AMRAD

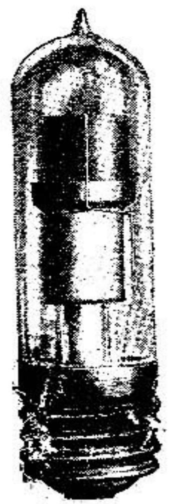
Bulletin J-3 | (Including Operating Instructions) | November 1, 1924

"S" Tube Rectifier

(Improved Type)

Uses:

- Changes alternating current to direct current
- Furnishes plate supply for power tubes
- Replaces "B" Batteries
- Charges storage "B" Batteries



"S" Tube, 4000-1
Price, $10.00

For operating time clocks, time stamps, telegraph relays and sounders, signal systems, or wherever D.C. is desired from 1 to several thousand volts at currents below 1 amp.

Specifications: Type 4000-1:

Rated to carry 100 Mil. Amps. at 1000 volts D.C. per Tube

No filament to burn out

Life — 3000 hours or more

Starting voltage — 300 volts A.C. (Instantaneous)

Normal voltage drop per tube — 125 volts, 1250 ohms resistance

Normal reverse current — 3 to 6 Mil. Amps.

Frequency — all commercial

Weight — 6 oz.

Diameter — 1½ inches

Length — about 6½ inches

Base — 1½-inch Mogul, 600-volt type

The AMRAD "S" Tube is a two-element gaseous discharge Rectifier designed for changing alternating current to direct current over wide ranges. Its uses are listed above. It consists of a tubular glass bulb within which is sealed a glass stem mounted on a substantial base. The stem supports an insulating thimble which carries the anode pin and cathode cup. The bulb is filled with a rare gas at low pressure.

A Remarkable Development

Announcement of the first "S" Tube over three years ago startled the scientific world, rectification being obtained by radically new principles of gaseous conduction. Continued research and engineering since the production of the first model has resulted in the improved present type, No. 4000-1, illustrated above. Handling is facilitated by the tubular shape, and increased dielectric strength is assured by the 1½-inch Mogul Base now provided.

THE RECTIFIER TUBE WITHOUT A FILAMENT

Exclusive Advantages

As the "S" Tube has no filament to burn out, the many inherent advantages of this Rectifier over other types are at once apparent. For instance, in its length of life, there is no comparison. The "S" Tube, properly handled, lasts *indefinitely*. Unlike thermionic tubes, there is no saturation point and only when the load is increased over normal rating and the glass is unable to dissipate the heat, does breakage occur.

Some distinctive advantages of the "S" Tube are listed below:

(1) No filament to burn out.

(2) Requires no external heating supply, no rheostats or switches. Operates at maximum efficiency without bothersome adjustments.

(3) No mechanical parts to wear out or chemicals to spill or corrode.

(4) Absolutely no deterioration while not in use.

(5) Noiseless in operation. Emits no light. No extreme heat.

(6) Requires no attention while in service.

(7) Starts and stops automatically and instantly without lag.

(8) Gives practically perfect sine wave rectification which means ease in filtering and pure D.C.

(9) Long life since there are no fragile parts to burn out.

(10) Low internal resistance which means high efficiency.

(11) Compact and portable.

(12) Rectifies over all commercial frequencies and, in special cases, at radio frequencies.

(13) Extremely cheap for power delivered, actual cost being 10c. per watt. (100 watts output for $10.00.)

Since the "S" Tube will not conduct on less than 300 volts A.C., it cannot be run directly from 110 volts A.C., but must have the voltage stepped up to at least 300 volts A.C. (usually by a transformer) before it will work. It frequently happens that the "S" Tube is called upon to deliver D.C. voltages far below 300, such as in filament lighting, "B" Battery supply, relays, etc. This may be easily accomplished either by means of a potentiometer (as shown in Fig. 5), or by a transformer with very high leakage.

OPERATION

In order to obtain satisfactory results from any kind of scientific apparatus, it is important that the operator be familiar with the basic principles of the device, its characteristics and limitations. For this reason the data and directions given herein must be carefully noted. Circuits covering usual uses for the device are given. In special instances not covered, please write the factory. We shall be glad to coöperate.

Characteristics: We show by four charts the rectified voltage obtained by using "S" Tubes for a given A.C. input. These cover the "S" Tubes in all common circuit combinations over normal range of operating voltages. A.C. voltage applied is plotted in each chart against delivered D.C. voltage, both at "no load" and at "full load," with and without a smoothing condenser of several microfarads. "Full load," of course, is understood to be 100 milliamperes per tube.

