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Radio

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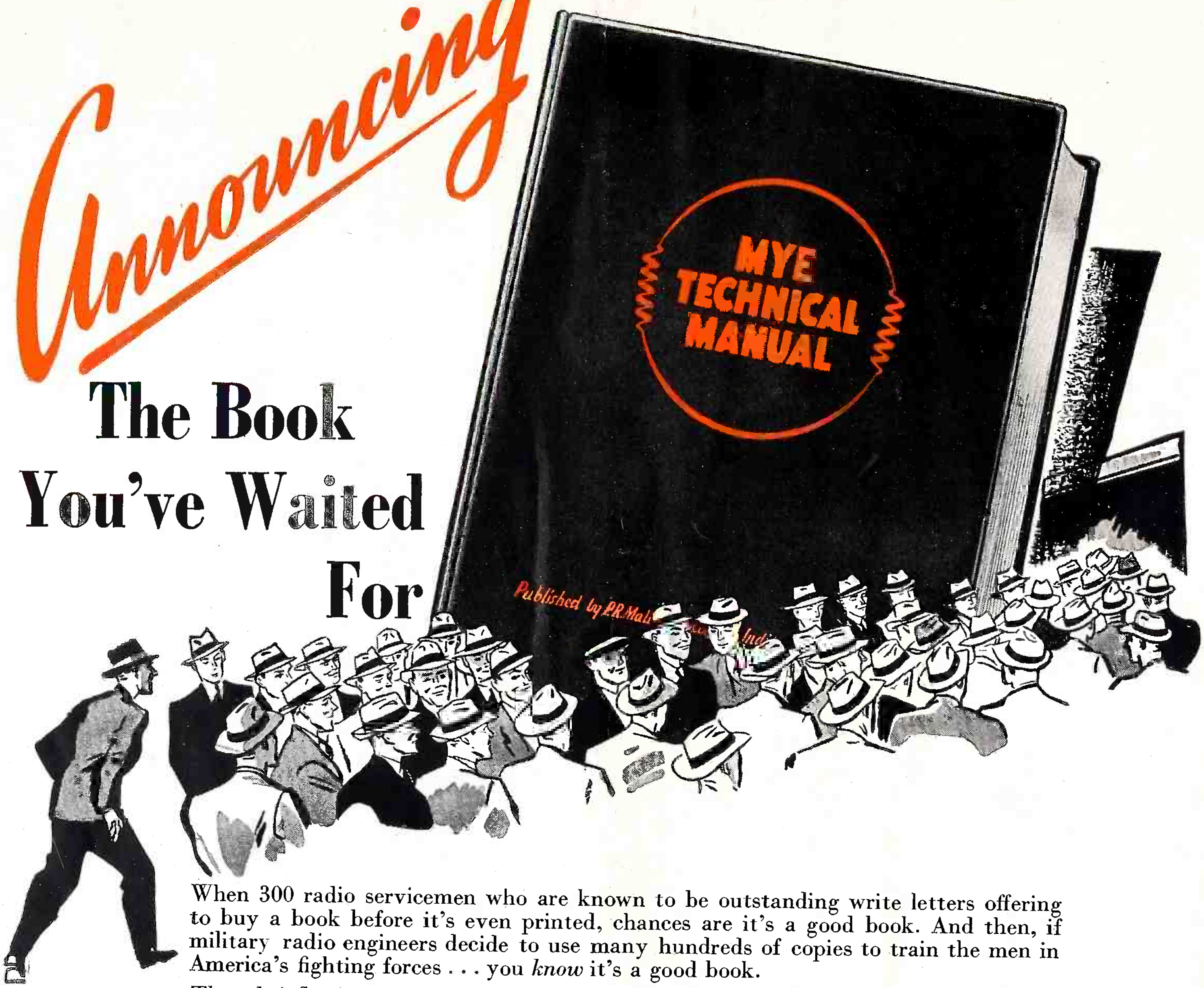

When 300 radio servicemen who are known to be outstanding write letters offering to buy a book before it's even printed, chances are it's a good book. And then, if military radio engineers decide to use many hundreds of copies to train the men in America's fighting forces . . . you *know* it's a good book.

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2 Superheterodyne First Detectors and Oscillators
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7 Frequency Modulation
8 Television—suggestions for the post-war boom
9 Capacitors—how to overcome war-time shortages
10 Practical Radio Noise Suppression
11 Vacuum Tube Voltmeters
12 Useful Servicing Information
13 Receiving Tube Characteristics—of all American tube types

Here's a suggestion. If you want to reserve a copy of this 392-page book, bound beautifully in hard cloth . . . go around to your Mallory Distributor today. The supply of manuals for civilian distribution, at the price of $2.00, is limited. Order your copy now! Your Mallory Distributor has it!

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Vol. 3. No. 8 ★ August 1942

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Radio SERVICE-DEALER

SOUNDMAN AND JOBBER

Reg. U. S. Pat. Off.

Ad Index

Contents

Suitable for framing, this chart makes the replacement of discontinued tubes simple.

Cover Picture

FM SOUND EFFECTS

Hammering a nail in wood makes an effective sound effect via FM. The thud of wood and the ring of the nail vibrating when struck are extremely high frequency sounds, making for more realistic sound effect's broadcasting, as demonstrated over W71NY, WOR's FM station.

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RADIO SERVICE DEALER, published monthly at 34 N. Crystal Street, East Stroudsburg, Pa., by the Cowan Publishing Corp.. Executive and Editorial Offices at 132 W. 43rd Street, New York, N. Y. Subscription rates—United States and Possessions, $2.00 for 1 year, $3.00 for 2 years; elsewhere $3.00 per year. Single copies 25c. Printed in U.S.A. Entered as Second Class Matter October 3, 1941, at the Post Office at East Stroudsburg, Pa., under the Act of March 3, 1879.

YOU FILL IN THE PICTURE—
THE LAW WON'T LET US

RACON HORNS & SPEAKERS used by the U. S. Navy, U. S. Army, U. S. Air Corps—at Camps—in Industrial War Plants, etc.

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RACON ELECTRIC CO. 52 EAST 19th ST. NEW YORK, N. Y.

THE PLOT THICKENS

SOME RADIOMEN CLASSED ESSENTIAL

IN ITS LATEST DIRECTIVE to local Boards, Selective Service Headquarters places the radio manufacturing industry and its employees, also broadcasters on the "essential" list. Actual deferment still lies within the discretion of each local Board, but you can wager that very few radio equipment assemblers or broadcast station employees will be placed in class 1-A since this promulgation. What about radio servicemen? They are given no preferential status. At face value this Selective Service directive tells Draft Boards that any ordinary production line assembler or radio station announcer or transmitter maintenance man is "essential" to the war effort and should be deferred but the independent radio serviceman who is keeping electronic equipment in industrial plants operating on war orders and the serviceman who is striving to keep tax-payers' sets operating so they can hear the latest news flashes and entertaining programs (which contribute to Morale) is *not* an "essential" contributor to the war effort. Is that good logic?

In like discriminatory manner WPB gives broadcast stations excellent priority status on parts needed for maintenance and repair while stopping all production of replacements needed for civilian use. President Roosevelt will relish broadcasting an important Morale message soon to a mere handful of listeners. Let's go back to the Pony Express days.

WASHINGTON SERVICEMEN, LISTEN:

OPA announced on July 20 drastic tire rationing regulations which specifically deny to radio distributors, dealers and servicemen new or recapped tires after July 28. Servicemen, after present tires wear out, must either repair heavy consoles in homes or let them rot lying idle. Small sets will be no problem. Customers must bring 'em in to the service shop. Servicemen cannot afford to make and have no time for pick-ups or deliveries. Under price regulations in effect they must maintain March levels and those levels do not afford margins for added transportation expense and time lost in making deliveries.

District of Columbia servicemen can wage a battle for the entire industry and all set owners in our efforts to make certain bureaucrats wake up to realities. Whenever a Congressman, WPBer or OPAer phones that he needs a serviceman because his set has gone hay-wire the servicer should ask, "Is it a small table model or midget"? and if the answer is "Yes"—the response should be, "Bring it in yourself Brother, we can't get tires." If the answer is, "No, it's a console" then the proper reply would be, "Then fix it yourself, Pal, for we can't get tires *and* we can't get parts. You're just a civilian!" Boy, oh boy,—would that sort of treatment get results for the servicing industry and for the layman who needs radio more now than ever before.

