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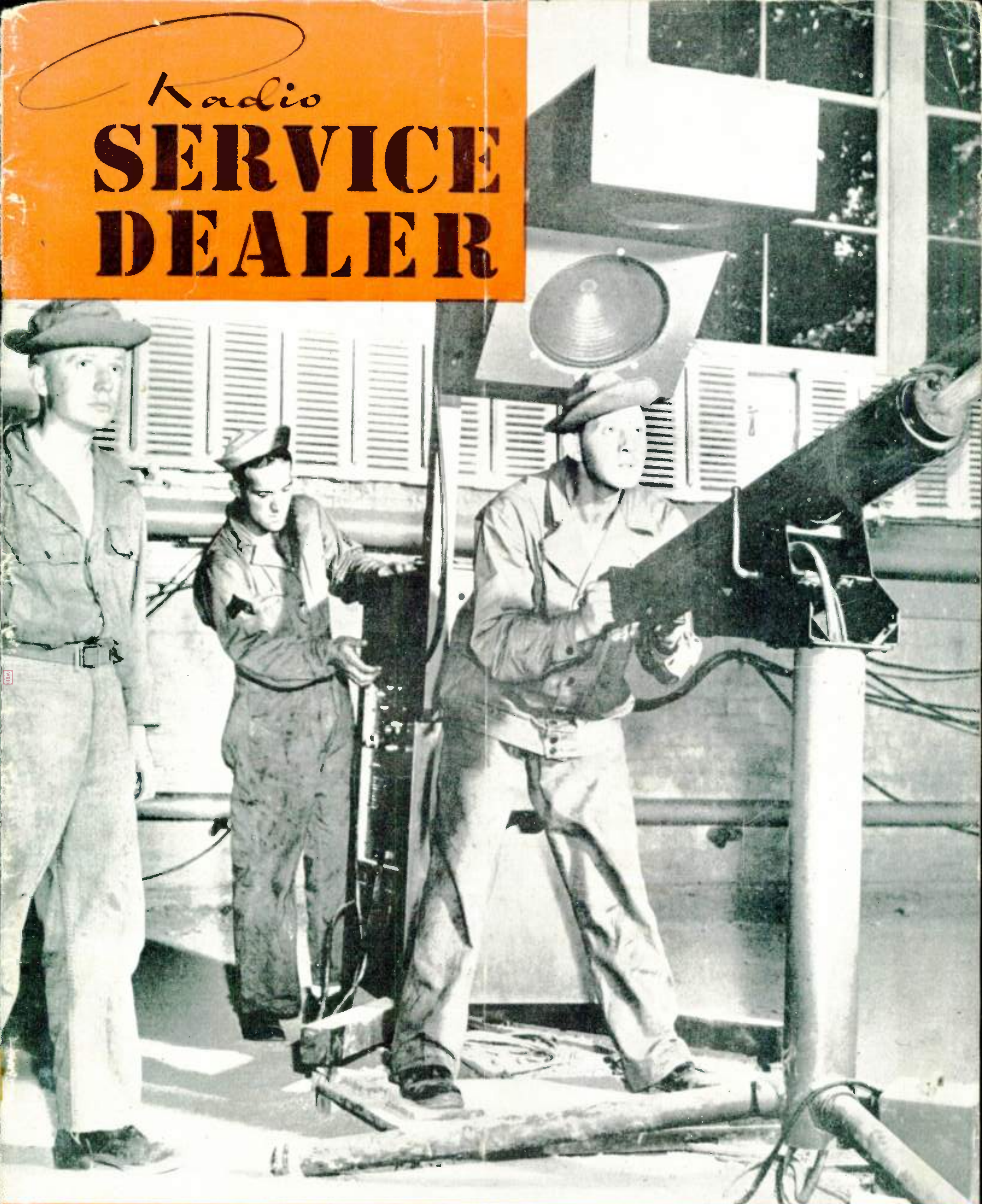

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Vol. 4, No. 9 ★ September, 1943

CONTENTS

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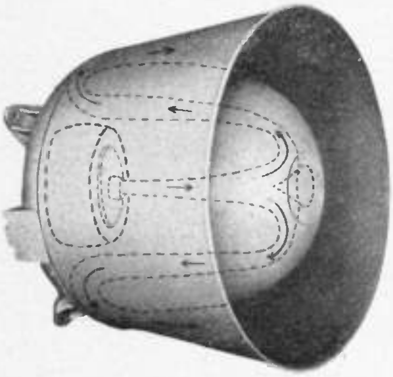

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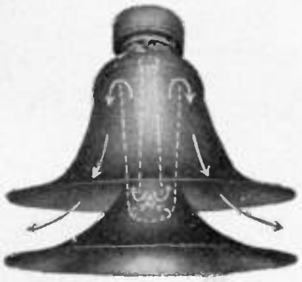

Left—RADIAL HORN SPEAKER; a 3½′ re-entrant type horn. Projects sound with even intensity over 360° area. Storm-proof. Made of RACON Acoustic Material to prevent resonant effects.

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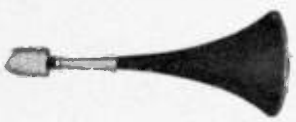

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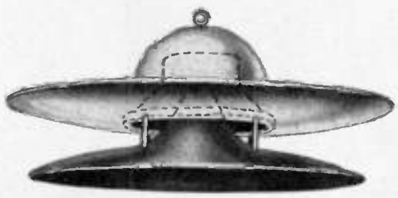

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WANTED—Two Hammarlund CHX chokes, also a set of Hammarlund SWK—6 coils. Richard K. Smith, Building B5, Apt. 1127, Willow Run, Mich.

FOR SALE—Pioneer Genemotor 6V to 150V, in good condition, $5. 1 set American Electric 84-B phones, $2.50. 1 G-E model LB530 portable radio in excellent cond., $35. James Hurd, U.S.M.C.R., Box 43, Acequia, Idaho.

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TUBE TESTER WANTED — State price, condition, make. Wally Havery Radio Shop, 384 Church St., White Plains, N. Y.

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CONDENSER TESTER WANTED — Any std. make. State lowest cash price. Paramount Radio Service, 313 East Market St., Wilkes-Barre, Pa.

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WANTED — Supreme Veedolyzer. Walt's Radio Shop, 11449½ Long Beach Blvd., Lynwood, Calif.

URGENTLY NEEDED—Will pay cash for late equipment in good shape: tube tester, set analyzer, condenser analyzer, RCA 5" 'scope or similar, Rider's Chanalyst, V.T.V.O.M. or what have you? T. A. Gililland, 1923 27th St., Lubbock, Texas.

SWAP OR SELL — Jensen A-12 speakers; Amperite RBHN 200 ohm velocity mikes; Atlas WX-12 baffles; steel projector baffles; Racon trumpet with 2500 ohm dynamic units, etc. Want Aerovox L-C checker 95C, Supreme 592, or 593. All inquiries answered. John H. Baker, 190 Bank St., Burlington, Vt.

WANTED AT ONCE—Signal generator; 2" or 3" oscilloscope; battery charger; Motorola auto radio; volt-ohm-milliammeter (NOT vtvm); Rider's manuals (all vols.); Superior appliance tester model 794; vibrator tester. R. E. Dinsmore, 52 Bridge St., Yarmouth, Maine.

WANTED—Will pay cash for Hallicrafter "Sky Buddy," Echophone EC-1 or other low-priced receiver. Will also consider higher-priced models. H. Schmictike, Jr., Morristown, Minn.

TEST EQUIPMENT FOR QUICK CASH SALE—Will sell for a fellow serviceman who is ill, for cash by money order or bank draft: One Supreme signal generator #189, ranges 100-3, 400 kc & 3.3-30 mc. in 6 bands, built in modulator and audio signal output plus one Supreme #385 set analyzer and tube tester to test all regular receiving tubes, analyzing ranges 0-15, 25, 125, 250, 500 & 1250 (6 ranges) in DC volts, AC volts, DC ma's., output volts. Ohmmeter 0-.25 ohms to 0-20 megohms in 6 ranges. Capacity analyzer .001 to 12.5 mfd. in 6 ranges. Free point analyzer, cable and plugs. A real "one piece lab" in excellent condition, almost new. Both for $100. Write to Askin Radio Service, 1107 South Main St., Paris, Illinois.

WANTED — Volt-ohm-milliammeter, crystal microphone, micrometer. Send full details and prices. Calvin Peters, White Hall, Md.

URGENTLY NEEDED—Will pay cash for late model combination tester, or tube tester, and signal generator. Send full particulars. Jas. B. Abernathy, 667 Ave. D., Boulder City, Nevada.

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editorial....

CONDITIONS IN THE FIELD

★ Our nation-wide study of conditions existent in the radio field has just been concluded. Facts brought to light will interest every service-dealer, jobber, and manufacturer. Certain disclosures, made in following paragraphs, may have devastating effect upon unscrupulous operators. The facts are published for the sole purpose of correcting evil practices that should never have been permitted to come into being; and to avoid their recurrence. But first, let us cover the more general subjects, then we'll touch upon the scandalous ones.

Universally the shortage of technically trained servicemen is acute. Only a few isolated service shops are capable of handling, with their present personnel, the large and ever increasing volume of jobs awaiting repairs. More sets require repairs than ever before and the combination of shortages existent makes it obvious that unless some relief is afforded, it is only a question of time before a large majority of American homes will be without an operating receiver. OWI, take heed!

Service-dealers have tried many expedients to alleviate their manpower shortage. Statistics show that women cannot be trained and taught to be competent trouble-shooters. Only a few women, in the entire country, are now engaged in servicing, and most of those who have "stuck it out" are bench workers who are now given specific, small manual jobs, such as disconnecting defective parts, under the surveillance of experienced old-timers. In contrast to the failure of women to make good, it is known that more can be accomplished by training young boys, still in the high school brackets, preferably if they were "hams" before Pearl Harbor. Most youngsters like these are showing excellent progress, but of course, may someday become competitors.

THE TUBE-PARTS SHORTAGE

★ It is now a toss-up as to whether the tube-parts shortage is as critical as that existing in manpower. Probably most sets now idle are so because of the tube shortage. The tube shortage is acute in all parts of the country, whereas, in only a few sections are there serious shortages of most components, such as transformers, condensers, volume controls, coils, etc. On August 21st, Mr. George D. Barbey, president of the N.E.D.A. reported, "statistics show that 1,700,000 civilian tubes were delivered in June." Mr. Barbey's figures may be correct, but he neglected to amplify his report and we have not been able to ascertain who, amongst the jobbers, received these tubes, and upon what basis. We do know that some jobbers have obtained rather small quantities of tubes recently. What the jobbers have done with these tubes, in some cases, is most outrageous and detrimental to all service-dealers in their particular sphere of influence. Read on!

JOBBERS STEAL SERVICE-DEALERS' TUBES

★ Several jobbers who received tubes, intended for distribution to service-dealers, have diverted these tubes to their own service departments—using them to repair civilian sets—retail jobs, if you will. The regular service shops who expected to get their share of tubes did not. Their jobbers, in fact, became their competitors. Outrageous is a mild word for this type of scoundrelism, and every service-dealer is urged to find out at once whether he is getting this sort of knifing from his wholesale suppliers. Those of you who are being victimized have no legal recourse, but there are other methods of dealing with traitors. Boycott and publicity about offenders will settle their hash. Also, once the evidence of malpractice is conclusive, inform the tube manufacturer at once. But the old adage of a "Stitch In Time" is worthy of consideration. We have contended, and always will maintain that under no circumstance should any jobber ever engage in any sort of retail service work while retaining his status of jobber. We unbend to the slight extent that now-a-days jobbers should be allowed to do wholesale service work for their regular service-shop customers only.

Another dodge, of which jobbers are admittedly guilty, even by the N.E.D.A., is that of diverting "MR" tubes away from non-priority holders to those who will afford ratings. By this means a jobber may get a few more tubes than he is justly entitled to. This is an illegal practice and government regulations will take good care of any jobber caught violating the law which expressly states that "MR" tubes must be obtained on a certification basis and in turn must not be used in any radio device for which replacements may be obtained under preferential ratings.

PAYROLLS AND PRICING AND PACKAGING

★ Despite the fact that service-dealers are busier than ever before, they are not making proportionately greater profits. All overhead and other costs have gone up higher than increased volume will offset. So far the general public has not accused radio servicemen of taking advantage of the times, and for this the industry can bow low to Allah. For once we are not unjustly accused of opportunism, nor are we guilty of it. But sh-h-h, Reader's Digest might need another fake, sensational squib to boost their circulation and waste valuable paper.

Last, but not least, watch out for "Package Tube Deals." Such deals require the purchase of a fixed lot of tubes. Included are some scarce but popular types, to obtain which the buyer is forced to accept in the package a few slow, or almost unusable deadheads.

GUNNER BY REMOTE CONTROL

His battleground is located far from the fighting fronts. His skill and long experience have been lent to the making of vital parts—parts that are vital to a boy in a bomber over Germany or his neighbor's son in a fighter in the Pacific. Their equipment is dependent on split-hair accuracy of Utah Parts—and he's giving it to them. He's a gunner by remote control.

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Tomorrow that knowledge and experience will be at the service of peacetime America. There will be better Utah products built—more convenience, enjoyment and efficiency for many Americans—because of today's great advancements, necessitated by war.

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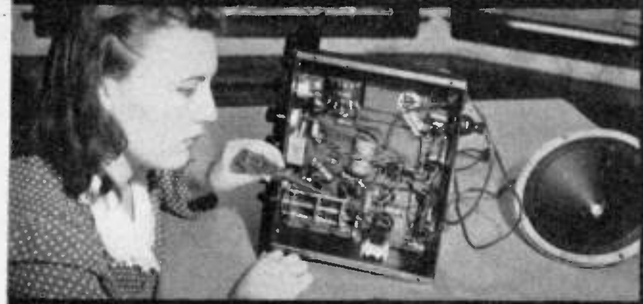

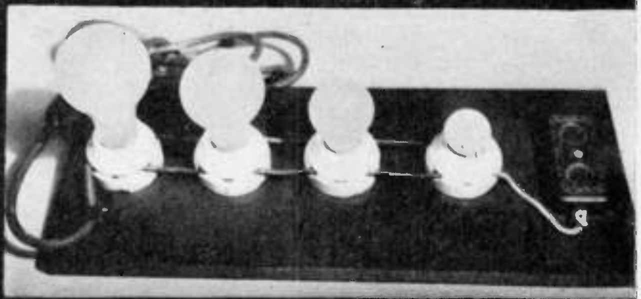

by F. L. Sprayberry*

PART I

FOREWORD

MOST radio men have long been under the impression that a wide variety of test equipment was necessary in the repair shop. It has taken the war to prove differently.

There are many forms of radio testing other than meters, and many men all over the country are employing them successfully—the reason: simply because electrical meters are no longer available.

For many years we, here at Sprayberry Academy, have on occasion used unorthodox test methods for various reasons. As a result, we have built up quite a storehouse of information which today is indeed well worth all the trouble and time expended. Now that manufactured radio test equipment is no longer available to the individual, we are glad to make this information more generally available.

The Author

★ In this timely series on how to service radio receivers without the use of meters, radio students of both sexes will find an excellent study reference; and, radio servicemen may find in this article the solution to problems not ordinarily solved without the use of now-unavailable meters.

It might be well, right at the start, to recognize some basic principles about radio sets, and in that way avoid possible confusion.

Basic Principles

It is safe to assume that in 99% of the cases the average radio set on the American market has the proper design—there are some few exceptions to this rule but it is of such minor consequence, that we don't have to worry about it. If we recognize and accept this principle, we don't need to worry about parts values, etc., because if everything else is normal, we can assume parts values also are normal. *This then is our 1st Basic Principle.*

Now let us consider the radio circuit itself. Basically it contains nothing more than units of Resistance, Inductance and Capacity, and Vacuum Tubes. No matter how complicated the circuit, it can be resolved to these 4 "basic items." Looked at in this way, a radio circuit is therefore a relatively simple device.

It is most important for you to remember this because it will serve you well. Every time you have a seemingly tough problem just remember this basic fact—then stop and ask yourself, "why should this problem have me stumped?". Say to yourself that this problem involves nothing more than the 4 basic items of radio. Then ask yourself, "what fundamental law of radio have I overlooked concerning these things?". If you will do this, and think over your problem carefully, you are sure to solve it. *This is our 2nd Basic Principle.*

Granted a radio circuit involves nothing more than resistance, inductance, capacity and vacuum tubes, it is well to remember how these react to our two basic forms of electrical power; namely, a.c. (alternating current) and d.c. (direct current). Resistance will pass both a.c. and d.c., the current value being limited only by the resistance value. *This is our 3rd Basic Principle.*

Inductance (which includes all wire leads and *all forms of coils*) will also pass both a.c. and d.c. But remember this important fact. Inductance does not react alike to both a.c. and d.c. For a.c., inductance offers both reactance and resistance. We usually combine these two terms (reactance and resistance) and call the combined effect *impedance*. Remember than for *alternating current* inductance offers impedance to the

*Pres., Sprayberry Academy of Radio.

flow of current, and the value of the current is limited by the value of the impedance and frequency (for a given value of voltage). Remember too an inductance may and often does carry *both* a.c. and d.c.

For *direct current,* inductance acts similarly to an ordinary resistance. From a d.c. voltage and current viewpoint simply consider an inductance (no matter what its form) as you would any other resistance. *This is our 4th Basic Principle.*

Capacitors

Now we come to Capacity (condensers in many forms). First, let us consider all forms of mica- and paper-dielectric condensers. These also have impedance but not in the same sense as inductance. While inductance will conduct d.c., condensers of the type we are talking about *will not* (if they are in good condition); every condenser no matter how good, has a minute d.c. leakage it is true, but until it assumes a comparatively high value, this d.c. leakage current may be neglected entirely. Therefore, remember this important fact—for all practical purposes, a good mica or paper condenser will not pass d.c. If it does, it is defective.