Chart A shows the standard circuit using a center-tapped transformer (such as the Acme 250- or 500-watt plate type), with two "S" Tubes each rectifying one half of the wave. The "S" Tube is so designed that the small disc, or center contact, of the base is connected to the anode, while the screw-cut section, or ferrule, is connected to the cathode. This means that current will enter by way of the center contact, and leave by way of the ferrule, but will not flow in the opposite direction; hence the rectifying action. This connection makes the ferrule contact of the tube the positive lead, as will be noticed in the charts where the circle represents the ferrule. It is customary to connect the outside taps of the transformer to the center contact of the sockets. The ferrule contacts are then connected together and form the positive terminal of the D.C. current supply. The negative terminal is then the center tap of the transformer.

This circuit will deliver up to 1,000 volts D.C. at 200 milliamperes when properly filtered, and is sufficient to operate one 50-watt transmitting tube.

Chart B shows the characteristics for double normal voltage by connecting two "S" Tubes in series. In this connection the outside ferrule contact of the first series tube must be connected to the center contact of the second tube, as shown in the diagram. This circuit will deliver 200 milliamperes at 2,000 volts D.C. and

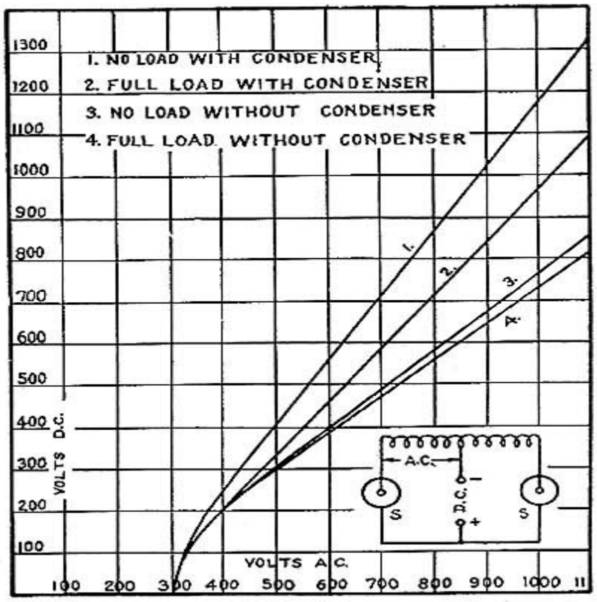


Chart A. — A.C.-D.C. characteristics of two "S" Tubes and Center Tap Transformer.

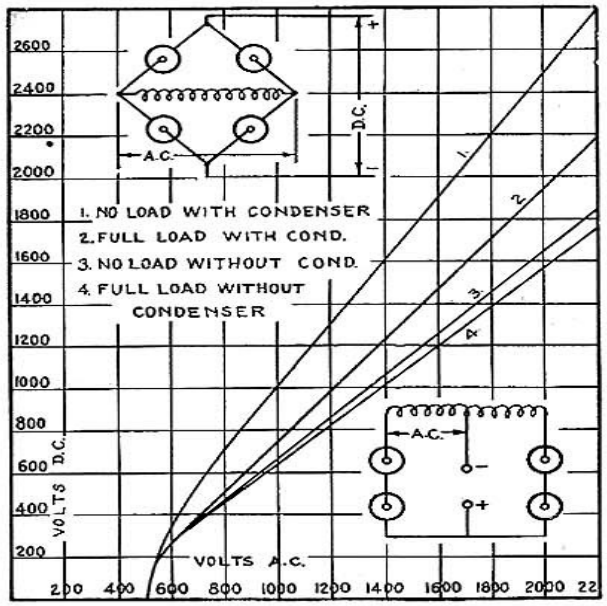


Chart B. — A.C.-D.C. characteristics of four "S" Tubes in series and bridge circuits.

is recommended where higher voltages than shown in Chart A are required. The bridge connection shown on this chart is essentially two tubes in series and also has the same characteristics, but it employs a single winding transformer, i.e., no center tap. This transformer should deliver 2,000 volts A.C. between its two terminals for maximum D.C. voltage, but the bridge circuit will work satisfactorily on lower voltages as well. As the ordinary 1,000-volt C.W. transformer with center tap delivers 2,000 volts between its outside leads, it may be advantageously used with the bridge circuit for high voltage work.

Chart C shows the method of connecting tubes in parallel, to deliver current in excess of 200 milliamperes. When "S" Tubes are connected in parallel, it is necessary to use balancing resistances in order to insure that the load is equally divided among the tubes. If the internal resistance of one tube is only slightly different from its companion, the one with the lower resistance or voltage drop will carry an excessive proportion of the load. The balancing resistances, "R", should have a minimum value of 500 ohms each, for which a Ward-Leonard enameled resistance unit, catalog No. E-B-500, is recommended. This resistance unit can be mounted in a standard porcelain lamp socket. If one of the paralleled "S" Tubes attempts to take more than its share of the load, the voltage drop across its resistance increases, thus decreasing the voltage across the tube, and so balancing the current.

The circuit shown in Chart C will deliver 400 milliamperes at 1,000 volts. The regulation (i.e., the change of voltage due to change of load) of the circuit is higher than that of the customary circuit shown in Chart A, due to the addition of the resistances. This circuit is recommended for operating two 50-watt transmitting tubes.