FALSE ECONOMY

By stopping production of civilian radios and parts WPB contends that 70,000 tons of steel, 10,500 tons of copper, 2,100 tons of aluminum and 280 tons of nickel were "saved" for more important applications. WPB failed to mention that if manufacturers of replacement parts and tubes for *all* purposes, civilian and industrial, were allowed to produce their products without restriction in the same quantities as 1941 only 112 tons of steel, 86 tons of copper, 65 tons of aluminum and 23 tons of nickel need to have been allocated and even then there would be surpluses of parts on hand from which industrial and war effort requirements might be immediately served. These now require special priority ratings and in the production of them many bottlenecks and much chaos is resulting. Here is a case of false economies most blatant; the throwing away of a pound in seeking a penny. On the average, much less than 7% of all "scarce" materials used by radio manufacturers during 1941 went into producing replacement parts and jobber items.

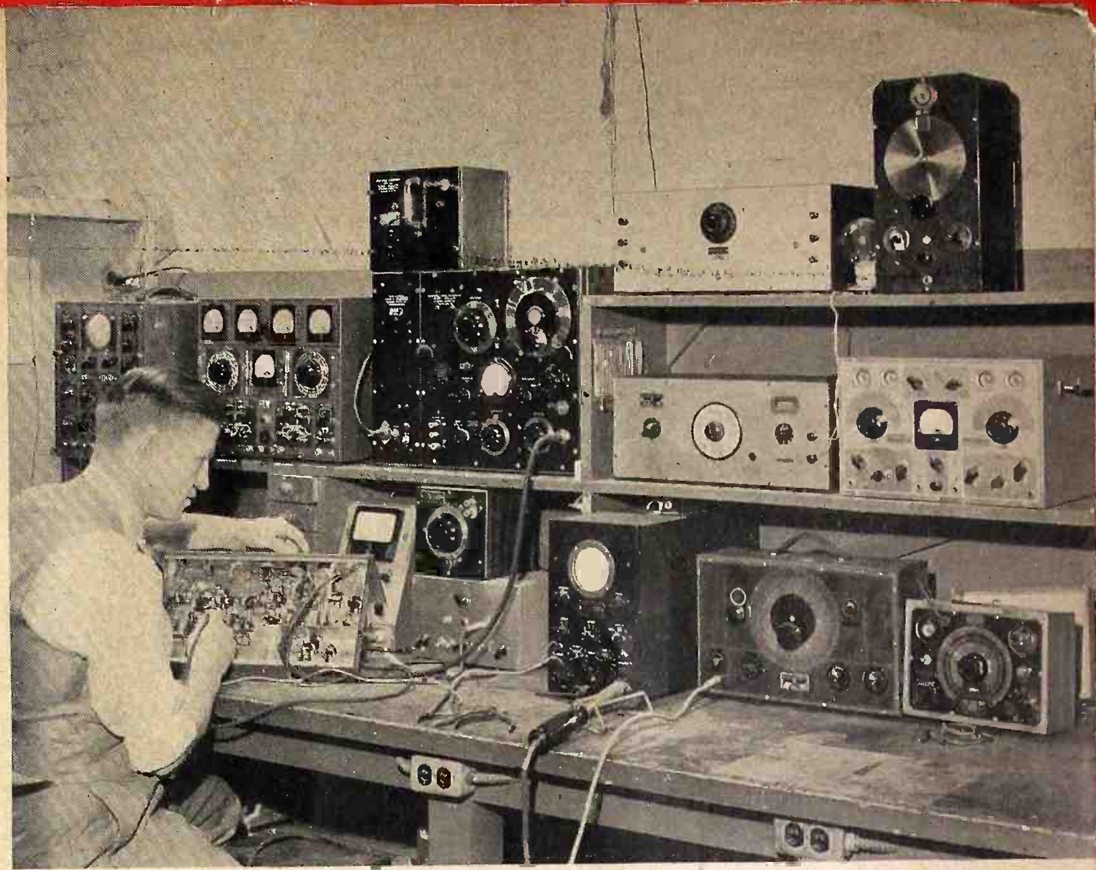
Meissner
RADIO KITS
ARE DOING THEIR DUTY
WITH THE ARMY SIGNAL CORPS!
...for Faster Radio Training

. . . *Army sponsored Signal Corps Schools* know the value of faster radio training . . . Meissner Kits are precision-built and engineered to give better results in basic radio instruction.
Illustration of actual Radio Kit instruction in Army sponsored Signal Corps School.
See your nearest Meissner Distributor

Meissner
MT. CARMEL, ILLINOIS
"PRECISION-BUILT PRODUCTS"

Fine profits can be made servicing industrial-electronic installations. Now, for the first time, service-dealers are told how to go about getting this type of business.

Some jobbers and large servicing organizations have already undertaken sub-contract war work. For example, Spokane Radio Company sends this view showing one of their laboratory benches where electronic war equipment made by them undergoes extensive tests.



INDUSTRIAL ELECTRONICS—SALES & MAINTENANCE

TO some extent each radio serviceman and every dealer knows his own potential status based upon what has transpired in the past. But such a basis as the past is worthless in reckoning the future. Now we live in an America that is "all-out" in an offensive war effort. To all practical purposes we must abide by laws and regulations, restrictions and limitations that are as severe as would be found under totalitarianism.

We should try to conduct our civilian radio servicing business in a fashion *as near to normal as possible.* At the same time we must look to new developments, such as the selling and servicing of industrial electronic installations, as a source of income backed up with priority assistance. Let's see how you fit into the picture.

Employed Servicemen and Part-timers

Let us consider all phases of the radio industry in an effort to determine what should be done by the men in each category to attain their own end, i. e., success. With no offense meant, we will start at what is generally considered "the bottom"—the employed radio serviceman, and work our way up.

Most employed radio servicemen are relatively young and are subject to induction, either military or civilian. Not long ago the average employed serviceman earned $20 weekly. War work and higher wages beckoned. Consequently many deserted the field. Those remaining now average $45 weekly. There is a scarcity of competent radiomen, and with no wage-ceiling restrictions, possibly higher wages are ahead for employees, provided their employers can afford to meet further demands while they are forced to operate under maximum price-charge ceilings.

Until recently many thousands of men with some radio training functioned as part-time servicemen operating out of their homes, carrying no stock or inventory except test equipment, yet obtaining dealer discounts from jobbers who cared not who bought so long as purchases were made. But a handful of "part-time" radio repairmen remain, and the few who still function as such are now employed as part-timers for legitimate retailing or servicing organizations who are paying better wage scales than the part-timer could earn working as an independent. Ultimately most all part-time servicemen will find themselves forced *by government regulation* to devote their "spare time" to Signal Corps maintenance work in civilian capacity. In like manner, it is quite likely that all full-time employed radio technicians will have to devote a part of their off-time to government work, particularly if they have qualifications that the Signal Corps can utilize. True, they will be paid for their efforts. But that is relatively unimportant. The prime purpose of the civilian should be to produce for the government now wholeheartedly, rather than gamble on losing the war, in which event we will all be slaves to the conqueror. And make no mistake about that!

Service Organizations

The genuine radio service organization needs less sympathy and enjoys brighter prospects than any other in radio. In contrast, the dealer who primarily depended upon retailing is, bluntly speaking, "out on a limb." But let us first consider the former.

For an indefinite period repairing, *and repairing alone,* will be the order of the day. *Some* replacement parts and *some* renewal tubes are and will be available to simplify matters. Washington has urged that no replacements be used if repairs to defective parts can be made. That is good logic and a patriotic service that competent servicing organizations can render in the war effort. Of course defective tubes cannot be repaired. Sometimes, to bypass a tube fault and not use a replacement a stage can be cut out. Whether or not the set owner will countenance such practice only time will tell. We advocate such by-passing only as a last resort. Let us repair what we repair to optimum efficiency rather than jeopardize customer good-will. After all, the labor involved in by-passing operations must be charged to the customer, and while OPA cannot find a basis upon which to limit such service charges it would be better to avoid possible contention that might arise. But, insofar as repairing is concerned, are radio servicing organizations going to be able to pay increased wages to employees and will the turnover of defective civilian receivers be high enough to warrant confining one's activities purely to home set repairs? No one knows the answer just now.

Electronic Servicing Plan Outlined

Servicing organizations have been urged to go after "electronic servicing" business to supplement their income. Anyone can tell anyone else to "do this" or "do that." Sounds simple, but it doesn't work out that way. It is a form of wishful thinking. Undoubtedly there are electronic installations of some type or other in every community. The fact that they exist does not imply that their owners are desirous, or even willing to utilize the services of any local radio servicing organization.