For a.c., capacity will in effect conduct current. That is, in an a.c. circuit, the condenser will assume a charge during one-half the a.c. cycle, will discharge, and recharge in the opposite direction (reverse polarity) during the remaining half of the voltage cycle. The amount (of a.c. voltage, and hence, current) involved will depend upon the impedance of the condenser and other factors which we do not need to consider here. For practical test purposes we don't need to know the value of a.c. through a condenser but, if it passes d.c., we do want to know it. *This is our 5th Basic Principle.*

One other common form of capacity is the *electrolytic condenser.* It is found in 2 forms: (1) using a liquid dielectric (called the "wet" type), and (2) using an electrolyte-saturated gauze or absorbent paper as the dielectric (called the "dry" type). Both forms react alike to a.c. and d.c. An electrolytic condenser (of the type used in radio sets) will not operate properly when used on a.c. only. It is used in circuits having a high content of varying current but a d.c. is necessary to keep the condenser polarized and in operating order. Such condensers therefore have polarity, and the positive (+) terminal of the condenser must be connected to the positive or high-potential side of the circuit; the negative (—) terminal of the condenser must connect to the negative or low-potential side of the circuit. As compared to other types of condensers, the electrolytic types have high d.c. leakage current but, due to large values of capacity, the normal leakage current is taken into account, in circuit design, and may be neglected. When an electrolytic condenser passes abnormally large values of d.c. under normal voltage values, it is no longer useful and must be discarded. *This is our 6th Basic Principle.*

The remaining basic unit in a radio set is the Vacuum Tube. Several different types are used in one set. They are designed to accomplish different things, and therefore, do not all react alike. Assuming everything else in the set is normal, there are various ways to determine the condition of tubes. The basic fact here is that, with all other things in the set normal, the substitution of a "good" tube for a "bad" one will correct the trouble. Later on, we will take up the question of how to prove that a given tube is abnormal, and therefore, unfit for further service. As for the assumption that every other thing in the set is normal, tests to be described later will fulfill this requirement. The remarks just concluded in regard to tubes cover *our 7th Basic Principle.*

Now to bring all of the basic elements into clear focus, let us review for a moment. First, we observed that 4 "basic items" make up a radio set. Namely, these are:

Resistance,
Inductance,
Capacity, and
Vacuum Tubes.

Second, these 4 items, for practical test purposes, operate under 7 Basic Principles as mentioned. If all of the foregoing is *clearly understood and memorized,* then the test procedure we are about to outline makes the testing and repair of radio sets a comparatively simple job.

Controlling Power to the Radio Set

Just as the foregoing has outlined the basic elements of all radio sets, it follows that these are of no use unless we can supply operating power to the set, and herein lies our method of testing.

Instead of plugging the power line cord into an ordinary power outlet, we set up our own power control to the set, and from actions which the set exhibits, we deduce what is wrong with the receiver. In effect, we make voltage tests throughout the set just as we would do if a voltmeter were available; and thereby, we obtain the same positive results.

Figures 1A and 1B show the circuit we use. Both diagram the same circuit; *1A* shows the pictorial and *1B* the schematic form. As indicating and controling devices, we use ordinary 110-125 volt lamps of the typical house-lighting variety. You will note 4 lamps are shown. Ordinarily, only 1 lamp socket is used at a time, but 4 sockets may be used for convenience in changing from one lamp-power value to another. *Figure 1C* shows the same basic testing circuit using only 1 lamp socket.

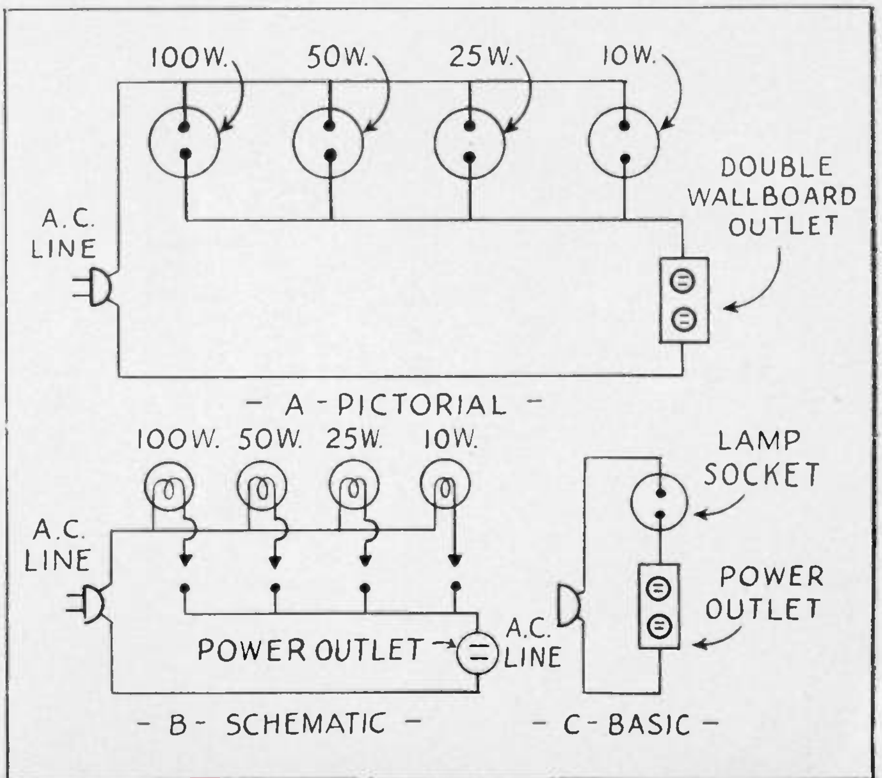

Fig. 1. (Right)—The elements of lamp circuits for meterless servicing of radio receivers. (C) is the basic circuit if one lamp is used. Advantages and time-saving accrue by using a multi-lamp circuit, shown pictorially as (A) and in schematic form as (B). (Porcelain standard base sockets should be used).

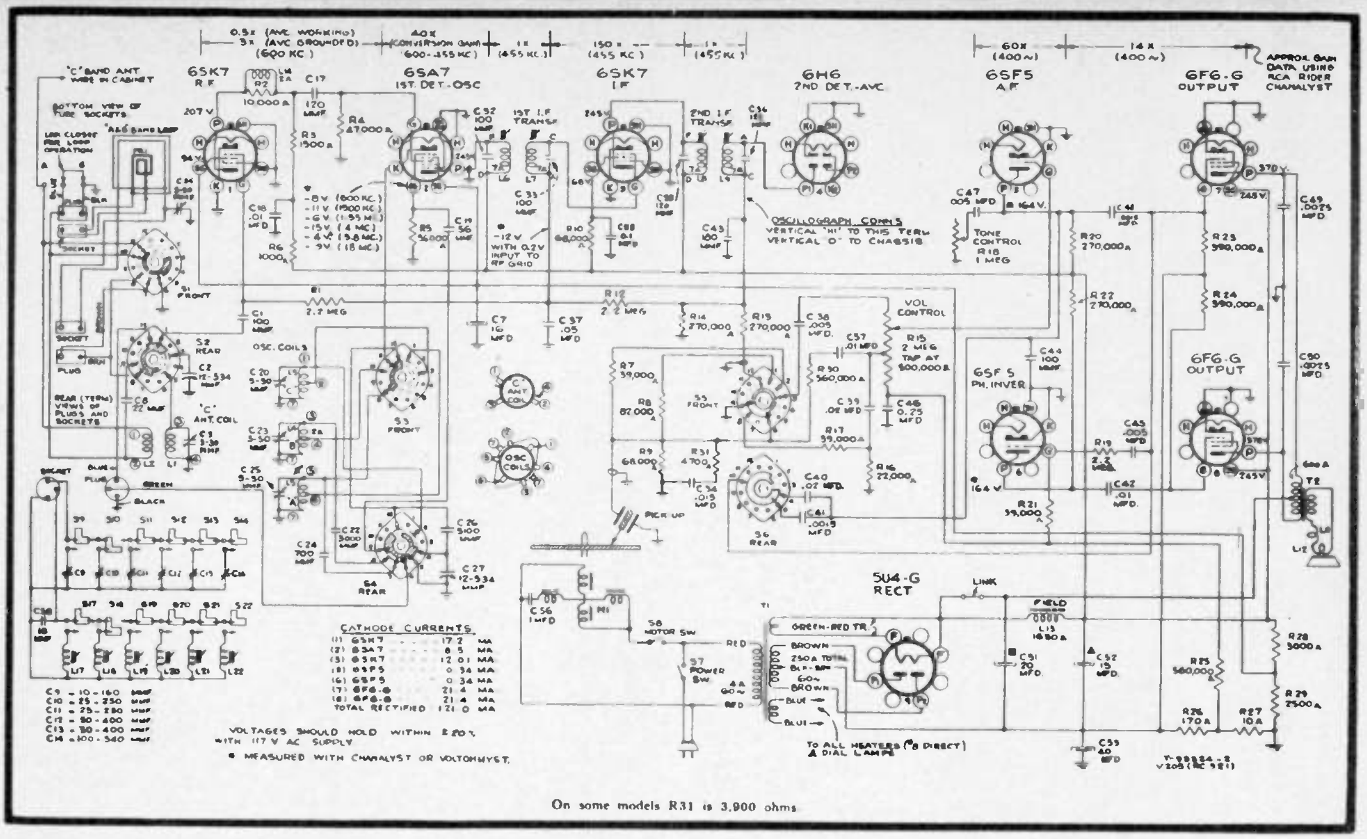

Fig. 2. Representative circuit of a modern multi-band phono-radi o receiver having pushbutton tuning, loop antenna, and other features. Such a receiver can be tested without meters, by followin g the author's step-by-step procedure.

You may use this arrangement if you prefer. Either arrangement will give the same results. The only difference is that each time you need to change a lamp in *Fig. 1C* you will have to unscrew one lamp and screw in another, whereas in *Fig. 1A*, it may only be necessary to screw in one more lamp of a different power rating to give a new power rating. Another advantage of *Fig. 1A* is that from 1 to 4 lamps may be used at a time to give different combinations of power. Thus, what follows is based on the use of *Fig. 1A*.

After studying these circuits, you will note that the lamp or lamps are in series with one side of the line, and if a radio set is plugged into the power outlet, it too will be in series with the line. *Thus, the radio set can draw no more power than the lamp will permit to pass.* The lamp therefore, becomes a controling device. Even though the radio receiver has a direct short-circuit, no harm will be done because the lamp limits the current which can be drawn from the line. The range of lamp ratings in *Fig. 1* will take care of all ordinary requirements for testing. We recommend the use of one each of the following: 10-, 25-, 50-, and 100-watt lamps. Assuming a power line voltage of 115 volts, a 10-watt lamp will draw 0.0869-ampere from the line; 25 watts, 0.217-ampere; 50 watts, 0.434-ampere; and, 100 watts will draw 0.869-ampere. Thus these are the maximum amounts of current which a full short-circuit of the radio set under test can cause to flow. *Anything less than a full "short" will cause less current to flow.* It is for this reason that the lamps will glow from full brilliance to less than visible light depending upon conditions. But no matter what the conditions, ample protection is given the set under test if the right lamp is used—more about this further on.

Elimination Tests

This method of testing a radio set can best be illustrated by using a standard manufactured receiver as an example. We have chosen an RCA model V-205, and V-405, using RCA chassis RC-521 and RC-521-B. The circuit of this receiver is shown in *Fig. 2*. Let us assume that this receiver has been brought to you for repair. All you know is that it won't operate and that the trouble may be anywhere in the set. It is your job to find the defect, not using any test instrument other than a circuit similar to *Fig. 1*, and a continuity tester to be described later. It is assumed, of course, that you have the receiver at your workbench and are otherwise free to take the required amount of time.

The first thing you should do is to remove all tubes from the receiver. Next plug your test circuit (*Fig. 1*) into an ordinary a.c. outlet. Then place the power line plug of the receiver into your power outlet on the lamp tester (disregard the power line connections in *Fig. 2* to the phono-motor for the time being —leaving switch S8 open). Next screw a 25-watt lamp into one of the sockets. Now turn on the power switch S7 of *Fig. 2* (you would go through a similar procedure for all other sets you test by this method).

If, on doing this, the 25-watt lamp does not exhibit a visible glow, remove the receiver power line plug from the power outlet. Then make a visual check on the connections to the power line plug, cord and switch (also fuse, etc., if one is used). If nothing seems to be out of order reinsert the power line cord, turn on the switch and cautiously (to avoid electrical shock to yourself) connect any 115-volt lamp across the primary terminals of the power transformer. If it lights, up, it is a definite indication that the primary of the power transformer is open-circuited. The transformer will in this case usually have to be replaced, because it is not practical to repair an internal open-circuit of a transformer winding.

With all tubes removed, the receiver should draw little current, if in normal condition. In fact, the normal current value will be determined by the reactance of the transformer primary winding plus a negligible leakage to the secondary windings —just enough current to cause the 25-watt lamp to glow. However, we are looking for *abnormal* conditions, and therefore, must take into consideration the possibility of defects in one or more parts of the entire

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receiver. The logical procedure therefore, is to eliminate the possibility of a defect in any one part of the receiver. This, of course, we can do, and therein lies the virtue of this type of testing.

One technique that you should develop in this type of testing is to learn how to make elimination tests on as many parts as possible at one time. This will shorten the testing time and enable you to get to the root of the trouble at once. As you gain experience, this technique will gradually come to you.

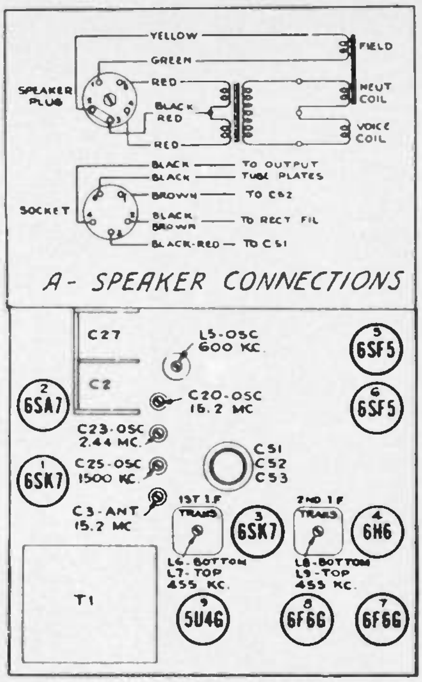
Step By Step Test-Transformers

Let's begin our test on the power transformer, or "P.T.", by first checking the low-voltage filament secondaries. This receiver has two of them, and the same procedure would be followed if more than two were used. With the receiver turned on, take a short length of insulated wire (but bare at the ends) and touch the ends across the 6.3 volt winding or to those two marked BLUE in *Fig. 2*. If this winding is open, there will be no change in the brilliance of the 25-watt test lamp and there will be no tell-tale sparks when you make the connection across the winding. *If the winding is normal, the test lamp will light up to full brilliance when you short-circuit the winding.*

While the 25-watt lamp in series with the primary, by limiting the amount of current which can flow in the circuit will protect against the short-circuit you place across the winding, nevertheless you should not maintain the "short" any longer than is necessary to notice the effect.

Note the foregoing procedure has enabled us to test for both an open-circuit and short-circuit of the winding. There remains the possibility of a "partial short" across the winding. This could be either internal or external. Regardless of what kind of short-circuit, if the leakage is enough to cause trouble, the test lamp will glow to full brilliance just as soon as the power switch is turned on (which it would not do normally) and shorting the terminals of the winding would make little if any difference in the brilliance of the lamp.

The rectifier filament winding should be tested next in the same way that we tested the 6.3 volt winding. The same conditions for an open, short-circuit or "partial short" would also hold true for this or any other low-voltage winding that might



B - CHASSIS LAYOUT ~

Fig. 2a-2b. Tube layout, aligning adjustments and loud speaker connections of RCA set models V-205 and V-405 illustrated schematically in Fig. 2.

be present. The high-voltage secondary winding is checked in the same way *except you should "short", by connecting a jumper (length of wire), from each rectifier plate* to the center-tap of the winding and not across the two high-voltage terminals of the winding. This is because the secondary center-tap divides the winding and a short from the center-tap to either of the other two end taps places less load across the winding than when shorting across the entire winding.

You will note the foregoing tests have been made right at the transformer terminals—this is good practice. However, there is much more length to the filament circuits. There may be opens or other defects along the circuit to the tube sockets. Therefore, if you have any reason to suspect that such a defect does exist, "short" the filament terminals (use a jumper to momentarily connect one filament terminal to the other in receivers of the type represented in *Fig. 2*) at each tube socket.

By this double-check you determine the condition of the transformer winding itself, and also the circuits leading to the tube sockets. The same conditions for "shorts" and "opens" apply even though you do make the test at the tube socket filament terminals. Practically speaking, it would not usually be necessary to test at more than one tube socket for each winding of the power transformer. The reason for this is that a test at one socket will establish conditions at the other sockets unless an open-circuit exists in the filament circuit. The chances for such an open condition are practically nil.

The foregoing tests will clearly establish the condition of the power transformer and all leads connected to it. Having done this, we can now eliminate it as a possible source of trouble and go on to other parts of the circuit.

More Power Unit Tests

We are now ready to test the d.c. portions of the receiver, and since these are more numerous, it follows that the tests will include many circuits, and here is where the technique of testing several circuits at once comes in handy as will be explained further on.

We will begin by *inserting the rectifier tube only in its socket.* It is important too, to not use more than a 10- to 25-watt lamp in the test circuit when first making this test. The purpose of this is two-fold—(1) to prevent the power unit voltage from rising to a value high enough to damage the filter condensers, and (2) to prevent damage to the rectifier tube and power transformer in case of a direct short-circuit in the power unit. The 10-watt lamp will give most protection against these factors.

With only the 10-watt lamp in place and the rectifier tube in its socket, turn on the power switch of the receiver. In general, for all receivers, the lamp should light to less than full brilliance for normal conditions. Assuming it lights to full brilliance, the rectifier tube then is defective, or one of the power unit filter condensers is shorted, or the circuit is grounded in some other way. Disconnecting one lead of each filter condenser will indicate which filter condenser is shorted. If, upon disconnecting a filter condenser in any receiver, the test lamp noticeably decreases in brilliance, then you may be sure that the filter condenser is shorted and needs replacing.