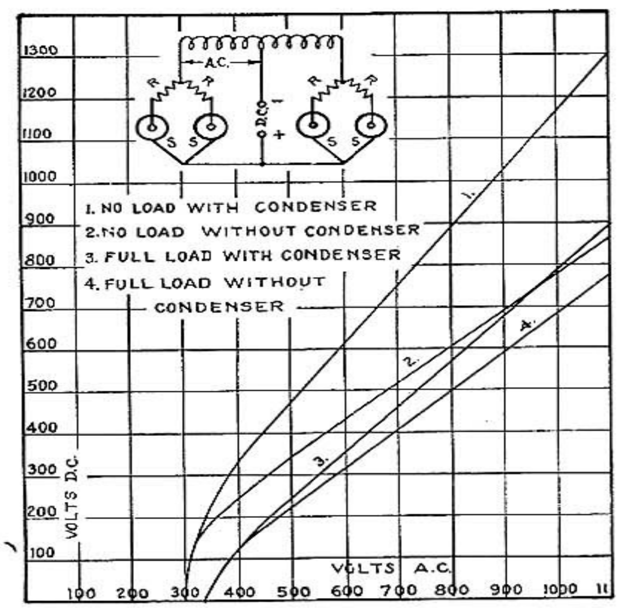


Chart C. — A.C.-D.C. characteristics of four "S" Tubes in parallel circuit with Center Tap Transformer.

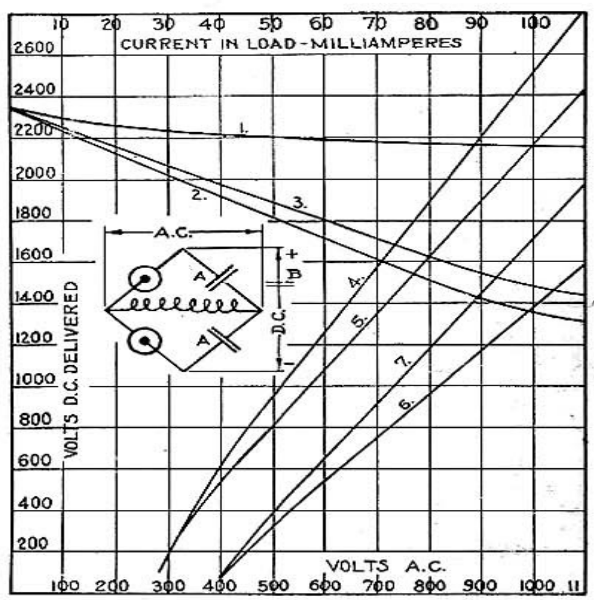


Chart D. — A.C.-D.C. characteristics of two "S" Tubes in voltage doubling circuit. (Curves shown are described in text.)

Chart D shows the characteristics for a "voltage-doubling" circuit in which two "S" Tubes are used to charge two condensers so connected that they charge singly and discharge in series. This circuit delivers 100 milliamperes at 2,000 volts D.C., using two "S" Tubes. With infinitely large condensers, the resultant delivered voltage would be twice peak voltage of the A.C. supply, neglecting the drop in the tubes. This circuit is useful for operating a 50-watt transmitting tube from a relatively low voltage transformer, or where a double half-wave rectification is desired when only two "S" Tubes are available with a single winding transformer. The regulation is high unless very large capacities are used in the bridge circuit.

Since the condensers in the bridge are subjected to a reverse potential, AMRAD Mershon Condensers cannot be used. As the condensers charge singly and discharge in series, full load current is the same as if the tubes were connected in series, and limited to 100 milliamperes. The regulation for condensers of 4 mfd. capacity in the bridge circuit is shown by Curve No. 1, and for a condenser of 1 mfd. capacity by Curve No. 2. Curve No. 3 shows the regulation when adding ½ mfd. capacity across the delivered D.C. Adding ½ mfd. across the D.C. when using 4 mfd. condensers in the bridge circuit does not materially affect the regulation. It does, however, assist in smoothing the D.C. Curves Nos. 1, 2, and 3, are made from a constant A.C. supply of 950 volts. Curves Nos. 4, 5, 6 and 7 show the voltage characteristics. Curve No. 4 is without load. Curves Nos. 5, 6 and 7 are with full load of 100 milliamperes.

The above data give the operator a good idea of the various circuits ordinarily used with the AMRAD "S" Tube, as well as an idea of the power available with various combinations. It should be noted that many other combinations are also possible, such as placing more than two tubes in series, or parallel, etc., for still higher outputs.