Most large factories that employ electronic devices also maintain a staff of engineers who are competent to keep all their electrical equipment in repair. Large factories simply don't trust their local small-business radio shops. Service shops, on the other hand, feel slighted, believing they are competent. It is understandable if one weighs both sides. The only solution then, to obtain electronic equipment service work is *salesmanship*. Every servicing organization manager will find it worthwhile to ascertain what local industrial firms are potential prospects. Then personal solicitation, and constant close-contact effort might result in the servicing organization being called upon if, as and when something goes wrong. A practical service-selling method is that of offering to act as year-around maintenance department for the prospect on a fixed-fee (plus parts cost) basis. Assuming that a factory employs an electrical engineer and maintenance man all year round at $60 weekly—it is logical to assume that frequently, if the engineer is busily engaged in some other matter when an electronic device goes hay-wire, he will neglect that job until finished with the one in work. But were that factory to employ, in addition to the staff engineer, a "Radio-electronic Maintenance Service" for a nominal sum, say $5 weekly, the periodic weekly checkup and services obtained when needed would undoubtedly prove the investment to be a sound form of business insurance.

The Service-Dealer who sticks exclusively to home set repairing might as well advertise like this.

Every servicing organization can afford to spend 1 hour weekly, on a fixed schedule throughout the year, acting as maintenance department for a customer's electronic equipment. And, the customer would get better service, for a competent radioman will smell a hot condenser that is about to blow—and make repairs before it does, he'll find tubes that are getting weak—whereas the less competent engineer must wait for the actual breakdown to occur, and then go trouble shooting, with corresponding loss in time and use of the facilities. Real competence and ability to prevent work stoppage from occurring are saleable items in the stock of every servicing organization. But they are valueless adjuncts until they have been sold to the potential buyer.

There is money to be made in electronic servicing, we repeat, but most emphatically we stress that the profits depend upon salesmanship . . . the getting of the order to render the services . . . that must come first. Don't go about it haphazardly. Scan for prospects, analyze their needs and submit, for the buyer's consideration, a *complete* plan which proves conclusively in dollars and cents that he profits in more ways than one by doing business with you. There are fifty or more working hours in every week. Were each hour per week sold to an industrial customer on a year-round basis at $5 per hour the servicing organization that functioned on that basis would have an income of $250 weekly for services alone. Sounds fantastic! It is, to some extent, but it is also possible. In a more reasonable light, if the servicing organization can sign contracts with 10 industrials to be their maintenance departments at $5 a week each the resulting $50 a week income (for only 10 hours of service rendered) would be rather nice billing to enjoy throughout the year. Give it some thought. The logical man to see at factories is the Works Manager. He may advise you to contact some lesser executive — possibly the purchasing department head, the electrical department head, or some other party. To sell them your service you must see them. Perhaps you can ask for and get $25. a week as a maintenance fee. Try—learn!

Are Dealers a Threat?

So much for the servicing organization who is trying to expand sales. What about the threat of increased competition? That, if permitted to occur, can offset the increased income from other sources that you might be pioneering. By now all dealers who formerly did not operate their own service department have either tried to establish one or have worked out subcontract deals on repair work with non-retailers. Bluntly, the dealer who functions exclusively as a retailer is doomed. It makes no difference what subterfuge he tries. A retailer requires fast-turn-over, high markups and all the other "angles" pertaining to electrical appliance sales. Having no electrical appliances to sell for the duration there simply is not enough profit margin in a relatively small volume of servicing to carry him. Now, in desperation, he tries to become a competitor to the established servicing organization. Forget him. Let him wallow in his own juice and he will fold. When we return to normalcy the surviving servicing organizations can fall heir to the electrical appliance business that will spring up again. It pays not to help keep your competition in business. The small returns you get from him now will be more than lost when your own position in future is given prime consideration. And, didn't President Roosevelt call this the War of Survival?

Jobber Problems

That some servicing organizations will face competition from parts jobbers who may decide to go into retail servicing is a foregone fact. You can fight such competition with boycott. Buy not from your competitors and keep from them the profits that allow

(Continued on page 21)

RESISTORS for REPLACEMENTS

The Army, the Navy, the Air Force have first call on all the radio parts and equipment that can be made today. Their requirements are *vital.* Maximum dependability, stability and accuracy are essential under all of the severe conditions of war. That is why IRC resistors are specified, and why IRC is producing resistors 24 hours a day, 7 days a week.

This explains the increasing difficulties service men are experiencing in securing dependable resistors for repair and maintenance of home radio sets.

Realizing the importance of maintaining and servicing home radio sets, IRC is making available for servicemen large stocks of the same dependable resistors the armed forces are using (but in ranges and tolerances not called for on war orders) and are offering the following suggestions to enable servicemen to obtain greatest possible use of resistors in these times.

1/2-, 1-, and 2-watt Resistors

The resistors in home and automobile sets are almost invariably of the so-called "Preferred Number" or "RMA" standard resistance values and are color-coded accordingly.

Jobbers have, in the past, carried in stock the ½-, 1-, and 2-watt resistors only in "nominal" or round figure ranges such as 1,000, 5,000, 10,000 and 25,000 ohms, etc.

Now, however, many jobbers are stocking the IRC resistors in RMA ranges. These resistors are being furnished by the factory from stocks originally accumulated for the set makers before the manufacture of home sets was discontinued. They are of exactly the same quality previously used in the finest radio sets, but as they are not the ranges and tolerances required for military equipment, they can be supplied without interfering with the all-out war program.

A defective resistor in a set can always be replaced satisfactorily by a new resistor within 20% of the color-coded resistance value of the original unit.

In rare cases, where close tolerance units are used as original equipment, they are usually identified by a gold or bronze band for 5%, or a silver band for 10% tolerance. If a close-tolerance unit is required for replacement, two resistors, one higher and one lower than the required range, may be used in series or in parallel when matched for their combination resistance value.

If a 2-watt resistor is required and none is available from the jobber, two 1-watt units in series or in parallel will do the trick. Similarly two ½-watt units can be used instead of one 1-watt. Any low-wattage unit can, of course, be replaced satisfactorily by any higher-wattage unit of the same range.

Power Wire Wound Resistors

All wire wound resistors above the 2-watt size are becoming scarce because they are made of critical materials which must be conserved for war requirements. Fortunately, however, they are seldom required for service work except in A.C.-D.C. sets. Also, they are seldom used at their full rating.

If a wire wound resistor of the required wattage rating is not available, a combination of any types of lower-wattage units, either in series or parallel, may be substituted. In combining resistors for this purpose, the wattage rating is cumulative based on the number and rating of the resistors used.

Substitutions

It is daily becoming more necessary to make substitutions in many civilian industries to conserve the critical materials needed for winning the war. The substitutions suggested above will not affect the quality of replacement jobs. We hope that these suggestions may help to keep the home sets of the country operating.

IRC

INTERNATIONAL RESISTANCE COMPANY

401 NORTH BROAD STREET, PHILADELPHIA, PA.

There's great demand for—but an insufficient supply of Home Recorder Combinations like this RCA VHR-207. This article describes how to convert and modernize ordinary home receivers easily at substantial profit.

by Willard Moody

MODERNIZE SETS BY ADDING RECORDERS

THERE is an unmistakable evidence of interest in the recording of outstanding radio programs, the preserving on wax of a Presidential speech, the music of an artist or even the dying confession of a murderer can be recorded for posterity. What the camera is to the painter, the recorder is to the musician.

At one time "canned music" was hated by performers who now hail it favorably and point with pride to a new "cultural" addition to the American scene--the Juke box!

How can a recorder be hooked onto a radio? Well, it depends, first of all on what type of recording head you happen to have or can buy. The recorder must be matched to the output of the radio set by means of a transformer. In some cases it is sufficient merely to switch over from voice coil of the loudspeaker to recording head, where the impedance of the speaker is the same as that of the recording head. If the head happens to have an impedance of 200 ohms, 7500 ohms or some other value, a special output transformer must be used to match the head to the output stage of the radio.

The turns ratio on the transformer necessary to do the job will be

$$T.R. = \sqrt{\frac{Z_p}{Z_s}}$$

where Z_p equals the primary impedance in the plate circuit of the output tubes and Z_s is the secondary impedance of the transformer, equal to the recorder head impedance.

The required plate loads for some typical tubes are:

6F6	7,000Ω	6F6-6F6	P.P.	14,000	P.P
6L6	2,500Ω	6L6-6L6	"	5,000	"
43	4,500Ω	43-43	"	9,000	"
47	7,000Ω	47-47	"	14,000	"
6V6	5,000Ω	6V6-6V6	"	10,000	"
25L6	2,000Ω	25L6-25L6	"	4,000	"
25A6	4,500Ω	25A6-25A6	"	9,000	"
2A3	2,500Ω	2A3-2A3	"	5,000	"
45	3,900Ω	45-45	"	7,800	"

As an example: if the manufacturer of a recorder head states its impedance is 200 ohms, or it is measured and found to be of 200 ohms impedance and the amplifier happens to have a pair of 2A3 tubes in the output, what transformer turns ratio is required?

$$T.R. = \sqrt{\frac{5000}{200}} = \sqrt{25} = 5$$

and the primary voltage would be 5 volts for 1 volt on the secondary. This voltage ratio could be checked by using an audio signal generator and vacuum tube voltmeter, supplying a 1-volt signal to the secondary and then checking the primary.

