRON RECEIVES APPOINTMENT

The Cornell-Dubilier Corporation, 4377 Bronx Boulevard, Bronx, New York, manufacturer of fixed condensers for more than twenty-six years, announces the appointment of Ray T. Perron, as Sales Director for the New England territory. Mr. Perron will operate out of his offices at 211 Winthrop Street, Taunton, Mass.

— RE —

LEICH BULLETIN

The Leich Electric Company, Genoa, Illinois, have recently released a 4-page Bulletin describing their No. 62 and No. 90 handset telephones. Also described is their high-efficiency No. 11B battery-feed repeating coil. These coils are said to be very effective and to give a high grade of transmission. This bulletin will be sent free on request.

— RE —

"PRACTICAL WAX RECORDING"

Everitte K. Barnes, M. E., Recording Engineer, has just written a treatise on "Practical Wax Recording." This 34-page booklet is copyrighted by the Universal Microphone Company, Ltd., Inglewood, California, and it may be obtained from them for fifty cents. While "Practical Wax Recording" is written in a manner easily understood by the beginner, it should also prove of interest to the more experienced recording engineer.

— RE —

WIRE GAUGE TABLE

A convenient table for the conversion of Brown & Sharpe to Washburn & Moen wire gauges and vice versa, along with decimal equivalents for both gauges, and feet per pound of iron and steel wires, has been issued by George W. Prentiss & Co., Holyoke, Mass.

JUNE SHIPMENTS SET AIR EXPRESS RECORD

Air Express revenue for June showed a gain of 78% over June, 1935, while in number of shipments the month set an all-time record of 40,450, according to an announcement made recently by Railway Express Agency. The comparative revenue and shipment figures for 1935 or before, are those of the Air Express Division of the Agency plus those of the air lines which later (February 1, 1936) consolidated their air express services with that of the Agency.

Total gain in Air Express revenue for the first six months of 1936 was 73.2% over the first half of 1935. The average air express shipment weighs 7.6 pounds.

— RE —

RMA NEWS

(Continued from page 26)

a decrease of 0.3 percent compared both with the previous month of February and also with the month of March 1935.

APRIL, 1936, LABOR INDICES

Increase in employment and payrolls of radio factories, together with an increase in working hours, was reported in the latest labor report of the U. S. Department of Labor, Bureau of Labor Statistics. The report presages the approach to peak activity in the industry.

The April government report detailed increased employment in radio factories of 1.3 percent compared with the previous month of March, and 3.4 percent above employment in April, 1935. Compared with the three-year official average of 1923-25, the April index figure was 188.6 as compared with 186.1 in April, 1935.

Radio factory payrolls in April, 1936, were 7.6 percent above the previous month of March, and 10.3 percent above April, 1935. The April index figure was 118.0 compared with the three-year official average, and compared with 109.7 percent last March.

Average weekly earnings in radio factories last April were $19.36 compared with $18.23 last March, an increase of 6.1 percent, and 6.9 percent above those of April, 1935.

Average employee hours worked per week in radio factories last April were 35.5 hours compared with 33.4 hours last March, an increase of 6.3 percent, and 8.7 percent above April, 1935.

Average hourly earnings during April of radio factory employees were 54.6 cents, a decrease of .3 percent compared with the previous month of March, and 1.9 percent less than average earnings of April, 1935.

MAY EXCISE TAXES

Internal Revenue Bureau collections of the federal 5 percent excise tax on radio and phonograph apparatus in May 1936 were $220,750.43, a decrease of 24 percent below the May 1935 tax collections of $291,536.71. May tax collections on mechanical refrigerators were $846,609.45, against $1,022,847.13 in May 1935.

AUTO RADIO SURVEY BY NBC

A survey on the listening habits of automobile radio owners has been made by the National Broadcasting Company. Drivers and passengers listen to automobile radio on an average of 65 minutes per day, according to NBC data and the network has a special program on Sundays for the millions of automobile radio owners. The survey predicts that eventually automobile sets will offer broadcasters a potential circulation as large, if not larger, than the present audience in radio homes.

CHICAGO GOLFERS MEET

Chicago golfers will hold their second golf tournament of the 1936 season Thursday, June 16, at the Edgewood Valley Country Club and all radio golfers are expected to turn out. Over 170 played in the opening Chicago tournament during the RMA convention last month.

CANADIAN SALES

During April 1936 the Canadian RMA reports the sale of 5,265 receivers by its members with a list value of $507,275. Canadian sales of battery sets in April were 513 valued at $42,742, and 2,322 automobile sets valued at $138,332.

