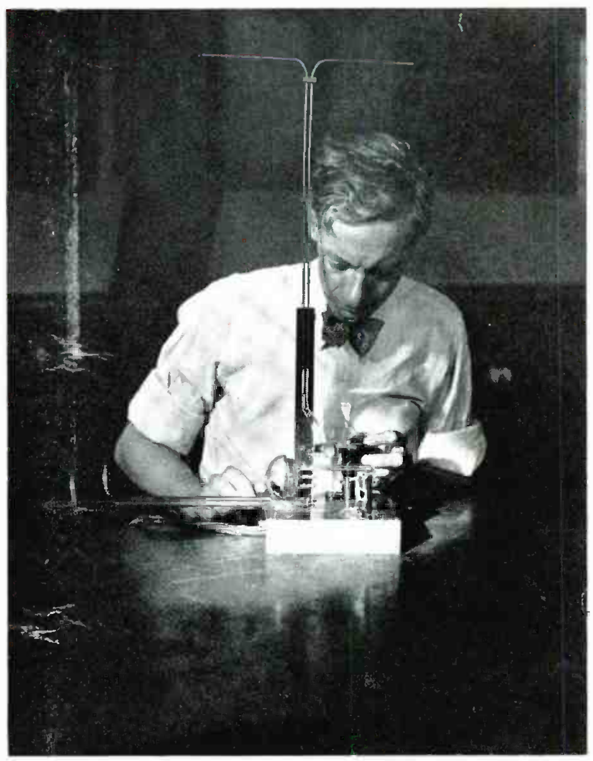
JULY, 1936

Radio Engineering

VOL. XVI NO. 7

DESIGN • PRODUCTION • ENGINEERING

- Broadcast Receivers
- Auto-Radio Receivers
- Electric Phonographs
- Sound Recorders
- Sound Projectors
- Audio Amplifiers
- P-A Equipment
- Electronic Control Devices
- Testing and Measuring Equipment
- Television Apparatus
- Loudspeakers
- Components
- Tubes
- Photocells



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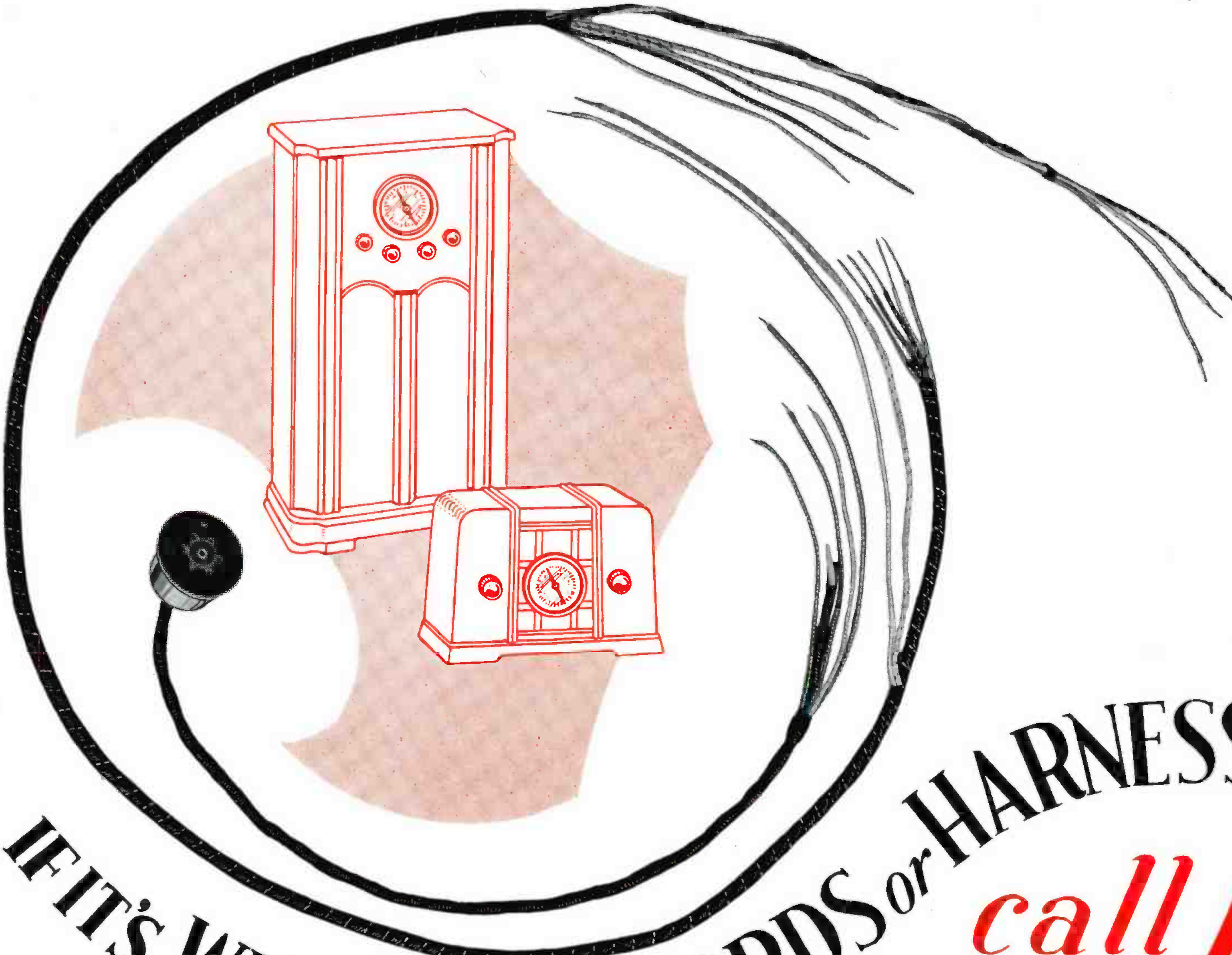

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COVER ILLUSTRATION

500-MEGACYCLE (60 CENTIMETER) TRANSMITTER USING THE NEW WESTERN ELECTRIC 316A VACUUM TUBE

VOL. XVI — *Member Audit Bureau of Circulations* — NO. 7

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Editorial

IN THIS ISSUE

CONTRARY TO CONVENTIONAL practice when new model receivers are appearing daily, RADIO ENGINEERING is not attempting to put any particular emphasis upon these receivers or their features. In the first place, we believe that the technical advances incorporated in the new receivers have, with few exceptions, been shown and discussed in sufficient detail to remove them from the category of news. Secondly, the engineers of those companies that are on pins and needles about their competitors' products aren't going to be satisfied with a few photographs and several hundred words—at the most—which may or may not describe the really important features of the receivers. These fellows very likely have already learned all there is to be learned by the simple process of ripping a few sets apart and taking some measurements.

We are, however, featuring several articles which we believe will be of real importance to the industry. Plant maintenance men will find the first of a series of two articles on the all-important subject of detecting and correcting power losses; and the production departments will also be interested in some of the possibilities for increased efficiency which are disclosed in this same article.

The mathematical analysis of loudspeakers—also the first article of a series—will be of import, especially in view of the electromechanical analogies which are derived in detail.

• • •

START "GUNNING" FOR THESE

WE BELIEVE THAT a considerable amount of research work could profitably be expended upon detectors and avc circuits. Far too many detectors are such a long way from approaching the ideal of linearity that it is useless to discuss quality and most detector circuits in the same breadth. Frankly, we don't know the answer, but the research fellows ought to start looking for it. Likewise in the case of avc; there are too many sources of distortion in these systems as currently used. Again, we don't know the answer, although we will suggest that receivers for high-fidelity reception—which, after all, means reception of powerful local stations only—don't need avc greatly.

Ahead of the detector, the i-f and r-f circuits do their bit, in the way of side-band cutting, to ruin quality. There seems to be some interest being shown in crystal-coupled i-f circuits, although there is an understandable hesitancy about adopting circuits which, at the present state of development, do not permit decreasing the bandwidth when the occasion, due to strong adjacent channel interference, demands.

R-f circuits for wide-band transmission are so well known that little if any discussion of their possibilities is needed. However, little or nothing is being done about their use in high quality receivers. Perhaps at some future time we shall review this particular subject in greater detail.

Here, then, are a few of the points to be watched; we don't claim to have covered all of them, but we do suspect that any radical improvement in any one of the points mentioned, or a series of less extreme improvements in some of the points, will assist materially in educating—which is, of course, simply a synonym for selling—the radio buyer.

• • •

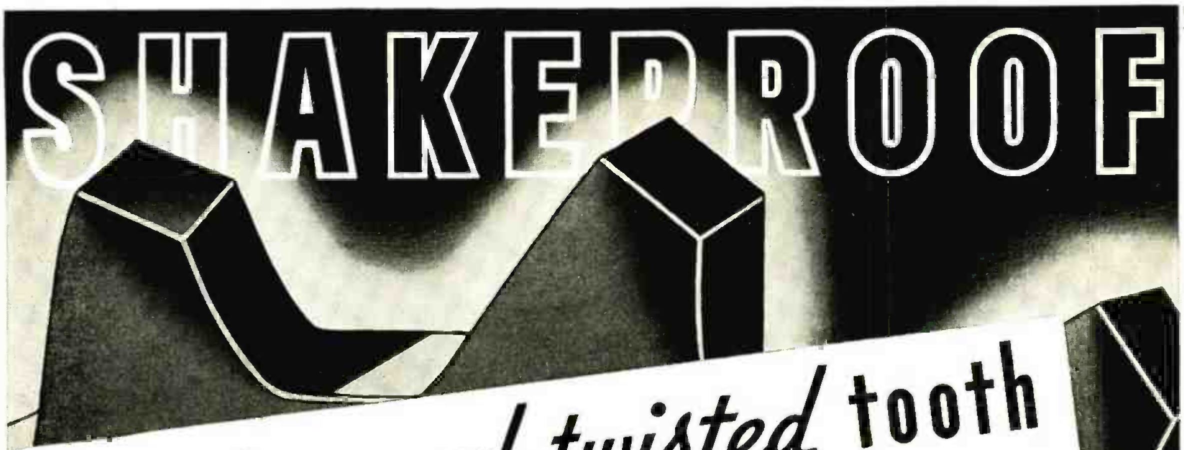
TUBE NUMBERS

ALONG WITH MANY others, we have been noting the apparent breakdown of the tube designation system which started so auspiciously a few years ago. Under this system, as it is used at present, one has only a faint chance of learning the purpose of any particular tube from its type number.

In so far as the numerals are concerned, there is little to be complained of, but it is on the various letters used that the system tends to become ineffectual.

Originally, we believe, the letter was supposed to give some indication of the use for which the tube is intended. The fallacy of this soon becomes apparent when one considers the number of tubes, generally to be classed as amplifiers, which bear different letters. Under the present classification scheme it is inherently impossible to follow the plan originally proposed; there are too many tubes, of the same heater voltage and the same number of elements.

It might be well, before the next avalanche of new tubes arrives, to give some thought to another, and final, reclassification with a system of designation which will not go "haywire" with the advent of each new tube.



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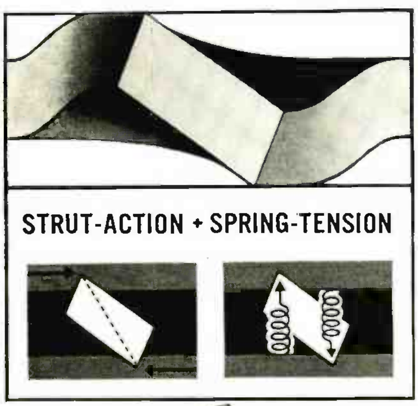

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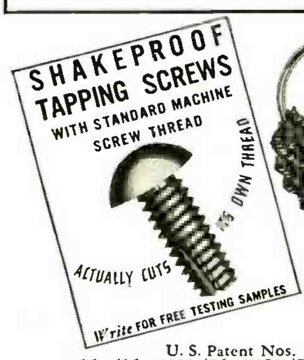

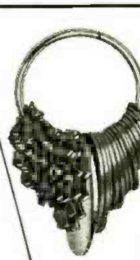

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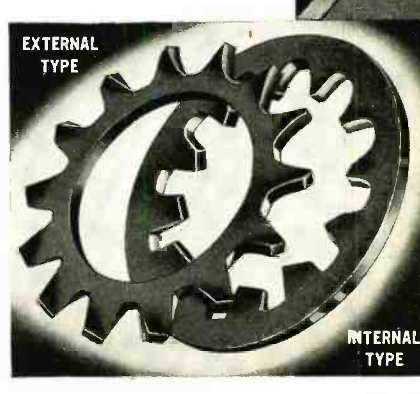

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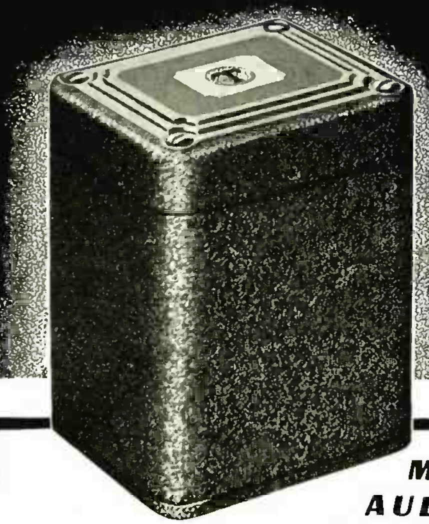

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RADIO ENGINEERING

FOR JULY, 1936

PLANT SURVEYS

by H. V. WENGER, Jr.*

THE purpose of this article is to give the reader a working knowledge of the different instruments which are available for surveys with graphic meters and to acquaint him with some of the hiding places of common power losses. In a subsequent article, the author will discuss the procedure to be followed in the making of an actual power survey in a radio manufacturing plant.

ONE NEED NOT tax his memory to recall the days when only a few "nuts" in the neighborhood had contraptions known as radios. These were only a maze of wires connected to a small crystal, but by tickling the small crystal with a tiny wire they could squirm out of the contraption a bit of fading music and blurred speech. Today every home and nearly every automobile is equipped with a highly developed form of this early contraption, and its early achievements are hardly noticed. Such is the growth of Radio.

Growth of Radio

Because of this rapid growth, many radio plants of today have been built for production with no thought at all given to economical operation of the producing equipment. This is due largely to the type of manufacturing in which radio production falls. The manufacturing of radio sets and parts is very seasonal and at certain periods during the year, production is stopped entirely. Then the seasonal rush begins and production goes pell-mell, with only one idea in mind and that is to fill the shipping room with finished products. Machinery is installed wherever there is room and no thought at all is given to the efficiency at which it operates. After the rush is over production goes into another slump and the machinery stands idle. The next year, new fads in radio design will necessitate the complete rearrangement of the factory and parts that were manufactured the year before will not even be made the following year.

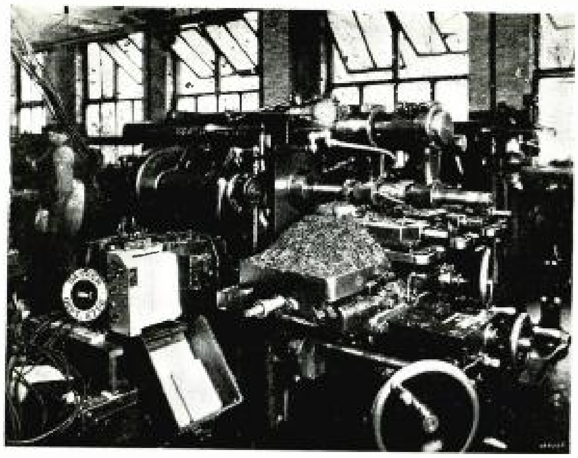
Very little heavy equipment is used in the assembly of radios or in the manufacture of their parts. At first glance, electric power appears to be an unimportant item, and labor is the gourmet which consumes most of the income. This has made managers concentrate their efforts on the latter item while power losses go gayly on their way slashing at profits without attracting much attention.

In the radio factory the majority of the power is consumed by three or four distinct types of equipment. These are a host of small motors on drill presses, spinning presses, coil winders, and other light equipment; a mass of punch presses with rather large motors; a group of spot welders; and a heavy lighting load. Simple sounding equipment, although it may be stealing a great deal of excess power. We can put a stop to these power losses by a careful survey of the power using equipment in the plant with graphic instruments.

Savings to Be Made By a Survey

But you say, "Are there any savings to be made in my plant by a power survey?" That is best answered by what others have found in plants of a similar nature. A large radio parts manufacturer in the Middle West purchased a set of survey instruments after much persuasion on the part of their engineer. A young college graduate was given the equipment and told to study the situation. The management was skeptical about the savings to be made in their plant which was strictly modern and carefully planned. The young graduate started through the plant with his graphic instruments. In department after department motors were found underloaded, defective equipment was uncovered, and grounds were found that had been wasting current for no one knows how long. The result was a decrease in the power load, a marked increase in the power-factor and a saving for the whole plant which amounted to a sum in five figures per year. This resulted in the management being convinced of the value of survey equipment, and when a new department

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



Making a test with a graphic meter.

was recently added, every motor was selected on the basis of the graphic meter findings. This same story has an equal in hundreds of plants throughout the country.

Many of the savings which are to be made by study of the individual units in a plant may be small but totaled together over a period of a years will be quite substantial. An example of this is the case of a Mid-Western manufacturing plant which had a 3-hp. motor driving the vacuum pump on the heating system. This motor had been in use 7 years when the engineer of the plant obtained his first graphic instrument. This instrument showed that this particular motor was drawing 5.4 kilowatts which was an overload for this size motor. It was replaced by another motor which took only 0.9 kilowatt. Investigations showed that the windings of this motor were grounded, and that 4.5 kilowatts were wasted when the motor was running. The engineer's test showed that this defective motor had wasted more than $4,000 worth of electrical energy. Except for the graphic meter survey, the loss would probably be going on yet. These same power losses are going on daily in nearly every plant and will never attract attention until a power survey is made or the motors burn up.

Ease of Measuring Electric Power

Development of the electrical motor was a great boon to the art of manufacturing. In the old days, all of the power in a manufacturing plant was derived from a large stationary steam engine and power was transmitted by a series of line shafts. In order to operate a small coil winder a mass of equipment would have been necessary. A pulley and reversible clutch would be needed on the main line shaft and in addition to this equipment it would be necessary to provide a counter shaft, several cone pulleys and a group of leather belts. To measure the power taken by the coil winder would be bordering on the impossible.