If the recorder head happened to have an impedance of 7,500 ohms, the formula would be:

$$T.R. = \sqrt{\frac{7500}{5}} = \sqrt{\frac{1.225}{1.5}} = 1.225 \text{ to } 1$$

in a step-up direction. That is, the voltage across the primary would be *lower* than that across the secondary. An audio signal of 1 volt supplied to the secondary would give 1×1.225 or 1.225-volt plate to plate on the 2A3-2A3 P.P. primary.

In order to monitor the recording and to use the unit at the proper level, an indicator is required and may take the form of a neon lamp connected across the recording head, a delayed action vacuum tube voltmeter employing a "damped" meter on a time delay circuit of R and C. A suitable vacuum tube voltmeter is shown in *Fig. 1—Top*, while *Fig. 1—Bottom* shows how to make turns ratio tests.

Fig. 1—A Suitable Vacuum Tube V.M.

How to switch over from the recording to normal radio or microphone op-

TECHNICAL SERVICE PORTFOLIO

SECTION XXI

About Tube Checkers

THE only conclusive test of any tube is to put it in the apparatus in which it is intended to be used and see how it works. But when the apparatus itself is not available, or fails to function, some independent means of test is needed. The tube checker fills this need. Just how well it does its job depends to a considerable extent on the type of test which it applies to the tube *and* the test conditions under which the tube operates. While it is the aim of designers of high grade tube checkers to approach the test conditions under which the tube normally operates, the great variety of applications to which many tubes may be put and the varying voltages and frequencies which may be normally present in the tube when functioning in a receiver or similar apparatus make it impossible closely to approximate such conditions in a simple test instrument. Fortunately, the great majority of faults which normally develop in vacuum tubes are readily detected by simple tests, so that even the most elementary type of test will suffice for a surprisingly large percentage of defects. But where the relative merits of similar tubes are to be compared, or when, of two fairly good tubes, it is desired to determine which should be replaced and which retained in service, an accurate tube checker must be employed. In this article we aren't going to tell you just how to build a complete tube checker, but we do hope to present sufficient information that a defective instrument may be intelligently serviced and, for those who so desire, test setups for common tubes may be made without difficulty. The actual building of a tube checker requires special switches and transformers which are now obtainable with difficulty even when high priority is available, and thus cannot be readily secured by the service industry.

"Shorted" Tubes Cause Overloads

All tube checkers are so designed that the tube under test is checked initially for shorted elements. This is necessary in order to avoid damaging the tube checker, as much as to detect the faulty condition, because the short circuit, if present, may cause an excessive overload on the tube checker power supply and other components. Usually a fuse or overload lamp is provided to form some protection for long continued overloads from this cause, but the short test should invariably be made first so as to catch such defects and thus prevent accidental overload.

It may seem rather simple to devise a short test which will check all possible short circuits in a tube, but actually this is one of the trickiest problems which the tube checker designer has to contend with. This is so because it requires a rearrangement of circuits and thus involves extremely complicated switching when a complete check of all possible shorts and leakages is to be made. It is necessary to be able to check the tube either hot *or* cold; that is, with or without heater voltage being applied, because shorts may be present when the tube is heated which are not evident when the tube is cold. Further, it is necessary in the simpler forms of tube checkers to determine if any of the tube elements are open-circuited, because, as we shall

LEFT—*the very latest Precision Apparatus Co. button-type Tube Checker.*

RIGHT—*the most modern Triplett Electric Co. lever-type Tube Checker.*

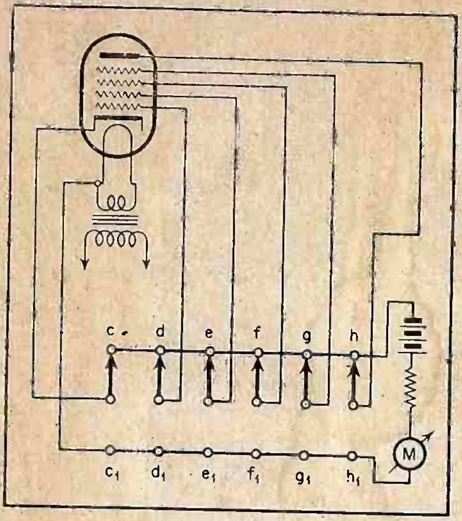


Fig. 1. A simple but effective method for checking tubes for shorts and opens.

see, some tubes may pass all tests even when one or more elements are open-circuited and thus render the tube unsatisfactory in actual performance.

Checker Circuits Explained

A good many circuits have been devised for checking short-and-open-circuits, usually by means of a neon lamp and a suitable switching system. For those who want a more accurate test, a very satisfactory circuit is shown in *Fig. 1.* If a reasonably sensitive meter is used, say 1 ma for full scale deflection, it is possible to detect with this circuit faults which are not revealed by other more commonly employed arrangements.

While a number of switches are shown in the diagram, their functions may be combined in a single, push-button type of the kind used in push-button operated receivers. This type of switch is ordinarily easy to obtain. A battery is shown, which may be replaced by an equivalent power supply voltage. A series resistance is required to limit the battery current. If a 9-volt battery is used, the series resistance required to limit the current in the circuit to 1 ma is 9,000 ohms; for a more sensitive meter, the series resistance needed is proportionately higher. But with such an arrangement and with these suggested values, leakage resistance between tube elements as high as 500,000 ohms may be readily detected. In some applications, particularly in television, it is important to be able to detect inter-element leakages as high as 10 megohms. To do so merely requires increasing the battery voltage and series resistance proportionately, or using a more sensitive meter, or both. In fact, if a standard multi-range ohmmeter is at hand, the combination of the series resistance, battery and limiting resistance may be replaced in its entirety by the ohmmeter. This arrangement will be found much more sensitive than any employing neon tubes as indicators.

In operation, all elements except the heater are joined to cathode and the resistance measuring circuit is placed between the heater and the joined elements. This enables a measurement of cathode-heater leakage, in combination with any leakage which may be present between any of the other elements and cathode. Then, with the cathode switch remaining connected to point *c*, each other push-button is depressed in turn, thus connecting each element to which they are connected to the heater. When this is done, the resistance-measuring circuit, composed of the battery, resistor and meter, are placed in series with the cathode and each of the other elements. The cathode, you will note. connects to the negative terminal of the battery while all others will be switched to the positive side. As a result, some emission current will result and the meter will indicate this current. If, however, any of the buttons when depressed, does not cause an indication on the meter, then the element which is supposed to be switched is open-circuited.

For checking shorts, all elements are first switched from points *c, d, e, f, g* and *h*, to the corresponding points *cl, dl, el, fl, gl,* and *hl.* This places the cathode and all elements on the positive side of the battery. Now, if each element is in turn switched to the point to which it was previously connected, elements so switched will be placed on the negative side of the battery and will therefore be negative with respect to the cathode. Under such conditions emission current cannot flow between cathode and any of the elements so switched and thus no current should be indicated on the meter. If the meter does indicate, then leakage or a shortage is present, depending upon the magnitude of the current. Thus it becomes possible to test for any possible condition of leakage, short or open circuit.

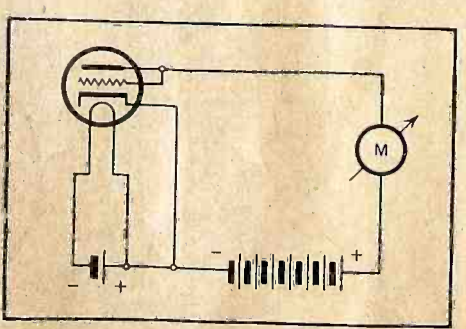


Fig. 2. In the emission test the tube functions as a diode.

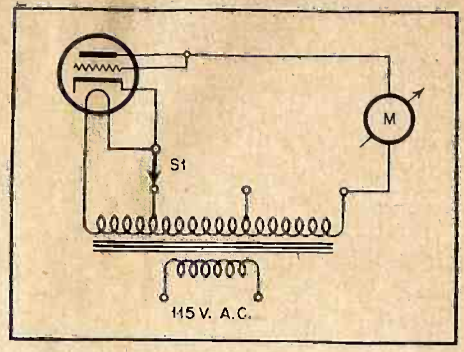


Fig. 3. A tapped transformer secondary supplies both plate and filament voltages in low-priced emission tube checkers.