Canadian manufacturers during May, 1936, sold 5,794 a-c sets with a list value of $496,066; 998 battery sets valued at $87,124, and 3,116 automobile receivers valued at $185,288, according to figures received by RMA through the cooperation of the Canadian RMA. Canadian inventories on May 31 were 19,518 a-c sets; 10,274 battery sets, and 1,673 automobile sets.

NEW LAWS AFFECTING MANUFACTURERS

In addition to the new corporation tax bill, the two major laws enacted by the Congress which adjourned recently were the so-called Robinson-Patman and the Walsh-Healey Bills. The RMA has sent copies to its members and additional copies will be forwarded upon request. The Robinson-Patman or "chain store" bill provides complex regulations for uniform discounts, with supervision by the Federal Trade Commission. The Walsh-Healey Bill is also known as the "industrial control measure" and establishes labor standards on Federal Government contracts in excess of $10,000.

ARMY SPENDS MILLION ON RADIO

The War Department is preparing for expenditure of about $1,000,000 on radio equipment for army air stations during the government's new fiscal year. Bids will be received soon by the Signal Corps for replacement equipment estimated at $500,000 at army air fields. New radio beacon-weather broadcasting equipment is planned for eighteen stations to cost an additional $400,000 and there will be replacements of present obsolete low-frequency equipment at each of the Army's thirty-one fields with high-frequency equipment.

RMA PATENT SERVICE IMPROVED

To increase the value to RMA members of the Association's weekly patent bulletins, detailing all new radio patents issued by the government, arrangements have been made for a comprehensive index of the RMA patent service. A 1936 index of all patents issued to June 30 is being prepared, and hereafter there will be a quarterly index of classifications of radio patents. The RMA patent service is provided without charge for all Association members and will hereafter include the valuable quarterly index.

Model 10B
MICROVOLTER

A convenient, portable, low power signal generator for measuring sensitivity of broadcast and all wave receivers.

Recommended for factory test and inspection work, sensitivity measurements and other laboratory work not requiring an elaborate or high power instrument. Its portability and ease of operation make it very useful in the design laboratory as an auxiliary to large instruments.

It is an ideal instrument for the advanced service organization, as it enables receivers to be measured as well as adjusted.

Operates from 115 volt, 60 cycle A.C.
Built in coils cover 100 to 20,000 Kcs.
Output continuously variable to 100,000 microvolts.
Up to 1,000 microvolts, output res. 5 ohms.
1,000 to 10,000 microvolts, output res. 20 ohms.
10,000 to 100,000 microvolts, output resistance variable from zero to 100 ohms.

Modulation approx. 30% at 400 cycles, non-adjustable. Can be switched off when CW output is desired.

Operation of calibrated output dial and attenuator switch have negligible reaction on frequency, even at 20 megacycles.

Radio frequency harmonics are held to a low value. (Approx. 1%.)

Price, $287.50 F.O.B. Newark, N. J., packed for domestic shipment.
$15.00 additional for operation on other voltage or frequency.
$2.50 additional for export packing and delivery to pier in N. Y.

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If you paid many times our rates you couldn't enjoy finer service, more comfortable rooms, more delicious food than are obtainable at The Lenox.

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Send for free official AAA road map and folder containing handy map of downtown Buffalo.

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BUFFALO, N. Y.

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• COMPOUNDS
• VARNISHES

For Insulation of Condensers

Transformers, coils, power packs, pot heads, sockets, wiring devices, wet and dry batteries, etc. Also WAX SATURATORS for braided wire and tape WAXES for radio parts. Compounds made to your own specifications if you prefer.

• ZOPHAR MILLS, INC.