Today with the electric power and the large assortment of motors available, it is possible to bring into the plant over a few wires a large amount of power and subdivide this power into small units as we need it. A further advantage of electric power and one in which we are greatly concerned, is the fact that the individual motors draw power from the supply line in almost direct proportion to the work they have to do. A graphic measurement of this flow of energy to the motor designates what the motor is being called upon to do. The intelligent application of electrical meters by power users reveals a mass of information as to the efficient and inefficient consumption of power.

Selection of Meters

The term "electric meters" is rather broad and should be limited to a few practical instruments. Will indicating instruments do the work? A great deal of information can be learned from this type of meter, but many important factors will escape the attention of the operator. Where loads are constantly varying, indicating instruments must be read every few seconds, and a graph must be made from these readings if the actual load is to be visualized. This being the case, the advantages of a record from a graphic instrument are self-evident.

Graphic instruments are available in as many different styles as there are manufacturers. They all work on the principle of having a pen operated by a measuring element which writes on a chart that passes under the pen. Some of these instruments are direct writing, and others get their pen movement by a relay system. The main item in choosing a recording instrument for survey work is the portability of the equipment, and the ruggedness of the instrument.

Several styles of charts are available on these instruments. Some recorders use the dial type, others use a strip type of chart that comes in long rolls, and still others use a rectangular chart that fits on a drum as in the common recording barometer. An instrument that writes with ink is recommended in preference to one that uses a smoked chart or a friction stylus as a permanent record is obtained, which can be handled without fear of destroying the record. A strip type chart has the advantage that different chart speeds may be employed. Oftentimes the load being measured fluctuates so rapidly that it is an advantage to increase the speed of the chart feed and spread the record out so that one will know just what is taking place.

In selecting a chart drive, there is the choice of a spring-wound clock for driving the charts or a synchronous-motor drive. In a portable instrument the spring-wound chart drive is the most convenient for one does not always have synchronous current available when using the instrument. The fact that the instrument has to be inked periodically and new charts added makes winding of the clock once a week of little disadvantage.

The most important instrument for survey work is a portable wattmeter which can be used on either alternating current with transformers or on direct current with shunts. This instrument should be equipped with a multiplier fixed to the case providing several potential ranges so that the instrument may be used on circuits of 110, 220 and 440 volts without potential transformers. The instrument should be equipped with a spring wound clock that will run eight days without winding and providing as many chart speeds per hour and minute as practical. The chart should preferably be of the strip type and wide enough to be read easily.

The self-contained range of the portable utility wattmeter described above is limited to loads of less than 5 amperes. Its ranges may be enlarged by using the instrument with current transformers for alternating current surveys and shunts for d-c measurements. Current transformers are available with multiple ranges providing continuous steps from 5 amps to nearly 1000 amperes. When measuring d-c a different shunt must be provided for each different range that is to be metered.

Other instruments which are of great help in meter surveys, but secondary to the wattmeter, are voltmeters, ammeters and power factor meters. The voltmeter is used to check the voltage drop in the line and to see that lamps and motors are operating at their proper voltage. The ammeter is very useful in determining the current passing through different feeder lines throughout the plant, setting circuit breakers, and determining fuse sizes. The power factor meter is useful in running surveys where large motors are employed. In addition to these power measuring instruments there are still other recorders which will be described as suitable for certain definite types of surveys.

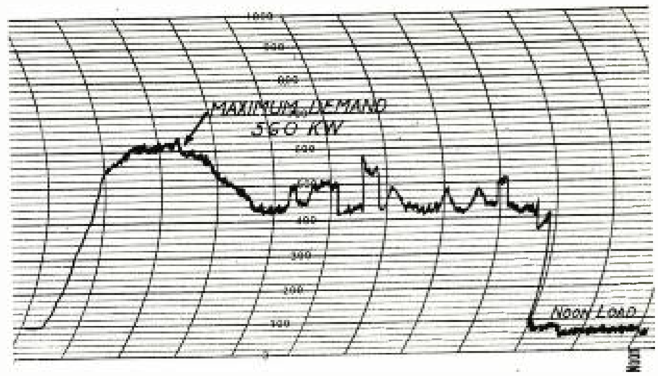
The thing that electricians so often fail to take into account is the fact that the instruments used in surveys are not restricted to mere power measurement, but are capable of bringing to light many things that are a function of power. It is this trait of the graphic meter with which the electrician must familiarize himself before he will be able to utilize the meters efficiently. A graphic meter, unlike an indicating meter, brings in the element of time with the measurement. This factor makes the record carry a host of hidden information.

The Wattmeter

Since the wattmeter is the most prominent instrument used in survey work, it should be considered first. Before this is done, however, it would be well to clear up some points which are constantly arising. The average electrician when called upon to measure the power of different motors will requisition an ammeter rather than a wattmeter. The reason for this is self-evident when it is realized that the indicating ammeter sells for nearly half the price of the indicating wattmeter. Most indicating ammeters are made with an iron-vane movement which is much cheaper than the dynamometer type necesary in the wattmeter. However, in the case of graphic instruments, the iron vane type movement is impractical and the ammeter is just as expensive as the wattmeter. Now the reason for using the wattmeter in preference to the ammeter depends upon the old bugaboo of power factor. An ammeter connected to a small motor will show nearly a constant current regardles of the load that is put on it. This is because the power factor goes down as the load is taken off and the magnetizing current rises proportionately. On the other hand, a wattmeter on the same motor will show actual changes of load on the motor. Thus the wattmeter is the ideal instrument to use in measuring the work of different motors.

Demand Control

The first step in making a plant survey is to lay out a plan of procedure. The plant electrician should have some idea where the different power losses which he plans to ferret out hide themselves, and the savings possible by the elimination of these losses. It is very important that he know the details of the company's power contract and the penalty clauses to which his company is subjected.



A chart showing maximum demand.

The majority of power companies have what is known as "demand charge" which makes the casual and inefficient use of power very expensive. This demand charge is based on the theory that the power company must have equipment available at all times for supplying the maximum load that the plant may call upon them to supply. It is only fair that the manufacturer should help pay for this extra equipment, which he has caused to be necessary, whether he uses the power or not.

The periods over which these demand charges are figured vary with the different utilities. Many are figured on the highest demand during the last twelve months' period, and others are for the last six months' period and some every month. The demand charge is not figured on the peak load that may be drawn at any one instant, but rather on the same load for fifteen minutes, thirty minutes or whatever the period is as set by the utility. It is impossible for the manufacturer to rid himself entirely of this demand charge; however, he may reduce it considerably by carefully controlling his load. For instance, on Monday morning when all the machinery is started at once, electric ovens are turned on after being cool all week-end, and all lights are turned on, the load will perhaps be far greater than the load for the rest of the week. True, this machinery has to be started on Monday morning, but by carefully scheduling operations, this high demand may be reduced. It may pay to start the furnaces 3 or 4 hours earlier so that they will be partially shut off when the heavy motors and other equipment is started. In other cases, the demand is often high due to different motors piling up their load, for example when several air compressors get in step, their combined load will be nearly double the load taken when one is on the intake stroke and the other is on the compression stroke. Only by the use of graphic instruments is it possible to tell just what period of the day or week the maximum demand occurs and what chance there is of reducing this demand.

Diesel Plants

Plants have often attempted to put in Diesel generating equipment in order to get away from what they thought were unreasonable power rates. They figured the size of the Diesel generator set that they need by noting the average kilowatt load from their monthly power bills. Often, however, when the situation is studied with a graphic meter they find that due to the excesive peak loads at certain hours their Diesel generating equipment would have to be several sizes larger than what they had originally planned and their power costs under this new arrangement would be comparable to the utility power costs. Many Diesel salesmen are now using graphic instruments to study their customer's load so that they will not make the mistake of selling the customer a plant which will not meet his maximum load requirements.

Stepping Up Production

Now the record taken from the wattmeter which has been connected to the motor of a machine doing work, shows much more than the mere power measured. For example, take the case of a wattmeter connected to a turret lathe as illustrated in the accompanying chart. Careful analysis of this chart shows the operation done by each tool on the machine. It shows exactly at what moment the tools start to work, the amount of power required, and the time taken before the next tool started in to do its work. The value of this record to the department can be quickly estimated in laying out the cams for this particular machine. They know how much of a load this machine is built to stand and with the information from this chart they are able to regulate their feeds to use the full capacity of the machine at all times and yet not overload it. This chart illustrates the increase in production that was obtained by the use of a graphic instrument.

Since the machine illustrated in this case is operated by hand, the chart furnishes an indisputable record of the operation by the employe. The record shows when he is rushing the work and if he is overloading the machine, or if he is loafing on the job. Thus, this same chart gives a record of the operator's efficiency which could never be equaled by a time-study man with his stop watch. Now, note on this chart the amount of power the machine is taking and compare this with the size of the motor on the machine. In this particular example, a two hp motor would be sufficient to handle this machine. The motor would be able to stand the overload shown by the peaks without overheating.

Often the schedule on other machines can be materially increased by an intelligent study of the situation with graphic instruments. Savings can be made in set-up time of the punch presses with a corresponding increase in tool life, by attaching a wattmeter to the motor driving the punch press and setting the die for the lowest friction loss as indicated by the graphic wattmeter. These are only a few of the many savings that are to be made and are mentioned only to stimulate the imagination as to the possible applications of graphic meters.

Defective Machinery

The graphic wattmeter can also be used to advantage in locating defective machinery. For example, take the case of a lathe which is believed to have poor bearings. A graphic meter is connected to the driving motor of the lathe while it is being run idle, and the power necessary to overcome the friction loss will indicate the condition of the bearings. If there should be a gear on the lathe whose teeth are bottoming or a shaft which is out of alignment, a graphic record taken with a rapid feed chart drive will show a peak every revolution of the gear or shaft. Ordinarily, you would never find these defects until the machine broke down, but with a graphic instrument they stand right out where they can be seen.

A manufacturer recently making a survey of every motor in the plant, came across a motor driving a pump which showed a very irregular consumption of power. The electrician making the survey questioned this odd condition, and on further investigation found that the pump impeller was loose on the shaft. Had it not been for this survey, this defective pump would not have been discovered until it ceased to function.

Labor Losses

One of the most surprising and probably most substantial savings that can be made in a survey with graphic instruments is in connection with labor losses in the factory. A graphic meter connected on the incoming line will show just how long it takes the factory to get in full operation after the starting whistle has blown in the morning. The accompanying chart shows that in one particular plant it took 37 minutes for the men to get all the machines in operation after the whistle blew at 7 o'clock in the morning. A continuation of this chart would probably show a slowing down before the noon hour and also an anticipation of the quitting time in the evening.

This slow starting in the morning may have been due to poor discipline on the part of the workers and then again may have been the fault of the management. Perhaps men had to wait on raw materials, or tools. It may be there was a long line at the store room ordering parts that should have been ordered the night before, or maybe the men were waiting for instructions before they could start their day's work.

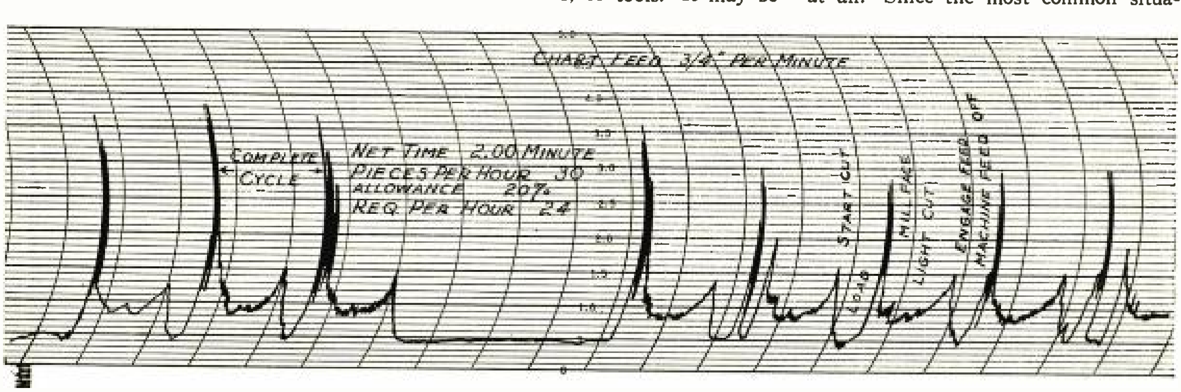
Mixing Processes

Another application of the graphic meter is showing when different compounds are added to the stage of the mixing cycle in process work. For example, take the case of paste for condensers and paste for storage batteries. These are mixed in a power-driven mixer and the consistency of the batch can be determined at all times merely by observing the record of a wattmeter connected to the motor on the mixer. This application not only shows the operator when his mix is ready to be dumped, but also furnishes the management with a record of the number of batches manufactured and the control of each batch.

Now we have covered some of the more common applications of the graphic wattmeter to industrial problems, and find that in addition to measuring the power load we can also determine the loading on a machine, the timing of processes, efficiency of a human operator, condition of eqipment, and control of mixing processes. This is by no means a complete list of the versatilities of the graphic wattmeter, but does tend to show the possibilities of this instrument.

Power Factor Correction

Another expensive item in the power contract is our old friend power factor. We know that in dealing with a-c, the voltage and current can be easily gotten out of phase with each other. When inductance is put in the circuit, the current will lag behind the voltage and when capacity is put in the circuit, the current will lead the voltage. When the current lags the voltage, it does less and less work until at zero power factor it does no work at all. Since the most common situa-



Turret lathe operation as shown by the wattmeter.

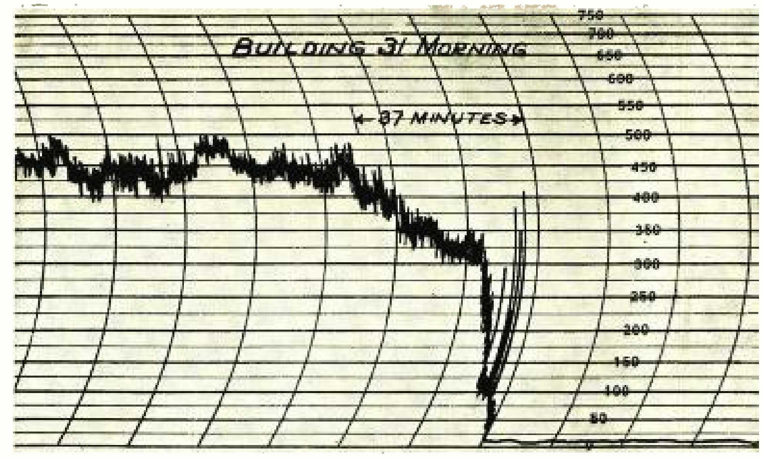
tion is lagging power factor, the power companies have created a penalty for the manufacturer with low power factor and often offer a bonus to the manufacturer with leading power factor.

The radio designer is well acquainted with the phase relations of voltage and current. They purposely add inductance and capacity to the circuits in order to regulate the phase relation to their fancy. The plant electrician deals with phase relation, but in a slightly different manner. He always has an inductive circuit and is constantly making an effort to decrease this inductive effect; since nearly all the motors used in a manufacturing plant are of the induction type, every added motor means more lagging power factor. The power factor of a plant is an accurate indication of the electrical efficiency of the plant. Low power factor means the plant is operating with a maximum of power at a minimum current.

Now, there are two ways in which we can correct power factor in a manufacturing plant. The first depends upon the proper selection of motors and after we have done all we can in this way we can bring up the rest of the power factor with capacitators or synchronous motors.

Induction motors have an efficiency curve which is high at full load and falls off rapidly as the load is taken off. This is due to the fact that the power factor of most induction motors is 80-85% when the motor is fully loaded and when the load is taken off the power factor may be as low as 10-15%. This explains immediately how it is possible to improve the power factor of the total plant load by careful selection of the individual motors. Oftentimes the power factor can be further raised by grouping the machines so that one motor is fully loaded at all times, and still has reserve capacity for the peak loads.

Power factor correction of the total load by capacity equipment is very expensive and there is a limit to the amount of this type of corrective equipment which is economical. The economical amount of capacity equipment can best be determined by a study of the load using a graphic power factor instrument. The power factor of the plant may be brought up cheaply if the plant has any continuous steady loads which may be driven by synchronous motors. A synchronous motor which is over-excited will have the same effect on the line as a group of condensers. Radio plants often have a motor-generator set, which can be driven by a synchronous motor, furnishing d-c for the equipment. In a plant making electrolytic condensers, the motor generator furnishing the d-c for the forming process could easily be run by a synchronous motor and would be quite effective in correcting the power factor of the total plant load.



A 37-minute delay in production.

A power factor recorder is usually limited to work on 3-phase circuits. Most single-phase circuits are either lighting loads, heating loads or small fractional horsepower motors. Lighting and heating loads being resistance circuits have a unity power factor, and the small fractional horsepower motors represent such a small portion of the load that their power factor is of little importance when considered alone.

It will be of interest to the plant electrician to know that where spot tests of power factor are needed and there is no requirement for a continuous record, power factor can be determined by a simple application of the wattmeter. The wattmeter has two potential circuits and two current circuits, and by taking readings with first one potential coil connected and then with the other potential coil connected, we get a relation that can be interpreted in terms of power factor. The ratio of these two readings is then taken and can be easily changed into terms of power factor by the simple use of a graph showing the relation of this ratio to the power factor.

Voltmeters and Ammeters

The voltmeter and ammeter also have faculties other than measuring quantities of electricity. For example, a voltmeter can often be used to record the time in which different operations take place. This is particularly valuable in time-study work where the operations are controlled by electric switches and relays.

The a-c ammeter when selected with the proper chart speed presents a very useful record in checking spot welding operation. Burnt welds or bad contacts between the place to be welded cause a very distinctive change in the record. The same method may be used to check welding timers to see that they are set properly and operating properly.

On our measurements concerned with direct current, we find an entirely different situation. The item of power factor has now disappeared and we find that an ammeter is often preferable to a wattmeter for measuring power load. The d-c ammeter, of course, has the d'Arsonval type movement and has a much faster speed of response than the d-c wattmeter which has the dynamometer type movement. This is important where we wish to record rapid variations. The accuracy of the d-c ammeter for power measurement is determined entirely by the voltage control.

Speed Recorders

We have two more instruments available to us which can be very valuable in survey work if we make the most of their abilities. The first of these is the speed recorder which operates from a small tachometer generator. This recorder has proved itself especially valuable in time study surveys.

