RESTRICTED RANGE SPEECH AMPLIFIER

Audio Amplifier Designed Expressly for Speech Work

FEATURES—

"Speech" range from 500–3500 cycles
Minimum distortion
Five millicomine tubes—one amplifiers
Power output of 10 watts

GENERAL CONSIDERATIONS

A speech amplifier for amateur radio service has the job of amplifying the human voice until the complex waveform which forms the human voice has sufficient power to drive the modulator tubes. The amplifier's job, then, is relatively simple. However, the frequency characteristic of the audio amplifier—that is, the amount of amplification which will be obtained at various audio frequencies—determines to a large degree the type of radio-frequency signal which is put on the air.

For example, if you are using a speech amplifier capable of amplifying frequencies beyond ten thousand cycles, and your voice (or extraneous background noise) contains energy at this frequency, then the radio-frequency signal from your transmitter will extend not at least ten thousand cycles—10 kilocycles—on each side of your transmitted radio frequency. Based another way, your signal has a minimum width of 20 kilocycles. Broad! Quite broad. Even aside from the fact that you have a broad signal, there is little point in transmitting a high fidelity signal. Primarily this is because the average communication receiver does not have an audio system capable of reproducing these high frequencies.

In addition, a highly selective receiver will further restrict the audio frequency characteristic. If you use another amplifier which has practically no gain at 10,000 cycles, but which drops rapidly in gain past 5000 cycles, then your voice, using this amplifier, will modulate the radio-frequency carrier so that energy exists out 5 kilocycles each side of the center frequency. This gives a signal with a width of 10 kilocycles. By using this second amplifier, have you lost high-fidelity, does your voice sound exactly the same to the listener receiving it over the air as it would if he heard you in person? No. Can you be understood? Yes.

How far can this process be carried? How much can we restrict the bandwidth of the speech amplifier, and still have voice modulation which is adequate for communication purposes? While it is impossible to give an answer to this question which will satisfy everyone, most engineers agree that a bandwidth for understandable speech, of 500 to 2000 cycles is adequate. This is not as narrow a band as might be imagined. For example, the major radio networks send their programs to their member stations on telephone lines. The best of these lines have a cutoff frequency of approximately 5000 cycles. Certainly

CONTENTS

Restricted Range Speech Amplifier ................................................................. pages 3–4

Tricks and Tips (Cleaning Old Sockets; Refreshing Panels; Joint Unsoldering) ................................................................. page 5

Questions and Answers (Suffice "W"); C-8 Tube Numbering; Glass Tube Numbers; Battery-Operated Tubes) ................................................................. page 6

Sweeping the Spectrum ................................................................. page 7

Technical Data (12V, 27) ................................................................. page 8
we do not think of network broadcasts as having "poor quality," and yet 5000 cycles (approximately) is the highest audio tone which will be heard when listening to network programs.

The primary advantage in using a speech amplifier which has a restricted high-frequency response is that the radio-frequency signal resulting will occupy less space in the spectrum. Recent FCC amateur proposals which refer to the bandwidth of radio-frequency signals (on which no action has been taken at the time of this writing) can be complied with more easily by sufficient reduction in the response of the speech amplifier at the higher audio frequencies. This is because the radio-frequency bandwidth of a properly operated transmitter is dependent only upon the range of the audio frequencies used to modulate the transmitter. This means that the transmitter is free of parasitic, in-operating on only one frequency, and the modulation applied is within the modulation capability of the modulated stage, to cite a few of the effects which may give a bad sound, even though the modulating frequencies are within the proper range.

(However, in the case of NBFM, the use of a restricted-range speech amplifier will not assure that the radio-frequency signal does not occupy too much space. If the frequency using cased by the modulation is carriers then the radio-frequency signal will be unnecessarily broad.)

Thus far we have discussed primarily the higher-frequency audio tones. However, it is also desirable to eliminate, or attenuate, the low frequency audio response of the speech amplifier. Elimination of all response below, say, 500 cycles, would have no effect on the width of our radio-frequency signal, but it would give us the effect of a stronger signal. It is difficult to get an exact number on the gain which could be achieved, but with relatively simple attentua-
tion means that normal precautions regarding sixty cycle hum need not be taken. As a result, the filament wires in this speech amplifier were either paired and twisted or carefully handled, 60 cycle noise could be minimized. Of course, the filament wires are not directly connected to the 60 cycle noise source, but indirect coupling through the power lines would be possible if proper precautions were not taken. The design procedure used in this speech amplifier is identical to that described in the "Technical Data" section of the July-August, 1948 G-E Ham News. References are referred to this article for the back ground work on the present design. Suffice it to say that C1 and C2 (see Fig. 2) have the job of attenuating the low frequency end of the audio spectrum, and C6 and C1 handle the attenuation of the higher audio frequencies. In other words, the entire job is handled by the proper choice of four components, two of which, would normally be employed in the amplifier even if a restricted bandwidth were not desired.