Warning

The "S" Tube differs materially from the thermionic rectifier in its low regulation. The current in a thermionic rectifier is limited by the electron emission from the hot filament and it cannot be overloaded without burning the filament at excessive brilliancy. In the "S" Tube the low regulation allows the tube to pass any current pre-determined only by the voltage, the resistance of the tube, and the load resistance. An increase in voltage or a decrease in load resistance can immediately overload the Tube. In other words, the "S" Tube will deliver more and more rectified current as the load circuit resistance is decreased, until such an overload is reached that the tube will break down due to excessive heat which the glass cannot dissipate. In fact, the "S" Tube would deliver several amperes D.C. upon short circuit, but, of course, be ruined in the process. Hence, care must be exercised in operating. "S" Tubes are rated at 100 milliamperes per tube, but will withstand *temporary* overloads of 50%, especially on *intermittent* service such as telegraph transmission, etc. Life of the tube depends upon the current passed through it. An increase in load shortens the life proportionately. Properly used, the "S" Tube will operate longer than any other type of tube rectifier, and is so guaranteed.

Where the "S" Tube is called upon to deliver more than 550 volts per tube, it is *absolutely necessary* to allow the tube to "warm up" on low power for *at least one minute* before applying full potential. After the tube has attained normal operating temperature, it will remain at full efficiency for ½ hour after shutting down, and it will not be necessary to repeat the above warming-up upon re-starting unless the tube has been idle for a longer period. The best method of warming-up the tubes is to insert a resistance of from 8 to 10 ohms in the primary circuit of the transformer, and start the tubes with the load circuit closed. At the end of a minute this resistance may be short-circuited, and tubes put on full load.

THE FILTER SYSTEM

Owing to the fact that rectified A.C is really pulsating D.C. and looks like the sharp teeth of a saw (see Fig. 2), it is easily understood that to be really useful, this irregularity must be smoothed out. A filter system performs this important function. Rectified A.C., properly filtered, cannot be told from direct current furnished by a battery. A filter system acts very much like an air reservoir in a compressed air line only instead of an air chamber, high capacity condensers and inductances are used. The capacity and inductance act as the source or reservoir from which energy is supplied during the momentary cessation of flow in a pulsating direct current. Either inductance or capacity

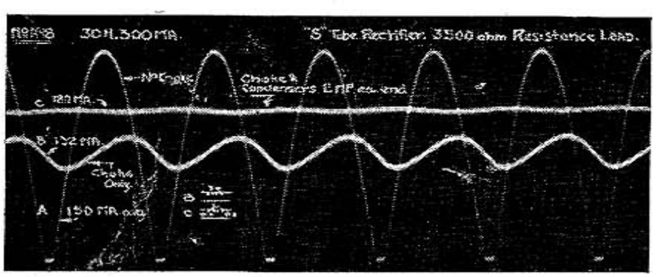


Fig. 2. — Oscillogram showing smoothing effect of typical filter used with "S" Tubes. Prepared by Prof. F. S. Dellenbaugh, of the Research Division, Electrical Engineering Dept., Massachusetts Institute of Technology.

alone will give considerable smoothing if the values are large enough. Ordinarily best results are obtained when capacity and inductance are used in combination as shown in the diagram of a typical transmitting circuit (Fig. 4).

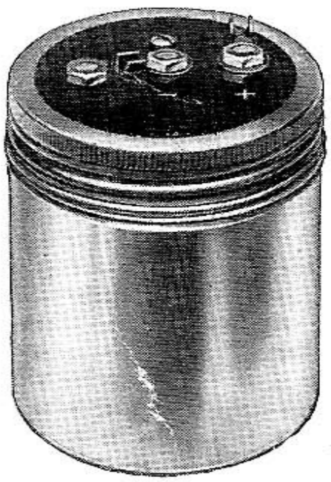
Inductance alone tends to decrease the delivered D.C. voltage while capacity increases it. In combination, inductance connected in front of the capacity decreases the voltage while if capacity is connected in front of the inductance, voltage is increased. A filter system consisting of 2 mfds. only, will give a maximum variation in the D.C. supply of approximately 60%, at 150 ma.; 8 mfds., 35%; 25 mfds., 10%; 4 mfds. of capacity and 20 Henries of inductance, 6%; 8 mfds. and 20 H., 4%; 8 mfds. and 30 H., 2%; 8 mfds. and 60 H., 0.5%; 15 mfds. and 3 H., 2%; 25 mfds. and 3 H., 1%; 25 mfds. and 30 H., perfect.

In C.W. transmitters, the variation of the ripple should not exceed 5%, or for telephone transmitters 1%. A very satisfactory filter system for C.W. operation can be made by employing one 30 Henry Choke (such as the Acme type) with 2 mfds. of capacity across each end. This filter was the one shown in the oscillogram (Fig. 2). At 200 milliamperes this filter will give a variation in D.C. of less than 5% which makes it perfectly satisfactory for C.W. work. For phone work at the same current, 30 Henries with 6 mfds. across each end should give a D.C. supply not over 1% in variation.

Amrad-Mershon Condenser

Uses:

For all types of filter work at moderate D.C. potentials where purity of tone is essential.