A radio company was recently interested in finding a method of making time studies on their high speed coil winding machine operators without their having the fear that somebody was standing over them with a stop watch. They decided upon a speed recorder with a tachometer generator which could be fastened by a belt to the different machines and a record taken over a period of several hours. The result was that the operator lost her uneasiness and then they got a

(*Continued on page 16*)

THEORY OF THE LOUDSPEAKER
AND OF MECHANICAL OSCILLATORY SYSTEMS

Part I

by HANS RODER*

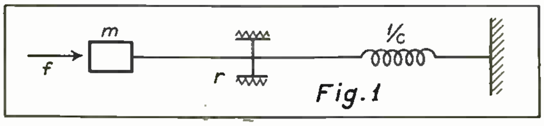


Fig. 1

THE FIRST LOUDSPEAKERS consisted of a telephone membrane to which a horn was attached. The frequency range of these loudspeakers was greatly limited; they usually had a high peak in the region of the membrane resonance which is around 800 or 1000 cycles. The lower frequencies were not reproduced by the horn and the higher frequencies were not reproduced by the membrane.

The next step in development was the electromagnetic drive. The underlying principle is to magnetize a small piece of iron by the audio currents. If this small iron piece is located in the field of a permanent magnet or electromagnet, it will move depending on the polarity with which it is magnetized. Connected to the small iron piece through a driving rod or a lever arrangement, is a conical paper diaphragm. The frequency range of this type of loudspeaker is better than that of the old horn loudspeaker but it is still limited, especially in the high-frequency range.

Considerably better results have been obtained with the electrodynamic drive. Here the force is utilized which is exerted upon a current which is placed in a magnetic field. Loudspeaker motors of this type require a field structure producing a strong magnetic field; this field is in most cases obtained by the use of an electromagnet.

We have four main types of loudspeakers working with the electrodynamic drive. The first is the ribbon loudspeaker[1]. A small, very light aluminum ribbon is stretched between the pole-pieces of a strong magnet. The audio current if passed through this ribbon will exert a force upon it which is normal to the plane of the ribbon. On account of the very small area of the ribbon, this type of loudspeaker is always to be used in connection with a horn. The same principle has recently been used for the design of a high-quality microphone.

The next type of electrodynamic drive is the Hewlett speaker[2]. A circular aluminum membrane is used, located in a radial magnetic field. The audio winding is so arranged as to cause circular eddy currents to flow in the membrane. The electrodynamic forces acting upon the membrane are normal to its plane. In this type of loudspeaker, practically uniform forces are obtained over the whole area of the diaphragm. The acoustical results obtained are very good. The field structure however does not lend itself to the use of iron in the magnetic circuit; therefore, the design is very uneconomical and commercial application of this speaker has never been made.

The next type of electrodynamic speaker is the so-called Blatthaller[3]. This speaker consists of a flat rectangular diaphragm to which, one one side, the conductor is fastened. The conductors which carry the audio currents are extending into an electromagnet structure having long narrow slots. In this manner a diaphragm is obtained which is driven almost uniformly over its entire area. This type of loudspeaker is rather expensive; it has never been used for home radios, but it lends itself very well for public-address systems. The largest design of this type is capable of radiating an acoustical power of approximately 200 watts[4].

The most popular model of the electrodynamic drive is the Rice-Kellogg loudspeaker[5]. The current coil is located in a narrow annular slot; the mechanical forces are in the direction of the coil axis. The coil is directly connected to a paper cone of suitable dimensions. This speaker is in regard to its cost, size, and performance, very well suited for the home radio. To date it has not been possible to improve it materially as far as acoustic performance is concerned: it has, however, been greatly improved in respect to economy of design.

Another type of speaker is that utilizing electrostatic drive[6]. Two conducting plates, if charged at different electrical potentials, either attract or repel each other depending on their polarity. A high polarizing d-c voltage

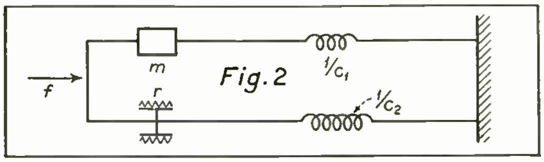


Fig. 2

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

is required which in practical models is somewhere between 1,000 and 10,000 volts. This type of speaker has the advantage that the mechanical forces act uniformly over the entire area of the diaphragm. In practical designs, however, this fact cannot be fully utilized due to the necessity of having a tightly stretched diaphragm. Another disadvantage is that the deflecting force is inversely proportional to the distance. This makes the speaker subject to certain types of unstable operation. For the same reason, this speaker is liable to produce distortion in the sound output if supplied by a purely sinusoidal voltage. It can be used only with small deflections and small exciting voltages, wherein the term small refers to the plate spacing and to the d-c polarizing voltage respectively.

As a fifth type of speaker, the piezo-electric type may be mentioned. Vibrations of the diaphragm are obtained by utilizing the piezo-electric forces of Rochelle-Salt crystals.

Mechanical Oscillatory Systems

In the sections to follow, capital letters will be used for electrical magnitudes. and small letters for mechanical magnitudes.

Mechanical-Electrical Equivalences

For a mechanical system consisting of a mass, m, a spring having a compliance, c, with the mass moving under a coefficient of friction, r (Fig. 1), we have the following relation describing the balance of forces reacting against the driving force, f.

$$m\frac{d^2x}{dt^2} + r\frac{dx}{dt} + \frac{1}{c}x = f \quad \ldots\ldots (1)$$

where

f = mechanical force
x = displacement against a point of reference
m = mass
r = resistance (friction)
c = compliance of the spring.

Since

$$v = \frac{dx}{dt},$$

equation (1) may be written:

$$m\frac{dv}{dt} + rv + \frac{1}{c}\int vdt = f \quad \ldots\ldots (2)$$

The equation for the balance of voltages in an electrical circuit, with L, R, and C in series, reads:

$$L\frac{di}{dt} + Ri + \frac{1}{C}\int idt = e \quad \ldots\ldots (3)$$

Inspection of (2) and (3) shows these equations to be of the same type. There is a complete equivalence between the mechanical and electrical oscillatory system. Equivalent magnitudes are:

Force: corresponds to voltage
Velocity: corresponds to current
Mass: corresponds to inductance
Compliance: corresponds to capacity, and so on.

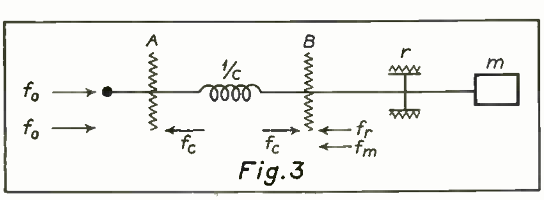


Fig. 3

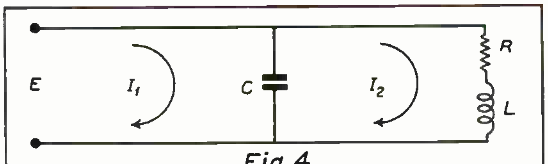


Fig. 4

For steady state conditions and sinusoidal currents and voltages, the solution of equation (3) is

$$i = I\epsilon^{j\omega t}, \quad e = E\epsilon^{j\omega t}.$$

By substitution in (3)

$$j\omega LI + RI - j\frac{1}{\omega C}I = E \quad \ldots\ldots (4)$$

This is the equation for the balance of the voltages in a series L, R, C circuit, written in complex form as conventionally used in electrical engineering. The same procedure can, for sinusoidal vibrations, be used in the mechanical case. We put as solution for (2)

$$x = x_o\epsilon^{j\omega t}, \quad f = f_o\epsilon^{j\omega t},$$

and get,

$$v_o = j\omega x_o \qquad f_r = j\omega r x_o = r v_o$$

$$f_m = -\omega^2 m x_o = j\omega m v_o \quad f_c = \frac{1}{c}x_o = -j\frac{1}{\omega c}v_o \quad \ldots\ldots (5)$$

whereby the factors $\epsilon^{j\omega t}$ are omitted, since they are common to all terms.

Substituting (5) in (2) yields

$$j\omega m\, v_o + rv_o - j\frac{1}{\omega c}v_o = f_o \quad \ldots\ldots (6)$$

which is perfectly analogous to the electrical case.

Table I is a list of the mechanical-electrical equivalences. The term "mechanical impedance," appearing on this list, is not conventional in mechanics. It was formed as the complex quotient of force/velocity, in analogy to electrical impedance.

Kirchhoff's Law for Mechanical Circuits

In many cases it is desired to know the behavior of a mechanical system at variable driving frequency, as is the case, for instance, in a loudspeaker. The knowledge of electrical networks and filters on the other hand has advanced very far. We are much more accustomed to work out electrical networks than to compute mechanical systems. It proves, in such cases, very advantageous to transform a given mechanical vibrating system into its electrical equivalent for which the frequency characteristics are known. If a mechanical system is to be built for a certain predetermined frequency characteristic, it is convenient to use the equivalent electrical network.

The arrangement considered in Fig. 1 has already been found to be equivalent to a series circuit. It can be readily seen that a system like that shown in Fig. 2 is also represented electrically by the L, R, c series circuit

$$\left(\text{with } \frac{1}{c} \text{ corresponding to } \frac{1}{c_1} + \frac{1}{c_2}\right).$$

As a second example, we choose the same system as that of Fig. 1, but driven from the other end (Fig. 3). For the balance of forces in point A there must be

$$f_o = f_c$$

while in point B there must be

$$f_r + f_m - f_c = 0$$

The total elongation of the spring to which f_c is propor-

TABLE I

Mechanical—Electrical Equivalences

MECHANICAL		ELECTRICAL	
Term	*Dimension*	*Term*	*Dimension*
Force f	$\frac{\text{mcm}}{\text{sec}^2} = \text{dyne} = \frac{10^{-7}\text{ joule}}{\text{cm}} = \frac{\text{erg}}{\text{cm}}$	Voltage E	Volts = Amp Ohm
Displacement x	cm	Charge Q	Coulomb = Amp Sec
Velocity v	cm/sec	Current I	$\text{Amp} = \frac{\text{Volt}}{\text{Ohm}} = \frac{\text{Coulomb}}{\text{Sec}}$
Acceleration a	cm/sec^2	Rate of Current Change	Amp/sec
Mech. Impedance z	$\frac{\text{m}}{\text{sec}} = \frac{\text{dyne sec}}{\text{cm}} = \frac{\text{erg sec}}{\text{cm}^2}$	Impedance Z	$\text{Ohm} = \frac{\text{Volt}}{\text{Amp}}$
Mech. Resistance r	$\frac{\text{m}}{\text{sec}} = \frac{\text{dyne sec}}{\text{cm}} = \frac{\text{erg sec}}{\text{cm}^2}$	Resistance R	Ohm
Mech. Reactance	$\frac{\text{m}}{\text{sec}} = \frac{\text{dyne sec}}{\text{cm}} = \frac{\text{erg sec}}{\text{cm}^2}$	Reactance X	Ohm
Mass m	$\text{m} = \frac{\text{dyne sec}^2}{\text{cm}}$	Inductance L	$\text{Ohm Sec} = \frac{\text{Volt sec}}{\text{Amp}} = \text{Henry}$
Compliance c	$\frac{\text{sec}^2}{\text{m}} = \frac{\text{cm}}{\text{dyne}} = \frac{\text{cm}^2}{10^{-7}\text{ joule}} = \frac{\text{cm}^2}{\text{erg}}$	Capacity C	$\text{Sec/Ohm} = \frac{\text{Coulomb}}{\text{Volt}} = \text{Farad}$
Viscosity	$\frac{\text{m}}{\text{cm sec}}$		
Work f x	$\frac{\text{m cm}^2}{\text{sec}^2} = \text{erg} = 10^{-7}\text{ joule}$	Energy, Heat	Watt Sec. = Joule = 10^7 Erg
Kinetic Energy	$\frac{\text{m cm}^2}{\text{sec}^2}$	Magnetic Field Energy	Volt Amp Sec
Potential Energy	$\frac{\text{m cm}^2}{\text{sec}^2}$	Elec. Field Energy	Volt Amp Sec
$\text{Power} = \frac{\text{Work}}{\text{Sec}}$	$\frac{\text{m cm}^2}{\text{sec}^3} = \text{erg/sec} = 10^{-7}\text{ watt}$	Power	Volt Amp = Watt = 10^7 Erg/Sec
Radian Velocity ω	1/sec	Radian Velocity ω	1/Sec
c m	sec^2	LC	Sec^2 = Farad Henry
r c	sec	RC	Sec = Farad Henry
m r	sec	L/R	Sec = Henry/Ohm

tional is equal to the difference in the displacements of the points A and B, hence according to (5)

$$f_c = \frac{1}{c}(x_a - x_b) = -j\frac{1}{\omega c}(v_a - v_b).$$

This yields in point A:

$$-j\frac{1}{\omega c}v_a + j\frac{1}{\omega c}v_b = f_o$$

in point B:

$$+j\frac{1}{\omega c}v_a + \left(r + j\omega m - j\frac{1}{\omega c}\right)v_b = 0 \qquad \ldots\ldots\ldots\ldots (7)$$

We compare this with the electrical circuit of Fig. 4. By assumption of the "mesh currents" I_1 and I_2, we take into account Kirchhoff's second law—sum of currents = zero in a node point. Kirchhoff's first law—sum of voltages around a closed mesh = zero—yields: in mesh 1:

$$-j\frac{1}{\omega C}I_1 + j\frac{1}{\omega C}I_2 = E$$

in mesh 2:

$$+j\frac{1}{\omega C}I_1 + \left(R + j\omega L - j\frac{1}{\omega C}\right)I_2 = 0 \qquad \ldots\ldots\ldots\ldots (8)$$

By the complete analogy between the equations (7) and (8) it is evident that the network in Fig. 4 is the electrical equivalent for the mechanical system in Fig. 3.

From this we make the following conclusion:

Kirchhoff's Laws can, for mechanical systems, be applied in exactly the same manner as for electrical circuits. Each *point in a mechanical system* which can move relatively to any other

(*Continued on page* 22)

BEAT FREQUENCY OSCILLATORS

by A. W. BARBER*

In Which Is Described Methods for the Avoidance of Spurious Frequencies, and the Reduction of Temperature Effects

BEAT FREQUENCY oscillators are firmly established in communication engineering fields as generators of audio frequencies. Certain limitations of this type of generator have been largely overcome in the last few years. Technique is well known by which almost any desired degree of performance may be attained. Under these circumstances weight and cost become relatively important design considerations. It is the purpose of this paper to describe methods which may be employed to reduce weight and cost without sacrificing a high standard of performance.

The major requirements of a beat oscillator are: wide frequency range, good waveform, stable frequency and constant output throughout the desired range. A wide frequency range may be obtained by proper choice of beating oscillator frequencies, careful shielding and filtering, buffer stages, good detector and audio amplifier design. Good waveform may be secured by using sine-wave oscillators, tuned buffers, proper detection and good audio amplifier design. A stable frequency will result from constant supply voltages and temperature control of the oscillating circuits. Constant output will result from the use of automatic volume control or audio compensating circuits.

The first step in designing a beat oscillator may well be to choose the frequency of the fixed oscillator and to decide whether the variable oscillator shall be varied above or below the fixed oscillator frequency. Fig. 1 shows a plot of various frequency relations which may be useful in carrying out this first step. A reference horizontal line at unity represents the fixed oscillator frequency α while the 45-degree

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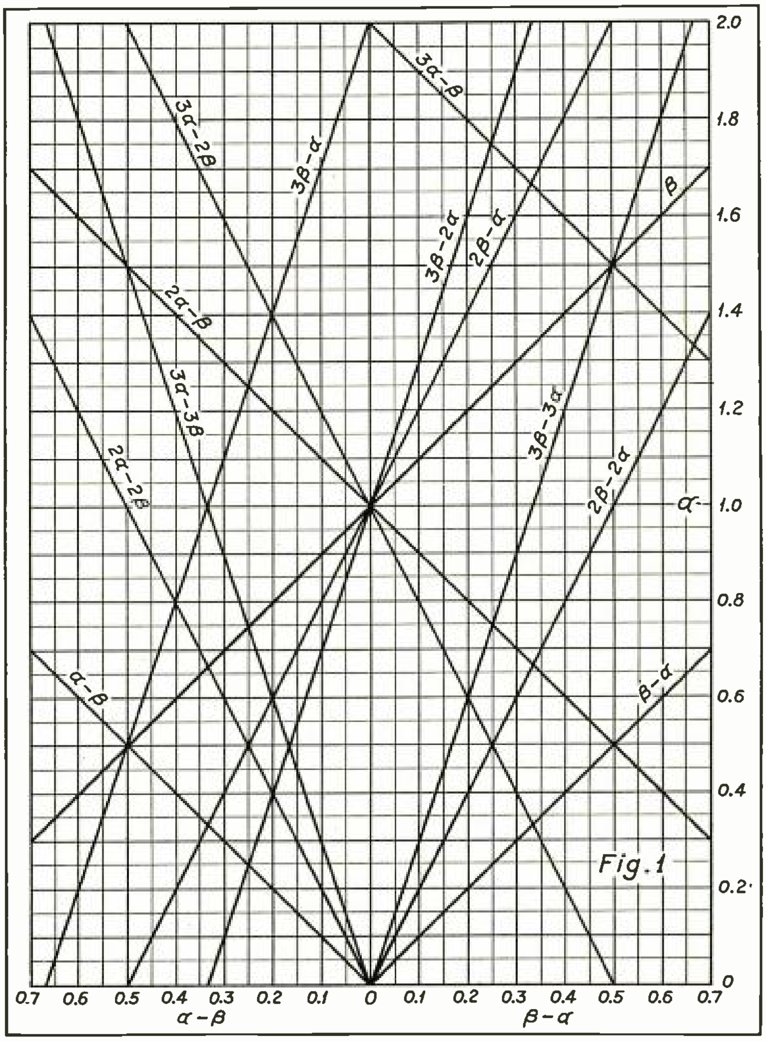


Fig. 1

line passing through the center of the diagram represents β the variable oscillator frequency. The right half of the diagram represents conditions when β is greater than α and the left half of the diagram represents conditions when α is greater than β.

The horizontal axis is $\beta - \alpha$ for the right half and $\alpha - \beta$ for the left half.