To return to the power unit circuit of *Fig. 2, a rough check* on the

(Continued on page 35)

Servicing Philco

"LIGHTBEAM" PHONOSYSTEMS

by Willard Moody

★ The serviceman who encounters a Philco receiver employing the lightbeam system of reproduction—models 41-608 and 41-609 for example—is apt to be a little apprehensive. For this reason an analysis of this portion of the audio pickup portion of the phonograph section is here presented, and shown detailed in *Fig. 1*. It will be noted that this circuit is a simplification of the same circuit as it appears in the complete instrument diagram, as supplied by the manufacturer for servicing purposes.

A standard form of oscillator is used. The circuit amounts to a shunt-feed Hartley in which the cathode coil-tap method is used to obtain feedback. If the oscillator is operating properly there will be no grid current.

Note that the output of this oscillator, in addition to supplying the signal heterodyne frequency, also delivers sufficient R.F. energy to light the phono pilot lamp, and therefore, if the pilot lamp in the phono head does not light up and the connections, as tested by an ohmmeter when the receiver power is off indicate that the wires are in good shape, we may suspect the oscillator circuit. Adjustment of the compensator *11B* may rectify the trouble. This compensator is part of a dual unit, the other part being used for alignment of the tuned circuit at 1,500 kc.

If the compensator has been damaged (due, perhaps to tampering by little Johnny or his dad!) a new one will be required. In many cases the cathode section of the coil opens up, due to excessive cathode current; if the trimmers short, the oscillator plate current rises, which may cause overheating of the winding.

Checking for Oscillation

The oscillator can be conveniently checked by connecting a high-resistance voltmeter across the gridleak. A negative grid voltage indicates circuit oscillation. If a Chanalyst or equivalent radio test instrument is at hand, the actual R.F. output across the trimmers and across *L3* may be checked. Coils *L1* and *L2* are coupled to *L3*, and induce an R.F. voltage. This causes signal current at the oscillator frequency of 1,800 kc. to flow through the pilot lamp in the phono head.

The variation of light on the photocell is obtained by means of a movable mirror that is coupled to a needle which moves in accordance with the record vibrations. Since the photo-voltaic cell gives an output voltage when light shines upon it, we

(Continued on page 38)

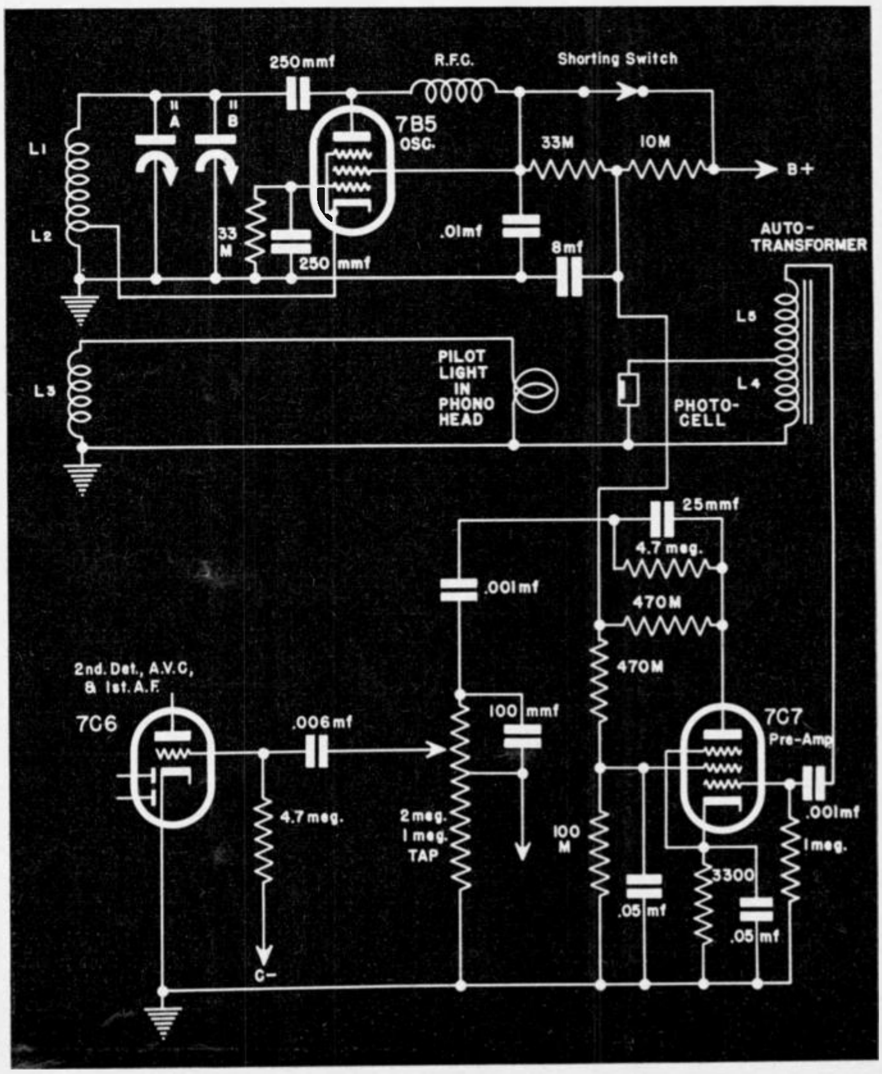


Fig. 1. (Right)—Simplified diagram of Philco Lightbeam System of Reproduction, as exemplified by Philco Receiver Models 41-608 and 41-609.

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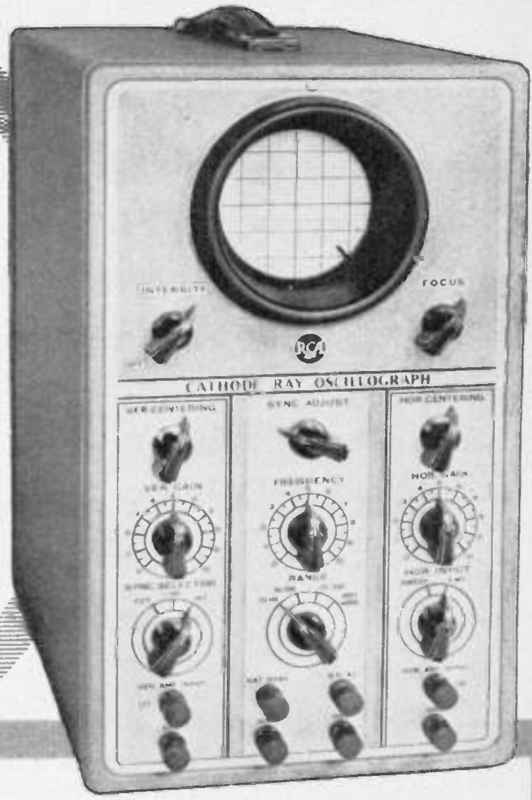

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MODULATION HUM

—Its Causes and Cures

by H. F. Gulliver

★ Modulation hum, or tunable hum, is still with us. This mixing of the 60-cycle line current with the broadcast signals, is very likely to be overlooked in the average service shop. The main reason for this oversight is that modulation hum, usually, *can not occur* in the service shop. The reason being that the a.c. mains are so well by-passed and filtered that no r-f is present on the a.c. line. Almost everyone uses fluorescent lighting now, and in our shops that means added line filter to reduce the "hash"—which will enable us to hear the sets we are working on. But these same "hash" filters also remove all chance of modulation hum occurring in the receivers while they are being serviced. If the line filter is defective in the set, it goes home and hums on every loud station. The various reasons for the generation of modulation hum, and the methods of testing for it and suppressing it are discussed below.

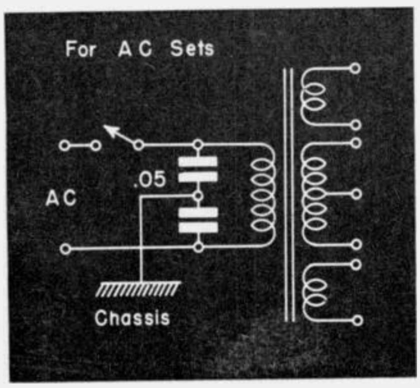


Fig. 1. Connecting a small condenser from each side of the light line to ground prevents r-f from reaching the rectifier tube.

A.C. Garbling R-F Signals

First, how can an r-f signal become mixed with the 60 cycle a.c.? Theory states that in order to mix two or more signals, we must have a circuit which is non-linear in characteristics, and common to the two frequencies. A detector, or rectifier type of circuit is needed. Since every a.c. receiver has a rectifier for the B supply, and since this same rectifier has a.c. across it, we may expect it to produce the mixing action if r-f is also introduced into the rectifier circuit. This r-f can be, and frequently is present on power lines, since the power lines in practice are collectors of r-f energy, being hung in the air like an antenna. If the power circuit to the radio is sufficiently receptive to r-f, considerable r-f energy may reach the rectifier tube of the receiver, through the power line. Wiring which is run in metal of any kind is not a very good conductor of r-f energy and little trouble may be experienced, but, where the building is wired with knobs and tubes, or cleats, as many old buildings were, the r-f energy easily moves over the entire wiring system. When this happens, a nasty hum is heard only on stations, particularly the louder stations, unless filters are introduced to stop the r-f from reaching the rectifier tube. Most radios were equipped with line filters, but they sometimes become defective.

To prevent the r-f from reaching the rectifier tube, a small condenser may be connected from each side of the light line to ground as in *Fig. 1.* Or in a.c.-d.c. sets, a single condenser may shunt the line as shown in *Fig. 2.* Another system sometimes used is to shunt the rectifier cathode and plate with a small condenser, (.01 to .05 mfd) is shown in *Fig. 3.* This latter system does not

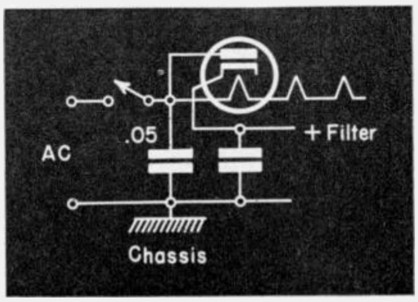


Fig. 2. In a.c.-d.c. receivers, a single condenser will shunt the line.

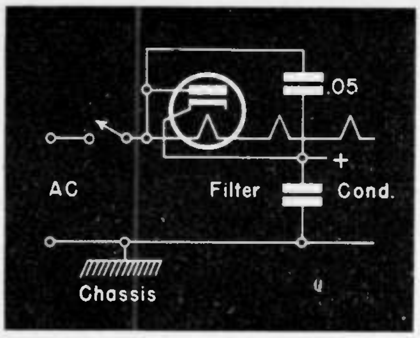


Fig. 3. An .05 mfd condenser will shunt the rectifier cathode and plate satisfactorily.

seem to be as universally satisfactory as either of the other two methods shown in *Fig. 1* and *Fig. 2*. In a.c.-d.c. sets, the circuit shown in *Fig. 4* will be found most effective in extreme cases of modulation hum, and where modulation takes place outside of the radio proper. It also results in a distinct lessening of man made static.

Hum From Line Filters

To determine whether a receiver is susceptible to modulation hum, due to defective line filters in the set, we suggest that an a.c. outlet in the shop be equipped with chokes and possibly with an antenna as shown in *Fig. 5*. Usually, the addition of the chokes will cause plenty of modulation hum in any receiver susceptible to modulation hum when it is operated in the receptacle equipped with chokes alone. However, an antenna coupled to the receptacle increases the r-f present at the receiver power terminals, and is guaranteed to show up modulation hum possibilities within any receiver. It has another advantage; sets which use the power line for the antenna will work much better when plugged into the special receptacle, since there is an abundance of r-f energy present on the power line. Use one antenna for this purpose, and don't try to use it for any other purpose at the same time.

There are other places where modulation hum may occur besides the rectifier tube. *Any* non-linear circuit can mix the r-f and hum, if r-f and a.c. are both present in the non-linear circuit. For instance, an oscillator tube operates in a non-linear condition, and if a.c. should be present in the plate circuit, due to insufficient filtering of the B supply, modulation hum may result. Most i-f and r-f amplifier tubes operate in a non-linear condition on loud signals, and should a.c. be present in the supply voltages due to lack of filter, or through a cathode to filament leak, modulation hum may result.

External Hum Causes

Modulation hum may take place outside of the receiver proper. One possibility we believe to be the frequent cause of modulation hum is poor connections in home wiring. To date, we have been unable to persuade a single customer, in the interest of science, to allow us to tear their walls apart to expose the wiring in an attempt to definitely locate the rectifying connections. However, we believe the non-linear connections take the form of copper-oxide rectifiers where the wires were not soldered at all and in other cases may be acid type rectifiers where acid core solder was used on the connections. This type of modulation hum can be heard on any radio used in the home, and can also be detected on portable battery radios. If the hum is heard on the battery set,

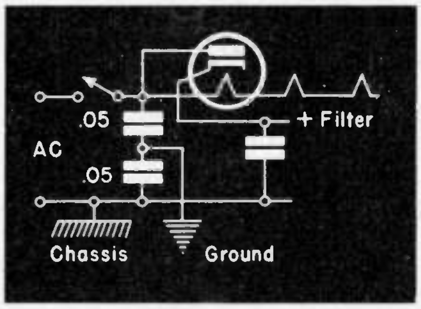


Fig. 4. To overcome extreme modulation hum originating from outside the receiver, in a.c.-d.c. models, this hookup is most effective.

with other electrical devices shut off (except light bulbs), you may be quite sure that the modulation is occurring along the lighting system wiring. The author recalls one particularly stubborn case of hum which turned out to be taking place in an automatic water heater through a short to the heating element from the frame of the heater. In such cases the r-f energy which has been modulated with hum, is re-radiated to the receiver antenna. One way to help eliminate such trouble is to use an outside antenna, located as far away from the house wiring as possible, thereby reducing the pickup of the modulated signal from the light circuit. Another help, is to reduce the r-f signal present on the light line by connecting .05 mfd. condensers from the hot side of the line to ground at several places throughout the house, starting at the fuse box. Sometimes, this one condenser will be enough. If it is possible, try grounding the ground side of the line wherever a short ground connection may be possible. These places will be where the wiring comes close to water pipes. Shunt the line with .05 condensers at the grounded points. This same procedure also eliminates or greatly reduces all types of man-made static. If the radio is of the type using the light line for an antenna, an outside antenna will then have to be used, since most of the signal energy formerly reaching the set via the power line will have been eliminated by the filtering and grounding of the power circuit.

Modulation hum which occurs in the house wiring will usually vary as different circuits are switched on and off. This effect will be most noticeable on sets using indoor antennas.

Cross Modulation

Cross modulation, or mixing of two strong broadcasting stations, may also occur where there are non-linear connections in the house wiring. The mixing of broadcast signals is not confined to just the house wiring, but may take place in any metal work like eave spouting, water pipes, gas pipes, telephone lines, metal roofing, metal lathing, etc. Cross modulation may occur in any metal which collects r-f energy in such way that a current occurs through some non-linear portion of the conductor, or from the conductor to ground through a non-linear union of some kind. The offending objects must be found and further grounded or bonded to eliminate the r-f currents through the non-linear joints.

It is going to be interesting to note what happens to the FM and television signals when they tangle with the various metal objects which resonate at those frequencies. At least a portion of the resonant objects should produce cross modulation.

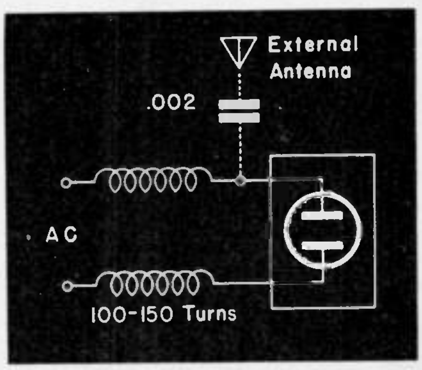


Fig. 5. An a.c. outlet equipped with chokes and an aerial, as shown, helps to determine whether a set's line filters are defective and susceptible to modulation hum.

TECHNICAL SERVICE PORTFOLIO

SECTION XXXIII

THE DESIGN AND CONSTRUCTION OF SIGNAL GENERATORS

★ Making a really good signal generator is a tough job for even the most skilled test equipment engineer. In no other type of equipment we know of are there so many pitfalls to be avoided and precautions to be taken. Yet, relatively little has been written which covers the difficulties which are likely to be encountered. Now that it is practically impossible to obtain equipment of this sort for service work, it seems to be an opportune moment to discuss these troubles, at least insofar as they concern the design of service test equipment. However, we want to emphasize again that the building of equipment of this type is difficult for even the most experienced, and it will be found cheaper and more satisfactory to buy even second-hand equipment—if possible—rather than attempt making it.

What To Eliminate

Some of the headaches associated with the construction of this equipment are minimized by the choice of simpler circuits to work with, and by keeping in mind at the start just what is going to be necessary in the completed instrument so that it may fulfill the requirements of high-grade service work. Thus, some of the more important needs of laboratory apparatus, which are not so necessary in service test apparatus, may be neglected without sacrificing anything of practical value in the applications with which it will be used. In particular, there is seldom any need, in service work, for precise measurements in microvolts of the sensitivity of the receiver being checked. Yet, the elimination of this feature makes for a vast simplification in the design and construction of the signal generator. We need not be so careful in the design of the oscillator circuit to assure even depth of oscillation over the tuning range. The shielding need not be quite so complete, because a slight amount of stray leakage will not affect the utility of a test oscillator but would be serious in a laboratory type signal generator. The attenuator need not be so carefully designed, because again we are not concerned with precise values, although we do need good attenuation. Nor will we need an expensive metering system to measure the signal level in the signal generator.