If the push-button type of switch which is commonly employed in receivers is used in the setup just described, it will be necessary to hold down the cathode button while depressing each of the others in turn to check for short circuits and leakages. This is necessary because such switches are so designed as to release all keys except the one depressed. A locking type switch, which holds each depressed key in position, may be employed, and will allow the test to be made without holding down the cathode button.

Emission

The simplest of all tests of tube performance is the emission test, which is widely used in low-priced tube checkers. As shown in *Fig. 2,* the tube under test is made to function as a diode and its emission current under such conditions is measured. This type of test shows merely that the cathode or filament is emitting a quantity of electrons but has no direct bearing upon the performance of the tube in a given circuit, except of course, when the tube is a rectifier type. However, the indirect relationship between emission and other tube characteristics is sufficiently close so that the emission test gives a fairly reliable indication of tube conditions, particularly of tubes which have been in service in receivers. The test is more accurate on the latter type of tubes because such tubes have originally functioned satisfactorily, otherwise they would not be in the receiver. And, as a result of long-continued use, the usual effect is a decrease in emission, which will of course be revealed by an emission test. However, displacement of elements as a result of jars, sagging due to long-continued heating, decomposition because of chemical action—such troubles will *not* be indicated by the emission test.

In *Fig. 3,* a common commercial method of making the emission test is shown. Note that alternating current

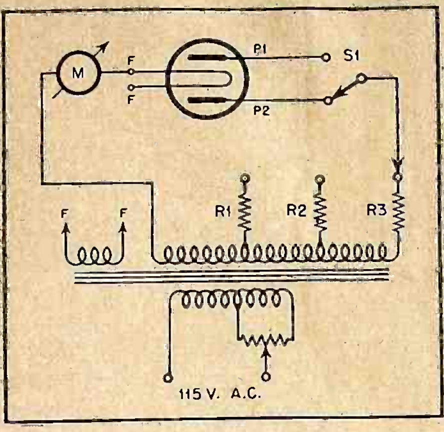


Fig. 4. A modern and highly effective method of checking rectifier tubes.

is applied to the tube, which is connected as a diode. In this form of connection the tube acts as a rectifier, and the d-c meter in the plate circuit thus indicates the rectified current. Usually the alternating voltage applied is limited to about 30 volts for this type of test. The total circuit resistance should be 200 ohms.

In *Fig. 4* is shown the emission test as applied to rectifiers of the full-wave type. This form of circuit is used in high-grade tube checkers and, if your present instrument is adaptable to the change, it is well worth while to incorporate same. Or, if so desired, a separate setup for checking rectifier tubes in accordance with this method may be readily made.

Emission Testing Rectifiers

The big feature of the circuit of *Fig. 4* is that rectifiers are checked at voltages which correspond to those at which the tube normally functions. Thus a type 80 tube should be checked at 300 volts, a type 25Z5 at 100 volts while the 6H6 may be checked at 10 to 30 volts. The switch *S1* enables each plate to be checked independently. *R1* is usually 5000 ohms for the 10-volt test of small diodes in combination tubes, 600 ohms is used for the 100-volt tap (*R2*) and 1800 ohms for *R3*. A tube is considered unsatisfactory *if its emission under such test conditions drops below two-thirds of its average normal emission.* For detector diodes, a much greater drop is permissible; usually to one-fifth or even one-tenth the normal reading.

The advantage of checking rectifiers at high voltages is that the presence of excessive gas is not revealed at low-voltage tests but becomes immediately evident at higher voltages. Further, the tube functions under load conditions which more closely approximate those under which it normally operates, so that the test approaches that of a true dynamic test.

In all amplifying tubes, the control action of the grid should be checked. This will be affected by variations in spacing of the elements, sagging, jars and other conditions. When the control action is reduced, the ability of the tube to function as an amplifier or as an oscillator is likewise reduced and the performance of the apparatus in which it is incorporated suffers.

Grid-shift Test Obsolete

One of the earliest methods of checking control action is the grid-shift test, which is made with analyzers. The tube is inserted in the analyzer and its grid potential shifted from a negative to a more positive value. The degree of change in reading of plate cur-

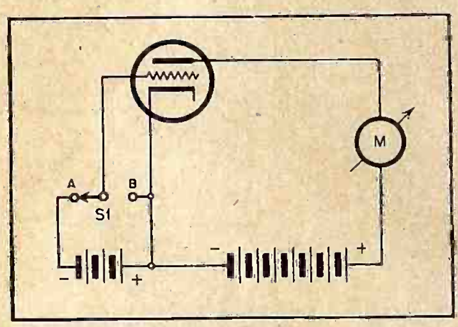


Fig. 5. The grid-shift method of checking tubes shown is one of the earliest and most widely used methods.

rent resulting from the change in grid voltage is an indication of the control effect of the grid. A fundamental circuit for this type of test is shown in *Fig. 5.* This form of test was commonly made by removing the tube and inserting an analyzer plug into the socket of the apparatus in which the tube was being used. The tube was placed in a socket of the analyzer and the voltages transferred through the analyzer cable to the test socket. Thus both the apparatus voltages and the

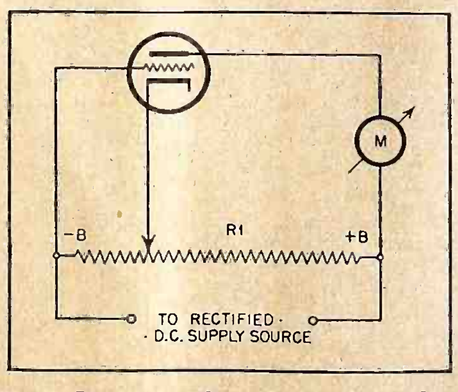


Fig. 6. By varying the cathode voltage along R1 a change in plate current is secured which approximates the grid shift test.

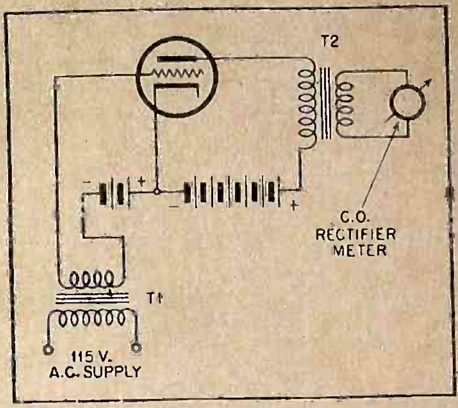


Fig. 7. Modern mutual conductance tube checkers employ test circuits similar to that shown above. The copper-oxide type of meter may be replaced, in some designs, with a rectifier tube and d-c meter.

condition of the tube should be checked simultaneously. In modern receivers the coupling between circuits which results when the analyzer is so connected causes serious trouble and has practically eliminated the use of the analyzer in the manner described.

A modern fundamental circuit for checking grid control action is shown in *Fig. 6.* As shown, a rectified d-c supply is employed, but this rectified voltage is not filtered. Thus a combination a-c and d-c voltage is applied to each element. The resulting current indicated on the plate meter is simply the plate current under these operating conditions, but, if the cathode connection is shifted along the resistor *R1* toward the *B minus* connection, a decrease in grid voltage and a corresponding increase in plate current results. The degree of increase in plate current thus produced is an indication of the *relative mutual conductance* of the tube under test.

Dynamic Mutual Conductance Tests

Such tests bear no relation to a *true* dynamic test. In the higher priced instruments, circuits of the type shown fundamentally in *Fig. 7* are employed. This approximates a true dynamic mutual conductance test. Rectified (and, in some cases, filtered) d-c supplies are employed, an alternating voltage is applied to the grid and the alternating current in the plate circuit is measured. The latter is a fundamental difference between the previously described tests and the dynamic test. A coupling circuit in the tube output connects the copper-oxide meter (which is usually employed) to the tube. In one instrument (Hickok), a tube rectifier rather than a copper-oxide meter is employed. A special circuit is employed which enables calibration of the indicating meter in terms of the mutual conductance in micromhos. In an instrument of another make (RCA), not yet available for the commercial market, a vacuum tube voltmeter replaces the copper-oxide type of meter as an indicating instrument. With this arrangement it is likewise possible to calibrate in terms of micromhos. Limitations of the copper-oxide meter method are that its relative insensitivity requires either a strong input signal to produce sufficient amplified current to produce a readable deflection with low mutual conductance tubes, or a high impedance plate load—or both. With the vacuum tube voltmeter, an amplifier circuit is interposed which increases greatly its sensitivity. In the Hickok circuit a bridge balancing arrangement increases its sensitivity.

Since a truly accurate reading of mutual conductance necessitates the use of a very weak signal at the grid (usually 1 volt or less), it is apparent that the more sensitive indicating methods are able to produce a more accurate indication of mutual conductance. However, this increase in accuracy is obtained only at increased cost and complexity.