If the variable oscillator is varied below the fixed oscillator, the desired audio frequency is represented by a 45-degree line starting at zero in the center of the lower axis and extending to the left, marked $\alpha - \beta$. If the variable oscillator is varied above the fixed oscillator, the desired audio frequency extends to the right and is marked $\beta - \alpha$. The other lines in the diagram represent various possible combinations of the fundamental and harmonics of the fixed and variable oscillators, as for instance $2\beta - 2\alpha$ which is the difference frequency between the second harmonic of the variable oscillator and the second harmonic of the fixed oscillator. Points on this line have vertical coordinates twice $\beta - \alpha$ and represent second harmonic of the desired audio frequency. The lines $3\beta - 3\alpha$ and $3\alpha - 3\beta$ are likewise third harmonics of the desired audio frequency.

Particularly interesting are the frequencies which decrease as the desired audio beat increases such as $3\alpha - 2\beta$ which has a frequency equal to the fixed oscillator at zero audio beat and decreases to zero when the audio beat is one-half the fixed oscillator frequency. It is this and similar components which give rise to the effect often called "tweets." It should be noticed, however, that if the audible range is $\beta - \alpha = 0.2$ that this undesired component comes into the audible range only when $\beta - \alpha = 0.4$ which is beyond the range used.

The situation is actually very complicated and only a few significant facts will be pointed out. The various components may be generated either by various detector actions or by rectification in the audio amplifier. For instance $3\alpha - 2\beta$ may be due to the presence of the third harmonic of α and the second harmonic of β detected by a pure square law detector or it may be due to the fifth power detection component of β and α alone. On the other hand if 3α and β only are present at the detector, the third order detector effect will produce $3\alpha - 2\beta$. This explains why removing all the harmonics from one of the oscillator outputs may not produce a harmonic or "tweet" free audio frequency. No detector is accurately square law and second audio harmonics will thus be produced by third order detector effects from 2β and α as $2\beta - 2\alpha$. Still higher order detector effects will produce "tweets" where various component lines cross, as for instance where $3\beta - 3\alpha$ crosses $3\alpha - 2\beta$ at $\beta - \alpha = 0.2$. The diagram also shows that undesired responses are more widely separated when the right side of the diagram is used, that is, when the variable oscillator is above the fixed oscillator.

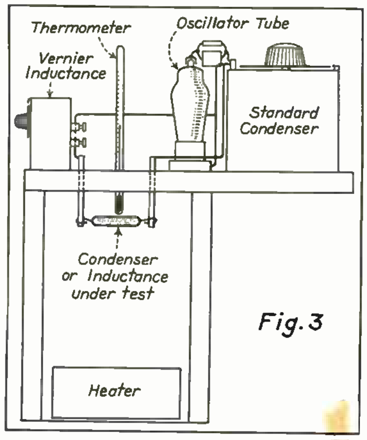


Fig. 3

The available variable condensers dictated a variable frequency less than the fixed frequency, which required a higher fixed frequency for the same freedom from distortion as would have resulted from using a higher variable oscillator frequency. The first component crossing on the $\alpha - \beta$ side occurs at $\alpha - \beta = 0.167$. The present beat oscillator is to go up to 15,000 cycles so that if $\alpha - \beta = 0.167 = 15{,}000$ cycles,

$$\alpha = \frac{1}{0.167} \times 15{,}000 = 90{,}000 \text{ cycles}$$

gives the minimum fixed oscillator frequency usable on this basis. Actually 100,000 cycles was used and the results obtained bear out the validity of the above arguments.

Having chosen the oscillator frequencies it was necessary to decide on the oscillator form. The simplicity of electron-coupled oscillators made it seem worthwhile investigating their merits. The stability of properly designed electron-coupled oscillators in the presence of normal line voltage changes indicated the possibility of using a simple unregulated power supply. It was found that if the triode or oscillating circuits were well shielded and decoupled, pull-in between the oscillators was negligible. Simple shielding of coils and condensers with aluminum shield cans and decoupling circuits consisting of 0.25-microfarad by-pass condensers and 75,000-ohm series resistors to the screens (triode plate) gave circuits which oscillated to within a fraction of a cycle of each other without interaction. At 15 cycles an essentially sine wave of audio was produced. Using pentodes with grounded suppressor grids kept the coupling to the plate circuit almost entirely electronic but the output waveform was rather disappointing. The solution to the waveform problem was worked out by Mr. R. D. Valentine and consisted in working both oscillators into a capacitative plate load. Much of the distortion was in the form of high order harmonics and since the capacity load attenuated proportionally to the harmonic order, a satisfactory waveform was obtained in this way. Applying the capacity to both oscillators cut the audio distortion due to cross-products and was found to be nearly as satisfactory as the familiar tuned amplifier system at the same time being far simpler. The detector used is a triode biased for plate circuit rectification. Since it was desired to obtain maximum output, a large input voltage was applied to the rectifier which gave essentially linear rectification. Under these conditions minimum audio harmonics were produced with the input from one oscillator about twice the other. This condition was obtained by using different oscillator plate load resistors which method was also contributed by Mr. Valentine.

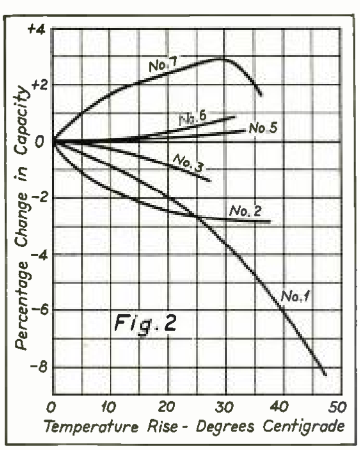


Fig. 2

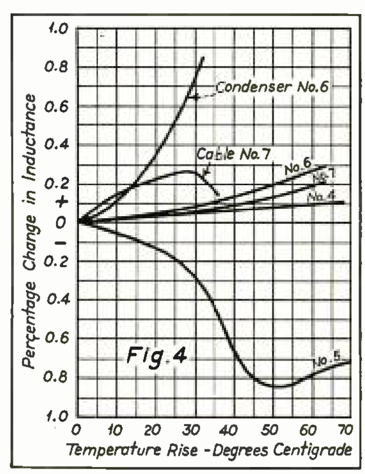


Fig. 4

A single stage of audio-frequency amplification was used giving zero level output. Generous cathode by-pass and coupling condensers maintained good low-frequency response. Two output circuits have been used. One consists of a tube-to-200 or 500-ohm line and the other of high- and low-output levels across 10,000 ohms of resistance without a transformer. In the transformer-coupled model the output fell considerably at both high- and low-frequency ends of the spectrum, mainly due to the transformer response, as a small transformer was used, in order to keep cost and weight at a minimum. Circuit compensation was chosen to correct the output characteristic as being simpler and more effective than automatic volume control. The compensating circuit consisted of a resistance and condenser in parallel connected between amplifier plate and output transformer primary for correcting the high-frequency output by causing a loss complimentary to the transformer loss effective above 3,000 cycles.

For the low-frequency correction a resistance and condenser in series was connected across the transformer primary causing a loss complimentary to the transformer loss below 250 cycles. The result was an output flat to within ± 0.5 db from 50 to 10,000 cycles. In the resistance-coupled output model correction was made in the same way for high-frequency loss due to the radio-frequency detector by-passing. No low-frequency correction was necessary. The result was an output flat to within ± 0.3 db from 15 to 15,000 cycles.

Perhaps the major problem in beat oscillator design is frequency stability and it becomes more serious as simplification is attempted. The use of electron-coupled oscillators essentially eliminated any change of audio frequency with normal line voltage changes. This put the burden on the coils and condensers of the oscillating circuits. Temperature changes in the small enclosed case of the beat oscillator were found to be of the order of 30° C. Temperature control was prohibitively expensive and bulky as were air padding condensers for the oscillating circuits. At first an attempt was made to obtain mica condensers with small temperature coefficients. Fig. 2 shows results obtained with several of the most promising condensers tried. Condenser No. 1 was a low-voltage type molded bakelite mica condenser ¾" by ¾" by ¼" of 1,000 micromicrofarads capacity. Condenser No. 2 was of the same make and type as No. 1 showing the wide variation in temperature coefficient in condensers of this type. Condenser No. 3 was the same type, but of a different make. Condenser No. 6 was a larger condenser rated at a working voltage of 2,500 volts, showing an improvement in stability due to thicker mica and better construction. Condenser No. 5 was of a similar type, but different make, and was artificially aged. As will be noted the most stable condenser was the one artificially aged. A 30-degree rise in temperature caused a change of 0.28 percent in the capacity of this condenser corresponding to 140 cycles change in oscillator frequency at 100 kc. Two of these condensers as padding condensers would thus cause a drift of 40 cycles in the audio-frequency generated if their temperature coefficients were within 0.30 percent of each other. Fig. 3 shows the set-up used in making these temperature coefficient measurements. A Hartley oscillator electron-coupled and similar to the oscillator used in the instrument was set up. A 60-cycle beat, indicated on a cathode-ray tube, was obtained with a standard oscillator. Increments of heat were applied and the frequency change due to heating of the coil or condenser under test was compensated for on the standard condenser in parallel with the oscillator coil where the change was large, or on the vernier inductance in series with the oscillator coil where the change was small. Readings thus obtained were transformed to equivalent percentage inductance or capacity change.

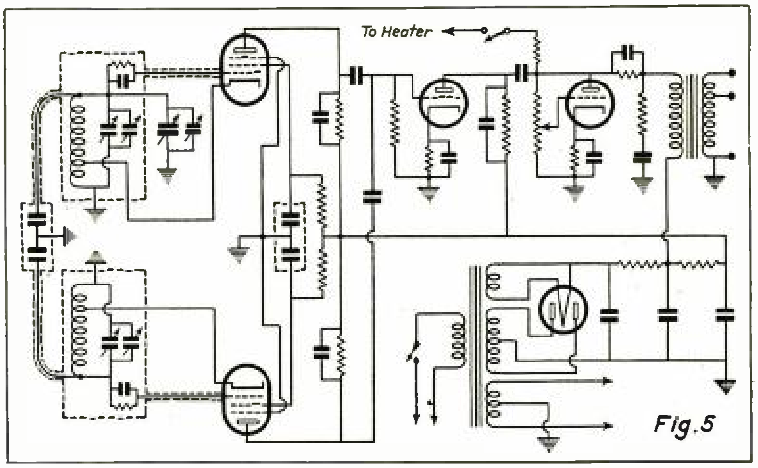
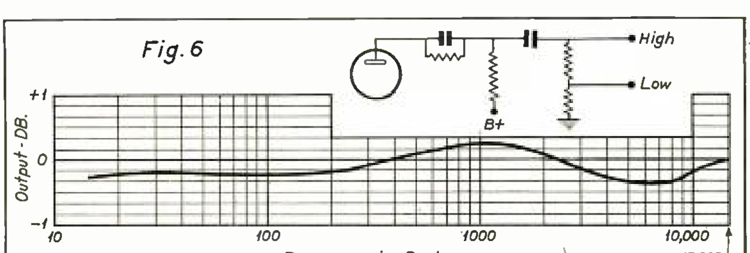


Fig. 5

Fig. 4 shows similar temperature coefficient measurements on a variety of universal wound coils. The inductances of the coils range between about 1 and 2 mh. Coil No. 4 was a solenoid on a bakelite form. This same coil without a binder showed about half as much variation. Coil No. 5 was a universal winding on a wood core impregnated in wax. Coils No. 6 and No. 7 were narrow universal coils on bakelite forms. These two curves show about the maximum variation among this particular type of coil, the average variation being about half that shown. Condensers of the type No. 6 were finally used in the oscillator and its curve is shown for comparison. A 30-degree rise using the coil No. 6 causes a change of 0.09 percent or 45 cycles at 100 kc. A 30-degree rise using coil 7 causes a change of 0.055 percent or 27.5 cycles. One-half the difference which is the average variation among coils is about 99 cycles. Since it takes about 2 hours for the oscillator temperature to rise 30 degrees the average audio-frequency drift is less than 5 cycles per hour. Actually the oscillators come very close to this predicted drift.

There are three possible solutions to the temperature coefficient problem. One solution is to keep coils and condensers in constant temperature compartments. Another solution is to use coils and condensers having zero temperature coefficients. The third solution is to use coils and condensers having small and identical temperature coefficients. A thin universal wound coil should have an inductance-temperature coefficient very nearly that of copper wire since only a very small part of the coil touches the coil form. For copper wire the inductance-temperature coefficient should be

Fig. 6



about 0.003 percent per degree centigrade.

Coils 6 and 7 shown in Fig 3 were of this type and had coefficients very close to the expected 0.003 percent per degree C. Furthermore these coils were very uniform and were chosen for use in the beat oscillator. This matching of coefficients reduces the change in generated audio frequency to a second order effect since if both oscillators change 0.1 percent then at an audio beat of 10,000 cycles, with oscillators at 100 kc and 110 kc, this 0.1 percent change will cause the audio beat to be 10,100 cycles or a change of 1 percent. If one oscillator had been fixed by crystal or other means, the audio beat would have been 11,000 cycles or a change of 10 percent. Since this procedure was not satisfactory in the case of the mica padding condensers due to their greater coefficients and non-uniformity, they were mounted in small shielded compartments on the outside of the oscillator front panel. Thus mounted very little heating was caused by the internal oscillator components which in the absence of room temperature changes, operated as a very satisfactory constant temperature control. The result of this coil and condenser technique was an oscillator which drifted very little even over long periods of operation. The average drift of several such beat oscillators was less than 5 cycles per hour.

The variable oscillator was varied from the frequency of the fixed oscillator to a frequency 15 kc lower by means of a 270-degree variable condenser having a special plate shape in order to give an open scale. A 270-degree airplane type dial with indicator attached directly to the condenser shaft was used. Direct individual calibrations were found to be easier to make than curves and certainly more convenient to the user. Standardization is by beating with 60 cycle line voltage introduced into the amplifier tube grid. A small condenser in parallel with the main frequency control condenser is used for this standardization adjustment and is equipped with a small vernier drive and scale for ease of operation.

As has been stated, electron-coupled oscillators made conventional power supply operation of the oscillators possible; the total high voltage current drawn by oscillators, detector and amplifier was only about 10-12 ma. This low current permitted using resistances in the filter in the place of the usual iron cored chokes. This resulted in a further reduction in weight and cost of the finished oscillator.

Fig. 5 is the circuit diagram of the finished beat oscillator. Fig. 6 shows the output vs. frequency of the resistance coupled output model together with the output circuit.

FILMING PRESIDENT'S TRIPS RECORD HIGH-PRESSURE JOB

How newsreels of the President on tour can be shown in all large cities within a few hours of filming, was strikingly illustrated in the news-handling of the Chief Executive's recent trip to Texas. The President's special train, carrying cameramen of all the newsreels, and photographers of press associations and news photo services, was accompanied by a representative of the Air Express Division of Railway Express Agency to arrange for high-speed distribution of films and pictures taken en route. He telegraphed ahead to express agents at all scheduled stops to be ready, the instant the President's special pulled in, to rush such shipments to the nearest airport for movement by Air Express to New York or Chicago for developing and printing, and reshipment by Air Express to all large cities in the country.

PLANT SURVEYS

(*Continued from page* 9)

true record of the time of each operation. The record showed when each layer was begun and ended, and the time that it took to set the machine for making the next coil. The record also showed how evenly the clutch was engaged, how fast the machine was run, and how smoothly it was slowed down. Schedules were then set on the basis of this study.

This application of the speed recorder would be useful wherever time studies of machine operations were desired and machines were stopped and started between operations.

Time Recorders

The last of the instruments is the time recorder. This instrument may be obtained with as many as 40 individually operated pens which record the sequence and time of different operations. These instruments are often installed permanently to give a continuous survey of the operation of different equipment in the plant. Each pen is connected to a relay on a different machine and shows exactly what portion of the day this machine ran, the shutdowns due to improper routing of materials, improper planning of work, broken machinery, as well as for other reasons. The record from this instrument would be of value wherever the sequence of operations or the continuity of operations was important.

Oftentimes, it is possible for one industry to borrow ideas from another industry of an entirely different character. In this particular case, the radio industry might take a lesson from a coffee packer on the West Coast. The packing of coffee is an automatic process, and in order for production to move smoothly, it is necessary that there be a constant supply of coffee, cans, lids, and that the cans leaving the machines are filled with coffee and have their lids in place. In order to check the operation of this equipment, this company installed a 5-pen recorder connected so that one pen showed the supply of cans, another lids, and the third coffee. The fourth pen showed when the cans came out of the machines empty, and the fifth pen showed when the cans came out of the machines filled but without lids. With this instrument, they were able to schedule the operation of this machine, and determine the causes of any shutdowns. The radio industry could well use this same scheme in checking upon the supply of parts to the assembly line.

BOOK REVIEW

HANDBOOK OF CHEMISTRY AND PHYSICS, twentieth edition, 1951 *pages, flexible covers. Published by the Chemical Rubber Publishing Co., Cleveland, Ohio. Price* $6.00.

There are any number of engineers, this reviewer among them, who would feel completely lost without the "Handbook" on their desks. Regardless of whether one's interest is in chemistry or mechanical or civil engineering, there is always something to be found in this publication.

It is hardly necessary to go into detail about the contents of the Handbook—it is familiar to everyone. However, new sections have been added; among these may be mentioned, Physical Constants of Organic Compounds, Formula Index of Organic Compounds, Pronunciation of Chemical Words (an idea which might profitably be extended to cover some other branches of sciences): X-ray Spectra, and Magneto-Optic Rotation.

It may be the height of something or other to use the expression again, but we do feel that if we were to be limited to one handbook, the volume being discussed would receive our vote.