It is especially recommended for filtering rectified "B" and "A" Battery supply, as a current reservoir in operating relays, time stamps and time clocks, and whereever a very high capacity in a small space is required.

Fig. 3. — Electrolytic Condenser
Price $8.00

Specifications:

Capacity — 25-30 mfds. at 300 volts D.C.

Size — 5 ins. high by $3\frac{1}{8}$ ins. diameter

Rating — up to 300 volts D.C.

Leakage — about 3 ma. at 300 volts D.C.

SELF-HEALING. Due to its oxide film, accidental over-voltages will not permanently injure this device.

The AMRAD Mershon Condenser is of the electrolytic type and the dielectric is an oxide film formed electrically on a thin sheet of aluminum called the "anode." This aluminum sheet is one element of the Condenser, and the electrolyte in which it is immersed is the other.

This Condenser has two great advantages over mica or paper condensers.

(1) It is self-healing, for if the film be broken down by accidental over-voltage, reapplication of direct current will shortly restore it.

(2) The leakage current of the Condenser is proportional to the cube of the voltage applied. Therefore, this Condenser across a pulsating direct current will act as a bypass at the peak value of the current — thus providing not only the smoothing effect of the inherent capacity, but also a decrease in the peaks by reason of the bypassed current. When used on rectified current, the peak value of the A.C. supply (1.41 times the A.C. volts as read by a voltmeter) less the voltage drop in the rectifier, will determine the voltage to which the condenser is subjected. Although the Condenser is rated at 300 volts D.C., this does not mean that it can be used on 300-volts pulsating D.C., such as is ordinarily furnished by a rectifier, since pulsating D.C. may rise to peak values far in excess of what is indicated on a voltmeter. A Condenser smoothing the output of one or two "S" Tubes supplied with 300 volts A.C. will be operating at full voltage, considering a drop of 123 volts in the rectifier. Mershon Electrolytic Condensers may be connected in series to withstand higher voltages at lower capacity or in parallel for greater capacity.

Operation

The Electrolytic Condenser is a polarized device and absolutely must be connected properly, that is, with the binding post marked + connected to the positive D.C. source, etc. For this reason it can never be used on A.C. Operating an electrolytic condenser on the wrong polarity or on A.C. will very quickly ruin the film. Operating on too high voltage will cause sparking (which can usually be heard as a crackling or hissing noise), at the electrodes and overheating of the solution which will also injure the film. Heating is positive evidence that the condenser is subjected to over-voltage, in which case either reduce voltage or add more condensers in series. An injured film may frequently be restored by operating for several hours on low voltage (150–200) D.C. and then gradually raising voltage to normal.

With proper care AMRAD Mershon Condensers will last indefinitely. Losses by evaporation of the electrolyte should be replaced by the addition of pure distilled water keeping the solution at a height sufficient to cover the anode. For replacing lost electrolyte, use only the solution which we provide for that purpose.

OPERATING "S" TUBES IN TRANSMITTING CIRCUITS
A 10-WATT C.W., I.C.W. AND PHONE SET

The "S" Tube was first developed as a rectifier tube to produce pure D.C. plate supply in transmitting circuits. It is now so used by thousands of amateurs from coast to coast and in foreign countries. "S" Tubes in use eighteen months and more have been reported "better than when first installed." Operators have been particularly enthusiastic over the pure D.C. obtained. The unsolicited endorsements in our files are much appreciated by the Corporation. It is unquestionably true that the best advertising the "S" Tubes have yet received has come from the word-of-mouth testimonials of "S" Tube amateurs.

Providing the D.C. plate supply for a small C.W. Phone Set was formerly a very serious problem, as motor generators are costly and chemical rectifiers are unsatisfactory. Now the AMRAD "S" Tube solves the problem in a very efficient manner. Two "S" Tubes provide 200 watts of D.C., namely 1,000 volts at 200 ma. This is sufficient to operate four 5-watt tubes, or one 50-watt tube. Four "S" Tubes, two in parallel on each half of the transformer will operate eight 5-watt tubes or two 50-watt tubes.

Figure 4 shows how two "S" Tubes and a conventional C.W. Transformer may be applied to four "5-watt" tubes in the well-known Meissner circuit.