Testing Power Amplifier Tubes

While, to a certain extent, a precise measurement of mutual conductance is the best single indication of the performance of voltage amplifier tubes, this is *not* true of power amplifier tube types. For the latter, a true dynamic test should indicate their power output when the input signal is of the magnitude to which it is designed to be subjected and its output load is of the specified value. A fundamental circuit for this type of measurement is shown in *Fig. 8.* Here the applied a-c signal is adjusted so as to produce a specified voltage at the grid normally sufficient to produce rated power output in the plate load for a normal tube. The tube is considered satisfactory if the alternating voltage across *R*, resulting from the amplified input voltage, reaches a value indicative of rated power dissipation in the load. Thus, if the tube were rated to produce 5 watts output into a 10,000-ohm load, the voltage *E* across *R*, may be determined from the formula

$$E = W\sqrt{R} = 5\sqrt{10{,}000} = 500 \text{ volts.}$$

Other values of output voltage for different loads and wattage ratings may be similarly calculated.

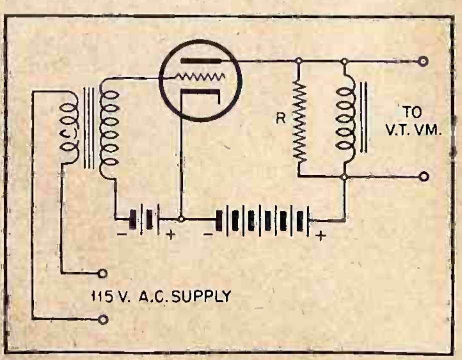


Fig. 8. This sort of setup illustrates the fundamental circuit employed in power output test.

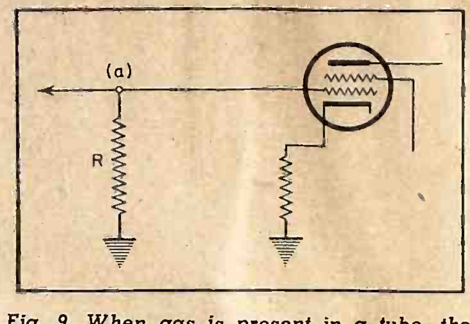


Fig. 9. When gas is present in a tube, the resulting grid current causes a positive voltage drop across R.

The choke in parallel with *R* in *Fig. 8* is used to provide a low resistance path for the d-c plate current. The impedance of the choke *must* be very high in comparison with *R* at the frequency used, otherwise the effective plate load will be lowered and the voltage across *R* for a given power output will be less than calculated.

Some tube checkers provide an indication which is proportional both to the power output and the mutual conductance of the tube. This is accomplished by varying the plate load, or, more simply, by using a relatively high value of plate load in place of the low value required for a true mutual conductance test. While the indicating meters for such instruments cannot be calibrated in micromhos, they do serve to provide a reasonably reliable indication of tube performance.

Unusual Test Methods

So far we have considered fundamental characteristics of tubes and fundamental test methods. There are a great many applications of tubes in which tube troubles which are not indicated by any of the tests so far described seriously interfere with the performance of the tube and its circuit. In power tubes, especially, the presence of a large amount of metal within the tube envelope makes for the production of spurious effects, such as gas, which affects tube performance and life. In *Fig. 9*, which shows a typical power tube input circuit, the effect of gas is to cause a current to flow in such direction in the grid circuit that point (*a*) becomes positive with respect to ground. As a result the normal grid bias on the tube is reduced, the plate current is increased and the overload point is lowered to a degree where a very small input signal causes distortion. In service, it sometimes requires a period of several minutes before the gas current reaches a maximum so that initial performance of a gassy tube may be satisfactory, only to become "fuzzy" after a few minutes' operation. Such conditions are readily checked in receivers by measuring the voltage (with an electronic voltmeter) between point (*a*) and ground. If no current is flowing—which is the normal condition—the reading will of course be *zero*. But any gas current will produce a voltage such that point (*a*) will become positive with respect to ground. In smaller receivers, the resulting decrease in grid bias and increase in plate current frequently overloads the power supply to an extent where the output voltage is greatly reduced. In a-c/d-c sets, for instance, the output voltage may drop to 70 or thereabouts.

The action of gas in bucking the grid bias is utilized in the test for gas incorporated in some tube checkers. It should be stated that only tube checkers of the highest grade are equipped to make this test properly, since a rectified, and preferably filtered, power supply is ordinarily required to make certain that rectification of any alternating current remaining in the power supply circuit does not itself produce a grid current reading.

Grid Current Measurements

A typical circuit for checking grid current is shown in *Fig. 10.* As shown, a switch and resistor *R* are incorporated in the grid circuit, with provision for cutting the resistor in or out of the circuit. To make the test, the switch is placed first on point (*a*) and the plate current reading is noted. Then the switch is moved to point

(Continued on page 22)

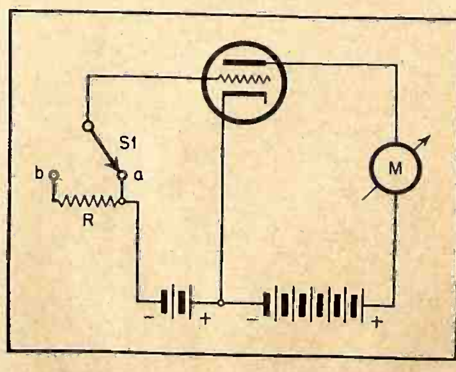


Fig. 10. This shows the fundamental circuit employed in most tube checkers for measuring gas current.

FUSES

(Continued from page 16)

minutes on 200% of rating. Formerly fuses were required to blow within 1 minute on 150% of rating. The above applies to fuses of less than 30 amperes.

Aircraft fuses are rated to National Electric Code specifications to carry 10% overload indefinitely and to blow on 50% overload as follows: rating up to 30 amperes, 1 minute, 31 to 60 amperes, 2 minutes, 61 to 100 amperes, 4 minutes, 101 to 200 amperes, 6 minutes, 201 to 400 amperes, 12 minutes.

High voltage fuses are used for the protection of transmitting equipment, X-ray apparatus, high voltage rectifiers, and like equipment. The Littelfuse line is designed for the protection of circuits up to 20 KW on D.C., and 30 KVA on A.C. These fuses are rated to blow at 50% above their indicated current rating. This margin has been found necessary on account of capacitative and inductive surges, usually present in high voltage circuits. This feature should be considered however, when it is desirable to protect meters, (such as thermo-couple type) in the line. The best types of high voltage fuses are extremely quick-acting under short circuit conditions.

Fuses for delicate equipment such as galvanometers, microammeters, radio tubes, testers, radio rectifier tubes, etc., are rated at their approximate blowing point. Since the ultimate blowing point varies with the rate at which the current is increased, a 10 second interval to the rated current is used. The rating on these fuses for delicate instruments must not be confused with that of higher capacity fuses. The time lag which might be quite an advantage in an identical 10 ampere fuse would usually be disastrous in instrument protection.

Part 2—the conclusion of this article—will appear in the next issue.

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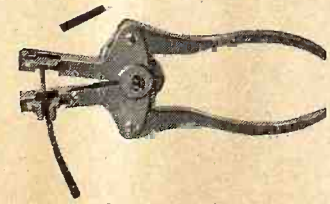
INDUSTRIAL ELECTRONICS

(Continued from page 6)

them to survive so they can compete with you. Jobbers should not establish retail service departments but they can and should establish wholesale service departments that can and should be of advantage to their customers, the service-dealers. The scarcity of help, the increased volume of civilian servicing has placed a burden upon service-dealers that jobbers can logically help to relieve.

(To be continued next month)

Wire Stripper Saves Time—General Cement Mfg. Co., of Rockford, Illinois announces an amazing new Wire Stripping Tool that saves time, money and trouble for Electricians, Radiomen, etc. This new handy unit instantly strips insulation from all types of wire eas-



ily and perfectly. Just press the handles and the job is done. It can also be used as a wire cutter. Saves many hours of time when making splices, repair jobs, etc. For information write General Cement Manufacturing Co., Rockford, Illinois.

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Adapter Harnesses Available—J. F. D. Mfg. Co., 4111 Ft. Hamilton Ave., Brooklyn, N. Y., announces a complete line of battery adapter harnesses. These factory made units save time for servicemen who must install substitute batteries for types no longer available. Models for all types of sets, and for all battery connections are available.