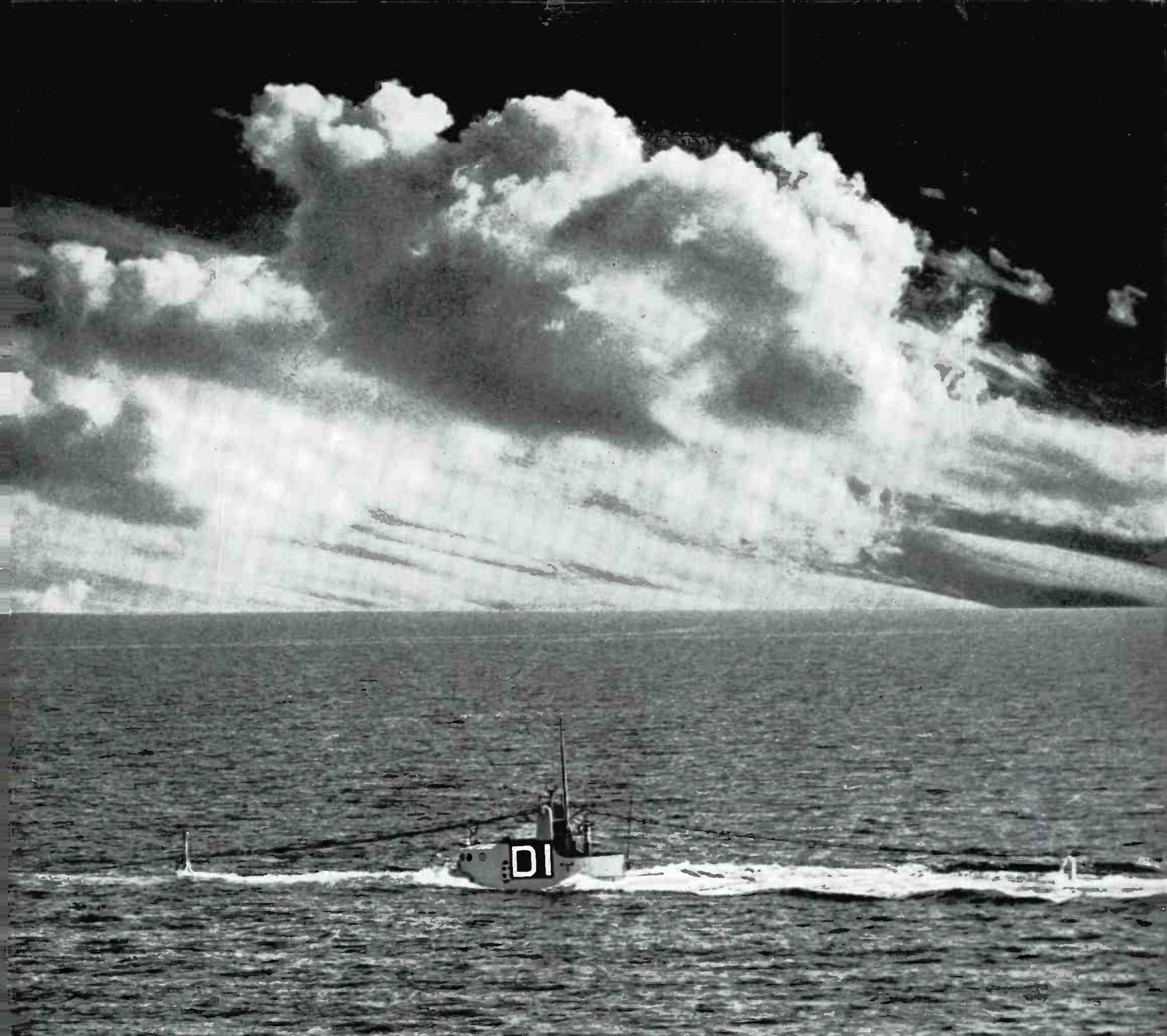
CORRECTION

In the article entitled "Power Amplifier Design," published in the June issue of RADIO ENGINEERING, equation (10) on page 13 should read:

$$I_a = \frac{V\mu k - V}{\mu k R}$$

Equation (12) should read:

$$\frac{1}{R}\left(\frac{V\mu k - V}{\mu k}\right)^2$$



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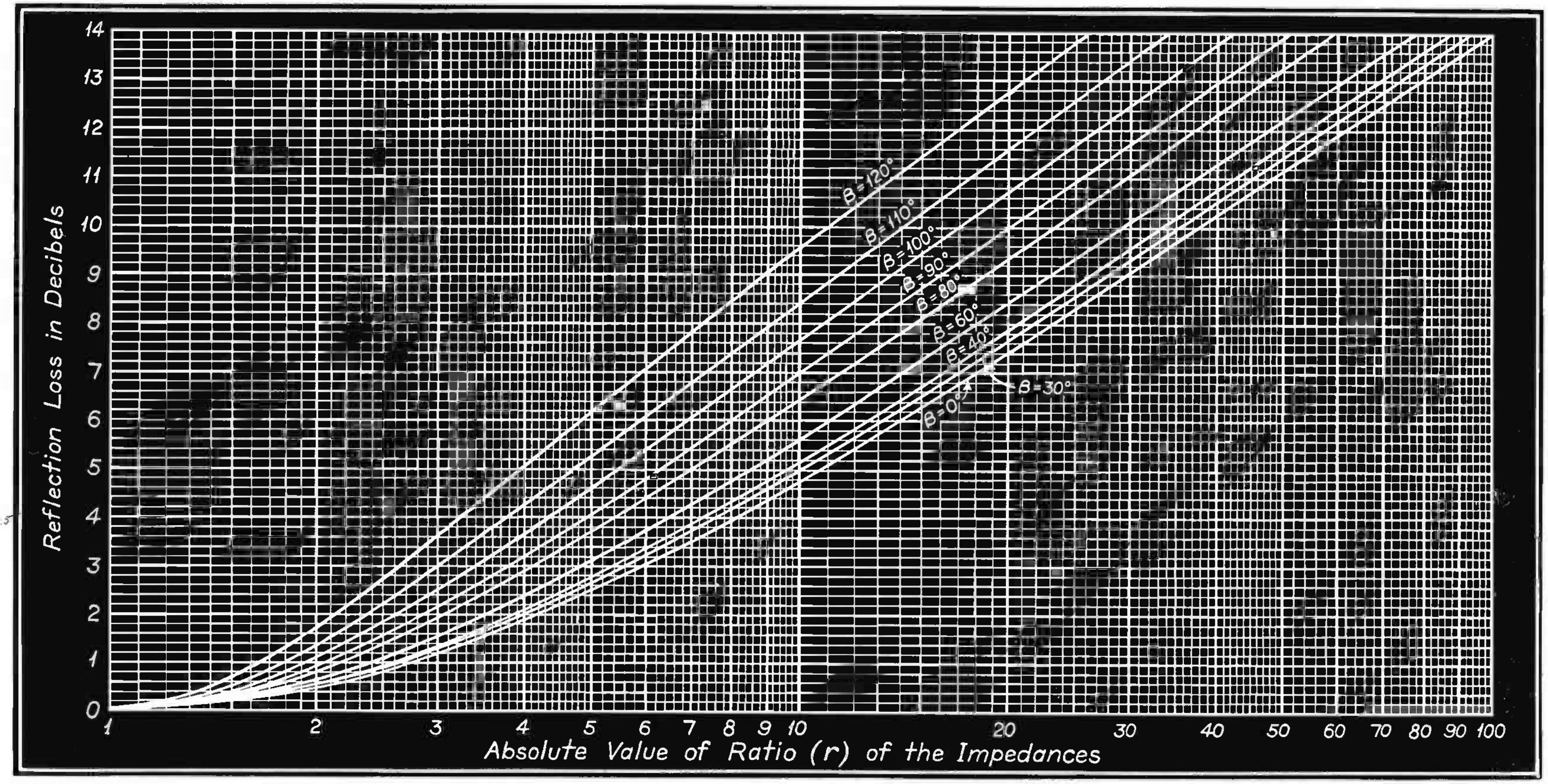


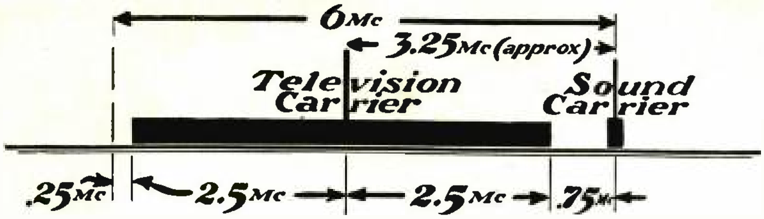
The curves show the loss, in decibels, resulting from a mis-match of circuit impedance, as, for instance, connecting a 200-ohm line to a 500-ohm amplifier input.

The chart is a plot of the equation:

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

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/—30° is connected to a circuit with an impedance of 4000/110°. Adding the angles algebraically, we find β = 80°. The ratio r of the absolute values of the impedances is 4000/500 = 8. From the chart, at the intersection of β = 80° and r = 8, is read the loss, 5.57 db, on the left ordinate.



Typical Television Channel

REPORT OF THE RMA TELEVISION COMMITTEE

THE TELEVISION COMMITTEE of the Radio Manufacturers Association, of which A. F. Murray is chairman, presented the following report for the consideration of the Federal Communications Commission at the meeting held in Washington on June 15. The personnel of the committee is: F. J. Bingley, Philco Radio & Television Corporation; R. B. Dome. General Electric Company; E. W. Engstrom, RCA Mfg. Company; P. T. Farnsworth, Farnsworth Television; C. B. Joliffe, RCA Mfg. Company; R. D. Kell, RCA Mfg. Company; H. M. Lewis, Hazeltine Service Corporation; A. F. Murray, Philco Radio & Television Corporation, and F. J. Sommers, Farnsworth Television.

The report, as presented by Mr. Murray, is given below.

"The time has arrived for the radio industry to recommend tentative television standards, and to suggest frequency assignments to the Federal Communications Commission. Television is a highly specialized branch of the communication family tree. It requires different engineering technique and presents different engineering problems. Engineers, conversant with these problems and able to sense the trend of future development, are limited in number because the art is so new. A group of television engineers, representing all of the leading companies active in this field, have met under the banner of RMA, to formulate for you recommended television standards. These standards will be read later.

"The Radio Manufacturers Association consider the following to be important basic television requirements:

"1. A single set of television standards for the U. S. A.

"2. Frequency channels of adequate width, 6 mc, necessary for the transmission of high-definition pictures—pictures which experience has shown possess sufficient detail to afford sustaining interest—pictures which will approach the quality of home movies.

"A channel 6 mc wide, from the viewpoint of the radio telephone engineer, seems very broad, broad enough for, say, 300 telephone conversations, but if we are to have pictures of satisfactory detail this is the minimum channel width the Federal Communications Commission can assign.

"3. Television, with its accompanying sound, should be in that portion of the ultra-high-frequency spectrum best suited to this service (the 42-90 mc region). This band must be wide enough for a sufficient number of channels to permit the simultaneous broadcasting of a reasonable number of programs in a given territory.

"4. The television frequency band, or bands, should be as continuous as possible because of the convenience this affords in tuning, and because this permits the design of simpler, cheaper home television receivers.

"5. A space in that experimental region above 120 mc for television relaying, pick-up work and expansion. This space is to be shared with other services until that time arrives when, in the opinion of the Commission, definite assignments should be made. Then there will be required the allocation of a continuous band wide enough for a sufficient number of channels for future television service.

"The technical considerations on which these requirements are based will be pointed out later.

"We turn now from purely technical consideration to facts regarding the economic and social side of television.

"In order that television may avoid the difficulties now being experienced in aural broadcasting, let us plan at the outset channels of sufficient width and proper arrangement. This means that plans for high-fidelity television, based on the standards suggested by the radio industry, must be laid now. Any other course will later lead to the obsolescence of television receivers.

"Today, in the laboratory, high-definition television is a reality. Some who have not actually seen it may naturally be skeptical. It happens that two of the companies in RMA have had the pleasure of demonstrating their high-definition television systems to some of the members of this Commission. It is not necessary, therefore, to offer proof, visual proof, that pictures of satisfactory detail can be transmitted. If this were not the case the RMA member company would not be spending one million dollars to continue laboratory tests in the field.

"How will this new art affect our national life? Television, supplementary to, but not taking the place of sound broadcasting, will some day win for itself a place of importance in our national life approaching that of present-day aural broadcasting. We say this because we engineers have observed with keen interest the reaction of individuals to whom we have shown television. The groups have been small, but sufficiently varied to present a cross-section of public opinion With one accord they have expressed deep interest.

"We believe television, when it reaches the commercial stage, will form the basis of a new industry, an industry producing television equipment in our factories and producing programs in the studios. Thousands of workers will be required to manufacture, distribute and maintain television service in the U. S. A.

"Naturally television will some day become the useful and valued servant of a large portion of the American people. The number of our people to be served will be limited by (a) the range of television transmission on ultra-high frequencies, averaging about 25 miles, (b) the initial cost of transmitters, receivers and programs, and (c) the yet unsolved problems of utilizing for transmission the higher end of the ultra-high frequency band.

"In asking for the frequency band beginning at 42 mc we point out that this part of the spectrum is now, and for years has been allocated by the Commission to experimental visual broadcasting. It has been found that in this band the peculiar requirements for television (that is, wide channels and metropolitan coverage) can be met, at least at the lower frequency end. It is logical, therefore, to ask for the continued use of these frequencies. The wisdom of the Commission in designating, five years ago, this particular band for this particular service is shown by the radio industry's recommendations today contained in the following formal report from the RMA."

Frequency Allocations for Television Broadcasting

Lower Frequency Limit: The RMA has previously recommended to the FCC: ". . . that a continuous band of frequencies from 40 mc to at least the neighborhood of 110 mc be reserved for television service. 6/27/33."

The RMA now recommends that the band allocated for television broadcasting should start at 42 mc. (Those companies agreeing: General Electric, Hazeltine, Philco and RCA. Mr. Farnsworth believes that it is satisfactory, but suggests that a frequency of about 60 mc would also be a satisfactory point to start, perhaps even better than 42 mc.)

Reasons for starting television band at 42 mc:

(a) The frequency must be sufficiently high to eliminate multiple transmission paths.

(b) The frequency must be sufficiently high to permit practical designs of circuits to pass the wide frequency bands required for picture transmission.

(c) In the light of present engineering knowledge, it appears that a large metropolitan area could be better served with frequencies near 42 mc, than at higher frequencies, because the attenuation increases rapidly with frequency.

(d) With existing transmitter design and existing tube types greater power output for television can be obtained at the lower frequencies and relatively lower output at the higher frequencies.

(e) It is believed that better and more economical receiver designs will result when starting the band at approximately this frequency.

(f) It is recommended that television services be started in a frequency band for which there are tried engineering designs. The present lower limit of 42 mc is considered satisfactory.

Some of the above limitations will be modified as the art progresses, but television should not be handicapped by imposing difficult frequency limits during the early stages of its commercial development. For example, as the frequency increases attenuation of the waves increases, and at the same time the possible transmitter power output decreases.

Upper Frequency Limit: It is the recommendation of RMA that the band allocated for television should have its upper frequency limit at 90 mc.

Reason: This is the range tentatively suggested by RMA so as to provide a reasonable number of channels. Single dial receivers can be designed to cover this range.

RMA recommends that the space above 120 mc be available for television research.

Reason: To provide space for research on remote pickup, relaying and for future expansion.

Television Channel Width

It is the recommendation of RMA that in allocating channels for television that these should not be less than 6 mc in width.

Reason: It is essential that television have lasting entertainment value. The band width required for picture transmission is directly proportional to frame frequency and to the amount of information to be transmitted. A 6 mc channel permits side bands up to 2.5 mc. A channel make up, in diagrammatic form, is a part of this report. It shows, reading from left to right:

Guard band	.25 mc
Lower side band	2.50 mc
Upper side band	2.50 mc
Guard band	.75 mc
Sound side bands	negligible
Total	6.00 mc

The portion of the channel from the television carrier to the sound carrier is fixed by apparatus and performance considerations.

The lower picture side band is not essential for the transmission of the picture, provided certain design considerations are taken into account. At present no method is known of designing a practical transmitter for completely eliminating one side band. It is, however, possible in the transmitter and receiver to favor one side band and to partially attenuate the other. Future development may indicate how to obtain sufficient reduction in the lower television side band so as to permit placing the sound carrier of the next lower channel closer to the television carrier of the channel under consideration than that indicated in the diagram. This, however, is a future development which may result from experience with television systems.

Television and Sound Carrier Spacing

It is the recommendation of RMA that the sound and picture carriers be separated by approximately 3.25 mc.

Reason: This is determined by the width of the upper picture side band and the practical circuit selectivity obtainable in the receiver so as to prevent "crosstalk."

Sound Carrier and Television Carrier Relation

It is the recommendation of RMA that in a television channel the sound carrier shall be at a higher frequency than the television carrier.

Reason: This permits a better receiver design when using a superheterodyne circuit.

Polarity of Transmission

It is the recommendation of RMA that a decrease in initial light intensity shall cause an increase in the radiated power. This means that negative transmission is recommended.

Reason: Negative transmission permits more efficient use of the transmitter output.

Number of Lines Per Picture

It is the recommendation of RMA that for a channel width of 6 mc, and a picture and sound carrier spacing of approximately 3.25 mc, that there should be between 440 and 450 lines per frame.

It is necessary to have this number to approach home-movie picture quality. When this number of lines is reached, the line structure of a picture of average size is no longer conspicuous. Also, this number makes optimum use of a 6 mc channel.

(Note: The highest number of lines used abroad for practical television is 405. This is one of the two British standards for number of lines per frame.)

Frame Frequency

The RMA recommends a frame frequency of 30 per second and a field frequency of 60 per second, interlaced.

Reason: Production of steady images at the receiver requires that the frame frequency be an integral sub-multiple of the power supply frequency.

Note: RMA Definitions: (a) "The frame frequency is the number of times per second the picture area is completely scanned." (b) "The field frequency is the number of times per second the frame area is fractionally scanned in interlaced scanning."

Aspect Ratio

It is the recommendation of the RMA that the picture aspect ratio shall be 4:3.

Reason: To conform with existing motion picture practice.

Percentage of Television Signal Devoted to Synchronization

It is the recommendation of RMA that if the total amplitude of the composite television signal is taken as 100% then not less than 20% shall be used for synchronizing pulses.

Reason: Receivers synchronize satisfactorily on 20% amplitude. Receivers designed to operate on a synchronizing pulse 20% in amplitude will also operate satisfactorily on pulses of greater amplitude.

Note: By a composite television signal is meant a signal where the combined video, blanking and synchronizing pulses are present.

Synchronizing Signal

The RMA appreciates the necessity for standards relative to synchronizing but this matter is still in a state of flux. Recommendations on this will be made later, after further field tests.

DIRECTION OF MOTION OF A CATHODE-RAY OSCILLOSCOPE SPOT

by J. R. HAYNES*

This material appeared originally in the Bell Laboratories Record for March 1936. It has been somewhat revised by its author to include some specific radio applications.