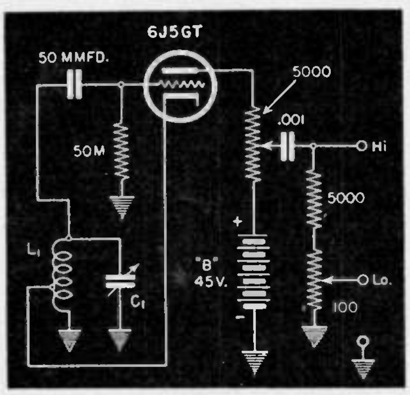


Fig. 1. This schematic shows an easily constructed Hartley oscillator circuit.

It should not be assumed from the foregoing that any liberties may be taken with the fundamental principles of good design without causing serious trouble. We still have to follow the rules if we want a good job. But, by choosing simple circuits, and by certain other simplifications, the work is made much easier.

Oscillator Circuit

Let us first consider the oscillator circuit to be used. If we are able to obtain commercial coils for the job, then this is no problem at all—we simply use the coils in the circuit for which they were designed and with the tube type specified. If not, and the chances are that we aren't going to be able to get coils which have been specifically designed for signal-generator service, we need to choose a type of circuit which requires but a simple coil design.

The Hartley circuit shown in *Fig. 1* is simpler and causes fewer head-

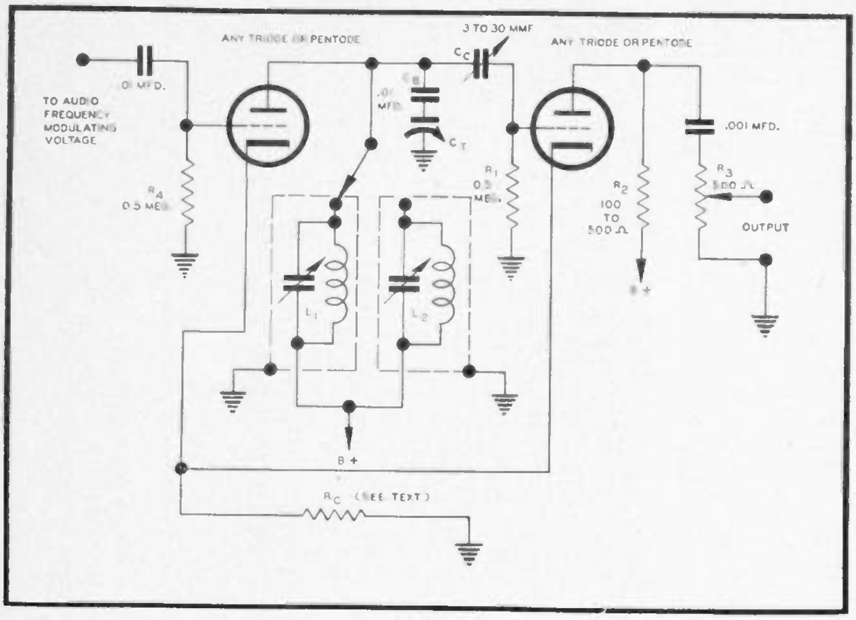


Fig. 2. (Left)—This two-terminal oscillator circuit functions through the common coupling provided by the cathode resistor, Rc.

aches than many other oscillator circuits frequently used in signal generators. The cathode tap is made about one-third up on the coil, except for very high frequencies where more feedback may be required. For this circuit, standard receiver tuning coils may be employed, preferably those taken from an all-wave receiver if several bands are to be covered with the test oscillator. It will be simple to make the tap on each of the single-layer coils used, but for the i-f range, some difficulty probably will be experienced. For this range, coils taken from a discarded i-f transformer may be employed. These should be connected in series after peeling off some turns from the coil which is to be connected between cathode and ground. Care should be taken to get the coils properly phased, otherwise oscillation will occur over only part of the tuning range.

The design of the oscillator circuit is further simplified if some sort of two-terminal oscillator circuit is employed. In such designs, no tap is required on the oscillator coil—the feedback is accomplished through electronic means. One method of accomplishing this is shown in the special circuit of *Fig. 2*. In this design, feedback occurs due to the common coupling of the cathodes of the two tubes through the resistor *Rc*. The value of this resistor is not critical and should be approximately one-half the bias resistor value required if a single tube were used as an amplifier. If a pair of 6J5's are used, *Rc* should be about 450 ohms. Pentodes are preferable and the 6J7 or 1852 types give good results.

In this circuit, the amount of feedback is regulated by the coupling condenser *Cc*. If too much coupling is used, the second tube will draw grid current and distortion will result. The proper adjustment is such that the circuit just oscillates over the entire tuning range.

Another big advantage of this type of circuit is in band-switching. In circuits employing tickler-feedback or other designs requiring more than one coil, it is often necessary to use a separate switching deck to short out the unused coils in multi-band oscillator circuits. In this design, if the coils are small and individually shielded, there is no need for this precaution. Switching may be done as simply as is indicated for *L1* and *L2*. If it is desired to use audio modulation with this circuit, the audio voltage may be applied to the input grid as shown.

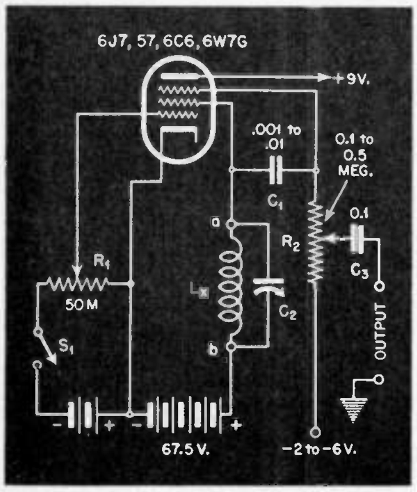


Fig. 3. This modern Transitron circuit requires no tapped coil and but one tube.

Transitron & Colpitts Circuits

The Transitron circuit as shown in *Fig. 3* meets the need for a two-terminal oscillator which requires only one tube. This circuit has the remarkable property of being able to operate over a range extending from the lowest audio frequencies up to about 15 megacycles simply by changing the coil *Lx*. If several coils are used and a band-switching system is to be employed, the moving arm of the switch may be connected as shown in the skeleton circuit in *Fig. 4*. If this circuit is used as an r-f oscillator, audio modulation may be introduced by feeding the audio signal to the control grid through a blocking condenser of about .01 mfd.

In all the circuits so far described, except that of *Fig 1*, the upper frequency limit is about 15 megacycles. For higher frequencies, using a two-terminal arrangement, the Colpitts circuit of *Fig. 5* is often used. In this design, the tuning condensers *C1* and *C2* are ganged together. In one signal generator, the RCA Signalyst, a change-over to this type of circuit is made for the extreme high frequency range (up to 100 mc) while the two gangs are operated in parallel in a conventional tickler-

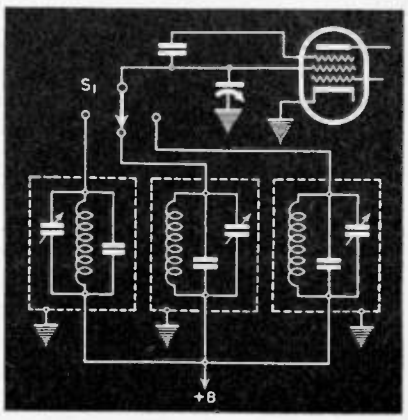


Fig. 4. Various bands may be covered by this simple system, using the Transitron circuit.

feedback circuit for the other ranges. The condensers *C1* and *C2* are of approximately the same capacity, which may be from 100 to 250 mmf.

A two-tube circuit which produces a high signal output is shown in *Fig. 6*. This is really the Transitron circuit of *Fig. 3* plus an r-f amplifier. Actually, the 6J7 also serves as a buffer tube in that adjustments of the output attenuator do not react on the oscillator circuit. This is a very useful arrangement of the two-terminal oscillator circuit. As with the previous circuit, audio modulation may be applied to the control grid of the r-f oscillator tube, through a blocking condenser. Or it

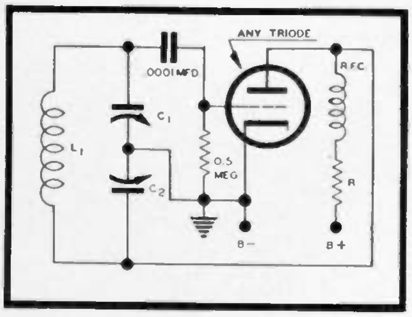
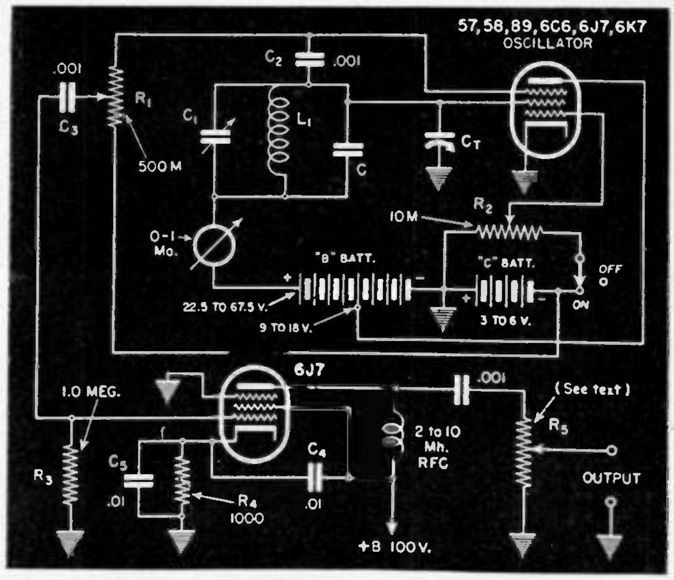


Fig. 5. The Colpitts circuit provides two-terminal operation and is effective at ultra high frequencies.

may be applied likewise to the suppressor, though the former connection is to be preferred. A special advantage of the amplifier-type of oscillator is that the strong signal enables "finding the way" in i-f circuits which are badly out of line. Further, it is of advantage in signal-tracing by means of the test oscillator. When the signal is extremely strong, it may be fed into a circuit under test by simply bringing the output lead near the input grid of the stage being checked. As we all know, there are many intermittents where any metallic connection whatsoever is sufficient to cause them to resume operation after they have "cut out," with resulting delay in localizing the trouble.

In the circuit shown in *Fig. 6*, the oscillator circuit has been dolled up a bit with the grid milliammeter. This is not altogether essential but the meter does provide a convenient means of indicating oscillation. Further, when the meter current is kept low so that the circuit just barely oscillates, the purest wave form is obtained. Obviously, who doesn't like a clean signal? Control of meter

Fig. 6. This modified Transitron circuit, plus an amplifier, provides an extremely strong signal which is valuable for special tests.



current is effected by varying the control-grid bias by means of *R2*.

Ladder-type Attenuation

The attenuators shown in the previous circuit diagrams are generally adequate for service work, but where more precise control is required, a ladder-type attenuator, such as shown in *Fig. 7*, is recommended. This type of attenuator is employed in a laboratory-type signal generator. The carrier signal level across the 2000-ohm plate resistor is measured by means of a vacuum tube voltmeter (not shown), and this signal is stepped down by means of a variable double potentiometer and the ladder attenuator. The resistors for this type of attenuator, as well as the potentiometers, have to be especially constructed to minimize effects and to distribute such inductance as cannot be eliminated in such manner that error in attenuation is minimized. The resistance values of the various steps are kept low—the output impedance is 10 ohms, except for the highest signal output, so the load of the circuit into which the signal is being fed will not appreciably affect the accuracy of the attenuator. Further, the low resistance makes negligible the effect of stray capacities across sections of the attenuator which otherwise would affect the accuracy. All grounds are made to a single point. The resistors which make up the attenuator are distributed around a circular form, and each low-resistance section projects radially from a common center ground point to the series resistors around the circumference. The variable control is calibrated in microvolts, the resulting reading being multiplied by the indicated factor for the point on the attenuator in use.

At very high frequencies, difficulties sometimes resulted with ladder and other type attenuators due to the

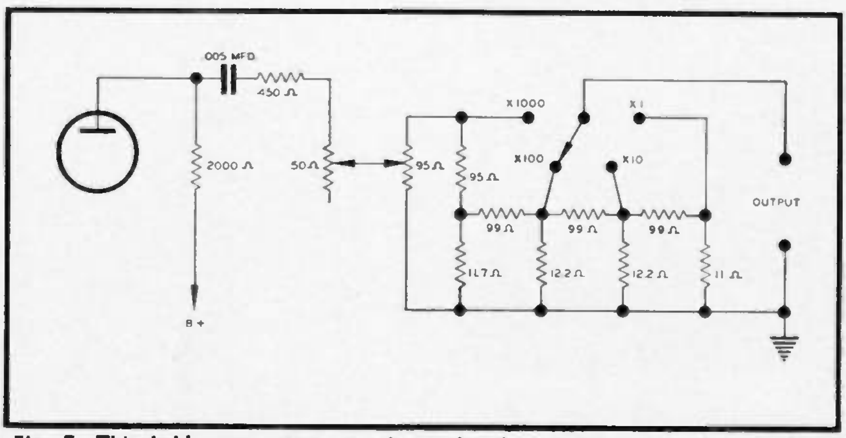


Fig. 7. This ladder-type attenuator is employed on a laboratory-type standard-signal generator.

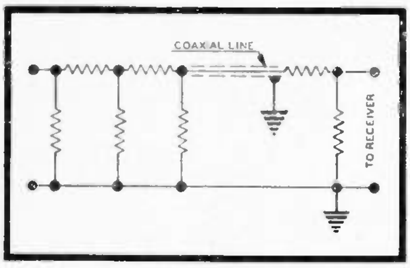


Fig. 8. By terminating the attenuator at the end of a coaxial cable, greater accuracy and ease of connection are secured.

distance between the section of the attenuator and the input circuit of the device under test. In checking receivers, it was frequently necessary to stand the chassis on end in order to make short connections from the signal generator to the receiver input posts (through a dummy antenna), to avoid error. Otherwise, the signal level would rise and fall along the connecting cable, depending on its length, with the result that the signal level at the receiver input was not the same as that at the output posts of the signal generator. A means of overcoming this difficulty is employed in many modern signal generators in which a coaxial cable is used between the sections of the attenuator so that the output section is not in the generator proper, but at the termination of the coaxial line. As shown in *Fig. 8*, this enables connection to the apparatus under test to be made easily and conveniently.

Capacitor Alternates

Capacitors instead of resistors may be employed in ladder attenuators in much the same manner as indicated in *Fig. 7*. However, the output impedance will then vary with frequency, which introduces complications in the design of the oscillator circuit as well as in the computation of the signal being fed into the circuit under test. Methods have also been developed for using the mutual inductance between two coils, one of which is fixed in position while the other is moved, the degree of coupling, and therefore the signal level, varying with the distance between the coils. But in this arrangement there are the same limitations as with the capacitor attenuator, and in addition, it is generally necessary to change the coils for different frequency ranges of the signal generator.

No matter what type of attenuator is employed, if it is to be effective the utmost care must be taken to make certain that the stray signal level does not exceed that at the attenuator output posts. In most test oscillators used for servicing, it will be found that the signal can be reduced to a certain point by turning the output control, but further reduction of the control setting causes an increase rather than a decrease, in signal level. This is usually caused by leakage or stray current in the shielding surrounding the apparatus. To eliminate this effect completely is impossible—there will always be a certain irreducible minimum of leakage—but with care, this can be kept low.

Shielding Precautions

One of the most essential points in reducing signal leakage is careful grounding to a single point each shield which carries signal currents. This is indicated in *Fig. 9*. Each coil (preferably) should be shielded individually, and the entire assembly grouped within another shield can, along with the band switch, assuming a multi-band type of oscillator is being built. The attenuator should likewise be shielded, taking care that individual sections are also shielded from each other. The interconnecting wires carrying signal currents should preferably be run in copper tubing and the tubing should be grounded to the common grounding point. Other sections of the apparatus, such as the tuning condenser, meters, etc., should likewise be shielded. An important point is that these shielded sections should not touch each other, nor should they touch the shielded box in which they are installed. Rather, a heavy bonding braid or bus should be soldered to each shield and should connect to the common grounding point, preferably at the output ground post. Each bypass condenser should likewise connect to this point, but where this is impracticable (when the condenser is located within one of the shield cans) connection is made to the can within which it is installed.

Now it is perfectly true that many signal generator designs do not follow too rigorously the procedure indicated in the preceding paragraph, yet they work well. There are many ways of minimizing the amount of shielding which is necessary. If the coils are kept small, the stray field is reduced and shielding is not so difficult. If the strength of oscillation is kept low, by using low voltages on the oscillator or by biasing or otherwise controlling the depth of oscillation, the degree of shielding required is also reduced. Often the shielding around the tuning condenser may be omitted, because there is merely an electrostatic field present here and this is easily kept within bounds by the external case. In general, it is better to make certain that no currents are induced in the box other than those which cannot be otherwise confined.

Let us see just what is behind the recommendations given in the foregoing. It is really not so complicated. The signal strength developed across an oscillator coil may be of the order of several volts, while that which we desire at the output posts of the signal generator may be of the order of one microvolt. Therefore, we must guide all the signal in ex-

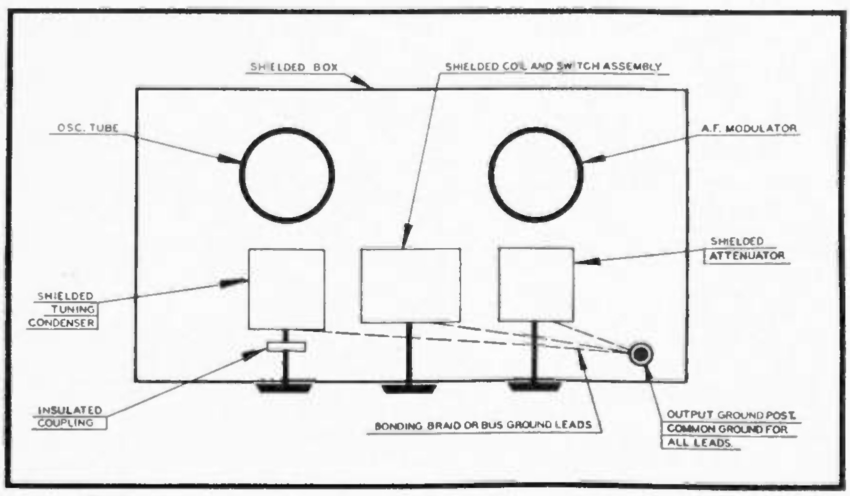


Fig. 9. Separate grounding leads, individually shielded components and a single grounding point are fundamentals in test oscillator layouts.

cess of the desired one microvolt to the common grounding point. If we ground directly to the outer case, then the signal currents must travel from the point to which we make our connection to the output grounding point. Now the resistance of the box, no matter how good the conductor, is sufficient to create a small voltage drop when the current flowing is high. If, for instance, the resistance is but 1/1000th of an ohm from one ground point to another, then the voltage difference between the two points will be as much as 10 microvolts when a signal current of 10 ma flows in the shield. Actually, the shield resistance will probably be considerably greater than 1/1000th of an ohm, therefore it is of the utmost importance to keep these currents in the shield to a minimum.