**ELECTRICAL DETAILS**

Referring to the circuit diagram, Fig. 2, the tube functions are as follows. The 6AK5 serves as a pentode amplifier stage capable of delivering a gain of well over 100. The first section of the high-mu triode amplifier stage has a triode gain of approximately 30. The second section of the same tube acts as a phase inverter. The 12AU7 tube is a push-pull cathode follower which acts as a low-impedance driving source for the push-pull 6AQ5 output tubes. It is absolutely essential that distortion be held to an absolute minimum if full advantage is to be taken of the restricted bandwidth of this speech amplifier. This is because distortion will cause the radio-frequency signal to become broadened, and this is one of the effects that we wished to overcome by restricting the audio bandwidth.

One of the major causes of distortion in the audio systems of amateur transmitters is the use of driver stages with high internal impedance to properly drive either 6BL or Clas B stages. Distortion results, in this case, because of poor regulation in the driving voltage when the driver is called upon to supply the grid current drawn during peaks. The 12AU7 cathode follower tube acts as a low-impedance driver. This permits more power output from the 6AQ5 tubes with less distortion than would be possible if the 6AQ5 tubes were driven directly from the phase inverter. Usually the 6AQ5 tubes are operated as class AB amplifiers. Normally this means that no precautions need be taken with the driver stage to ensure minimum distortion provided that the grids are...
never driven positive. This condition is difficult to achieve unless the average level is kept quite low. By using a fiber which possesses a low source impedance, which the 12AU7, the average level may be pushed up quite high and the 6AQ5 tube driven all the way up to the grid bias point. Even if an occasional video peak causes this voltage point to be exceeded, no distortion will occur due to "folding-up" of the drive stage. The net result is high output, minimum distortion, and a "narrow" radio-frequency signal.

Components C2, C4, C9, and C16 (the frequency correcting condensers) are listed in "Circuit Constants" with values which are not stock values. The values were obtained by varying these condensers during assembly until the best sound was obtained. Try to obtain condensers moderately close to these values. It is not wise to select the values marked on condensers, and it is recommended that a capacitance bridge be borrowed to check through your stock of micro condensers. It may be safer to parallel condensers in order to get the proper value. For example, C9 could easily be made up with a 1000 mfd and a 500 mfd condenser in parallel.

One further point might be made, with reference again to the circuit diagram. Fixed bias is supplied to two stages, the 12AU7 stage and the 6AQ5 stage. The bias supply is unusual in one respect. Cathode current for the 12AU7 stage must flow through Rc. The total current for both 12AU7 sections is approximately 10 ma. In other words, this bias supply must be capable of supplying a voltage and a current, instead of just a voltage as in the usual case. If the circuit diagram is followed without difficulty will be encountered. However, if you attempt to use another source of bias, make certain that it can supply the required current.

MECHANICAL DETAILS

The amplifier was constructed on a 17 by 10 by 3 inch chassis. However, inasmuch as practically any layout scheme will work, the prospective builder can use any convenient size chassis and change the layout to suit. The entire speech amplifier and power supply could fit easily in a chassis of half the size of the one just mentioned.

The placement of parts can best be seen in Fig. 1. The tubes are, from left to right, 6AQ5, 12AX7, 12AU7, 6AQ5's, and the 1Y3-GE rectifier tube in the rear. Note that the 6AQ5 uses a shield. On the rear of the chassis, at the left, is the bias transformer, T1, with the choke and C8 to the right. The power transformer occupies the rear corner and the output transformer is directly ahead of it.

Only two controls are employed—the on-off switch and the gain control. The microphone input jack and the microphone may be mounted on the front of the chassis, and the bias on the rear of the chassis. The construction of the speech amplifier, Fig. 4, indicates the placement of the remainder of the components. A shielded wire was used in all input connections. The shield was grounded at the first two stages were shorted. If the layout is altered from that indicated, it might be advisable to shield all long leads in the first two or three stages.