IT IS SOMETIMES important to know the direction of motion of the spot of a cathode-ray oscilloscope and methods of doing this have been proposed.[1] The gas tube relaxation oscillator circuit shown in Fig. 1 provides a simple means of fulfilling this purpose which has the advantage that it can be used with all types of oscilloscopes. It operates by gradually building up a potential difference across the condenser C until the critical breakdown voltage of the tube is reached at which time the condenser discharges. By properly choosing the values of R and C the condenser can be made to charge and discharge at rates varying from one to 20,000 times per second. If the output of such an oscillator is connected to one axis of a cathode-ray oscilloscope and the other axis is made a time sweep circuit a saw-toothed wave like that shown in Fig. 2 results. The saw-teeth which are caused by the sudden increase of voltage across R when the condenser C discharges and the subsequent slow decrease as it charges again may be thought of as arrows pointing in the direction of motion of the spot. Thus if it is desired to measure the direction of motion of the cathode-ray spot in any cathode-ray oscilloscope figure it is only necessary to connect the relaxation oscillator, tuned to the appropriate frequency, through suitable high resistance leads r_1 and r_2, Fig. 1, and superpose the saw-toothed wave on the figure in question. It has been found that a Western Electric 256A vacuum tube used with a capacity of .0005 mfd and a resistance of one megohm will cover the frequency range of from 700 to 8,000 cycles per second.

* Department of Physical Research, Bell Telephone Laboratories, Inc.

The appearance of an oscilloscope pattern without and with the relaxation oscillator is ilustrated in Figs. 3a and 3b, respectively. The direction of motion of the spot in this case was clockwise.

In determining the phase angle between voltages developed across various parts of an electric circuit a knowledge of the direction of motion of the spot is of definite aid. If the figure approximates an ellipse, which is usually the case, the phase angles between such voltages may be measured in magnitude and in sign. The x and y components of the ellipse shown in Fig. 4, for example, may be represented by the projection on the respective axes of single points moving uniformly around circles of reference. If it is known that the spot will trace the inclined line as shown, when the voltages are in phase, it follows that the points must move in the same direction about the circles of reference. Further if it is known that the spot moves in the direction indicated, a consideration of the figure will show that the points in the circles of reference must move in the direction of the arrows. Therefore, the voltage on the x axis in this case leads the voltage on the y axis by an angle ϕ.

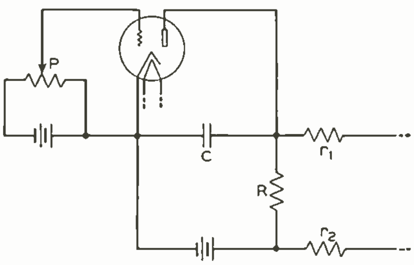


FIG. 1. A GAS TUBE RELAXATION OSCILLATOR, SHOWN HERE, DIAGRAMMATICALLY, IS USED TO PROVIDE A RAPID SUCCESSION OF TIMED PULSES.

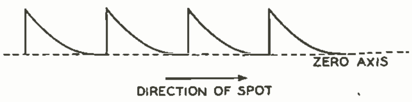


FIG. 2. A SAW-TOOTHED WAVEFORM IS OBTAINED WHEN THE OSCILLATOR IS CONNECTED TO A CATHODE-RAY OSCILLOSCOPE WITH A TIME SWEEP AXIS. THE SERRATIONS POINT IN THE DIRECTION OF MOTION OF THE OSCILLOSCOPE SPOT.

Since this device makes possible the measurement of the phase angle between voltages a convenient application is found in determining the sign of the components of an impedance. In this case the oscilloscope is connected as shown in Fig. 5, which makes use of the fact that the voltage across the resistance R is proportional to and in phase with the current through the impedance Z. The equations for resistance and reactance are:

$$R = \frac{E}{I} \cos \phi$$

$$X = \frac{E}{I} \sin \phi$$

The device should also prove useful in the study of the phase conditions which exist between various components of multi-stage amplifiers and, more especially, feedback circuits.

[1]E. R. Mann, Rev. Sci. Insts., Vol. 5, No. 6, June, 1934; H. E. Hollmann and W. Saraga, Hoch. Tech. u. Elec. Akus., Vol. 41, No. 53, 1933.

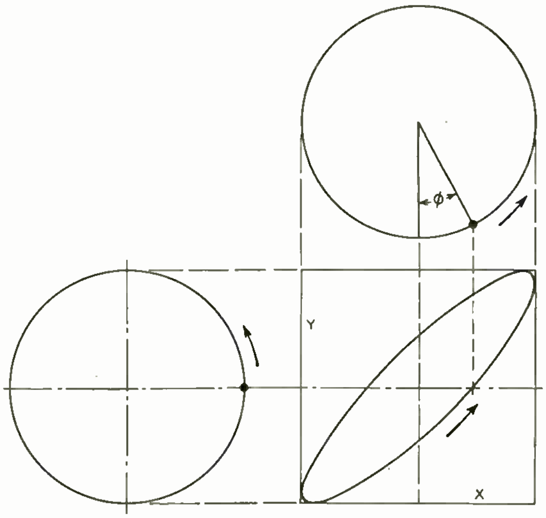


FIG. 4. WHEN THE OSCILLOSCOPE PATTERN IS AN ELLIPSE IT CAN BE RESOLVED INTO TWO COMPONENTS WHICH MAY BE REPRESENTED BY POINTS MOVING UNIFORMLY IN TWO CIRCLES.

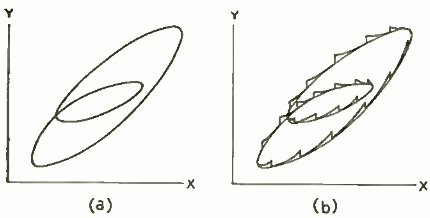
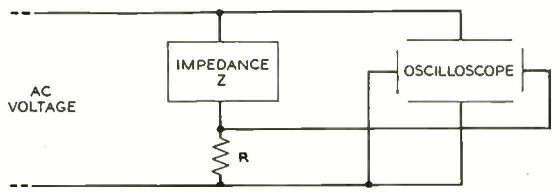


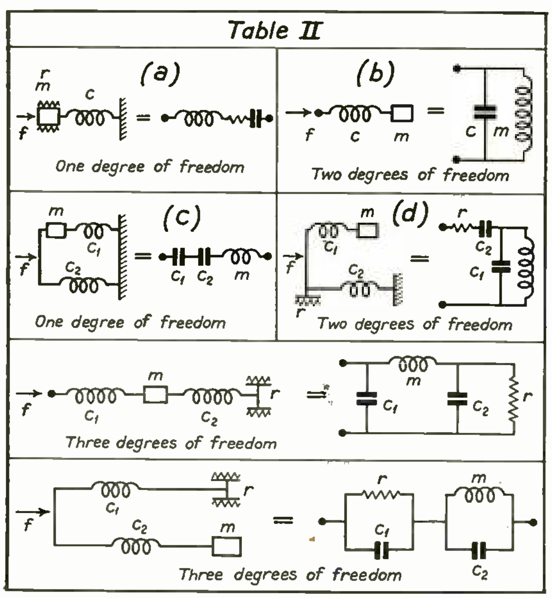
FIG. 3. THE OSCILLOSCOPE PATTERN (A) IS CHANGED TO THAT SHOWN AT (B) WHEN THE RELAXATION OSCILLATOR IS APPLIED, THUS INDICATING IN THIS CASE THAT THE OSCILLOSCOPE SPOT IS ROTATING CLOCKWISE.

FIG. 5. TO MEASURE THE PHASE ANGLE BETWEEN THE APPLIED VOLTAGE AND THE CURRENT OF AN IMPEDANCE THE VOLTAGE ACROSS THE IMPEDANCE Z IS APPLIED TO ONE PAIR OF THE OSCILLOSCOPE PLATES AND THE VOLTAGE ACROSS THE RESISTANCE R, WHICH IS IN PHASE WITH THE CURRENT, IS APPLIED TO THE OTHER PAIR OF PLATES.



THEORY OF THE LOUDSPEAKER

(*Continued from page 12*)



one corresponds to a closed *mesh* in an electrical network. In other words, the number of "degrees of freedom" of a mechanical system is equal to the number of meshes in the equivalent electrical network. The condition for the balance of *mechanical forces* in such a point corresponds to Kirchhoff's first law that the sum of the voltages around a closed mesh must be zero.

A number of mechanical oscillatory systems and their equivalent electrical networks are shown tabulated in Table II.

(*To be continued*)

REFERENCES

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[2]C. W. Hewlett, Phys. Review, 19, 52, 1922.

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NON-RADIATING SUPER-REGENERATIVE DETECTORS

by W. E. BONHAM*

The Elimination of High-Frequency Radiation from Receivers — Super-regenerative or Superheterodyne— Which Employ Local Oscillators

THE SUPER-REGENERATIVE detector is a development from the early regenerative detector since the regenerative detector at the extremely high frequencies could not be consistently maintained at the threshold of oscillation where it is the most sensitive and selective. The super-regenerative detector is one that is caused to break into and out of oscillation at some low, but inaudible frequency, and in so doing it passes through its most sensitive and selective operating point.

It seems to be commonly agreed that the outstanding desirable characteristic of the super-regenerative detector is its ability to almost totally reject the external forms of interference so common to the high-frequency band, such as car ignition, signs, and the like. When it is maintained in the proper state of super-regeneration it is extremely sensitive and fairly selective. This type of detector is known to radiate badly into the antenna with which it is directly associated, and the loading effect upon the detector by having to couple the antenna or a radio-frequency amplifier to the input circuit removes the detector from its optimum operating condition. When the detector constants are so selected for the optimum sensitivity and selectivity possible, it is sufficiently critical that the least loading effect caused by the antenna, local wiring or absorption from improperly designed shielding causes the sensitivity to drop much below the normal level or even stop the detector from oscillating. The occurrence of dead spots due to the oscillator frequency becoming equal to some harmonic of the antenna or the local circuits has for some time been one of the chief drawbacks of this very promising detector.

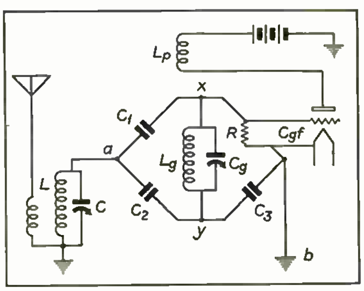

Fig. 1.

Radio-frequency amplification helps eliminate radiation into the antenna circuit; however, radio-frequency amplification at the extremely high frequencies is not very effective.

The circuit principle described in this article is designed primarily for the purpose of enabling the super-regenerative detector to be constantly maintained at its optimum operating condition without being affected by the absorption of energy from coupling either to the antenna or a radio-frequency amplifier. It enables optimum coupling to be maintained to the input circuit of the detector and prevents radiation into the antenna when it is directly coupled to it. The basic principle involved can also be applied to the high-frequency superheterodyne receiver to eliminate radiation into the antenna when the oscillating type of first detector is used without radio-frequency amplification, and to prevent the losses caused by having to detune the oscillating detector from the incoming frequency to produce the required intermediate frequency.

The basic principle explained below with the aid of the circuit of Fig. 1 is that of a balanced bridge arrangement. While this particular method of feedback, from plate to grid circuit, to produce regeneration is not adapted ideally to the high-frequency super-regenerative detectors, it is used to show the principle involved which can be applied to any type of oscillating detector.

The bridge is in balance when C_1/ C_2 equals C_{gf}/ C_3. When the capacity C_2 is equal to the interelectrode capacity, C_{gf}, of the tube, half of the voltage developed in the oscillatory circuit due to the oscillations from the tube is fed to the grid-filament of the tube. Because the circuit voltage divides across two capacities the coupling between the plate and the grid circuit coils must be in-

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creased slightly to maintain oscillation. With the bridge in balance the voltage set up in the oscillatory circuit L_gC_g produces no voltage between the points a and b which, being connected to the antenna and ground. respectively, enable the circuit to oscillate without feeding energy into the antenna ground circuit. In this respect the antenna or the pre-selector circuit, L C, is in no way affected by the tube oscillations or the tuning of the oscillatory circuit. On the other hand, an incoming signal is tuned into the pre-selector circuit and the signal voltage from it is applied to the points a and b where it divides equally. one part through the path C_2 - C_3 and the other through C_1 and the grid filament capacity C_{gf}. By having C_1 large compared to the grid filament capacity practically all of the signal applied across the points a and b is available to the grid of the tube. Since the bridge is in balance there is no voltage developed across the points x and y due to the incoming signal; these points being across the oscillatory circuit, it means that the incoming signal or the tuning of the pre-selector circuit has no effect upon the oscillatory circuit. In this manner the antenna can be coupled to the oscillating detector with optimum coupling and yet at the same time be completely isolated from the oscillatory circuit. Thus the detector can be designed with the same considerations as though no antenna coupling existed.

The pre-selector tuning capacitor C has in parallel with it the joint capacity of the two paths of the bridge namely, C_1 - C_{gf} and C_2 - C_3. The capacity C_g has no effect as long as the bridge is in balance. Also, the tuning condenser C_g of the oscillator circuit has in parallel with it the joint capacity of the two paths C_1 - C_2 and C_{gf} - C_3. The pre-selector tuning or antenna-ground capacity have no effect with the bridge in balance.

If the capacity in parallel with the tuning condenser C, and that in parallel with the oscillator, are expressed as the joint capacity of the arms of the bridge, then by placing C_3 equal to C_{gf} and differentiating each of the added capacities it can be shown further that as the C_1/C_{gf} ratio increases from unity to infinity the capacity in parallel with the antenna tuning condenser varies between the limits of C_1 and 0, and, the capacity in parallel with the oscillator tuning condenser varies between the limits of C_1 and $\frac{1}{2}C_1$. The practical limit for this ratio to extend in the design of the bridge has been found to be essentially from 1 to 100. At unity ratio half of the signal tuned into the pre-selector circuit is available to the grid of the tube, and at the latter ratio practically all of it is available to the grid. Experimentation has shown that C_3 can be kept equal to the input capacity of the tube for several types of detector tubes.

The graph of Fig. 2 shows the interpretation of the effects of the bridge upon each of the tuning capacitors.

Fig. 2 shows that for a fixed value of C_1 the effects of the bridge upon the tuning circuits becomes less as the C_1/C_{gf} ratio increases. Since the available signal to the grid also increases

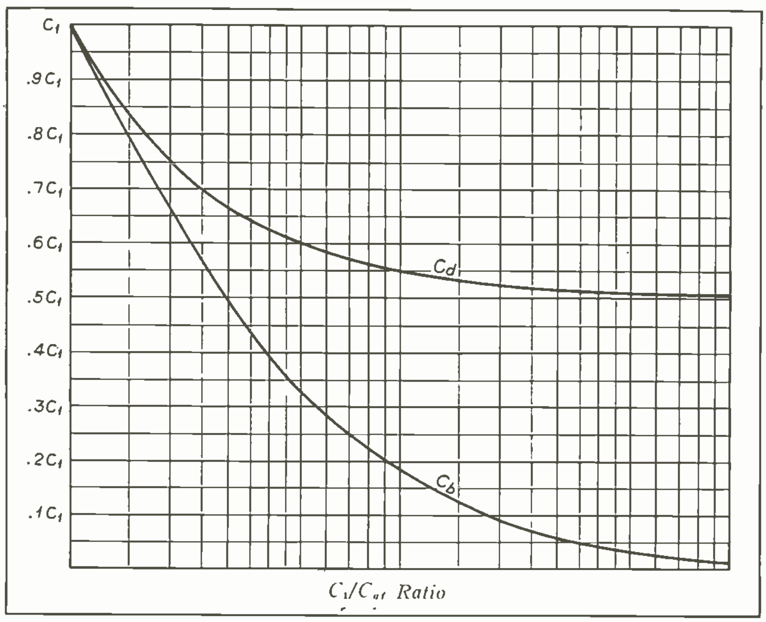


Fig. 2.

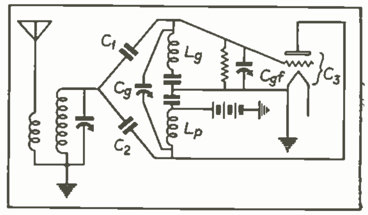


Fig. 3.

with this ratio, the increased ratio promotes better operating conditions. Also as this ratio increases, the added capacity across the oscillator tuning becomes greater than that across the pre-selector tuning; thus the capacity-inductance ratio in the oscillator circuit increases over that in the pre-selector circuit. This aids the circuit also because it increases the gain factor and the selectivity in the pre-selector circuit and increases the stability in the oscillator circuit. But if the ratio C_1/C_{gf} is too large, then C_1 may add more capacity to the oscillator circuit than the total minimum required to tune it to the highest frequency. From this it is obvious that adding a compensating condenser across the pre-selector tuning condenser to compensate for the difference in the effect of the bridge on the two tuning condensers does not aid to the performance of the circuit.

Since the inductance-capacity ratio in the pre-selector circuit is always larger than that in the oscillator circuit, the difference between C_{max} and C_{min} will be less than the difference between $C_{g\,max}$ and $C_{g\,min}$ to tune over the same frequency band; then also, since C_{min} is less than $C_{g\,min}$ the values for the entire circuit are set by the limitations presented in the mechanical construction in building C to the desired minimum and the required maximum. The lower C_{min} can be built the more capacity effect can be allowed for the bridge and the greater can be the C_1/C_{gf} ratio. Thus the design of the bridge is based upon a compromise between the minimum which the C_1/C_{gf} ratio should be, and the limitations set by constructing the pre-selector tuning condenser to the lowest minimum and retaining the required maximum.

Because of the number of variables and the nature of certain limiting conditions an indirect and elementary method in arriving at a design for the bridge seems the most practical. Since the bridge design is based upon the compromise between the C_1/C_{gf} ratio which should be used and the limitations of C_{min} and C_{max}, and since the C_1/C_{gf} ratio sets a value for C_b, the relation between L, C and C_b must be shown by formula; then upon the proper com-

(*Continued on page* 29)

MEETING OF EMPORIUM IRE SECTION

A TWO-DAY MEETING of the Emporium Section of the Institute of Radio Engineers was held at Emporium, Pa., on Friday and Saturday, June 26 and 27.

With a roster of out-of-town guests numbering twenty-five, the first day was spent largely in getting acquainted and in visiting several of the industrial plants of the vicinity. Early comers were shown the Emporium plant of the Hygrade Sylvania Corporation, and a trip was made to the Stackpole Carbon Company's plant at St. Marys, Pa.