For the same reason, it is important that all grounding leads be of very low r-f resistance. A bus bar of strip brass, silver-plated, is often used. This joins each shield to the common ground. In some designs, the bus bar runs along the inner portion of the shield box, but is insulated from it, and then is grounded to the common grounding point. If the currents are low, as is the case in most of our service test oscillators, it is usually satisfactory to make all ground leads to the metal strip.

Battery Operated Oscillators

Least trouble from stray fields is encountered when battery operation is employed with the batteries self-contained in the oscillator case. When a.c. line operation is used, it is necessary to filter each circuit as well as the input to the transformer. This filtration is indicated schematically in *Fig. 10*. The r-f chokes (not always required) in the primary circuit should be able to carry the full current of the transformer, which may be of the order of 100ma or more. The choke in the filament, or heater, circuit of the oscillator tube is also vitally important in high-grade u-h-f jobs, though often omitted in service test oscillators because of the high current rating and low d.c. resistance required. Fortunately, an inductance of a few microhenries is usually adequate at this point, which can be secured by winding 50 to 100 turns of enameled wire on a ¼-inch form. The by-pass condenser C3 is of the order of 100 mmf. For lower frequencies, this filtration is seldom required. All r-f chokes should preferably be shielded and should be installed outside the shield compartment into which the connection is made.

In making by-pass condenser connections, the important thing is to keep the lead to the point being by-passed as short as possible. The lead to ground may be longer. The reason is that a certain amount of by-passing will take place between the foil of the condenser and the metal chassis, in addition to that which is by-passed along the leads. But a long lead to the point being by-passed may have sufficient inductance so that ineffective by-passing results.

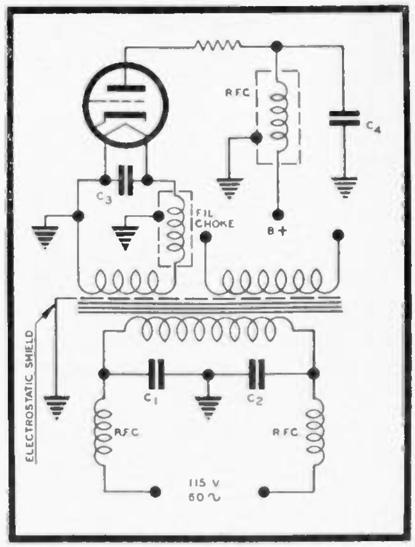
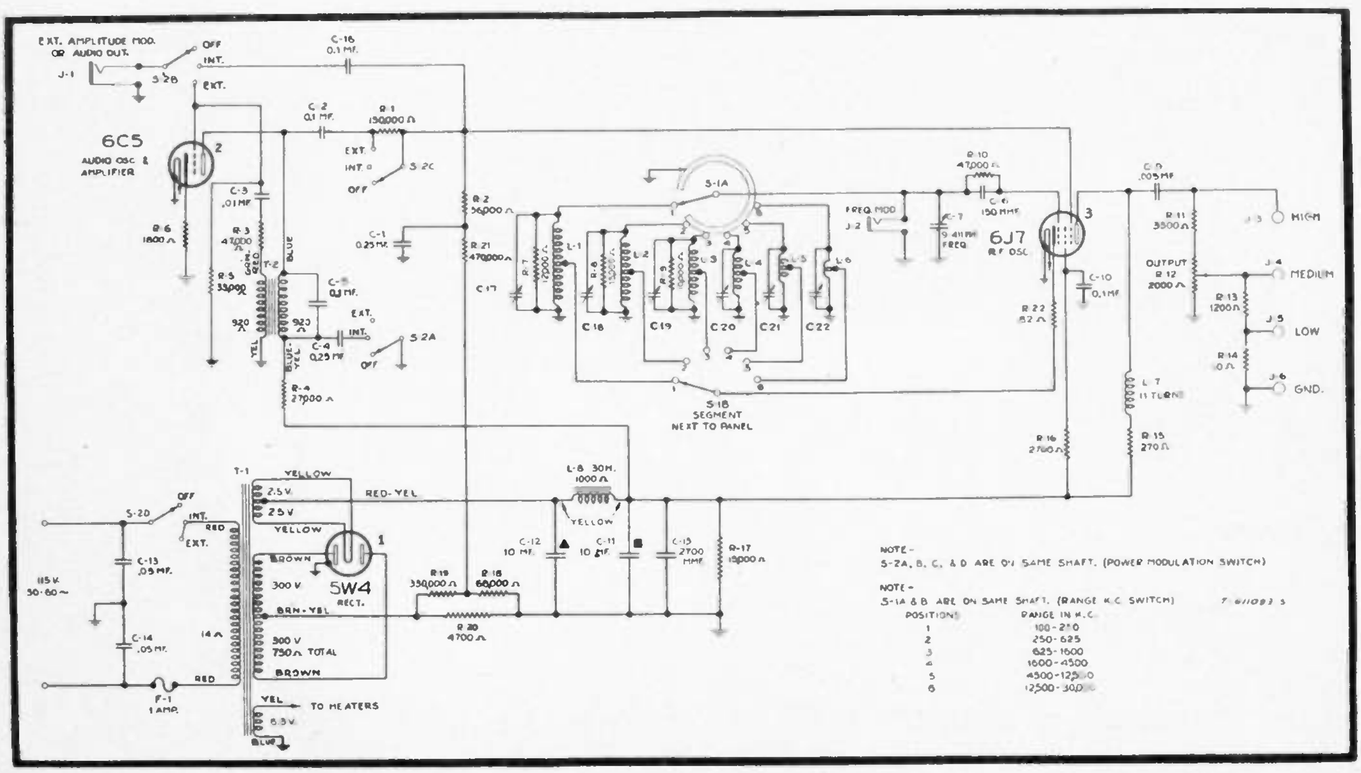


Fig. 10. Careful filtration in the manner shown helps keep down stray signals.

Much stray field, external to the signal generator, is often caused by leakage around the shaft of the variable condenser. Since the signal strength is a maximum across this component, and because the rotor is

Fig. 11. (Below)—A schematic circuit of the RCA Model 153 Test Oscillator.



difficult to ground directly to the common grounding point, this is rather to be expected. The cure is to use an insulated coupling to the tuning dial. In many of the commercial test oscillators, trouble of a similar nature arises from the shaft of the attenuator control, especially when this is at high signal level. The same treatment applies.

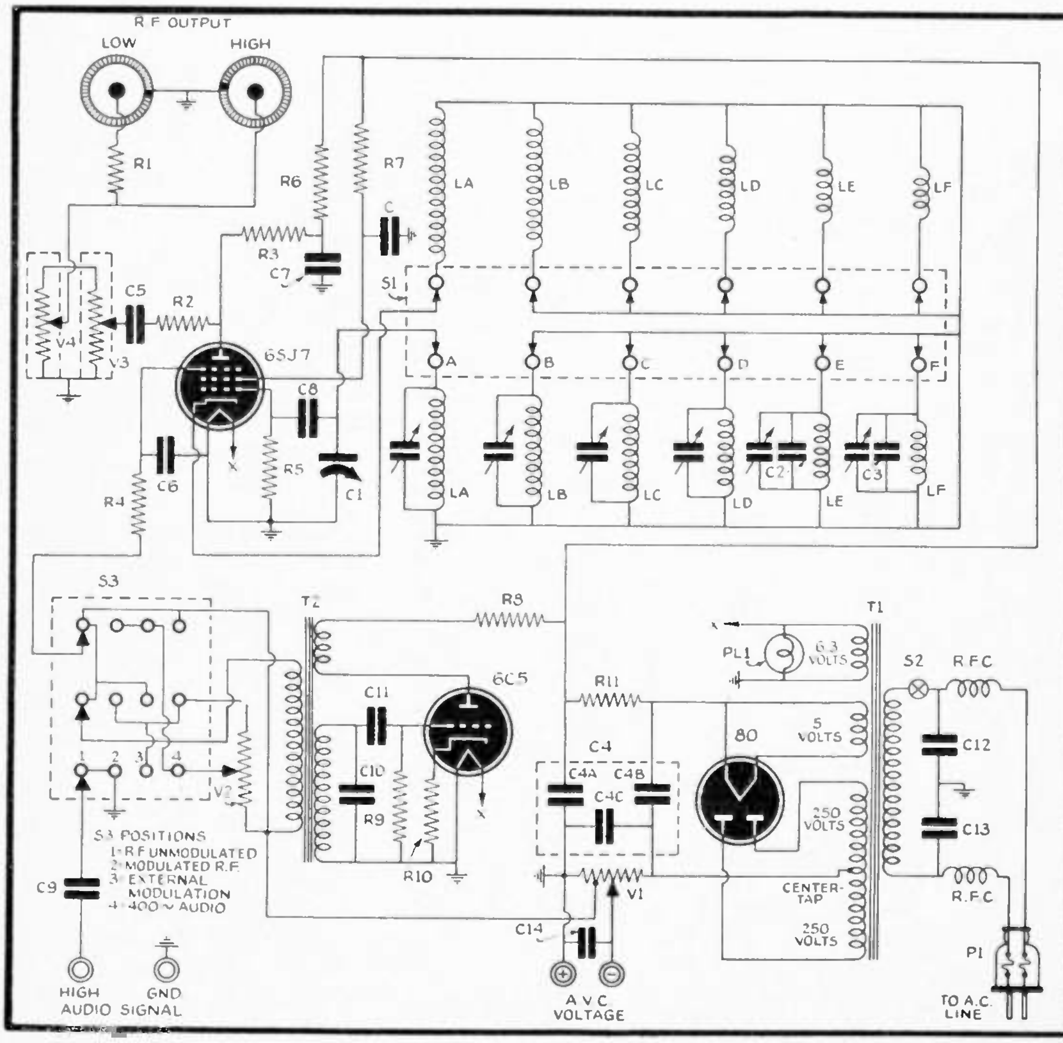
Commercial Oscillators

The RCA Model 153 Test Oscillator is an instrument which is in wide use for servicing purposes. As shown in the schematic, *Fig 11*, the 6J7 r-f oscillator is operated in a Hartley oscillator circuit similar to that shown in *Fig. 1*. The output circuit is electron-coupled to the oscillator section of the tube. Note that individual shielding is employed around the output section and around the coils and switch. This is not required for the a-f oscillator, which is the 6C5 triode operating in a tickler-feedback circuit. The audio oscillator coils are arranged similarly to those of an a-f transformer—a simple and effective means of making this type of oscillator. The frequency range is 100 kc to 30 mc in six bands on fundamental frequencies. The a-f modulation frequency is 400 cycles.

Another commercial test oscillator which has achieved wide popularity is the Precision Model E-200 shown in *Fig. 12*. This uses a tuned grid, tickler-feedback circuit with electron coupling to the output circuit of the 6SJ7. The a-f modulator tube is a 6C5, and a tickler-feedback circuit is also used with it. A third winding on the a-f transformer is employed to feed the audio signal to the oscillator tube for modulation purposes. Provision is also made for external modulation. Note that the modulating signal voltage is applied to the suppressor grid of the 6SJ7 and that a control is provided to vary the modulation percentage. This is quite useful in many tests. Note also that r-f chokes are used in the input circuits to the primary of the power transformer, thus preventing the signal being fed back into the line.

AVC Biasing

A means of supplying an avc biasing voltage for alignment purposes is also provided in this instrument. It has been found that the alignment changes with a change in grid bias, due to capacity changes in the amplifying tube circuits. By means of this avc substitution voltage, the tubes may be biased to a point where they are more commonly used, i.e., on strong signals, and the alignment effected at this high signal level. This obviates the need for some type of output indicator which operates on the avc voltage variation, because a modulated signal may be used and the set alignment may be done by peaking the trimmers for maximum audio output without interference from the avc action.



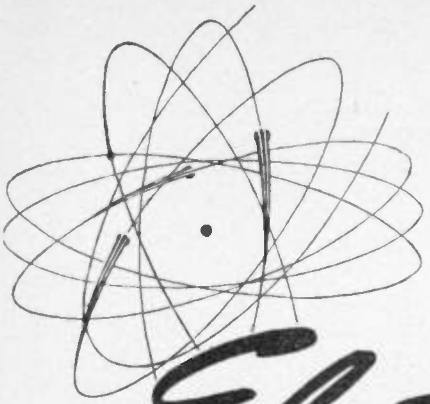
ITEM	PART NO.	SPECIFICATION
44	C14	.01-MFD.
43	C13	.01-MFD.
42	C12	.01-MFD.
41	C11	.01-MFD
40	C10	0.1-MFD
39	C9	.01-MFD.
38	C8	.00005-MFD.
37	C7	.01-MFD.
36	C6	.0002-MFD.
35	C5	.002-MFD.
34	C4	ELECTROLYTIC FILTER BLOCK C4A - 8 MFD, 450 W.V. C4B - 8 MFD, 450 W.V. C4C - 25 MFD, 100 W.V.
33	C3	.000015-MFD, SILVER MICA
32	C2	.000015-MFD, SILVER MICA
31	C1	.00025-MFD, TUNING CONDENSER
30	C	.01-MFD.
29	R11	3,000 Ω
28	R10	9,000 Ω
27	R9	250M Ω
26	R8	5,000 Ω
25	R7	40M Ω
24	R6	15M Ω
23	R5	50M Ω
22	R4	15M Ω
21	R3	300 Ω
20	R2	4,000 Ω
19	R1	4,000 Ω
18	PL1	6.3 VOLT PILOT LIGHT
17	T2	AUDIO OSCILLATOR TRANSFORMER
16	T1	POWER TRANSFORMER
15	R.F.C.	R.F. LINE CHOKES
14	S3	AUDIO SIGNAL SWITCH
13	S2	ON-OFF SWITCH GANGED TO V1
12	S1	6 POSITION BAND SELECTOR
11	P1	DOUBLE FUSED LINE PLUG
10	V4	100 Ω R.F. CONTROL № 2
9	V3	100 Ω R.F. CONTROL № 1
8	V2	500M Ω MODULATION CONTROL
7	V1	4,100 Ω A.V.C. CONTROL (TAPPED)
6	LF	COIL & TRIMMER FOR BAND "F"
5	LE	COIL & TRIMMER FOR BAND "E"
4	LD	COIL & TRIMMER FOR BAND "D"
3	LC	COIL & TRIMMER FOR BAND "C"
2	LB	COIL & TRIMMER FOR BAND "B"
1	LA	COIL & TRIMMER FOR BAND "A"

PRECISION APPARATUS CO.
BROOKLYN, N.Y.

SERIES E-200 SIGNAL
TITLE-GENERATOR-SECOND SERIES-
STARTING WITH SERIAL № 1301

DRAWN BY Wm Kadlecek Jr DATE 5/27/40
CHECKED BY [illegible] DATE 5/29/40

Fig. 12. Circuit of the Precision Series E-200 Test Oscillator.



Electronics

by Paul R. Heyl, Ph. D.

Part I. "Historical Introduction"

★ It has been my experience, when confronted with an intricate and highly developed scientific subject, that the best line to follow is the historical approach. However complicated such a subject may appear in its present state of development, its beginnings were much simpler. A few outstanding facts attract the attention of the first observers, and a comparatively simple theory is devised to coordinate and account for these phenomena. Further study on the part of the curious brings to light additional facts, less obvious than those first observed, and theory has to be modified to include these new discoveries. Again and again this process is repeated until the subject embodies such a formidable mass of interconnected detail that it is difficult to get it in focus and perspective without retracing step by step its historical development; and along this line we shall approach the subject of electronics.

Electronics is a logical outgrowth of the study of the structure of matter, which led first to the recognition of molecules and atoms, and finally to those sub-atomic particles which we call electrons.

Two opposite views of the structure of matter are possible, and both have been held since ancient times. We need know nothing of the ultimate nature of matter to recognize that its structure must be either as continuous as it appears to be, or else discontinuous, but of so fine a grain as to elude our observation. In that Great Age of Greece centering around 400 B. C. we find philosophers holding both theories of the structure of matter. The continuous theory was maintained by Anaxagoras and Aristotle, while the existence of atoms was upheld by Democritus and Epicurus.

> **FOREWORD**
>
> Dr. Heyl, world renowned author, for many years a Physicist with the National Bureau of Standards, Washington, D. C., was recently commissioned by P. R. Mallory & Co., Inc., to deliver, as a public service, a series of lectures on "Electronics".
>
> *RADIO SERVICE-DEALER* gratefully acknowledges Mallory's courtesy in granting permission to reproduce Dr. Heyl's series of copyrighted lectures. This is Part 1, "Historical Introduction" — subsequent lectures, "Electrons at Work" and "Electron Optics" will appear in future issues.—EDITOR.