OPERATING ADJUSTMENTS

Once the amplifier has been completed, and it has been established that voltage can be applied without anything smoking, the 12AU7 bias voltage and cathode-return voltage should be adjusted. Re should be adjusted so that the bias, as read from the arm of R4, to ground, is 15 volts. Adjust R5 until the voltage from the arm of R5 to ground is 45 volts. Next, check the bias on the 6AQ5 tubes by reading the voltage from pin 1 of either tube to ground. This voltage should be 15 volts. If this is not true, change the tap on Re slightly until the 6AQ5 bias (pin 1 to ground) reads 15 volts. The 45 volt cathode-return voltage should remain unchanged during this adjustment. It will not be necessary to have any input signal to the speech amplifier during the foregoing tests.

The last check to be made, assuming that the am-

Fig. 4. Under-chassis View of the Restricted-range Speech Amplifier

Fig. 5. Top View of the Restricted-range Speech Amplifier
TRICKS AND TOPICS

How did you solve that last problem that almost had you stumped? Be it in tubes, antennas, circuits, etc. Lighthouse Lorry would like to tell the rest of the story about it. Send it in for each "trick" published you win $10 worth of O-E Electronic Tubes. No entries returned. Mark your letter "Entry for Tricks and Tips" and send to Lighthouse Lorry, Tube Division, Inc., 1659 General Electric Company, Schenectady, New York, or in Canada, to Canadian General Electric Company, Ltd., Toronto, Ontario.

CLEANING OLD SOCKETS

The experimenter who is perpetually using the same old ceramic tube sockets over and over again finds that eventually the sockets become dirty with surplus resin and dirt. These sockets may be cleaned to look like new in the following manner.

Pour a small bottle— a pint jar—is about the right size—and fill half of it with sand or fine gravel. Put in the socket and fill the remainder of the jar with paint remover. (Alcohol, turpentine or acetone are equally good—Ed's note.) Shake the jar vigorously for a minute or so. When the socket is removed it will be perfectly clean. Be careful that you do not try to clean sockets that are made of a material which is soluble in the solution you use.—GL.1392.

REFINISHING PANELS

Rack and panel transistors are good looking when new, but the black or gray crease finish eventually gets dull and shabby in appearance. It is generally difficult to completely repaint a panel and still maintain the crease appearance, unless a professional does the job.

However, here is an easy way to repaint panels. The crease finish will still be present when the job is complete.

First dust the panel thoroughly with a lintless cloth. Next, apply a coat of black (or gray) enamel with a brush. Use good quality enamel. Apply only a thick enough coat to ensure that the panel is covered. Brush off any excess paint.

Let the enamel dry for 10 minutes, then make a wash of cloth and wipe the panel in long sweeps. Turn the cloth wash to a clean portion before each stroke, so that you continue to remove the enamel. After excess enamel has been removed, procure a clean cloth and rub the panel in short circular strokes, applying only light pressure. This gives the panel its finish. (A sponge will not work.) Finally, let the panel dry in a dust-free room.—W.GGV

(Ed's note—This same idea can also be carried out by those with spray guns. Spray the panel with a very thin coat of flat black (or gray) paint and let dry. Do not rub. The result will be a completely reassembled crease panel.)

JOINT UNSOLDERING

Often it is necessary to unsolder a well-made joint and remove parts without damaging them. If the joint has been made using the sound practice of getting a good mechanical connection before applying the solder, the removal of a part is difficult. A good clean job can be made of this removal by using a well-tinned, but soldering iron which is hot on the joint. In such a way that the force of gravity will cause the molten solder to run off the joint onto the tinned surface of the iron where it can be wiped off with a rag. In this way, most of the solder can be removed from the joint. It is then possible to grasp the end of the wire with long-nose pliers and carefully unwind it from the terminal with an action similar to that used in opening a screwcap. The end is then straightened, and it can be slipped out of the hole in the terminal when heated over more with the iron. In this way, the lead length on the used part is preserved. The terminal is also left clean, ready for the new part, free of the danger of shorts due to surplus solder.—WJRGC

5
QUESTIONs AND ANSWERS

Do you have any questions about tube or tube circuits that are of general interest? For each question published you will receive $10 worth of G-E Electronic tubes. Mark your letter "G-E for Questions and Answers" and send to Lighthouse Laryx, Tube Division, Bldg. 264, General Electric Company, Schenectady, N.Y., or in Canada to Canadian General Electric Company, Ltd., Toronto, Ontera.