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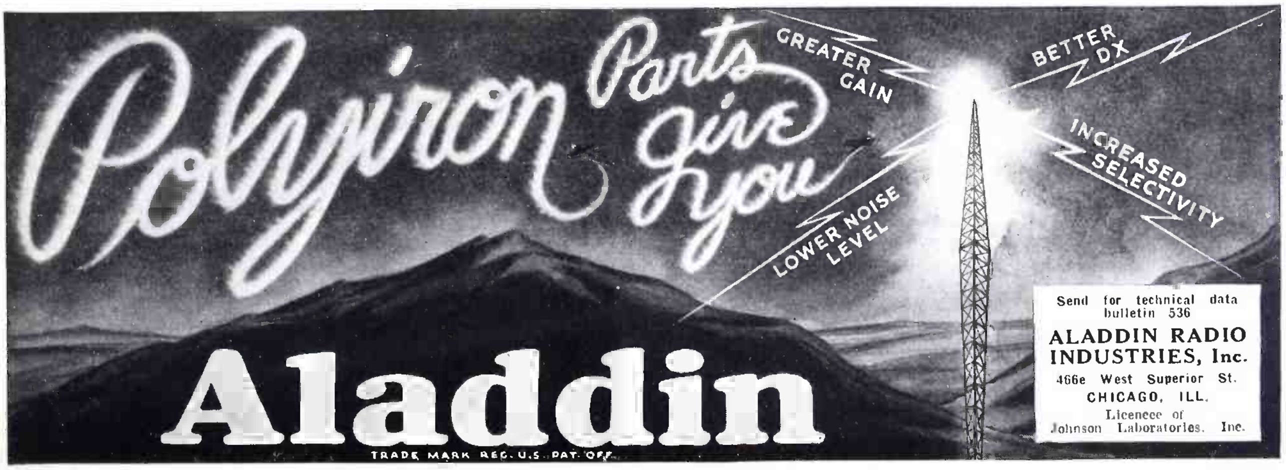
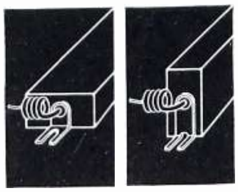


NEW PRODUCTS

FLEX-MOUNT CONDENSER MOUNTING

Permitting easy mounting in any position, "little giant" dry electrolytics are now available with an adjustable mounting lug at each end of the container. This "Flexmount" is a movable universal tab which makes the condenser actually reversible. It may be mounted either flat or on edge, and position is changeable at will.



Although the connecting wires are generally sufficient support for these midgets, the Solar Manufacturing Corporation has designed "Flex-Mount" to take care of tight corners and difficult installations where it is advisable to mount the condenser more rigidly. Further details may be obtained from Solar Manufacturing Corporation, 599 Broadway, New York City.

— RE —

RESISTANCE BRIDGE

Recent years have found an increased demand for a Wheatstone Bridge capable of measuring below 1 ohm. The newly developed Shallcross 637 Hi-Lo Resistance Bridge consists of a standard Kelvin Bridge for measuring from 0.00001 ohm to 11 ohms and a Wheatstone Bridge for measuring from 1 ohm to 11 megohms.

The resistors employed are of the well-known Shallcross construction. Any further information regarding this instrument can be obtained by writing to the Shallcross Mfg. Company, Collingdale, Pa.

— RE —

RESINS FOR CELLULOSIC IMPREGNATION

Wood pulp and cellulose materials in many forms can be strengthened and given greater resistance by impregnation with a new line of resins recently developed by General Plastics, Inc., North Tonawanda, N. Y. The resins are supplied in solution form, and they are said to eliminate the shrinking and swelling due to moisture absorption of wood and cellulose, and also give greater resistance to solvents, acids and alkalies, and greater impact strength and surface hardness to articles treated with these new Durez resins.

— RE —

ARCTURUS 6L6-G TUBE

The Arcturus Radio Tube Company, Newark, N. J., has recently marketed type 6L6-G beam amplifier tube. Similar in characteristics and pin connections to its metal counterpart, the 6L6-G is in a ST-16 bulb.

The large bulb area and improved provisions for insulation of the Arcturus 6L6-G are said to have proved to be of very definite advantage in specialized work, where maximum performance and efficiency are required.

LANSING INTRODUCES NEW SPEAKER

Extending its line of speakers for the radio and public-address field, Lansing Manufacturing Co., Los Angeles, is adding the new "Lansing Monitor" designed primarily for program monitoring, high-quality speech reinforcement, and deluxe radio receiver use.

— RE —

BRUNO CABLE CONNECTOR

The Bruno Cable Connector is a small all-metal coupling unit which permits instant connection or disconnection of two single conductor shielded cables. Its contact points are positive in action, self-wiping, and maintained under extremely high pressures. Failure to hold contact is a practical impossibility. This makes the unit ideal for use where dependability is essential, as in "microphone-to-amplifier" circuits. Further details may be obtained from the manufacturer, Bruno Laboratories, Inc., 20 West 22nd St., New York, N. Y.

— RE —

TRANSMITTING COIL FORM DEVELOPED BY HAMMARLUND

The Unit Development Division of the Hammarlund Manufacturing Co., Inc., has just developed a giant coil form for use in transmitters. It employs a low-loss insulating material, SP-53 dielectric, the same substance that is used for the popular SWF coil forms. The forms are grooved ribbed to permit air spaced windings for maximum efficiency. Substantial flange grips for easy handling are another feature.

— RE —

CAP MOULDING

Pyramid Metals Company, 455 North Oakley Boulevard Chicago, Illinois, manufacturers of Stainless Steel Mouldings, announces a new cap moulding for covering the edges of wallboard, tile, etc. Information is available from the manufacturer.