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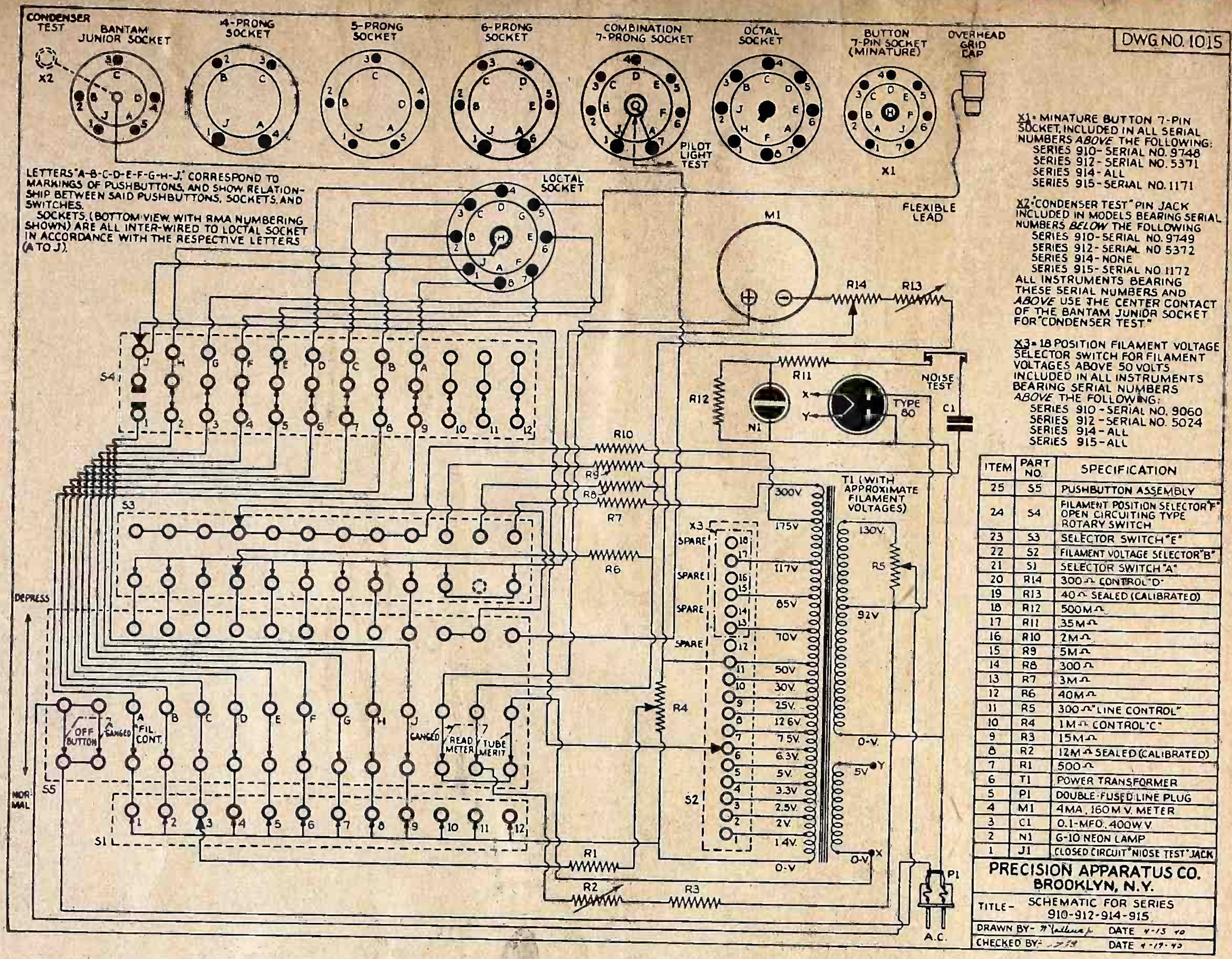

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24	S4	FILAMENT POSITION SELECTOR "F" OPEN CIRCUITING TYPE ROTARY SWITCH
23	S3	SELECTOR SWITCH "E"
22	S2	FILAMENT VOLTAGE SELECTOR "B"
21	S1	SELECTOR SWITCH "A"
20	R14	300 Ω CONTROL "D"
19	R13	40 Ω SEALED (CALIBRATED)
18	R12	500 MΩ
17	R11	.35 MΩ
16	R10	2 MΩ
15	R9	5 MΩ
14	R8	300 Ω
13	R7	3 MΩ
12	R6	40 MΩ
11	R5	300 Ω "LINE CONTROL"
10	R4	1 MΩ CONTROL "C"
9	R3	15 MΩ
8	R2	12 MΩ SEALED (CALIBRATED)
7	R1	500 Ω
6	T1	POWER TRANSFORMER
5	P1	DOUBLE-FUSED LINE PLUG
4	M1	4 MA, 160 MV. METER
3	C1	0.1-MFD. 400 W.V.
2	N1	G-10 NEON LAMP
1	J1	CLOSED CIRCUIT "NIOSE TEST" JACK

Fig. 11. A Modern tube checker circuit.

(*b*). If grid current is present, the bias on the tube will be reduced and the plate current will be increased. The amount of increase will depend upon the value of *R* used and the mutual conductance of the tube under test. For example, if *R* is one megohm, a grid current of one microampere will produce a voltage drop of 1 volt. If the mutual conductance of the tube is 1000, the one-volt change in grid voltage will produce a one-milliampere change in plate current. Other values can be calculated accordingly.

Some discretion should be utilized in applying the gas test. In all tubes, some gas is present. Usually, for tubes of the voltage amplifier type, such as the 6K7, 6J7, etc., the gas current should not exceed 1 or 2 microamperes. For power tubes, the limits are normally somewhat higher; for example, 2-5 microamperes. Tubes in which a higher gas current is indicated should be discarded.

There are quite a number of other tests which might be applied to tubes to advantage; in fact, they are used to some extent in factories. For example, it is necessary to make a special test for oscillation if one is to be certain that a tube will perform satisfactorily in certain converter circuits. In other applications, such as frequency multipliers, again the ordinary tests don't work out too well. But the complications involved in preparing special setups to take care of such contingencies are ordinarily not warranted by the amount of value which will be derived from them, so they are accordingly omitted from this discussion.

One question which always comes up in a discussion of tube checking for which there is no satisfactory answer is—*when should a tube be replaced?* We refer, of course, to those cases where the tube still functions but does not test as well as another tube. Much depends upon the type of test and the circuit in which the tube operates. For example, a pentode such as the 6K7 amplifies in proportion to its mutual conductance in most circuits where it is ordinarily employed. Thus a mutual conductance test should indicate the relative performance capabilities of such a type of tube. But even new tubes vary greatly in mutual conductance—perhaps as much as 20 percent above or below their nominal rating. So there may be as much as 40 percent difference in the gain secured from perfectly normal tubes. Therefore, because one tube gives a better reading on the tube checker than another is not sufficient justification to discard the tube giving the lower reading. Tube checkers which have meters bearing the designations "GOOD", and "REPLACE" are so calibrated that the "REPLACE" section starts at a point corresponding to about a 35 percent drop in mutual conductance below the nominal value given in tube handbooks. Some tube checkers place their reject point a trifle higher (at around a 25 percent drop), but since most inexpensive instruments are relatively inaccurate anyhow, this figure may be equal to a 35 percent drop in individual instruments. Substantialy the same limits are employed for emission-type tube checkers, though the results are not nearly so reliable.

In general, more attention should be devoted to tests for gas and leakages, particularly at the present time, when shortages of vital components in tube manufacturing tend to make it difficult to keep the gas content at a low level. More attention to such a test will reduce the number of occasions which we all encounter, where tubes which test okay in the checker cause trouble in the receiver.

New Improved Staple Driver is announced by the Walter L. Schott Company, Los Angeles, Cal. The new model 500A staple driver is now made with hardened steel inserts which prevent all possibility of jamming and clogging its automatic staple magazine.

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Stromberg-Carlson Service Minded—a series of Wartime Radio Service Bulletins is being mailed to servicemen who are registered with the factory at 100 Carlson Rd., Rochester, N. Y. The literature is intended to help servicers render speedier and better service on receivers produced by that company. Address your request to Stanley Manson, service manager.

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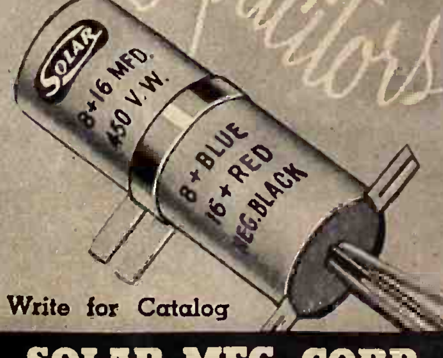

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TUBE SUBSTITUTIONS

(Continued from page 10)

a set using it, best thing we can think of to do is to change over to the 6V6. To do the job right you'll have to change the output transformer, though many of the tin-eared gentry wouldn't be able to tell the difference, and readjust the voltages to meet the requirements for the 6V6, as listed in any current handbook.