The antiquity of the atomic concept is sometimes cited as an instance of the keenness of thought of the ancients, much as if they had made by the unaided intellect a discovery which in modern times has received much experimental study. We must be careful, however, not to over-rate the ancients in this respect. Neither theory as held by them had anything which we today would call an experimental basis; both were equally pure speculation. It does not require an exceptional intellect to formulate two alternatives when there is no evidence for or against either. The modern crank, who ignores or is ignorant of experimental facts, can spin out of his inner consciousness hypotheses in profusion. Ancient science is frequently disappointing. The ancient philosophers guessed at the causes of phenomena, but often stopped there. We of to-day guess also, but we check our guesses by experiment, and call them hypotheses.

It cannot be urged that experiment was altogether impracticable for the ancients. There may be mentioned two accepted doctrines of antiquity, the falsity of which might have been shown by experiments simple enough to be possible at any time or place, yet which no one seems to have thought of carrying out.

The first of these is the dictum of Aristotle that heavy bodies fall with speeds proportional to their weights. It is remarkable that with the exception of one fruitless and soon forgotten criticism of this dictum, made by a philosopher of the sixth century A. D.(1),* there is no record of any other skeptic until the time of Galileo, two thousand years after Aristotle.

The second of these erroneous notions is embalmed in our word "crystal," which comes from a Greek word meaning ice. The ancients knew quartz in the form of rock crystal, but in their experience this mineral was chiefly found in very cold localities, such as among the Alpine glaciers. They believed it to be water which had been premanently frozen by the long and cold winters. Apparently no one ever thought of leaving a vessel of water to pass the winter in these regions —or was willing to take the trouble.

While perhaps no particular credit is to be assigned to those ancient philosophers who suggested that matter was discontinuous in structure, the idea was thus placed on record, to be taken up again centuries later. But all through the Middle Ages, due to the ascendency

* *Numbers in parentheses indicate references given at end of Part I.*

and authority of Aristotle, the continuous theory was supreme.

The discontinuous or atomic theory is today so familiar and generally taken for granted that it is difficult to imagine any other hypothesis as worthy of serious consideration, yet the opposite theory continued to have its advocates down to quite recent years. Among these may be mentioned T. Sterry Hunt, the chemist and geologist, who died in 1892, and the still better known name of Ernst Mach, of Vienna, who lived until 1916(2). The atomic theory, though of a respectable antiquity, had a long struggle for acceptance. Its final victory presupposes some rather cogent experimental evidence in its favor, which it may be of interest to set forth and consider. Of this evidence we may distinguish four independent lines which we shall discuss in their historical order.

The atomic theory began to regain favor with the birth and growth of experimental science after the revival of learning. Perhaps the Roman poet Lucretius, who shared the renewed interest of the learned world of the Renaissance in the classic writers, may be said to have had a share in the revival of the atomic theory, for he was an earnest upholder of this view. In one place he compares the apparent continuity of matter to the appearance of a flock of sheep on a distant hillside. From a distance they appear as a uniform white patch which, on closer examination, is seen to be made up of individuals. But the principal reason for the revival of the atomic theory was of a general nature. With increasing knowledge of natural phenomena many things were found to be more simply explainable on the discontinuous theory. The expansibility of gases and the great change in volume from water to steam stretched the continuous theory to the breaking point, while on the alternative theory it was necessary merely to suppose that the particles of steam were farther apart than those of water. Boyle and Newton believed in the existence of atoms, though they used the term rather loosely, and in many cases where we would say "molecule." The modern distinction between molecules and their component atoms was not clearly established until the nineteenth century.

This general line of reasoning, of course, did not satisfy everybody. There were, as we have said, skeptics throughout the nineteenth century; but by the year 1805 the atomic theory had so far established itself as good form that Dr. Thomas Young offered no apology for attempting to determine the size of a molecule.

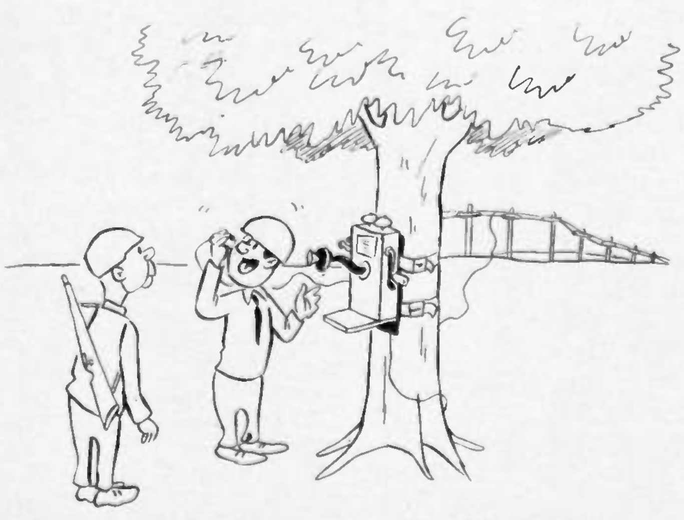
The nineteenth century did some things well, and one of these was the determination of the size of a molecule. Young's estimate was substantially confirmed by Rayleigh and others from eighty-five to one hundred years later. Young's conclusions were reached by a study of thin films of liquid. A drop of oil placed on water will spread out into an incredibly thin film before breaking, and its limiting thickness must be at least the diameter of one molecule. If we know the density of the oil and the weight of the drop, the volume of the drop is known; and if we measure the area of the film it forms, the thickness of the film is a matter of a moment's calculation. By such measurements Young concluded that the diameter of a liquid molecule was not greater than about one hundred millionth of a centimeter (10^{-8}). Other lines of experiment led later workers to the conclusion that the molecules of the simpler gases, such as hydrogen, nitrogen, oxygen and carbon dioxide, have diameters of from 2 to 3 times 10^{-8} cm. For solid molecules, the twentieth century work of the Braggs, who determined the structure of such molecules by their X-ray shadows, indicates a diameter varying with the substance, and ranging from 1 to 5 times 10^{-8} cm.

Roughly speaking, this means that if a drop of water the size of a pea were magnified to the size of the earth, its molecules would appear comparable in size to a football, and its atoms, of course, considerably smaller.

The second line of evidence for the existence of molecules and atoms is of a chemical nature. It was put forward by Dalton in the early years of the nineteenth century. So great was the impetus which Dalton gave the subject that he has been called "The Father of the Atomic Theory." What he did to warrant that title was something characteristic of the nineteenth century: he made the theory quantitative.

Dalton introduced the idea of atomic weights, a definite weight for the atom of each element. He appears, on the evidence of his manuscript note books(3), to have been led to this by physical rather than chemical considerations, such as the diffusion of gases and the varying solubility of different gases in water. By a study of these phenomena he was led to the concept of a difference in the size of the molecules of different gases (which has not been confirmed by later workers). Dalton visualized the solubility of a gas in water as due to the slipping of gas molecules into the spaces between the water molecules; and the smaller the gas molecules the more readily would they find chinks into which they could slip. From definite sizes it was an easy step for him to the idea of definite weights characteristic of each substance. This explained much with regard to quantitative chemical combination, and appears to have been the origin of his laws of definite and multiple proportions.

These laws of Dalton, whatever may have been their origin, now rest securely upon the results of chemical analysis. They follow at once from the assumption of the combination of atoms with atoms, while on the continuous theory there is no simple explanation of the results of experiment. As Dalton himself said: "The doctrine of definite



"This may not be the latest thing for communication, but it's the best gadget ever invented for eavesdropping!"

proportions appears mysterious unless we accept the atomic hypothesis." And again: "It appears like the mystical ratios of Kepler, which Newton so happily elucidated." With the later development of analytical technique, especially at the hands of Berzelius and of Stas, the atomic theory reached a high degree of probability.

In the year 1827 there was made a discovery which was destined to furnish a third independent line of evidence for the reality of molecules. The full development of this evidence, theoretical and experimental, required eighty years for completion. In 1827 Robert Brown, a British botanist, was investigating the pollination of plants, and had occasion to observe under the microscope minute grains of pollen suspended in water. He noticed that even under the best observing conditions these grains were never at rest, but vibrated slightly and irregularly about a mean position. This phenomenon has since been known as the Brownian motion.

Brown's original paper is most interesting reading(4). It reveals the working of a mind essentially logical and scientific, albeit hampered in one respect by a traditional intellectual fetter. Brown first satisfied himself that the motion was not due to the vibration of his apparatus nor to convection currents nor to evaporation of the liquid. He observed the motion in drops of water suspended in oil, which completely prevented evaporation, and found that the motion continued for many days, while differences of temperature should have equalized themselves in a comparatively brief time.

Among these grains of pollen Brown noticed smaller particles of a roughly spherical form which showed a more brisk vibration than the larger grains. These smaller particles he called "active molecules."

There was current in biological circles at that time a theory that there was an ultimate element or atom of life, an idea which some dozen years later was merged into the concept of the newly discovered cell as the biological unit. Brown appears to have believed that in his active molecules he had found these atoms of life. He had satisfied himself that the motion was not due to extraneous causes, but appeared to be a characteristic of the particles themselves; and as the particles were derived from a living plant it was but natural that he should have reached the conclusion that their motion was in some way due to life.

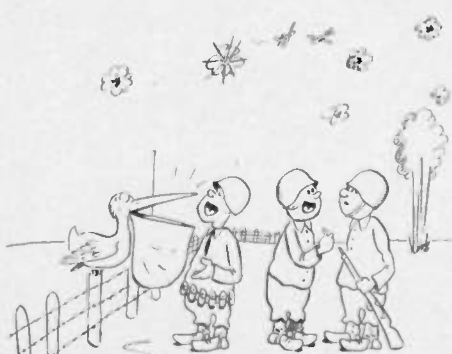
To check this conclusion he killed a plant by steeping it in alcohol for several days. Much to his surprise he found that he could extract from this dead plant active molecules of apparently undiminished vitality. It then became of importance to determine how long these particles would retain their vitality after the death of the plant.

From a herbarium Brown obtained a specimen which had been twenty years in the collection, and from this he obtained active molecules. Another specimen which had been in the collection for a century gave the same result. It was then obviously necessary to work with material of geological age, and specimens of lignite and bituminous coal were tried, in each of which active molecules were found. Surprise was added to surprise when Brown found that the London soot seemed to be composed almost entirely of active molecules, though it had but recently been through the fire.

Brown then tried a piece of petrified wood. He knew that in this substance the wood fiber had been entirely replaced by silica, but he thought it possible that some active molecules might have lingered behind. He found, in fact, active molecules in surprising abundance.

This led Brown to experiment with materials which, as far as was known, had never been living, such as specimens of British granite, and again the active molecules were in evidence. Finally, to obtain a specimen of undoubted antiquity, he tried a chip taken from the Sphinx!

This test was not as childish as it may seem today. In 1827, and indeed for many years after, the whole of Western Christendom, learned and unlearned, was still under the spell of Archbishop Usher's chronology, which assigned to the Creation the date 4004 B. C. To question this was in those days no laughing matter.



"It's not really a talking pelican, the bird is carrying our walkie-talkie!"

The universal presence of these active molecules was a mystery which Brown did not attempt to explain. A later writer(5) (1863) says that Brown was of the opinion that these particles of elementary life, existing everywhere, might bridge over the gap between the living and the non-living, the idea apparently being that in some substances these active molecules lay dormant but eternal, while in others they developed into living organisms.

Brown's discovery attracted but little attention at the time. It was generally thought that this motion must be in some way similar to the dancing of motes in a sunbeam, in spite of the care that Brown had taken to eliminate the explanation of convection currents. It was not until 1863, when the concept of atoms and molecules had become well established, and a beginning had been made in the kinetic theory of heat, that Wiener(5) suggested the explanation now generally received—that the motion of these particles was the result of the impacts of the molecules of water, much as a swiftly moving bullet may produce a slight motion in a much heavier cannon ball.

Wiener's suggestion attracted in its turn but little attention. Some fifteen years later Delsaulx and Carbonnelle(6) again put forward the same explanation with an important addition. It was apparent to Carbonnelle that the impacts of the water molecules would occur in such rapid succession that they could not produce any perceptible disturbance of a large particle, the successive impacts cancelling out on the whole. But Carbonnelle pointed out that if the surface of the suspended particle was small enough it might be that the irregularities would no longer compensate; that there would be a perceptible resultant which would change continually in intensity and direction. In consequence, the smaller the particle the more brisk should be its vibration. It will be remembered that this is just what Brown observed with the pollen grains and the smaller particles which he called active molecules.

These suggestions seem to have attracted as little attention as that of Wiener, but in 1888 Gouy(7) published an account of experiments on this subject which for some reason attracted wide attention. From this time the Brownian movement was recognized as an important physical problem.

The next important step toward its explanation came with the early years of the twentieth century, and with it were connected the names of

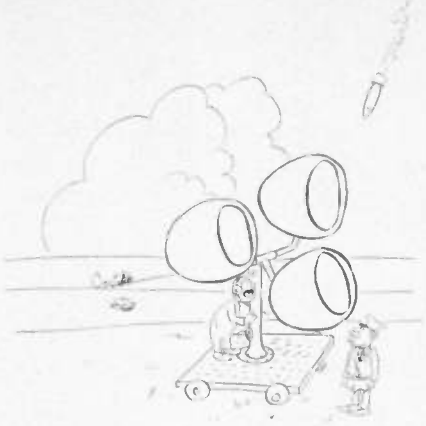
Einstein, Smoluchowski and Perrin(8). The contributions of the first two were theoretical, while that of Perrin was largely experimental, and furnished confirmation of the theories of the others. Einstein and Smoluchowski by independent paths arrived at formulas almost identical, which led to the conclusion that the ultimate distribution of the particles in an emulsion under the joint influence of gravity and molecular impacts should follow an exponential law similar to that of the density of the atmosphere as a function of the height.

Perrin saw in this an opportunity for a crucial experiment, and with consummate skill carried it through to a successful conclusion.

In addition, these formulas involved Avogadro's constant, the number of molecules in a gram-molecule. Perrin's experiments gave a value for this constant in good agreement with that given by other well-known methods, none of which involve the suppositions of the Brownian movement.

Taking a broad view of the subject, Perrin saw that instead of accounting for the Brownian movement as a consequence of assumed molecular structure of the suspending liquid, one might logically deduce the existence of molecules from the observed phenomenon of the Brownian motion. Perrin pointed out that what is really new and strange in the Brownian movement is that it never stops, which at first sight seems in contradiction to our everyday experience of friction. If, for example, we pour a bucket of water into a tub, in a short time the motion possessed by the liquid mass apparently disappears. As a matter of fact, what disappears is the coordination of the movement of the different parts of the water. The velocities at different points, at first almost equal and parallel as the water left the bucket, become more and more random and chaotic, distributing themselves in a fashion the more irregular the smaller the parts which we consider.

Perrin pointed out that this decoordination does not proceed indefinitely. On the scale of microscopic observation, at the level of the Brownian motion, a re-coordination begins to be evident. If at any instant certain of the suspended particles stop moving, there are at the same instant in other regions particles which change from rest to motion. Since, therefore, the distribution of motion in a fluid does not progress indefinitely, but is limited by a spontaneous re-coordination, it follows that the fluid itself is composed of granules or molecules which can assume all possible motions relative to one another, but which constitute a barrier to the further subdivision of the motion. If there were no limit to the size of the water particles it is not apparent how there could be any limit to the de-coordination of motion.



"It must be broken Sir, all I can hear is a whistling sound—like the approach of a bomb!"

Whether atoms might again be subdivided was generally regarded during most of the nineteenth century as rather an academic question. Physical changes, such as water to steam, could be explained without going farther than the molecule; chemical changes without going below the atom. But toward the end of the nineteenth century there were discovered new phenomena which not only furnished a fourth line of evidence for the reality of atoms, but opened our eyes to the existence of sub-atomic particles. This line of evidence arose from the study of the electric discharge through gases and from the discovery of radio-active substances.

In the early 1870's the chemist William Crookes was making weighings with a vacuum balance, and found certain disturbances, arising apparently from one side of the balance being a little warmer than the other, caused by a patch of sunlight falling on one pan. It was natural to account for these irregularities by convection currents, and the remedy was obvious: there must be a better vacuum. About this time the mercury air pump had undergone some improvements, and Crookes, becoming interested, added some refinements of his own which enabled him to attain a vacuum of better than a millionth of an atmosphere. Strangely enough, he found at this exhaustion that the disturbing effect of light increased, and he was led to the construction of his radiometer. In such a vacuum the mean free path of a molecule of residual air becomes a matter of centimeters, comparable to the dimensions of the vacuum tube, and in tubes exhausted to this degree Crookes discovered some novel and beautiful effects which he exhibited at the meeting of the British Association for the Advancement of Science at Sheffield in 1879.

Crookes showed that there was in such a tube a stream of negatively electrified particles shot out from the cathode. He unquestionably supposed these to be molecules of residual air. It remained for later workers to show that these particles were not molecules nor even atoms, but bodies of a minuteness hitherto unknown, being about 1/1800 of the mass of a hydrogen atom. For these tiny bodies a new name was needed, and they were called "electrons" (electro-ions), the term "ion" having been in use for some time in connection with electrolytic phenomena. It will be of interest to review the experiments which led to this conclusion.

It was not at first possible to measure the mass of these electrons. All that could then be done was to obtain a value for the ratio of the electrical charge to the mass which carried it (e/m). It was found that the stream of electrified particles could be deflected by a magnet or by an electrostatic field. Now there are three things which determine the amount of deflection of a moving charged particle in either an electric or a magnetic field of given strength—the charge e, the mass m, and the velocity v of the particle. In a field of either kind, an increase of e will mean a greater deflecting force, and an increase of m or v will bring about an increase in the inertia or the momentum of the particle, and resist deflection.

The formula for the amount of reflection will be different in the two fields. In an electrostatic field a particle whose initial direction is perpendicular to the lines of force will move in a parabola; in a magnetic field it will move in a circle. This enables us to write two equations for the three unknown quantities e, m and v. To solve for three unknowns we need three equations, and unfortunately there is no third independent way known of deflecting the stream of electrons.