— RE —

MARKAL PAINT HOLDER

The manufacturer of Markal, said to be the first paint in stick form, has just announced a new nickel-plated metal holder which makes Markal easier to use, and enables the operator to use the stick right down to the end. This metal holder is furnished without charge, one being included in each package of twelve. It is made of flexible steel and slips right over the paint stick, with a fit just snug enough to hold for use in marking. As the stick wears down, it is pushed through the holder with the thumb and finger. The holder enables the workman to use practically all of the stick instead of throwing away the stub. Markal can be obtained from Helmer & Staley, 2354 So. Park Way, Chicago, Ill.

RCA TUBES

RCA Radiotron Division has recently announced to equipment manufacturers the All-Metal Duplex-Diode Pentode RCA-6B8.

The 6B8 is a heater type of tube consisting of two diodes and a pentode in a single shell. It is recommended for service as combined detector, amplifier (r-f, i-f, or a-f), and a-v-c tube in radio receivers. The 6B8 is similar in characteristics and application to the glass type 6B7.

RCA-920 is a twin phototube of the gaseous type. It has two separate units in one bulb and is intended for use with dual sound track motion-picture equipment.

RCA-1603 is a pentode amplifier designed to have low-noise and low-microphonic characteristics. It is intended for use in high-gain pre-amplifiers.

— RE —

SOLVENT DEGREASING MACHINE

A new two-dip solvent degreasing machine, designated as size 624, has recently been added to the line of Detrex Degreasers manufactured by Detroit Rex Products Company, 13005 Hillview Avenue, Detroit, Michigan.

Among the important features of this machine are a water jacket type of condenser completely encircling the machine, and a solvent condensate collecting trough located directly beneath the condenser.

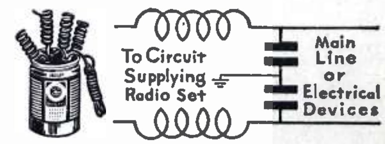
— RE —

LINE NOISE FILTER

Blocking line noise before it reaches the house wiring system is the function of the latest F1005DH Filtercon made by Continental Carbon Inc., 13900 Lorain Avenue, Cleveland, Ohio.

In analyzing the cause for the intensity of interference at ground levels, which necessitates special aerial lead-ins, the Continental Carbon engineers discovered that much of this interference was radiated from unshielded electric wiring within dwellings. The radio set picked up the disturbance through its aerial or through the power supply connection. The cause of the interference was often several blocks away, the power lines conducting it within range of the radio set. A new heavy-duty Filtercon was designed to keep this form of radio disturbance out of the house wiring system and divert it to the ground.

The Filtercon may be connected between the main line fuse plugs and the individual circuit fuse plugs. It is provided with a mounting bracket for open panel installations. Its small size, 4⅜" by 3" in diameter, permits mounting within most of the larger metal cabinet fuse boxes. It is conservatively rated to carry 10 amperes at 110 or 220 volts.



INDEX TO ADVERTISERS

The General Radio Company Modulation Monitor

1 INEXPENSIVE—$195.00 complete with tubes and accessories. Only a simple pick-up coil or coupling condenser required to place in immediate operation.

2 APPROVED—by the FCC as meeting all requirements of the Government for this type of equipment. In addition a marked improvement in transmission can be expected.

3 COMPLETE UNIT—the General Radio monitor is a self-operated unit of the complete Class 730-A Transmission Monitoring Assembly, the two additional units of which may be added to the Modulation Monitor at any time. The complete assembly guarantees peak performance of the transmitter at all times.

4 LONG LIFE—is assured since the General Radio Monitor is correctly designed, carefully manufactured, accurately calibrated and rigidly inspected. Many years of low-upkeep performance are guaranteed.

Write for Bulletin 45-Y for additional details.

GENERAL RADIO COMPANY

30 State Street, Cambridge, Massachusetts

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pproximately
ree times ac-
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ght; Cap shield
r directed, con-
ntrated light
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ght) No. 99043

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ft) No. 99129

al Light Socket
. 3153

wer Right; No.
10

With a wide variety of mounting methods to choose fro
Cinch dial light sockets assure mechanical and electric
perfection in illuminating dials under any set specifica
tion or construction. Some of the more generally use
types are pictured here. There are many other

Wherever the light, Cinch shows th way to mount it.

Only the best materials and painstaking wor
manship can produce these carefull
designed parts; all metal parts are plate
and all assemblies are inspected an
tested. The spring contact in the Cin
screw type sockets prevents vibratio
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