SUFFIX "W" Question: I noticed in a recent receiving tube list that several tubes had the letter "W" added at the end of their regular number (6SN7W for example) and that the price of these tubes was greater than the regular tube price. What is the difference between the tubes? Are they useful for amateur service?—D. Ringler.
Answer: The regular and the "W" type tubes are identically electrical but the latter are much more rugged mechanically. These tubes must pass very severe mechanical tests as specified in the JAN specifications—for example, shock tests and vibration fatigue tests. The suffix W is used with only a few tube types.

The amateurs could certainly use these ruggedized tubes, but the question is whether it would be worthwhile to spend the extra money. If the tubes are used in an application where shock and vibration are important, such as a mobile installation, then their use could certainly be considered.—Lighthouse Laryx.

6-C-8 TUBE NUMBRING Question: I understand that the type designations for cathode ray tubes have a special meaning concerning the characteristics of the tube. How should these designations be interpreted?—Walter H. Bryan.
Answer: There is a definite system which is followed when giving numbers to cathode ray tubes, although the number itself may not give the user too much information. For example, consider the number 12FK4. The number 12 refers to the nominal size of the face of the tube, in inches. The letter K indicates the sequence in which the tube was registered with RCA, and in this case shows that the 12FK4 was the eleventh twelve-inch tube registered.

The letter K also indicates that the 12FK4 is a design different from that of the 12JP4, for example, or from that of any other twelve-inch tube. However, there is no relation between the K in the 12FK4 number and a K that may appear in some other number. The final letter-number group, P4 in this case, indicates the type of screen characteristic. Actually it means the fourth phosphor registered. All cathode ray tube numbers with the same phosphor number will have the same type of screen, both in color and persistence.—Lighthouse Laryx.

GLASS TUBE NUMBERS Question: What is the difference between G, GT and GTG tubes having the same number? Are these tubes interchangeable?—H. Farber.
Answer: The suffix G used after a tube number indicates that it is a glass tube. For example, the 6K7-G is the glass version of the 6K7 metal tube. Tubes with the G suffix have large glass bulbs. In the case of the 6K7-G, the tube is 1 1/2 inches high and 1 1/2 inches in diameter. The 6K7-GT is a glass tube using a smaller glass bulb. This particular tube is 3 1/2 inches high and 1 1/2 inches in diameter. The 6K7-GT-G is a tube which is identical to the 6K7-GT. The extra G has been added to the tube type number to indicate that the tube is interchangeable with the 6K7-G. Other than a different in marking, they are the same tube. The 6K7-G and the 6K7-GT, while different in size, are interchangeable. They are slightly different electrically. For example, the interelectrode capacities are not exactly the same. However, both carry the same ratings and as operating conditions are concerned. The remarks made above concerning the interchangeability of the 6K7-G, the 6K7-GT and the 6K7-GT-G also hold for any other tube types with the same suffix.—Lighthouse Laryx.

BATTERY-OPERATED TUBES Question: Why are battery-operated tubes more microphonic than other types? What is the best cure for this?—R. Britton.
Answer: Battery-type tubes have a low voltage, low-power filament. This means that the filament wire itself is very small. For this reason the filament is much more liable to move, when the tube is subjected to shock, than the heavier filament and canode structures found in the higher-voltage tubes. Inasmuch as the microphones is inherent in the battery-type tubes, the only cure is to make sure that the tube is not subjected to shocks of any sort.—Lighthouse Laryx.
Sweeping the Spectrum

The questionnaires sent out with the May-June, 1949 Ham News have elicited a very nice response, due to your generosity in sparing the time to fill them out so completely. It will take some time before the results can be thoroughly tabulated, but you may expect to see the results in this column at some time in the future. If you have not yet sent in your questionnaires, there is still time. Shoot it along.

Speaking of questionnaires, many of you who sent in your completed forms for back copies of the Ham News, or asked questions of one sort or another. Due to the automatic manner in which these questionnaires are being handled, it would not be possible to sort through a few thousand of them to locate those few which contained extra requests. Kept, if you were one of those who did not ask a question or make a request directly on the questionnaire, let me have it again.