The Sylvania Club at Emporium was the host to those from out of the city. Among its distinguished guests were: L. C. F. Horle, nominee for the presidency of the IRE, and Prof. E. C. Woodruff, president of the ARRL.

The club provided many excellent opportunities for what the program called "Bull Sessions," only one of which was officially scheduled. But the engineers evidently found the temptation too great to resist the lure of a "postman's holiday." Television seemed to be the chief topic of these informal discussions, although other phases of the art came in for their share of the general argument.

The social features of the meeting came to a close, following the Saturday morning technical session, with a field day at a camp in the mountains near Emporium.

The technical sessions started Friday evening. Raymond R. Hoffman, Chairman of the Emporium Section, opened the meeting with a few remarks welcoming the guests and then turned the meeting over to L. C. F. Horle.

Mr. Horle, in introducing the first speaker, remarked that in the thirty years since the advent of the electronic detector, radio had become of age in that there was a return to fundamental principles—the implication being, obviously, that the wisdom of age dictated the return to circuits which had been discarded in the search for high-gain detectors, and that the results obtained with these detectors left much to be desired from the standpoint of quality.

The first paper, "Diode Coupling Transformers," was presented by F. H. Scheer of the F. W. Sickles Company. Mr. Scheer traced the development of the diode detector and pointed out the distinctions between the triode and diode as detectors, with particular emphasis upon the necessity for separate consideration of the two types.

It was shown that for certain values of diode load resistance, modulation capabilities of as great as 93% could be obtained. Optimum values of the diode loading network were discussed, and the effect of the avc filter resistance was shown.

Various types of transformers for coupling the i-f stage to the diode were discussed and conditions for maximum gain and selectivity were given. Equations giving the gain as a function of the coupling transformer constants were given.

To summarize the paper briefly: The LC of the transformer must be held constant; LC should have a resonant frequency impedance of $Q\omega L = Q/\omega C$; better selectivity results from slightly under-coupling the transformer; the gain is greatest and the selectivity least with large values of transformer secondary inductance, although a large value of secondary inductance insures that the Q of the coil will have a minimum effect upon gain and selectivity.

The second paper of the evening session, "Applications of Cathode-Ray Oscillographs," was given by H. J. Schrader of RCA Victor Division, RCA Manufacturing Company.

The design features of a new cathode-ray oscillograph were discussed in some detail, including a method of increasing the high-frequency response of the oscillograph amplifier; the system used an inductance, in series with the plate load resistor of the final amplifier tube, which was so proportioned as to be resonant with the deflector-plate capacity of the cathode-ray tube at a frequency slightly higher than the upper frequency limit for which the equipment is designed.

With this equipment, the line-up of i-f amplifiers can be shown by the superimposition of the curves of i-f transformer primary and secondary response characteristics.

Many applications in the mechanical field are possible; the measurement of shaft vibration and torsion, measurement of cylinder pressure and gun barrel pressure being some examples mentioned and discussed.

A cathode-ray oscillograph of the type under discussion was on demonstration.

The Saturday morning session, which was also conducted by Mr. Horle, got under way after a trip through the Hygrade Sylvania plant.

The first speaker was C. T. Wallis of the Delco Appliance Division, General Motors Corporation, whose paper, "Vibrator Power Supplies," was a comprehensive treatment of this important feature of automobile radio receivers.

Mr. Wallis showed numerous slides of micro-photographs of vibrator contacts which had been operated under various conditions of voltage, pressure, etc. Considerations in the design of circuits associated with vibrators were discussed, as well as acoustic insulation requirements, and the need for effective grounding of the vibrator can cover. Characteristics of vibrators for various conditions of contact pressure and for both capacitive and inductive inputs to the filter system were described.

The final paper of the meeting, "Extending the Upper Frequency Limit of Receiver Sensitivity Measurements," was presented by C. J. Franks of the Ferris Instrument Corporation. Tracing the development of the standard signal generator from its inception to the present precision laboratory tool, Mr. Frank showed some of the means provided to insure flexibility along with the great degree of stability needed for present-day receiver measurements.

The attendance at the first meeting—Friday evening—was ninety, while there were seventy present at the Saturday morning session.

Design . . NOTES AND

ITALIAN TUBE PROJECTS TELEVISION IMAGES

THROUGH THE COURTESY of Societa Anonima Fabbricazione Apparecchi Radiofonici, Milan, Italy, we are privileged to present below the details of a new type of cathode-ray tube which is said to provide sufficient illumination for actual projection of the television image.

The new tube was developed to help reduce the physical dimensions of television receivers and at the same time to give larger and more luminous images. Problems to be met in mass production of this type of tube were also attacked.

It can be seen, in the illustrations, that the bases of these tubes are of metal. The leads pass into the base shell through beads of glass or of ceramic material. The plate lead, insulated to carry 7,000 volts, also passes through the base shell.

Cathode-ray tube for image projection. The interior ceramic structure is shown in detail.

Metal, glass and ceramics were experimented with for the envelope, the model shown being of the ceramic type. Hard glass screens were sealed into the envelopes; in the glass-envelope type, the screen was formed by blowing in a die. It is understood that ceramic envelopes have the advantage of relatively inexpensive manufacturing equipment, although this type is naturally more fragile.

The glass screens are optically corrected (presumably for proper curvature—Ed.) before the luminous salt, of a new type, is applied. This salt is said to be highly resistant to the effects of high temperatures, and to have an exceptional degree of brightness.

The tube elements are mounted in ceramic material which is vitrified after the tube has been assembled. Means are provided to preserve the proper alignment of the elements.

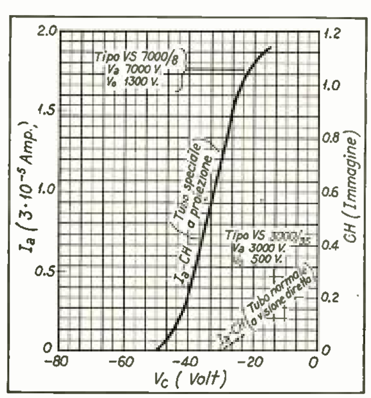
Comparison of the direct-viewing and projection type tubes; projector tube on the right.

The tube uses an interchangeable cathode with indirect heating. The cathode is a disc of pure nickel, highly polished, on which is deposited the active material. There is no direct contact between the heater and the cathode. The interchangeable cathode apparently is more readily adaptable to the ceramic envelope tube than to the metal variety.

The accompanying curves show the plate current characteristic and the light intensity of the new tube as compared with the conventional direct viewing cathode-ray tube.

The direct image obtained from the new tube is about 50 by 50 mm; this may be enlarged by projection to 300 mm square.

At the present time, tests are being made to determine the feasibility of using a plate potential greater than 7000 volts, and for determining the possibility of increased cathode life.



Curves showing the relative characteristics of the tubes illustrated above.

A NEW DESIGN OF SOUND-LEVEL METER

A NEW SOUND-LEVEL meter which will give a quantitative measure of noise independent of the personal element, and at the same time give results commensurate with the sensations experienced by the ear, has been developed by the General Electric Company. The meter was developed to provide performance in accord with the newly adopted American Standards Association standards. Special precautions have been taken to make the amplifier unit of the instrument suitable for use in the neighborhood of electrical machinery where stray magnetic fields are common. The complete instrument, including microphone, tripod; calibrating unit, and batteries is contained in a compact metal case 15¾ by 9½ by 8¼ inches. The carrying weight is approximately 39 pounds.

General Electric sound level meter.

The microphone is a small, nondirective, piezo-electric type with practically flat frequency response up to 8000 cycles per second. It is shielded against stray electric fields, and is not affected by stray magnetic fields such as those usually surrounding electrical machinery.

The five-stage amplifier is resistance-transformer coupled and has special small-size, low-drain tubes mounted in shock-reducing sockets. A convenient switch permits the selection of either a flat-frequency response to measure sound intensity, or a weighted response which approximates that of the ear at a loudness of 40 decibels. The sound-level meter is calibrated to read in decibels above the standard reference level of 10^{-16} watts per square centimeter at 1000 cycles. The range of the instrument is 30 to 120 decibels. This is sufficient for noises ranging from those in quiet country homes to sounds that are intense enough to be painful to the ear. Suitable jacks are provided in a 500-ohm interstage circuit to permit the use of auxiliary equipment such as an analyzer or a vibration velocity unit or special filtering and control circuits as needed.

A receptacle is provided for connecting external batteries where the instrument is to be used on permanent location.

A simple mouth-blown calibrating unit is provided to insure accurate overall field calibration. Factory calibration is obtained by placing the microphone in a standardized sound field.

INDUSTRIAL PHOTOCELL CONTROL

A NEW PHOTOELECTRIC control unit in which sensitivity and operating speed have been doubled, and which is said to be highly dependable even under difficult service conditions, has been introduced by the Weston Electrical Instrument Corporation, Newark, N. J. It is applicable to a wide range of industrial control purposes in which interruption of a light beam conveniently provides the initial impulse for opening or closing an electrical circuit, such as counting, sorting and weighing devices, automatic processing control, safety cut-offs, alarm warnings and the like.

The assembly consists of a Weston photocell of high output characteristics in a protective mounting, the complete relay unit in a separate panel box, as well as a light source of standard design. A light intensity of 100 foot-candles falling on the cell provides adequate energy for positive operation of the relay system in contrast to the 200 foot-candle level formerly required. Output capacity of the new relay is 500 watts, so that most installations can be handled directly by the relay contacts without the use of external contactors.

The relay is arranged for single-pole, double-throw operation, with an overall speed of response of 0.15 second. Positive action of the relay at speeds up to 400 operations per minute permits automatic control of high-speed industrial processes for which previous units of this type were unapplicable.

A particularly useful feature of the panel assembly of the new unit is the microammeter calibrated in light units, which has been included to show the level of illumination reaching the photocell. The meter forestalls the possibility of operating difficulties resulting from failure to maintain the light on the cell at an adequate level.

Both the initial sensitive relay and the secondary power relay used in the new control are reported to be of simpler and more rugged construction than in previous units. Mechanical improvements in mounting and case design, such as the use of a threaded back for screw mounting of the photocell, are also said to make for added simplicity in installation and maintenance. The complete new control device (Model 729), including photocell, relay panel and light source, will be sold at a price substantially below that of the former units offered for photoelectric industrial control.

As in former units, the Weston photocell generates sufficient electrical energy directly from the light energy to operate the relay without external amplifying tubes or other current supply to the cell. The cell and relay panel may be mounted at different locations as required.

Weston photoelectric control unit for industrial applications.

GAS IN METAL

THE COMMON CONCEPTION of gas in metal is that the gas is held between crystals of the metal in a manner similar to the way a clay humidor holds moisture. It is further believed that all that is necessary to remove this gas is to lower the pressure on the surface of the metal and the gas will escape by diffusion, hastened by the application of heat. Another method is to heat in an atmosphere of hydrogen since the undesirable gas is replaced by pure hydrogen which is readily pumped off later.

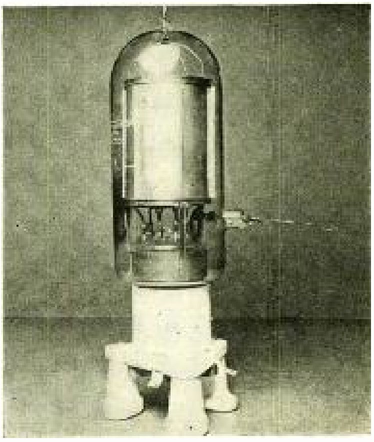
If this were true, degassing would be a relatively simple procedure. The problem is that the quantity of gas held in this manner is relatively small depending on the metal, its method of refining and preparation. The gas which causes headaches is in the form of bubbles under pressure as a result of the rolling of the metal. Here another idea is exploded—namely, that such bubbles are just under the surface. While of course they are under the surface, they are usually exactly half way between surfaces and held there so firmly that the only quick method of removal is by literally "exploding" the pocket through application of heat.

The reason is obvious. It is well known that glass tubing when heated and drawn out to a mere thread is always hollow. So it is with metal. A bubble of gas acts in the same manner and may be rolled out, leaving a train of minute bubbles running in the middle of the strip even to very thin gauges.

To observe this effect a length of material should be fired in hydrogen at 1100° C. Blisters from internal gas will appear on the surface and examination with magnification will show the true location of the gas pocket.

Svea-onics

THE FARNSWORTH MULTIPACTOR TUBE



This development is an important part of the Farnsworth television system.

RMA NEWS

HIGHLIGHTS OF TWELFTH RMA CONVENTION

A THREE-DAY program packed with enthusiasm, interest and future plans for the radio industry, including many committee and group meetings, featured the Twelfth Annual RMA Convention at the Stevens Hotel, Chicago, June 17-19. More than 100 manufacturers attended and nearly 400 enjoyed the "RMA Party," the cabaret-membership dinner last Friday evening.

President Leslie F. Muter of Chicago, who presided, and other RMA officers were reelected. There were meetings of the Set, Tube, Parts and Amplifier Divisions and of the Association's Board of Directors, the Credit, Export and Service Committees and other groups. There were no merchandising displays but wide discussion of radio merchandising practices, and a special committee on fair trade practices, headed by E. F. McDonald, Jr. of Chicago was appointed.

Important and tangible sales promotion aid by the Department of Commerce to RMA was detailed at the Chicago Convention. A new RMA short-wave program service is being sent to the leading foreign countries by the Department of Commerce. The weekly bulletins of the Government include short-wave programs of all American stations and is distributed in the leading foreign countries through all commercial attaches of the Department of Commerce. The American short-wave program service is compiled by the RMA but distributed throughout the world by the Government and is expected to greatly increase foreign listening of American short-wave programs and also stimulate export sales of American manufacturers.

Secretary of Commerce Roper in his letter to President Muter of RMA stated, "I am proud that the Department of Commerce has been permitted to assist you in attaining your enviable record, and I cannot urge you and your members too strongly to make a greater use of the facilities of this Department.

"Your industry is a progressive industry," Secretary Roper also declared, "constantly striving for an improvement of your art, and that your efforts have been crowned with success is clearly demonstrated by the fact that you have established all-time records in both your domestic and your export business in 1934 and again in 1935.

"Through your efforts the broadcasts of all the world are now at our finger tips and it is my belief that through the medium of radio broadcasting and particularly through the reception of foreign programs we have the means of promoting international good will which, in the last analysis, is the very essence of foreign trade."

Further Government aid to the industry was offered by the Department of Commerce representative to the RMA Convention, Mr. Andrew W. Cruse of the Bureau of Foreign and Domestic Commerce. He detailed the functions of the Government in promoting both domestic and foreign radio trade, including recent reciprocal trade treaties in nearly all of which substantial concessions were accorded. "It is the function of the Bureau of Foreign and Domestic Commerce," said Mr. Cruse, "to get orders for merchandise."

Minimum wage and other labor and legal problems were discussed by Judge John W. Van Allen of Buffalo, general counsel of the RMA. Industry must choose, said Judge Van Allen, and take action to retain either the present minimum wage laws of various States or consider a national minimum wage law with its complications of Government regulation.

"We must study these problems more closely from their national aspect," said Judge Van Allen. "If we do not do this but leave it to those who would malign all industry as evil and iniquitous and whose information and ideas are gathered from university halls and book reading rather than from practical experience, we shall deserve what we shall certainly get—legislation founded upon theory rather than practical experience."

Future development of television, facsimile and other radio services were discussed at the Set Division meeting, with A. S. Wells of Chicago presiding in the absence of Chairman Arthur T. Murray of Springfield, Mass. The RMA recommendations for future commercial use of television and other new radio services were detailed by James M. Skinner of Philadelphia, chairman of the RMA special committee which presented the industry's recommendations recently at the hearing in Washington of the Federal Communications Commission. Tube merchandising problems were discussed at length by the Tube Division, under the acting chairmanship of David T. Schultz of New York, in the absence of Chairman B. G. Erskine. Important problems and future activities of parts, cabinet and accessory manufacturers were discussed at the Division meeting under the chairmanship of Arthur Moss of New York, and problems of amplifier, loud speaker and sound equipment manufacturers were discussed at the Division meeting presided over by Chairman Henry C. Forster of Chicago.

The RMA cabaret-membership dinner Friday evening more than repeated the success of a similar "RMA Party" last year. Over 400 Association members and guests enjoyed a cabaret program arranged by Chairman A. S. Wells of the Convention Committee and compelled the transfer of the event from the Stevens Tower Ballroom to the larger Boulevard Room. During the evening the associates of President Muter of the RMA Board presented him with an elaborate golf outfit in appreciation of his work during the past year and a traveling bag also to Mrs. Muter.

Three new directors of the RMA Board were elected: Commander E. F. McDonald, Jr., James Knowlson and Peter L. Jensen, all of Chicago. The present RMA organization was continued, including reelection of Bond Geddes of Washington as executive vice president, general manager and secretary, and John W. Van Allen of Buffalo, general counsel.

Arthur T. Murray of Springfield, Mass., was reelected vice president and chairman of the Set Division; B. G. Erskine of Emporium, Pa., vice president and chairman of the Tube Division; Arthur Moss of New York, vice president and chairman of the Parts, Cabinet and Accessory Division, and Peter L. Jensen of Chicago, vice president and chairman of the Amplifier and Sound Equipment Division. Directors Ben Abrams of New York and Powel Crosley, Jr., of Cincinnati were reelected to the RMA Board for the three-year terms. Retiring directors were Paul B. Klugh of Chicago, A. Atwater Kent of Philadelphia, and Henry C. Forster of Chicago.

CONVENTION REPORTS

Detailed reports of the Chicago Convention, including those of President Muter, all Division and Committee chairmen, and of the speakers at the membership meeting, Andrew W. Cruse of the U. S. Bureau of Foreign and Domestic Commerce and Judge Van Allen of Buffalo, are being prepared and will be forwarded to all RMA members soon.

EXPORT COMMITTEE ACTIVE

Unusual volume of foreign trade difficulties are being handled by the Export Committee of which Mr. S. T. Thompson of Pilot Radio Corporation of Long Island City is chairman. In efforts to preserve export trade of the industry from harmful action abroad, the RMA through Chairman Thompson recently filed protests with the State and Commerce Departments at Washington against the new quota restrictions of Australia, the threatened embargo of Chile on radio imports because of the foreign exchange situation, and similar conditions in Spain, and against reported plans of the British industry and the new labor government in New Zealand to increase radio tariffs. All possible assistance of the Government has been promised the RMA in these and other foreign trade problems.