As for the 6A4 (which is interchangeable with type LA), neither of which is often encountered hereabouts, the 6K6GT will serve as replacement provided the socket is replaced with an octal type. And, of course, any of the substitutes mentioned previously as being similar to the 6K6GT may likewise be substituted for the 6A4.

The 89 is a tough one to work on, as was intimated in our first article in this series. Best way out is to change the socket for an octal type, reduce the grid bias resistor value to 275 ohms, put in a 6V6GT and listen to the improvement. Lots of trouble, but the sensitivity of the set will be doubled, and the power output will be increased about 50 percent. It pays to put in a little extra effort when you can see real advantages forthcoming.

The 7C5 and the 7C5LT are interchangeable, and, if you don't mind changing the socket to an octal instead of the loctal required, you'll find the 6V6GT an ideal replacement, since it is electrically identical to the 7C5. This, again, works the other way around, too. And there is a possibility that loctals may be easier to get than octals in the near future. So don't worry if you have an apparent excess of 7C5s, or of 6VGT's. There'll always be a place for them.

Which about winds up the pentodes, as well as the beam power type. One reader has asked about the 6AC7—what can be done when these become unobtainable? Which means, in effect, now. Unfortunately, there is no equivalent for this tube, and any attempt to take liberties with circuits in which it is employed is very likely to result in difficulties. But, if it's a question of taking a chance or letting the customer down completely, because of inability to get 6AC7's, then, by all means, go to it. Our recommendations must necessarily be considered as merely suggestions which look good on paper; we've checked the characteristics and know of cases where substitutions have been successfully made, but only in apparatus which the average serviceman is unlikely to encounter. And we think the best bet is the 6AG7, which is none too easy to get, either. Its plate current is higher, pin connections are different, but it fits the same socket. You'll have to juggle the voltages to get it functioning properly and,—*and this is vitally important* — by all means keep your leads short. This tube will go into oscillation on the slightest provocation. Alternatively, there's the type 1231, which requires a loctal socket and has slightly lower mutual conductance than the 6AC7. But it may be somewhat easier to handle than the 6AG7. Just make certain that its cathode bias is as recommended in your tube handbook and, again, that each lead is as short as possible.

Pentagrid Converters

Which brings us to pentagrid converters. The 6A7, as you know, has characteristics similar to the 6A8 and its glass counterparts, so by simply changing to an octal socket, any of the latter types may be substituted for the former. And vice versa. As for the 6SA7, don't be misled by its similarity in designation to the 6A7. These tubes have nothing in common and cannot be substituted one for the other under any circumstances. The 6SA7 requires a special form of oscillator circuit for best results, usually a Hartly type, which is not at all suitable for the 6A7. There is also a difference in the arrangement of the grids in these two types of tubes—which, in fact, necessitates the variation in circuits.

The 6D8G closely resembles the 6A8G and these two tubes are interchangeable with no requirements other than realigning to compensate for differences in inter-electrode capacitances. But there is a difference also in heater current, the 6D8GM requiring but 0.15 amperes as against the 0.3 amperes required for the 6A8G. The conversion transconductance of these two types is substantially the same, so it is apparent that the 6D8G is a pretty desirable and efficient substitute for any of the pentagrid converters of its general type.

The 7B8 and the 7B8LM are, of course, identical and their characteristics are similar to those of the 6A8. So, the matter of making substitutions of these types involves only the changing of sockets and socket connections to meet the requirements of the specific tube selected.

Triode-Hexode-Octode Series

Insofar as the triode-hexodes, octodes and the like, it is best not to attempt substitutions. The design of the oscillator circuits is so critical that substitutions of other converters having differing characteristics is likely to result in complete failure. As a last resort, it is suggested that a separate oscillator triode be employed, such as the 6J5G, installed in the converter socket, and a standard converter operated as a mixer (6A7, 6A8 or equivalent) be used. Alternatively, the 6L7 may be employed for this purpose. But this brings in wiring problems and should by all means be avoided if working on an FM set, or any other type which utilizes a high intermediate frequency excessive lead length in such circuits.

We'll wind up this session with electron-ray tubes. Not much to discuss here, since only the 6U5/6G5 and the 6AB5/6N5 are interchangeable, and these two to a limited extent only. The 6U5 is designed to operate at voltages up to 250, while the 6AB5 should not be used at any voltages over 180, and these are supply voltages—not element voltages. Furthermore, the heater current of the 6N5 is only 0.15 amps. as against 0.3 amps. for the 6U5. But, within the limitations given, these types are interchangeable.

The chart, as now presented, gives the picture in regard to replacements as it exists today. We plan to add to it and to make changes as the rapidly varying conditions now require.

The author plans to cover other tube substitution examples so that every radio service-dealer will be able to "carry on". The time element is important. Why not write. Tell us what tube types or receivers are giving you most difficulty. Ask any questions that you wish. Be sure to make your questions brief and yet clear. Give details as to the receiver model number, and watch this column!

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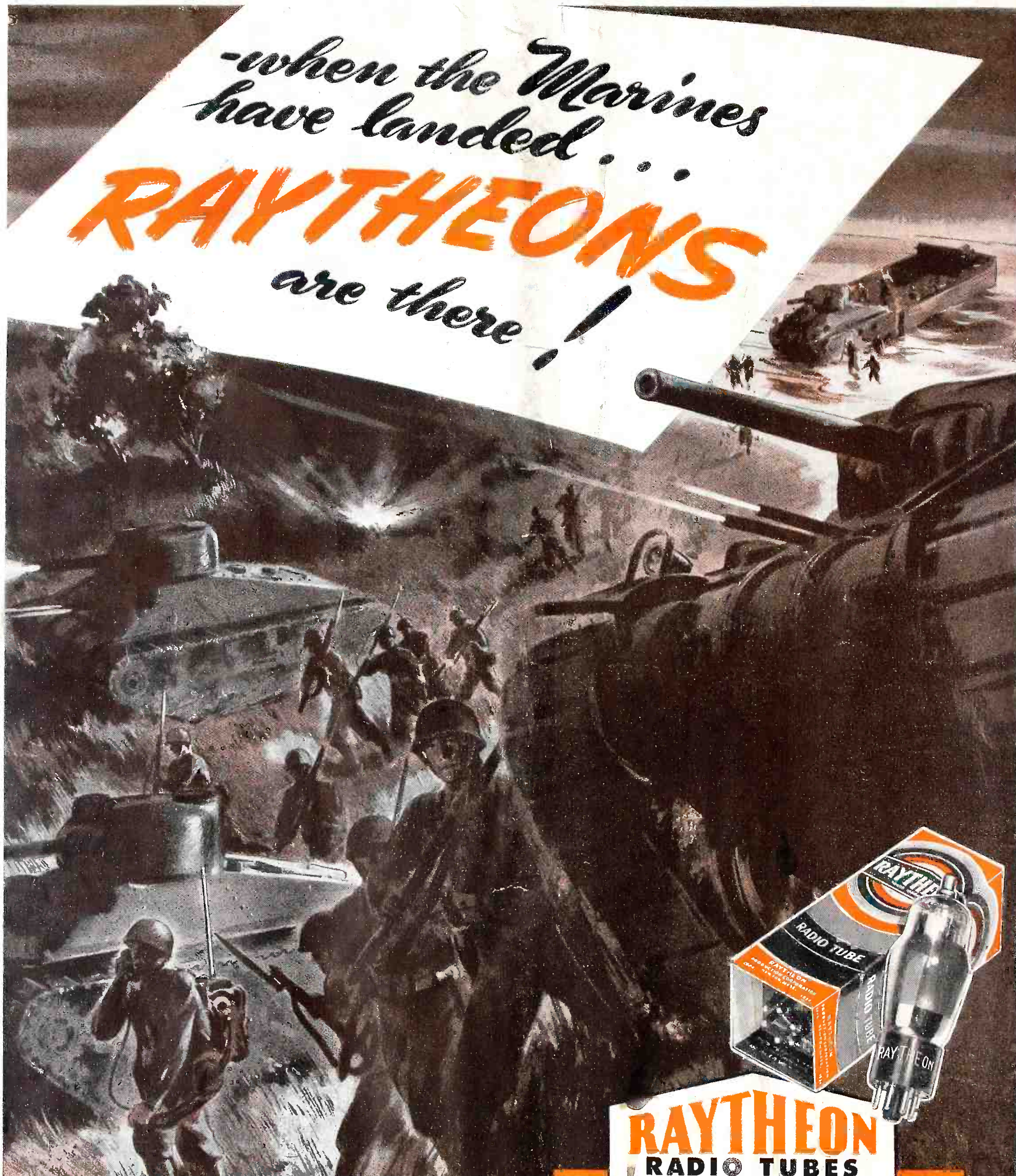

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