Are the pieces of equipment described in the Ham News just pretty show pieces, or do they actually work? This question came from an amateur recently. It also came as quite a shock to me, since I haven't learned what prompted his question. Perhaps he had built one of the Ham News units and had bad luck with it. Or, if I prefer this answer, he hadn't built any of the Ham News units, so that he was in no position to judge their merit.

Rather than leave you in suspense, here is the lowdown. After the design has been decided upon, the unit is constructed in the laboratory. It is then subjected to a series of tests to determine if it will operate properly. If something is lacking in the performance of the unit it is redesigned and rebuilt. Many units have been built which will never be described in Ham News because 1) they were too critical of adjustment, or 2) required special hand-made parts which the average amateur could not make, or 3) they just would not work.

If there is any doubt that an amateur might find it difficult to construct a certain unit, then two of these are constructed. The second unit will have its components arranged in a different manner, so that the wiring will not be identical to that in the first unit. If both units perform in the same way, then the chances are that the circuit and mechanical construction is sound, and that most amateurs will find no difficulty in constructing a similar unit.

Therefore, when you see some piece of equipment described in the Ham News, you are sure that it has been built carefully, thoroughly tested and debugged, and if it is a transmitting unit, given complete on-the-air tests.

Of course, none of the above holds for "Tricks and Topics." These submitted ideas are published if they seem to be clever and new, but no attempt is made to thoroughly check each one.

There is an old saying "there is nothing new under the sun." I had to prove it the hard way. When writing the "Sweeping the Spectrum" column for the March-April, 1949 Ham News I came to the last couple of inches in the column and decided I'd use the space to tell you about a little trick I'm fond of. You recall—the nuts and washers on an log-periodic. You should have seen the letters that came back at me on that one. Most of them just plainly stated that they had been using that idea for years.

However, Weil & Barstow stated that he was glad to see that "great minds run in the same channel." Thanks for the kind words, Bernie. Of course, even Bernie had an idea to go me one better. So, expect to see (in a future "Tricks and Topics") a number of ideas on how to get a nut on a screw which is in one of those "hard-to-get-at" places. And don't expect to get too many more of my ideas. I surrender, fellows!

—Lighthorse Larry
**TECHNICAL INFORMATION**

**12AX7**

**GENERAL DESCRIPTION**

Principal Application: The 12AX7 is a nine-pin miniature tube consisting of two triode sections each having an amplification factor of 100 and an individual cathode connection. A center-tapped 12.6-volt 150-milliampere heater is provided, which may be con-

**Cathodes**

- **Control Unipolar:** Series Parallel
- **Heater Voltage (A-C or D-C):** 0.6 Volts
- **Heater Current:** 0.15 A
- **Envelope:** T-6/7 Glass
- **Base:** EA-1 Small Glass-Button 9-Pin

**MAXIMUM RATINGS**

- **PLATE VOLTAGE:** Design Center 300 Volts
- **PLATE DISPLACEMENT:** Each Section 1.0 Watts
- **GRID VOLTAGE:** Negative Bias Value 50 Volts
- **Positive Bias Value:** 0 Volts
- **PEAK GRID-CATHODE VOLTAG:** 180 Volts

**CHARACTERISTICS AND TYPICAL OPERATION**

**CLASS A, AMPLIFIER (Each Triode Section)**

- **PLATE VOLTAGE:** 100 Volts
- **GRID VOLTAGE:** -1 Volts
- **AMPLIFICATION FACTOR:** 100
- **PLATE RESISTANCE:** 80000 Ohms
- **TRANSCONDUCTANCE:** 1250 Volts/Microamp
- **PLATE CURRENT:** 0.2 Milliamperes

**PHYSICAL DIMENSIONS**

- **TERMINAL CONNECTIONS**
  - Pin 1—Plate (Section Number 1)
  - Pin 2—Grid (Section Number 2)
  - Pin 3—Cathode (Section Number 3)
  - Pin 4—Heater
  - Pin 5—Heater Center-Tap
  - Pin 6—Plates (Section Number 1)
  - Pin 7—Plates (Section Number 1)
  - Pin 8—Cathode (Section Number 1)

**ELECTRONICS DEPARTMENT**

**GENERAL ELECTRIC**

Schenectady, N. Y.

(In Canada, Canadian General Electric Company, Ltd., Toronto, Ont.)

**PRINTED IN U.S.A.**

File No. 6150