It happens, however, that in both equations the quantities e and m occur as their ratio e/m. Taking this ratio as one unknown we can solve

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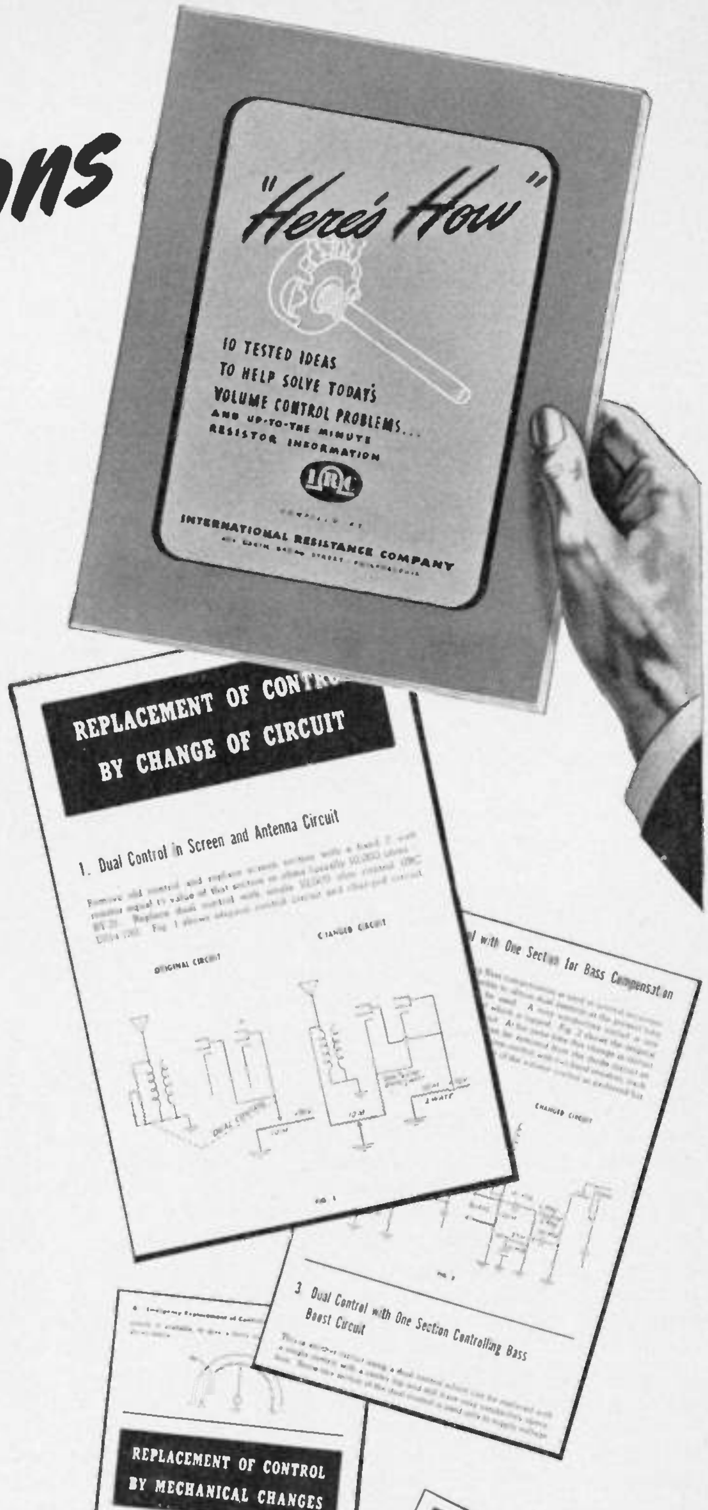

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for it and for *v*. In this way two surprising results were obtained. The value of e/m for the electrons in a vacuum tube was found to be about 1800 times as large as the greatest value previously known, that for the hydrogen ion in an electrolyte; and the value for *v* was still more surprising, being in fact comparable to the speed of light.

It was obvious that such results must mean something new and important. The large value of e/m could be explained in two ways: either the charge on the electron was greater than that on the hydrogen ion or the mass was less; and the very large value of *v* suggested the smaller mass. It therefore became important to obtain information about the separate values of *e* and *m*.

It was recognized that a gas and a liquid were quite different things, and that the ratio e/m in an ionized gas might well be different from that in a liquid electrolyte. Attention was thus directed to the subject of the conduction of electricity through gases, and to the comparison of gaseous and electrolytic ions. Several lines of experiment in this field were devised, the earliest of which was that of Townsend.

It had been known for a hundred years that hydrogen evolved when a metal dissolves in an acid carries with it an electrical charge. Townsend found that hydrogen developed in electrolysis was also charged, positively when the electrolyte is dilute sulphuric acid and negatively when it is caustic potash. Such electrical charges probably arise from the well-known phenomenon of frictional electrification of spray. Townsend saw in this a convenient method of obtaining gaseous ions all of one sign. He found that such an ionized gas could be dried by bubbling it through sulphuric acid without serious loss of its charge, and that when the dried gas came in contact with moist air it condensed moisture and formed a stable cloud. This he explained on the assumption that the charged ions attracted water vapor from the air and condensed it about them.

In order to find the charge on each ion Townsend proceeded as follows:

1. He assumed that in saturated water vapor each ion condensed moisture about it, and that the number of ions was equal to the number of droplets.

2. He determined with the aid of a quadrant electrometer the total electrical charge of the cloud.

3. He found the total weight of the cloud by passing it through weighed drying tubes.

4. He found the average weight of the water droplets by measuring their rate of fall under gravity, and computing their mean diameter by means of Stokes's Law for air resistance.

5. He divided the weight of the cloud by the average weight of the droplets of water to obtain the number of droplets which, if assumption 1 is correct, was the number of ions, and then he divided the total charge carried by each ion, that is, the quantity *e*. Townsend obtained a value for *e* of about 3×10^{-10} electrostatic units, considerably less than the present accepted value (about 4.8×10^{-10}). Like all pioneer work, Townsend's experiment had several weak points which were improved upon by later workers. Among these were his fundamental assumption that the number of ions was the same as the number of droplets, and the assumption that the rate of fall was uninfluenced by evaporation. Later workers (J. J. Thomson, H. A. Wilson) modified Townsend's method in several ways, but still obtained rather widely varying results, Thomson's figure being 6.5×10^{-10} and Wilson's 3×10^{-10}. These figures, however, were sufficient to show that the value of *m* for electrons in a vacuum tube was much less than that of a hydrogen ion.

There was one source of error in all this work: the measurements were made not on individual droplets but on a large collection. It was recognized that the result in such a case might be merely a statistical mean of a widely varying quantity.

In 1909 Millikan(9), by a very ingenious method, succeeded in isolating individual droplets and measuring both charge and mass.

To eliminate effects from evaporation Millikan used a fine spray of oil instead of water. He observed individual droplets by means of a short focus telescope, and measured their rate of fall when uncharged. This enabled him to calculate by Stokes's Law the diameter and the mass of any particle under observation.

The air around the oil particles was then ionized by irradiating it with X-rays. This, of course, produced ions of two different signs, and some of the oil particles picked up a negative ion and some a positive ion. By applying a vertically directed electrostatic field it was possible to distinguish between the two kinds of charges on the drops. Under the action of the field some of the drops would move downward at a more rapid rate; others would have their rate of fall diminished, reduced to zero, or would even move upward, according to the strength of the field.

Consider a particle that is brought to rest by the field. It is obvious that there is an equality between the weight of the particle, *mg*, and the upward force of the field on the charge which the particle carries. If *F* is the field strength, this force will be *Fe*, and we have the equation

$$mg = Fe$$

in which *e* is the only unknown quantity.

In practice, it was not always as simple as this. A perfect balance was a somewhat rare occurrence, and most of Millikan's measurements were made on particles with a slow motion up or down. In such cases the equation involves the measurement of the velocity of the particle both charged and uncharged.

It is to be expected that a drop may pick up not one ion but several, and this is what Millikan found. In a certain number of cases he obtained a minimum value of *e* of about 4.8×10^{-10}. In all cases where different values were obtained they were integral multiples of this minimum value.

In these results we have a direct proof that the electronic charge *e* is not a variable quantity, but a natural constant. They also tell us that the large value of e/m for negative electrons in vacuum tubes must be interpreted to mean that these electrons are of much smaller mass than a hydrogen atom.

Additional evidence for the existence of sub-atomic particles (were such needed) was obtained when it was found that X-rays were capable of ionizing even monatomic gases such as argon and helium. Here we have direct evidence that an atom is a complex structure and that electrical charges enter into its make-up.

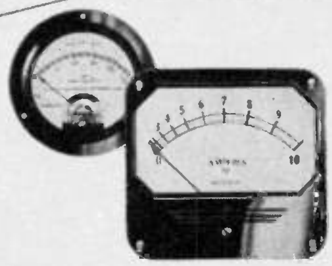
The possibility of the existence of sub-electrons has not been overlooked. Several observers believed that they had found experimental evidence of such particles. Millikan(10), however, after an exhaustive discussion of the subject, came to the conclusion that the evidence for a sub-electron is unsatisfactory.

Just why, in a Crookes tube, a similar stream of positively charged

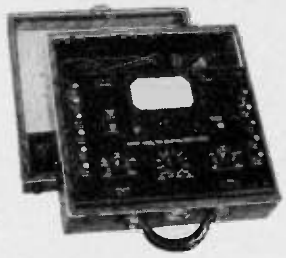
(Continued on page 34)

FOR ELECTRONICS MEASUREMENTS, TOO,

the Standards are Weston

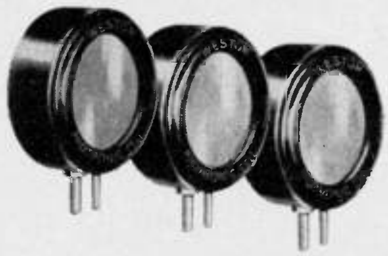


Panel Meters for Electronic applications



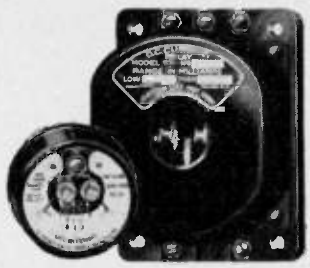
Electronic Circuit Testers

Ultra-Sensitive Laboratory Portables



*Photronic (photo-electric) Cells

Electronic Tube Checkers



Sensitive Relays

In the field of electronics, too, the measurement tools bear the name most familiar to you. For just as WESTON pioneered fundamental electrical measurement, as well as the special measurement needs of radio, so WESTON has provided simple, precise instruments and devices for the problems encountered in electronics research, production and control. Weston Electrical Instrument Corporation, 597 Frelinghuysen Avenue, Newark, New Jersey.

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HINTS ON CAPACITOR SUBSTITUTIONS

A colorful new folder recently issued by the Sprague Products Company, North Adams, Mass., illustrates and describes "Victory Line" Sprague Atom Midget Dry Electrolytic Capacitors and TC Tubulars which will be supplied regularly through its distributors in conformity with wartime limitations on capacitor production for civilian use.

The Sprague "Victory Line," necessarily limited to only nine Atom types and nine TC Tubulars which have been carefully selected as to capacities and voltages to enable service-dealers to handle practically any replacement job. Of utmost importance is an article included as part of the folder "How to Use Victory Line Capacitors." This contains many helpful hints on how to substitute the few "Victory Line" Capacitors for the many varieties of standard types. Subjects covered include "Connecting Capacitors in Parallel to Make Capacity Values Not Available in a Single Unit"; "Replacing Filter Applications Higher Than 450 V.D.C. with Victory Line 450 V. Capacitors"; and "Replacing Wet Electrolytics with Dry Electrolytics."

Service-dealers will find this folder an invaluable guide to present day capacitor replacement procedure. Copies may be obtained direct from Sprague Products Co., North Adams, Mass., or through authorized Sprague Distributors.

Book Reviews

THE ABC's OF RADIO, by Electronics Department, General Electric Company, Schenectady, N. Y. Card board cover, 8½" by 10¾", 68 pages. Price 25c.

This primer is intended to help the beginner understand the fundamentals of radio and is the outgrowth of a training course in radio prepared for those employed in non-technical radio positions. The scope is broad with mathematical and engineering treatment on fundamental theory held to a minimum.

As the point of view of the practical serviceman, rather than engineer, has been adopted, this book should be very helpful to service-dealers who are training new personnel. In fact, several portions will prove most beneficial to experienced servicers. Copies available for 25c in coin from the Advertising Division, Electronics Department, General Electric Co., Bridgeport, Conn.

★

ELECTRIC INSTRUMENTS—Principles of Operation. General Electric Company, Schenectady, N. Y. 8" by 10½", self cover, 40 pages.

Electric instruments are merely tools which enable one to ascertain, by means of eye and ear, essential information about electric circuits. A knowledge of the construction and design of an instrument permits one to obtain more advantages from a given device. To facilitate this understanding the G.E. engineers have presented in *Electric Instruments* a clear and concise presentation on the principles of instrument operation.

★

(BUD) PRINCE GETS COMMISSION

Kenneth C. (Bud) Prince, Chicago attorney, active for many years in the radio and electronic industry, has been commissioned Lieutenant (j.g.) in the United States Naval Reserve.

Mr. Prince was executive secretary of the Sales Managers Club, Western Group, (now Association of Electronic Parts and Equipment Manufacturers) for nine years. He also served as general counsel for the Radio Parts Manufacturers National Trade Show Inc., and Radio Servicemen of America, Inc., and acted as the legal consultant for the Priorities Committee of the Radio Parts and Associated Industries. Mr. Prince represented many of the leading manufacturers of radio and electronic parts and equipment.

★

W. L. FATTIG NAMED SUPERVISOR

W. L. Fattig has been appointed acting supervisor of the Technical Service section of the General Electric Receiver Division, Bridgeport, Conn.

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IF YOU'RE MAKING MORE MONEY

...WATCH OUT!

WE WANT TO WARN YOU, before you read this page, that you've got to use your head to understand it.

We also want to warn you that—if you don't bother to read it carefully enough to understand it—you may wake up after this war as poor as a church mouse.

• • •

This year Americans are going to make —minus taxes—125 billion dollars.

But this year, we civilians are not going to have 125 billion dollars' worth of goods to spend this on. We're only going to have 80 billion dollars' worth. The rest of our goods are being used to fight the war.

That leaves 45 billion dollars' worth of money burning in our jeans.

Well, we can do 2 things with this 45 billion dollars. One will make us all poor after the war. The other way will make us decently prosperous.

This way the 45 billion dollars will make us poor

If each of us should take his share of this 45 billion dollars (which averages approximately $330 per person) and hustle out to buy all he could with it—what would happen is what happens at an auction where every farmer there wants a horse that's up for sale.

If we tried to buy all we wanted, we would bid the prices of things up and up and up. Instead of paying $10 for a dress we're going to pay $15. Instead of $5 for a pair of shoes we're going to pay $8.

This bidding for scarce goods is going to raise prices faster than wages. Wages just won't keep up.

So what will people do?

U. S. workers will ask for more money. Since labor is scarce, a lot of them will get it. Then farmers and business men who

feel the pinch are going to ask more money for their goods.

And prices will go *still higher*. And the majority of us will be in that same old spot again—only worse.

This is what is known as Inflation.

Our government is doing a lot of things to keep prices down . . . rationing the scarcest goods, putting ceiling prices on things, stabilizing wages, increasing taxes.

But the government can't do the *whole job*. So let's see what *we* can do about it.

This way the 45 billion dollars will make us prosperous

If, instead of running out with our extra dough, and trying to bid on everything in sight, we buy only what we absolutely need, we will come out all right.

If, for instance, we put this money into (1) Taxes; (2) War Bonds; (3) Paying off old debts; (4) Life Insurance; and (5) The Bank, we don't bid up the prices of goods at all. And if besides doing this we (6) refuse to pay more than the ceiling prices; and (7) ask no more for what we have to sell—no more in wages, no more for goods—*prices stay where they are now.*

And we pile up a bank account. We have our family protected in case we die. We have War Bonds that'll make the down payment on a new house after the war, or help us retire some day. And we don't have taxes after the war that practically strangle us.

Maybe, doing this sounds as if it isn't fun. But being shot at up at the front isn't fun, either. You have a duty to those soldiers as well as to yourself. You *can't* let the money that's burning a hole in your pocket start setting the country on fire.

★ ★ ★

This advertisement, prepared by the War Advertising Council, is contributed by this Magazine in co-operation with the Magazine Publishers of America.

KEEP PRICES DOWN!

Use it up
Wear it out
Make it do
Or do without

KARET NOW UTAH SALES MANAGER

R. M. (Bob) Karet has been appointed Sales Manager of the Wholesale and Sound Division of the Utah Radio Products Company, O. F. Jester, Vice President in-Charge-of-Sales, announced.

A member of the Utah organization since 1936, Mr. Karet has had extensive experience in the radio and sound equipment industries, and is well known to the radio trade throughout the country.

He assumes responsibility for the sale of Utah products distributed through parts jobbers, sound houses and similar organizations. At present he is engaged in the company's war activities—as well as taking an important part in postwar plans.

★

"DEDUCT-O-GRAPH" PAYROLL TAX COMPUTOR

"Deduct-O-Graph," which automatically shows the proper payroll tax deduction for any employee when proper settings are made as to marital status,

wage range and pay period, are available to Radio Service-Dealer readers, without charge, George S. May, President, of George S. May Co., 2600 North Shore Ave., Chicago, Ill., announced today. Request your "Deduct-O-Graph" on a business letterhead.

$1.00 PAID FOR SHOP NOTES

Write up any "kinks" or "tricks-of-the-trade" in radio servicing that you have discovered. We will pay $1 in Defense Stamps for such previously unpublished "SHOP NOTES" found acceptable. Send your data to "Shop Notes Editor," RADIO SERVICE-DEALER, 132 W. 43rd St., New York, 18, N. Y. Unused manuscripts cannot be returned unless accompanied by stamped and addressed return envelope.

BUY MORE BONDS!