Operating Hints

General precautions to be observed in operating a set employing "S" Tubes are:

1. Check filament voltage before lighting filaments of power tubes. On initial transmission, light power tubes at least three minutes before applying plate voltage. Tubes are then heated and less liable to break down.
2. Screw "S" Tubes firmly in sockets to insure good contact.
3. When adjusting wave length, reduce plate voltage as low as possible, gradually increasing for efficiency.
4. Do not overload either electron or "S" Tubes by the use of excessive plate voltage. Remember efficiency of output depends on the effective height, resistance, effect of dielectrics in field of antenna, and counterpoise or ground. In other words, look over your radiating system before you decide to overload your set. Overloading also causes erratic operation on the short waves.
5. Do not attempt to tune the transmitter by "feeling up and down" the inductances with the plate current on. This interruption of the circuit may cause an excessively high potential surge, sufficiently strong to break down the "S" Tube insulation.
6. Watch the plate milliammeter closely. Adjustments can be made in tuning so that high output can be had with low plate current.
7. Even though a series plate supply is shown, it will pay to use a radio frequency choke of proper design. It is a good plan to insert ultra H.F. chokes in all grid leads, close to socket.
8. If available, use an antenna meter with lower range calibrated in tenths of an ampere.
9. Coupling. The coupling of the coils will vary with the wave length, and conditions existing at each station. As a suggestion, couple the grid and plate coils rather closely, and couple the antenna coil loosely to the plate inductance.

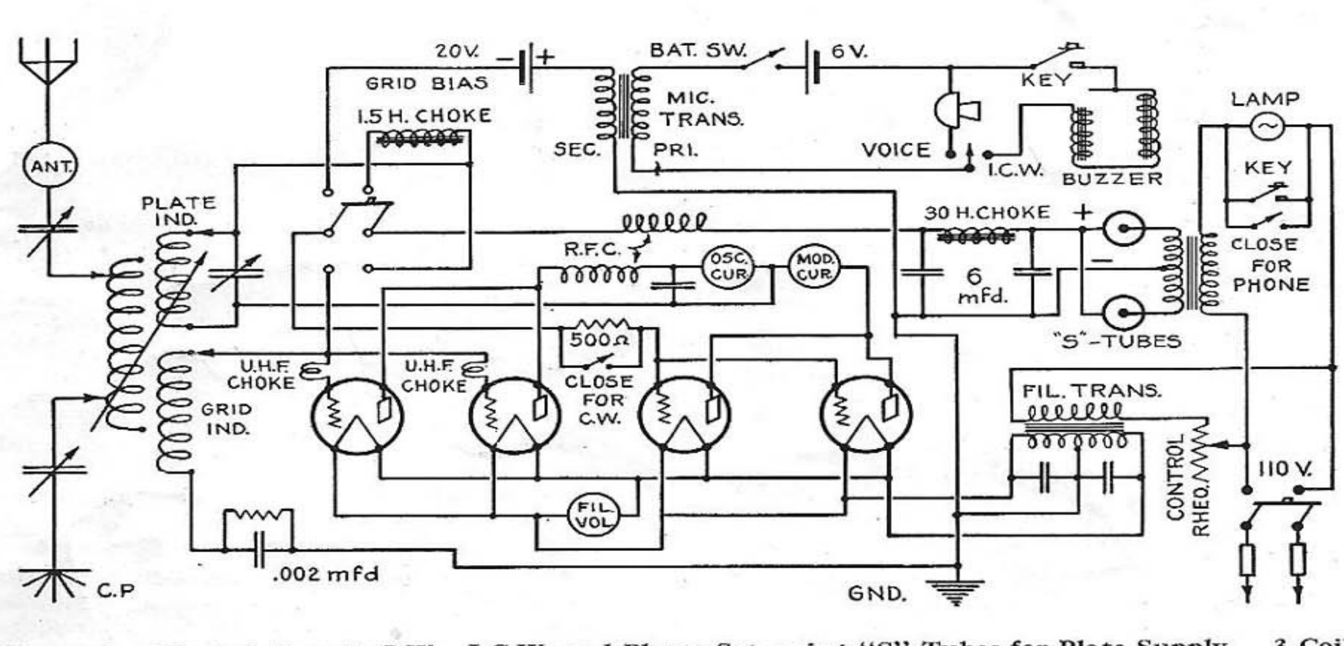


Figure 4. — Typical 10-watt C.W., I.C.W. and Phone Set, using "S" Tubes for Plate Supply. 3-Coil Meissner Circuit shown.