APRIL EXPORTS INCREASE

Although there was a slight reduction in exports of receiving sets last April, total radio exports during the month, according to the latest report of the U. S. Bureau of Foreign and Domestic Commerce, showed an increase. Total April exports were $2,104,065 compared with $1,989,663 in April 1935.

Receiving set exports last April were 46,046 sets valued at $1,221,688, compared with 47,980 sets valued at $1,250,530 in April 1935.

Tube exports last April totaled 648,955 units valued at $277,425, compared with 551,280 tubes valued at $236,028 in April of last year.

Radio speaker exports numbered 20,907 last April with a dollar value of $45,127, compared with 8,595 units valued at $20,134 during April 1935.

April exports of radio component parts were $401,976, against $331,275 in April 1935, and April exports of transmitting apparatus amounted to $120,648 against $100,739 in April 1935.

NON-RADIATING SUPER-REGENERATIVE DETECTORS

(*Continued from page 24*)

promise between the two relations the remaining circuit values are established.

At the highest frequency, ω:

$$C_b = \frac{1 - \omega^2 L C_{min}}{\omega^2 L} \quad (1)$$

and, at the lowest frequency, ω_1:

$$C_b = \frac{1 - \omega_1^2 L C_{max}}{\omega_1^2 L} \quad (2)$$

from which

$$L C_{min} = \frac{1 - \omega^2 C_b}{\omega^2} \quad (3)$$

and,

$$L C_{max} = \frac{1 - \omega_1^2 C_b}{\omega_1^2} \quad (4)$$

At the highest frequency the capacity in the pre-selector circuit is $C_b + C_{min}$ and at the lowest frequency the capacity is $C_b + C_{max}$; thus a trial value for C_b can be selected which is the most consistent with the minimum and maximum values of C that can be constructed in a condenser to tune to ω and ω_1. From the graph of Fig. 2, the corresponding ratio C_1/C_{gf} is observed. As long as the ratio is at least 9, the trial value may be retained. Any lower ratio which must be maintained just means that a certain amount of sensitivity in coupling the antenna to the grid is necessarily being sacrificed. With C_b determined, a corresponding value for C_d is known after which C_d is substituted for C_b in equations (3) and (4) giving the L_g $C_{g\,min}$ and the L_g $C_{g\,max}$ products. In practice it would be impractical to determine C_d from C_b through the medium of the graph when it can be exactly determined from the original differentiation for the graph. The graph serves as a rapid means for associating the allowable C_1/C_{gf} ratio with the design limits of the pre-selector tuner.

The bridge when properly applied to the type of super-regenerator shown in Fig. 3 makes a circuit which offers possibilities for super-regenerative detectors. The C_3 arm of the bridge is represented by the plate-to-filament capacity of the tube which, if larger than the grid-filament capacity, requires the addition of the small balancing condenser in parallel with the grid-filament.

When the bridge is out of balance there will be radiation into the antenna system and if it is badly out of balance, with a sensitive adjustment of the detector, the detector will stop oscillating. The most effective balance is obtained when the grid current ceases to dip as the antenna pre-selector tuning passes through the frequency of the oscillator.

NEWS OF THE INDUSTRY

WEBSTER SOUND SYSTEMS

The Webster Electric Company, Racine, Wis., wishes to announce that it now offers to the trade a full line of Sound Systems licensed under patents owned or controlled by Western Electric Company, Inc., and the American Telephone & Telegraph Company.

— RE —

G-E CHANGES

Co-ordination of the activities of the G-E Plastics Department under the direction of Vice-President C. E. Wilson has been announced by the General Electric Company.

C. K. Mead has been placed in charge of a newly formed Insulation, Glyptal, and Plastics Sales Section of the Appliance and Merchandise Department, with headquarters at Bridgeport, Conn. The newly formed section, besides assuming responsibility for plastics sales, will carry on the activities of the former Miscellaneous Sales Section which was supervised by Mr. Mead and was concerned with the sale of insulation and Glyptal. The new section will be under the general direction, as was the former Miscellaneous Sales Section, of J. H. Crawford, manager of Construction Materials Sales.

R. E. Coleman, manager of the Plastics Department, has been transferred to the Appliance and Merchandise Department and will report directly to Vice-President Wilson, as will G. H. Shill who has been placed in charge of the manufacturing and engineering activities of the Plastics Department.

— RE —

UTAH APPOINTEE

Mr. Robert M. Karet has been given the post of Director of Sales of the Jobber Division of Utah Radio Products Company, one of the oldest and largest radio parts manufacturers in the field today.

— RE —

TCA RE-ORGANIZES

Transformer Corporation of America announces the opening of a new and modern plant at 69 Wooster Street, New York City, N. Y., for the manufacture of radio and allied products under their Clarion trademark.

This company has just recently been reorganized and Mr. Hubert Shortt has been elected president and general manager of the company.

Mr. Frederick H. Skrotzki becomes treasurer and sales manager for the company.

Among the new products announced by the company is a complete new line of Clarion public-address amplifiers which are said to include many new and important features just recently developed in its laboratories.

— RE —

FAIRCHILD EXPANDS

Expansion of its Recorder Division and refinement of its recording instruments through the acquisition of the manufacturing and sales rights of the B. A. Proctor Company, Inc., of 17 West 60th Street, New York, New York, is announced by the Fairchild Aerial Camera Corporation of Woodside, L. I., N. Y., which in recent years has been engaged in the development of high fidelity recording apparatus in addition to the manufacture of precision aerial cameras, aviation instruments, and the Kruesi type radio compass for aircraft.

— RE —

TECH CATALOG

A new catalog covering precision type resistance instruments and allied products is announced by Tech Laboratories, 703 Newark Avenue, Jersey City, N. J. The products covered in this catalog comprise: Volume control attenuators, attenuators for measurements, L, T and H pads; fixed loss pads; taper pads; voltage dividers, faders, output controls, speaker pads; precision attenuators for laboratory use, gain sets, transmission measuring sets, volume indicators, decade resistance boxes, r-f precision laboratory resistors, decade potentiometers, etc.

— RE —

NEWARK WIRE CLOTH DETROIT REPRESENTATIVE

Announcement is made by the Newark Wire Cloth Company, Newark, New Jersey, manufacturers of high-grade wire cloth and wire cloth products, that they have appointed Carl J. Eberly as their representative in the Detroit, Michigan, territory. Mr. Eberly's business address is: 2-251 General Motors Building.

— RE —

MUTER APPOINTEES

The Muter Company, 1255 S. Michigan Ave., Chicago, Ill., takes pleasure in announcing the appointment of Mr. Jack Scanlan as Vice-President and General Sales Manager. Mr. Fred Stevens becomes Vice-President and Western Sales Manager.

— RE —

SOLDER BULLETIN

As a service to their customers and all other users of silver solders and brazing alloys, Handy & Harman, 82 Fulton St., New York City, have published a new Bulletin No. 1 entitled, "How To Use Handy Silver Solders, Sil-Fos and Easy-Flo Brazing Alloys."

— RE —

AMERICAN LAVA OPENS NEW PLANT

On June 24 the American Lava Corporation, Chattanooga, Tenn., completed moving into its new plant. The removal from the old location required about a month and was accomplished without serious interruption to a daily production schedule of over a million pieces.

RESISTANCE PROBLEMS

Convenient and unusually complete engineering answers to most resistance problems are provided in a collection of loose-leaf bulletins just issued by Clarostat Mfg. Co., Inc., 285 North 6th St., Brooklyn, N. Y. These bulletins are arranged in groups covering fixed resistors, adjustable resistors, and automatic resistors or ballasts, the entire collection being bound in a neat loose-leaf binder. Future bulletins can be added as issued.

— RE —

WENDT DIRECTS AMERICAN INSTITUTE

Dr. Gerald Wendt, editor of Chemical Reviews and formerly Assistant to the President of the Pennsylvania State College, has been elected Director of The American Institute of the City of New York, succeeding L. W. Hutchins, who has resigned to devote himself to his business interests.

— RE —

CUTLER-HAMMER LOS ANGELES OFFICE

The Los Angeles sales office of Cutler-Hammer, Inc., Milwaukee, Wisconsin, manufacturers of electric motor control apparatus, has moved to new quarters at 1331 Santa Fe Avenue, Los Angeles, California. Here they will continue to carry a complete stock of C-H standardized motor control, safety switches and electrical specialties for quick delivery. This office is in charge of Mr. W. G. Tapping.

— RE —

KAY PRODUCTS QUADRUPLES PRODUCTION FACILITIES

Because of tremendous business increases during the current year, Kay Products of America has been compelled to move its offices and factory to the Epco Building at 39-01 Queens Blvd., in Long Island City, New York. The new quarters not only more than quadruples manufacturing facilities but brings Kay in closer proximity to its parent company, the Etched Products Corp. The personnel has also been materially increased to insure the trade of prompt and efficient service on the Kay line of universal heads for all makes of auto-radios.

— RE —

WESTINGHOUSE APPOINTS McELHONE TO NEW POST

H. C. McElhone, who has served in various capacities in the works, headquarters sales, stock control and executive departments, has been appointed assistant to vice-president of the Westinghouse Electric & Manufacturing Company. Associated with Westinghouse since 1919, Mr. McElhone for the past five years has been attached to the president's office. In recent months he has been in charge of Westinghouse Golden Jubilee Year activities.

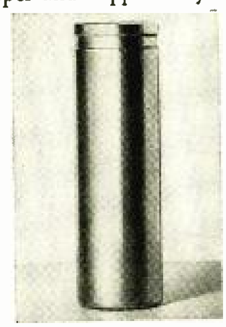
A recognized source of supply for

RADIO PARTS

of Copper and Copper Alloys

VACUUM tube base pins, plug and socket parts, eyelets, rivets, grommers, terminals, contacts, aerial hardware, electrodes, fuse clips, sockets, screw shells, condenser shells, miscellaneous stampings, shells, etc. The Waterbury Brass Goods Corp., as this division of The American Brass Company was formerly known, has long been a recognized source of supply for these and similar radio parts of copper and copper alloys.

Can Shields



We manufacture the following four types of cans in several sizes, either brass, copper or aluminum.

(1) Plain Round (for shielding tubes), (2) Rectangular (for paper condensers), (3) Can with Cover (for intermediate or short coils), (4) Round Can with Sunken Bead (for electrolite condensers). If your needs include special shapes or sizes, our engineers will gladly cooperate in working out your individual problems.

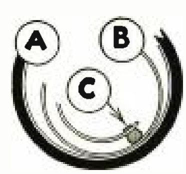
The comprehensive scope of our lines and the unvarying high quality of our products . . . combined with prompt and efficient handling of orders and inquiries . . . provide an ideal service for manufacturers of electrical and radio equipment. May we quote on your present requirements or cooperate with you in designing new parts from the standpoint of production economy.

ANACONDA
from mine to consumer

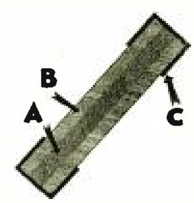
WATERBURY BRASS GOODS BRANCH

The American Brass Company
General Offices: Waterbury, Connecticut

Big boy—you've learned your service lesson well when you've memorized this page. For it leads on to page "P" for PROFITS and page "S" for Success. Be wise—stick to CENTRALAB for ALL replacement work.



A. Resistor strip on inner circumference.
B. Non-rotating metal band.
C. Oilless wood bearing.



A. Center core of resistance material.
B. Core and jacket fired together.
C. Pure copper end contact.

Centralab

MILWAUKEE, WIS.

BRITISH CENTRALAB, LTD., Canterbury Rd., Kilburn, London, N.W. 6, England
CENTRALAB, 68-70 Rue Amelot, Paris, France

VOLUME CONTROLS
FIXED RESISTORS

New Products

MIDGET AUDIO TRANSFORMERS

New "Midget" audio-frequency transformers have been developed by the Amer-

ican Transformer Company, 178 Emmet Street, Newark, N. J. These units have an average weight of only 3¼ ounces. They are suitable for operation at levels from —80 to 0 db and have a frequency characteristic uniform within close limits throughout the band of 20 to 20,000 cycles, it is stated. Thirty-five standard designs are offered.

In addition to "midget" audio transformers, AmerTran also offer small-size audio reactors, filter reactors, and plate-filament transformers. AmerTran midget components are described in Bulletin No. 1003 which will be mailed free upon request.

— RE —

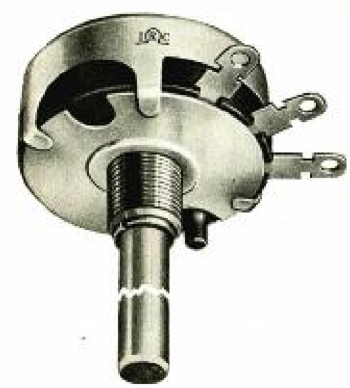
ISOLANTITE GRID CAP

Isolantite Inc., 233 Broadway, New York City, has placed on the market a new grid cap assembly for the all-metal tubes. The use of permanent low-loss insulation at this point is now made possible without any changes in tube design or assembly equipment as the unit is directly interchangeable with assemblies previously used.

— RE —

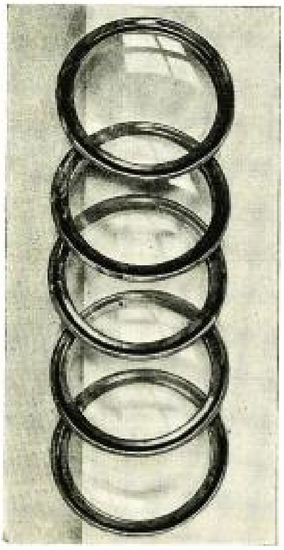
IRC VOLUME CONTROLS

An unusually compact and modern volume control has just been made available to the radio industry with the introduction of the IRC Type "C" Volume Control by the International Resistance Company of Philadelphia.



MOLDING PLASTICS AROUND GLASS

An interesting application in the plastics field is the molding of a plastic frame around glass in a single operation, which has been developed and perfected by the Plastics Division of the Erie Resistor Corporation, Erie, Pa.



Illustrated are several bezels, 4¾" diameter consisting of a one-piece circular ½" frame, injection-molded from Tenite around a 1/16" thick convex glass. These bezels are designed to enclose the tuning dial of a radio set. There is practically no limitation as to the shape of the frame to be molded and plate or convex or concave glass may be used.

For further details write Plastics Division, Erie Resistor Corporation, Erie, Pa.

— RE —

MAGNAVOX SPEAKER

The Magnavox Company, Fort Wayne, Ind., has announced their model 305 speaker which is said to possess exceptional power handling ability. The speaker is available with several different values of voice-coil impedance and field resistance.

— RE —

MOTOR OPERATED TIMING DEVICES

Struthers Dunn, Inc., 139 N. Juniper Street, Philadelphia, Pa., have recently added several motor operated timing devices to their line of timing devices which also includes thermal, inertia, air dash pot and capacitor types.

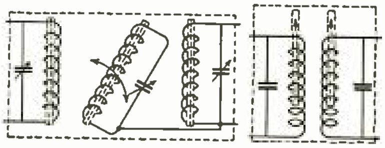
— RE —

AUDIO OSCILLATOR

Communication Instruments, Inc., 125 West 40th Street, New York, N. Y., has made available an audio-frequency oscillator which is said to have an output exceptionally free of harmonics. Frequencies from 50 to 20.000 cycles are covered in ten steps. The oscillator is battery operated.

SELECTIVE BAND EXPANSION

A three-circuit continuous flat-top band-expansion i-f "transformer" is the latest development of Aladdin Radio Industries, Inc., 466 West Superior Street, Chicago, Illinois. This new coupling device, known as the Type D-101, makes it possible to obtain selective band expansion in an economical and efficient manner.



To prevent code interference from commercial ship-to-shore stations, a unique new type of wave trap has been placed on the market by the same company. This wave trap differs from ordinary interference filters in that it is tuned by the movement of a magnetic core of patented Aladdin Polyiron. The movable core varies the inductance of the coil which in combination with a fixed capacitor tunes to the frequency of the undesired code signals.

— RE —

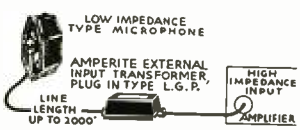
ARMATURE IMPREGNATING RESINS

For the impregnation and coating of motor and generator armatures, General Plastics, Inc., North Tonawanda, N. Y., has developed several improved thermosetting resin solutions. Instead of being dependent upon more oxidation as is the case in oil varnishes, these resins set up to a permanent and infusible film by chemical reaction. Other values claimed for the resins are higher insulation and greater resistance to water, oils and chemicals, plus a stronger mechanical bond between wires and armature frames, which prevents the wires from throwing out at high speed. Metal castings are also impregnated with these resins to reduce porosity, subsequent baking hardening the resin infusibly.

— RE —

CABLE-TYPE INPUT TRANSFORMER

The new Amperite input transformer of the cable type is designed to operate low-



impedance microphones directly into amplifiers having high-impedance input. It permits the cable of the low-impedance microphone to be any length up to 2,000 feet, and is said to make high-gain amplifiers immediately adaptable to any location. Equal output is obtained by the use of this transformer and the low-impedance velocity as is obtainable with high-impedance microphones. As many as four velocity microphones can be fed into one transformer. Write to Amperite Company, 561 Broadway, New York City.

INDEX TO ADVERTISERS

JOIN THIS NETWORK*

OF good stations who are using the **General Radio Type 731-A Modulation Monitor.** There are many reasons why these stations are G-R equipped. For one thing, the Type 731-A Modulation Monitor is reasonably priced. **Complete with tubes and accessories** it **costs only $195.00**, ready to operate.

For another, it not only guarantees that your station will comply with the FCC regulations, but its consistent use will give you a better signal in all modern high-fidelity receivers, and your coverage will be increased.

For still another reason, it is a part—a separately operated part—of the complete G-R Class 730-A Transmission Monitoring Assembly in use by many of the finest stations to insure absolutely peak transmitter performance at all times.

And lastly, since it is a G-R product, you are assured of years of useful, low-upkeep performance since it is correctly designed, carefully manufactured, accurately calibrated and rigidly inspected.

We are having a hard time keeping up with orders, but if yours is received soon we should be able to make delivery from the next lot sometime early in September.

* Only a partial list of purchasers of the G-R Monitor.

For additional details ask for Bulletin 39-Y

GENERAL RADIO COMPANY
Cambridge, Massachusetts