STANDARD VOLUME CONTROLS

★ The American Standards Association, War Committee on Replacement Parts for Civilian Radio, announces that the list of so-called "Victory" model volume control has been cut down to eleven types as follows:

COMPOSITION ELEMENT WITH INTEGRAL FLATTED SHAFT

Part Number	*Resistance in Ohms*	*Taps at Ohm Points*	*Taper*
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VVC-2	25,000	—	Symmetrical
VVC-3	250,000	—	Clockwise Audio
VVC-4	500,000	—	Clockwise Audio
VVC-5	500,000	150,000	Clockwise Audio
VVC-6	1 megohm	—	Clockwise Audio
VVC-7	1 megohm	300,000	Clockwise Audio
VVC-8	2 megohms	—	Clockwise Audio
VVC-9	2 megohms	15,000 & 500,000	Clockwise Audio
VVC-10	2 megohms	500,000 & 1 megohm	Clockwise Audio

Wire-Wound Element With Integral Flatted Shaft

Part Number	*Resistance*	*Taper*
VVC-34	10,000	Linear

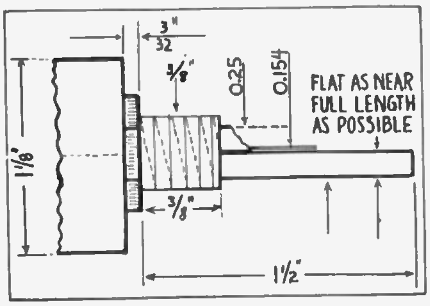
Switches

Units furnished with switches shall have the applicable suffix listed below added to the part number.

Suffix	*Switch*
S	single pole, single throw
T	double pole, single throw
U	single pole, double throw
V	4 pole, single throw shorting

Mechanical Specifications

The composition types will be the standard 1⅛" diameter control as shown in the following sketch:



The wire-bound control will be the standard 1⅝" diameter control.

Electronics

(Continued from page 28)

particles was not emitted from the anode was a question not raised by Crookes. Some years later, in 1886, such particles were found by Goldstein, who called them "canal rays," from the shape of his apparatus. Upon the discovery of radio-active bodies by Becquerel in 1896(11) it was found that these bodies emitted positively charged particles in abundance as well as those negatively charged. Eventually it was found that there were two kinds of positive particles, both much heavier than the negative electron. The first kind, called protons, were found to have the mass of a hydrogen atom (atomic mass 1), and the second kind, called alpha-particles, to have the mass of a helium atom (atomic mass 4). There was some reason to suppose that the alpha-particle was not an elementary unit, but was made up of four protons and two negative electrons. Protons and negative electrons, therefore, at this stage of the game, came to be regarded as the ultimate building blocks of nature and remained, in fact, the only sub-atomic particles known up to 1932.

Seeing is believing; and much in the way in which the Brownian motion enables us to see the effect of the impacts of the invisible water molecules upon a suspended particle, there is a way in which we can see the impacts of the heavy and energetic alpha-particles emitted by radium. Take a watch or a clock with luminous radium paint on its dial into a dark closet and examine it with a good magnifying glass; a jeweler's eye glass will serve well. The glow, which to the unaided eye appears uniform and steady, can be seen under the glass to be made up of myriads of tiny sparks, flashing up and down continually.

Take a piece of lump sugar into the dark closet and break it by pressing on it with a knife blade. A flash of bluish light can be seen for an

(Continued on page 36)

Servicing With Lamps

(Continued from page 11)

complete power unit circuit may be obtained by touching a metal screwdriver blade to the pole piece (the metal core around which the voice coil loosely fits) of the dynamic speaker. This same test will work for any receiver employing the field-coil type of dynamic speaker. With a 10-watt lamp in the test circuit, there will be only a slight pull by the electromagnet on a screwdriver blade.

Increasing the size of the lamp will increase the pull on the screwdriver blade up to the saturation limit of the circuit. You can check this by leaving the 10-watt lamp in its socket and screwing-in the 25-watt lamp, using the type of circuit in *Fig. 1A*. This establishes a total of 35 watts (insofar as the lamp rating is concerned) in your test circuit, and the pull on the screwdriver blade will increase in proportion to the increase of lamp power in your test circuit. Likewise, screwing-in the 50-watt lamp of *Fig. 1A* will increase the magnetic pull on the screwdriver, for we now have 85 watts "lamp power" in the test circuit. This assumes, of course, that such an increase does not reach the saturation limit of the circuit. Whether or not this saturation limit is reached *for normal conditions*, the addition of more lamps in parallel in the test circuit, will cause all lamps to dim or decrease in brilliance. This is because the lamps do not actually dissipate 85 watts in the series circuit. Their presence simply means that the *circuit* can not dissipate more than 85 watts.

Under conditions of 85 watts or less (down to 10-15 watts) of "lamp power" in the test circuit with only the rectifier tube in its socket, if the lamp or lamps light to full brilliance it is a sure indication of trouble—(and that the full power of 85 watts is "circulating" through only the lamps) an overload. This overload may be in the form of a defective rectifier tube, a shorted filter condenser, a grounded speaker field, or it may even mean a shorted bypass condenser somewhere along the B+ circuit. At any rate, tests to be described later on will show the exact location of the defect.

In the foregoing, we referred to a *rough test* by checking the magnetic pull of the speaker pole piece on a screwdriver blade. This gives a rough test on the entire power unit circuit. If the magnetic pull increases uniformly with an increase in lamp power, and if at the same time the lamps decrease in brilliance, then the chances are that the power unit circuit is entirely normal and may be eliminated as a possible source of trouble. On the other hand, if there is no increase in magnetic pull with an increase in lamp power and if the lamps increase in brilliance instead of decreasing, then it is an indication of a heavy load (representing a defect), and the cause of it will have to be found. *We will go into this procedure in detail in Part 2 of this article. See our next issue.*—ED.

SOLAR MOVES GENERAL OFFICES

Solar Manufacturing Corp. and Solar Capacitor Sales Corp. moved their general offices to 285 Madison Avenue, New York 17, N. Y., from Bayonne, N. J. Manufacturing activities continue in Bayonne, West New York and at Chicago. Accounts, Credits, Sales and Export matters are now handled by the N. Y. C. office.

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AERO NEEDLE OPENS OFFICES

Aero Needle Company, manufacturers of the new Aeropoint Long Life Phonograph Needles have opened general sales offices at 737 N. Michigan Ave., Chicago.

Electronics

(Continued from page 34)

instant along the edge of the knife as the sugar breaks. Light developed by the fracture of crystals is a well known phenomenon, called "tribo-luminescence." It is quite different in nature from the spark produced when flint and steel are struck together. It is probably tribo-luminescence on a small scale which produces the glow of radium paint. This paint is usually composed of a special form of zinc sulphide mixed with a trace of a radium compound. The alpha-particles emitted by the radium strike the sub-microscopic crystals of zinc sulphide and each tiny fracture generates a flash of light.

The great disproportion (about 1800 to 1) in the masses of the negative electron and the positive proton did not fail to attract attention. Considerations of symmetry (always present in the mathematical mind) suggested that there might be light positive and heavy negative particles. Dirac speculated on the possible existence of what he called an "anti-electron," with a mass equal to that of the negative electron, but carrying a positive charge. Some of his conclusions were so strange that it was difficult for many physicists to take his ideas seriously. For one thing, it appeared, according to Dirac, that this anti-electron would be a very short-lived affair. Collision with a negative electron, or indeed with an atom or a molecule, would, as Dirac thought, terminate the independent existence of the anti-electron, and in its stead would appear a little group of light waves, called a photon.

In 1932(12) positively charged particles were discovered, of about the same mass as the negative electron. These positive electrons actually seem to have the short life predicted by Dirac, and after their brief existence is terminated by a fatal collision they are re-incarnated as light. This short life is probably explainable by relative abundance. In their usual occurrence positive electrons are few in number as compared with their negative counterparts, and the few positive electrons can hardly avoid collision with some of the negative variety.

As long ago as 1920 Rutherford directed attention to the theoretical possibility (perhaps even the probability) of the existence of an electrically neutral particle corresponding in mass to the proton. In 1932(13) such a particle was discovered, and was named a neutron. Whether this particle is a combination of a proton with a negative electron, or whether it is an independent entity is still uncertain.

A light neutral particle corresponding to the positive and negative electrons is as yet undiscovered. There are certain theoretical difficulties which would disappear if such a particle existed, and with the predictions of the positive electron and the neutron in mind experimen-

TABLE I

Mass	*Negative Charge*	*Neutral*	*Positive Charge*
Heavy (1800)	———	Neutron	Proton
Medium	Mesotron	———	———
Light (1)	—electron	(Neutrino)	+ electron

tal search for this light neutral particle has been made. Though such search has as yet been unsuccessful, this particle has been named in advance—the neutrino.

A heavy negative particle corresponding to the neutron and the proton is also unknown; but between the years 1934 and 1937(14) evidence accumulated indicating that in the complex mixture of cosmic rays at sea level there exist negative particles intermediate in mass between the electron and the proton. The determination of the mass of these particles has proved to be a difficult matter, and at first widely varying figures were obtained. The most recent results give a mass between 220 and 240 times that of the electron. Because of this intermediate mass these particles have been called "mesotrons."

We may summarize our present knowledge of nature's ultimate particles in a tabular form as shown in *Table I.*

Since all these particles take part in what are now-a-days called "electronic" reactions, they may all be called electrons, though strictly speaking, in the case of the neutron this title is perhaps only an honorary degree.

It is not impossible that the vacant spaces in Table I will at some time be filled, as has already been the case with the periodic table of the elements.

In this lecture we have reviewed, in their historical order, the four lines of evidence for the atomic structure of matter; we have seen that the latest of these afforded evidence not only for the existence of atoms, but of sub-atomic particles. Of such particles there are five kinds now known, four with electrical charges, positive or negative, and one neutral; all five, however, take part in what are called electronic reactions.

We have reviewed the experimental methods that have given us a knowledge of the charge and mass of these particles, and have seen that though they differ widely in mass they all possess the same electronic charge (positive or negative), which is now regarded as one of the fundamental constants of nature; but we have arrived at no knowledge of the ultimate nature of either matter or electricity of which these electrons seem to be composed. What modern theory has to say on this subject will be covered in the next issue.

References

(1) John Philoponus, cited by Heidel: "The Heroic Age of Science," p. 187. Baltimore, Williams and Wilkins Company, 1933.
(2) Brauner: Nature, June 28, 1924, p. 927.
(3) Roscoe and Harden: "A New View of the Origin of Dalton's Atomic Theory," Macmillan, 1896.
(4) Brown: Phil. Mag., vol. 4, p. 161, September, 1828; vol. 6, p. 161, September, 1829.
(5) Wiener: Pogg. Ann., vol. 118, p. 79, 1863.
(6) See an article by Thirion: Revue des Questions scientifiques, January, 1909.
(7) Gouy: Journal de Physique. vol. 7, p. 561, 1888; Comptes Rendus, vol. 109, p. 102, 1889.
(8) Einstein: Ann. der Physik, 1905, p. 549, and 1906, p. 371; Smoluchowski: Bull. de L'Acad. des Sciences de Cracovie, July 1906; Ann. der Physik, vol. 21, p. 756, 1906; Perrin: Annales de Chimie et de Physique, September, 1909. Translated by Soddy: "Brownian Motion and Molecular Reality," London, Taylor and Francis, 1910. (An excellent summary of the whole subject.)
(9) Millikan: "The Electron," Chap. V. University of Chicago Press, 1918.
(10) Millikan: loc. cit., Chap. VIII.
(11) Becquerel: Comptes Rendus, vol. 122, 1896, pp. 420, 501.
(12) Anderson: Science, vol. 76, 1932, p. 238.
(13) Chadwick: Nature, vol. 129, 1932, p. 312.
(14) Neddermeyer and Anderson, Phys. Rev., vol. 53, 1938, p. 219 (footnote).

formation.

Cover Picture

SOUND EFFECT GUN TRAINER

Photo Courtesy of Operadio Mfg. Co.

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Ad Index

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Servicing Philco "Lightbeam" Phonos

(Continued from page 12)

can check the audio output by measuring the voltage across the cell, with a vacuum-tube voltmeter. The output is small, about .01-volt (or about that figure). But you don't even need to measure it if you have an audio generator or can pick off the modulation tone from your regular servicing generator.

A small input signal can be fed to the 7C7 preamplifier grid from the generator or from a crystal microphone. A lapel-type crystal mike, if you have one around (from a hearing-aid or P.A. work), can be carried on the service job and is handy in establishing what ails the set when obscure causes of trouble are being run down.

Treble Compensation

There is a unique arrangement in the plate circuit of the 7C7 for passing through only the higher portion of the signal. It is the writer's opinion that this is compensation for the loss of "highs" in the auto-transformer, *L4-L5*. The voltage across *L4* induces a voltage in *L5* which is much larger and this is applied, in series with the voltage of *L4* to the control-grid of the 7C7, through the .01-mf coupling condenser. In the plate circuit, the "highs" pass through the 4.7 meg. and 25 mmf. combinations since the condenser has little reactance at high frequencies, while the lower frequencies are clipped.

The action of the remainder of the amplification system is standard. Treble compensation is secured in the volume control, for even though the control is set at half-full rotation, there is a high-frequency current path through the 100 mmf. condenser across the upper part of the control resistance.

An open in *L4* or *L5* would, naturally, "kill" the signal from the photocell. The cell may be disconnected while testing the coil. A short-circuited cathode condenser would mean slight distortion in the 7C7 stage. A hum may be due to an open 8- mf. unit connected to the end of the 7C7 plate load resistor; intermittent hum, is a fault sometimes found on phono operation, and may be due to this electrolytic open-circuiting at indefinite intervals.

Distortion may also be due to improper bias on the 7C6. This effect sometimes may be due to a defective (leaky) i.f. tube, which results in excessive current through the 26-ohm resistor in the power supply.

Focusing

Most phono troubles, however, resolve about the head of the instrument. An important item for consideration is proper adjustment of the focusing controls. An adjusting screw on the side of the head allows the spot of reflected light from the lamp to be half on and half off the photocell. An allowance must be made for variation of the mirror movement; when replacing the lamp, check the focus. If necessary rock the bakelite lugs on the back of the assembly to move the light toward or away from the lens. This adjustment can be carried out properly by moving the light forward until the image of the filament is exactly focused on the photocell, then continuing the movement until the image, including the halo, is about 5/32-inch wide. If it is not vertical, it can be set straight by slight rotation of the lamp, using the bakelite lugs on the back of the assembly. It is now possible to adjust the screw on the side of the pickup head so that the spot will be half on and half off the photocell.

The width of the beam may be adjusted by carrying out the proper adjustment as mentioned above.

★

G. E. OFFERS PRIMER ON TUBES

A 24-page non-technical book titled "How Electronic Tubes Work" has been produced by the Electronics Department of G. E. at Schenectady, N. Y.

Illustrated with 117 sketches and photographs, the book is a primer whose main emphasis is on how the electronic tube operates. The eight basic types of industrial electronic tubes and their uses are described. The book (GEA-4116) is available free on request to Dept. 6-215, Publicity Divisions, General Electric Company, Schenectady, New York.

★

NEW IDEAL HANDBOOK

War plants are running 24 hours a day, 7 days a week, which means that equipment motors and generators are wearing out quickly.

The new Ideal "Maintenance Handbook" tells how to keep motors and generators operating continuously at peak efficiency without dismantling.

A free copy will be sent on request. Write Ideal Commutator Dresser Co., Sycamore, Ill. Every page, (88 pages in all), is crammed full of valuable information.

Cover Picture

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Photo Courtesy of Operadio Mfg. Co.

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Start of production began in early September.

How an RCA Electron Tube Can Help Dress a Woman

REMEMBER how radio once mystified people? "What? Hear music from 1000 miles away through a bunch of *tubes* in a wooden box?" Well, you know the rest of that story. You helped write it!

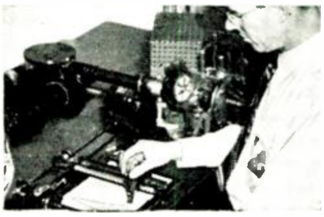
Now it's Electronics—*your* biggest opportunity for tomorrow.

Today, thanks to an RCA electron tube, a device might even be built to stop a cloth-printing press the instant the uniformity of the printed color changed in the slightest. It's been estimated that such a modern "electric eye" can analyze and sort out 2,000,000 separate color variations. Think what that can mean to the woman who insists on perfect color matching—and to the textile industry that has to supply her.

You, Mr. Distributor, may well find yourself one day selling electronic equipment for this and a thousand other uses. And you, Mr. Serviceman, installing and maintaining it.

Just bear in mind two things: First—that its operation will largely depend on circuits, tubes, and parts already familiar to you from your radio days. Second—that *the Magic Brain of All Electronic Equipment Is a Tube and the Fountain-Head of Modern Tube Development Is RCA! RCA Victor Division, Radio Corporation of America, Camden, N. J.*

TUNE IN "WHAT'S NEW?"—*RCA's great new show, Saturday nights, 7 to 8, E.W.T., Blue Network*



This electronic automatic recording spectro-photometer is used at RCA for testing luminescent materials for cathode-ray tubes. In 2 minutes it does accurately what a trained man formerly did, but not as well, in 2 weeks.

RCA

RCA ELECTRON TUBES

The former radio serviceman now in the Army Signal Corps or Navy Communications knows from peacetime experience that he can depend on Raytheon tubes. When he uses Raytheons for installations and replacements he knows they will stand by him when the going is toughest—like a trusted friend.

The reason the Raytheon trademark is seen so frequently in the armed forces is the same reason it was so widely used and respected by the serviceman in peacetime.

When peace is won, and the serviceman is back in his shop, Raytheon tubes will be giving the same dependable and efficient service as ever.

Four "E" Awards

Each division of Raytheon has been awarded the Army & Navy "E."

RAYTHEON TUBES
RADIO & TRANSMITTING

RAYTHEON PRODUCTION CORPORATION

NEWTON, MASS. • LOS ANGELES • NEW YORK • CHICAGO • ATLANTA

DEVOTED TO RESEARCH AND THE MANUFACTURE OF TUBES FOR THE NEW ERA OF ELECTRONICS