"S" TUBE TO REPLACE "B" BATTERIES

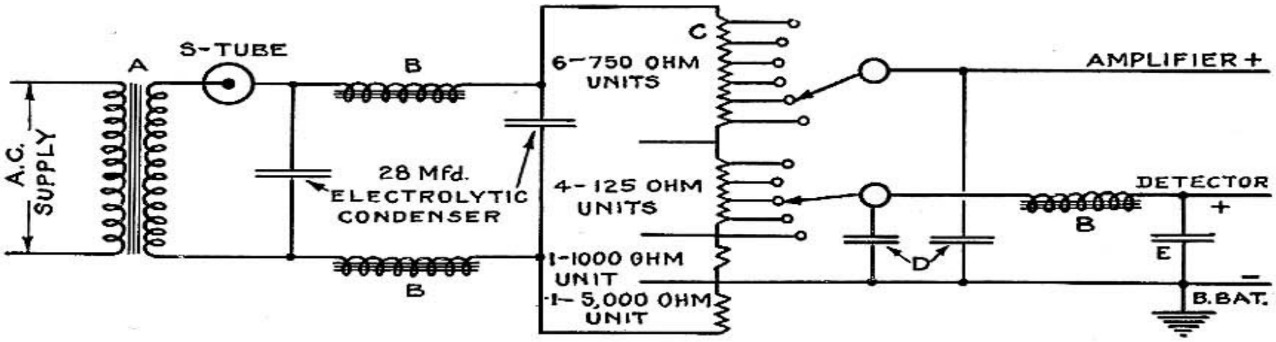


Figure 5. — Circuit using "S" Tubes and Electrolytic Condensers eliminating "B" Battery. In the diagram "A" is a 100 to 350-volt Transformer; "B" a 10 H. Choke Coil; "C" a 11,000 ohm Resistance Unit; "D" a .005-mfd. Bypass Condenser; "E" a 1-mfd. Paper Condenser. "S" Tube and Electrolytic Condensers are indicated.

There are two common sources of supply for the "B" Battery potential of radio receivers; dry cells and storage batteries. Both necessitate care and upkeep expense, not to mention the initial investment in a charger.

The potentials necessary for both the detector and amplifier voltage can be obtained from the house lighting 60-cycle 110-volt circuit by means of the "S" Tube and AMRAD Electrolytic Condensers. The delivered potential will approximate so closely the constant potential from a battery that the difference cannot be distinguished.

A practical unit eliminating the "B" Batteries is obtained by using the circuit shown in Figure 5.

Construction Data

Specifications are given below for the construction of a practical "B" Battery eliminator:

Transformer:

Core: Laminated ¾-in. square cross-section. Outside dimensions 3¾ x 3¼ in.

Insulation:

1/16-in. paper between primary and core.

1/16-in. paper between primary and secondary.

.002-in. paper between layers of both primary and secondary.

Winding: Primary: Wind 450 turns No. 22 S.C.E. layer wound on each 3¾-in. leg.

Secondary: 1,575 turns No. 30 S.C.E. layer wound on each leg over primary.

Choke Coils:

4,000 turns No. 36 S.C.E. wire, random wound on any audio frequency transformer core.

Resistance Units:

The resistance should be made from small resistance units of which the Ward Leonard types A and O, 2-in. units are preferable. For this purpose, 12 units are required, one of 5,000 ohms, one 1,000 ohms, four 125 ohms, and six 750 ohms. These should be connected in series as shown in the diagram. Taps taken from the end of the 1,000 ohms unit and each of the 125-ohm units provide for the detector voltage of from 15 to 23 volts in 2-volt steps. Taps from the end of each 750-ohm unit provide the amplifier voltage up to 100 volts in 15-volt steps.

Condensers:

Condensers "D" are .005-mfd. mica bypass condensers and "E" a 1-mfd. paper condenser.

CHARGING STORAGE "B" BATTERIES

Storage "B" Batteries used for the plate supply of receiving sets may readily be recharged from the 110-volt 60-cycle A.C. house lighting circuit by means of the "S" Tube and a simple transformer as shown in

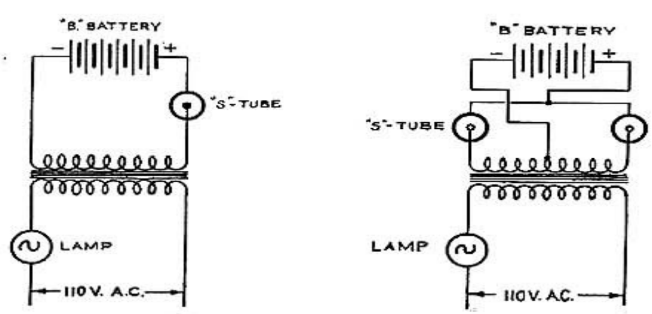


Fig. 6. — Circuits using "S" Tubes in charging Storage "B" Batteries.

Figure 6. The transformer should be capable of delivering from 400 to 1,000 volts A.C. with a current capacity of from .2 to .5 amps. An Acme 200-watt C.W. Transformer or similar plate transformer, is satisfactory. By placing a lamp or equivalent resistance in the primary circuit of the transformer as shown in the Figure, the charging current may be limited to the desired rate. With "B" Batteries of from 20 to 100 volts the charging rate is about as follows with a 200-watt Acme Transformer on the 550-volt tap.

Wattage of Lamps in Primary.	Charging Rate using 1 "S" Tube.	Charging Rate using 2 "S" Tubes.
100	Approx. .045 amps.	Approx. .080 amps.
150	Approx. .070 amps.	Approx. .130 amps.
200	Approx. .90 amps.	Approx. .170 amps.
250	Approx. .100 amps.	Approx. .200 amps.

With higher voltage "B" Batteries the charging current falls off slightly and it is necessary to use some-what higher wattage lamps in the primary circuit to make up the loss. It is, of course, suitable to use either carbon or tungsten lamps for primary resistance, and several small lamps may be connected in parallel to make up the required wattage.

Owing to the limited current output of the "S" Tube it is not recommended for charging heavy current "A" Batteries.

Where the "A" Battery is used for light intermittent work, however, such as signal systems, fire alarms, one-tube receivers, etc., it is entirely practical to employ the "S" Tubes to furnish a "trickle" charge or continuous low current charge of .25 amps. The same circuit as is used in "B" Battery charging is suitable for this work, and two "S" Tubes will furnish .25 amps. continuously at such low voltage.

CARING FOR "S" TUBES IN OPERATION

Before attempting to operate "S" Tubes in any circuit the following general information should be carefully noted.

1. Always insert a series resistance in the primary circuit of the "S" Tube supply transformer to permit warming-up the tube slightly before submitting it to full voltage. This "warming-up" reduces chance of breakdown. One or two minutes' "warming-up" is usually sufficient for an evening's work.
2. Transformers and line potentials are apt to vary under varying conditions, and in various localities. For this reason, if working the "S" Tube at highest possible voltage, — namely, 1,000 volts, always be sure the transformer is not delivering 1,200 or 1,300 volts instead of the specified 1,100. Voltage in excess of 1,100 might be sufficient to break down the tube, and cause serious trouble. If there is reason to believe that excess voltage is being delivered to the tube, or if the characteristics of the transformer are uncertain, a variable primary resistance will furnish a control which will insure the "S" Tubes operating at a safe potential. Example: It may be found that the "S" Tubes flash over when the full transformer potential is applied to them, but a primary resistance of 1 or 2 ohms may reduce the secondary potential to a point at which it is safe for the tubes to operate, — thus avoiding serious injury to the tubes themselves. Even very high voltage transformers may, on occasion, be used, if careful primary regulation is adopted. In a case of this kind, always be sure to have all of the resistance cut in when first starting up, — gradually cutting out resistance as the tubes warm up and become ready for service. Also be sure, when using primary resistance, that the key is in the primary circuit, as breaking the secondary circuit would cause excessive voltage.
3. Never take the load off the "S" Tubes suddenly, unless absolutely necessary, since the average transformer on no load has such a leakage factor as to raise the voltage applied to the tube considerably. Example: An Acme Transformer, and two "S" Tubes delivering 1,100 volts D.C. at 200 ma., will rise to over 1,500 volts D.C. on no load, — thus imposing a severe strain on the tubes. This is the reason why keying the "S" Tube circuit in the primary of the "S" Tube Transformer is advised, thus preventing the tubes from being thrown on to "no load" when the key is raised.
4. When working on low wave lengths in a C.W. transmitting set, it is advisable to keep an eye on the plate milliammeter, as it frequently happens that the oscillating tubes will draw more plate current at the shorter wave lengths. When working near the voltage limit of the "S" Tube, — that is, 1,000 volts delivered D.C., — it is not safe to exceed the current rating of 100 ma. per tube. If, however, the tube is used intermittently, as in C.W., it is sometimes safe to raise this current slightly up to 125 ma. per tube. This value, however, should never be exceeded. Where the tube is used to deliver voltages not in excess of 500 or 600 volts, it is possible to draw as much as 150 ma. per tube, if the work is intermittent.
5. If an "S" Tube breaks down and ceases to rectify, due either to over-voltage or over-current, it is frequently found possible to save the tube, provided internal arcing has not continued too long. The best way to do this is to operate the tube on low potential A.C. for 8 to 24 hours, at a current not exceeding 100 ma. About 500 volts A.C. is correct for this purpose, and no condenser or smoothing device should be used. One convenient way of obtaining this low voltage is to insert a lamp in the primary of the regular plate supply transformer, and connect the tube directly across the secondary. With an Acme 500-watt transformer and a 100-watt lamp in the primary, an "S" Tube will conduct about 50 ma., when shorted directly across the secondary. Letting the tube operate this way for a number of hours will usually overcome the trouble and fit the tube for renewed service.
6. Do not be alarmed if a faint glow is visible when the tube is operating. This is caused by the static fields, slightly ionizing the gas within the tube. The danger signals of a tube are either "flash-over" (which consists of a bright flash occurring at the point between the lava and the glass) or the cathode cup becoming a dull red. Either of these signs warns the operator to lower the potential. Do not be alarmed if a tube occasionally blows the primary fuses of the transformer. A sudden surge on the line, or a flash within the tube, may occasionally occur without indicating any serious trouble. Especially in starting up the tubes, when working with high voltage, these flashes and surges are apt to occur, and usually disappear after the tube has warmed up properly.
7. Owing to the fact that most condensers are liable to breakdown without warning when used on high voltage, it is well to test these carefully when breakdowns occur in an "S" Tube circuit. A shorted condenser may result in blown "S" Tubes as well as fuses.

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