Linear R.F. Amplifiers

Their Design and Adjustment

BY STYRK G. REQUE,* W2FZW

• Linear r.f. power amplifiers have been neglected by amateurs because of their alleged inefficiency and difficulty of adjustment. However, they are the amplifiers one uses in single-sideband transmitters, and they are far from inefficient in this application. Also, they are far from difficult to adjust, as this article clearly demonstrates. Here is a basic technique everyone should have tucked away in his noggin.

A LITTLE over a year ago a few hardy experimenters in the amateur ranks began describing their experiences with a new (amateur-wise) system of communication, single sideband. In general, the techniques they used had little resemblance to the conventional a.m. 'phone technique or, for that matter, to the newer technique of n.f.m. So it is not surprising to find a new jargon to describe these techniques, and one now hears such things discussed as "balanced modulators," "sideband suppression," "phase-shift networks," and "linear r.f. power amplifiers." This article concerns the last of these for, although the linear r.f. power amplifier is an old technique of broadcast-station design, it has had practically no use in amateur radio stations. Yet almost without exception the pioneers who are introducing us to single-sideband transmission are using this type of power amplifier.

Linear Amplifiers

A linear amplifier is one in which the output voltage is proportional to the input voltage. All of our audio amplifiers are of this type, or we get very objectionable distortions. Similarly the r.f. and i.f. amplifiers of our receivers are linear r.f. amplifiers, for if there were any serious distortion of the modulation envelope the detector would give us a distorted output signal. In fact, any amplification of a signal with a modulation envelope must be linear if we are to be able to recover the modulation in a detector system without severe distortion.[1]

The simplest form of linear amplifier (r.f. or audio) is the Class A amplifier, which is used almost without exception throughout our receivers and our low-level speech equipment. While its linearity can be made phenomenally good, it is unfortunately quite inefficient. The theoretical limit of efficiency in this case is 50 per cent, while most practical amplifiers run 25–35 per cent efficient at full output. At low levels this is not worth worrying about, but when we exceed the 2- to 10-watt level something else must be done to improve this efficiency and reduce tube, power-supply and operating costs.

The use of Class B amplifiers for high-level audio amplifiers (commonly miscalled modulators [2]) is now well known and common amateur practice. Class B amplifiers are theoretically capable of 78.5 per cent efficiency at full output, and practical amplifiers run at 60–70 per cent efficiency at full output. The same amplifier tubes, with suitable tank circuits substituted for the driver and output transformers, will make good linear r.f. power amplifiers of the same power rating and efficiency. In fact, we can even generalize this and make the following statement: Any reasonably distortion-free audio amplifier may be converted to a linear r.f. amplifier by replacing the input and output transformers with properly designed and loaded r.f. tank circuits, provided, of course, that the tubes are suitable for use at the desired frequency. In r.f. circuits running Class B, only one tube need be used if only half the power is wanted, because the flywheel action of the tank circuits will smooth out the missing half cycle.

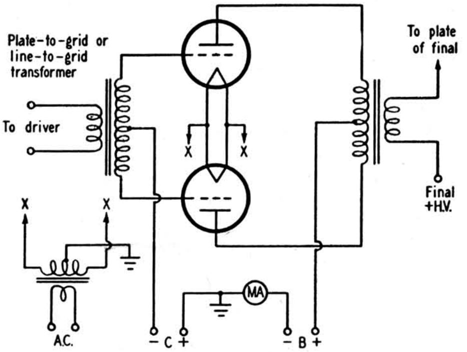

Fig. 1 — A circuit diagram of the familiar Class B modulator.

One side issue is well worth considering at this

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[1] N.f.m. is not subject to this rule, because true f.m. or p.m. has no envelope which must be preserved. This is the same feature that gives f.m. its advantage in reducing certain types of BCI

[2] Modulation takes place because of the action of the Class C amplifier. The so-called modulator simply supplies audio power for the process.

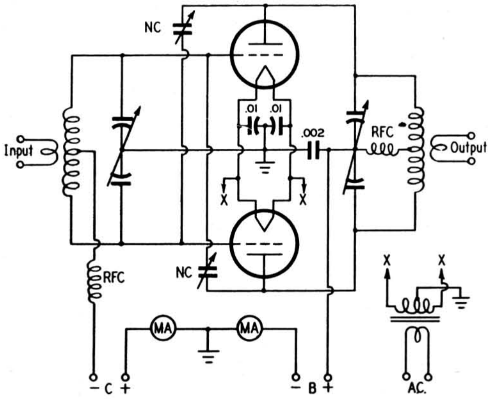

Fig. 2 — **A Class B linear r.f. amplifier circuit resembles Fig. 1 but uses r.f. instead of audio components.**

moment. If you look up the Class B r.f. amplifier ratings of a given tube, you will undoubtedly be shocked to see that the efficiency given is in the order of 33 per cent and not the 60–70 per cent quoted above. The discrepancy arises because the figures given are for a conventional a.m. system. The efficiency of a Class B amplifier is proportional to the signal voltage; i.e., at full output it is 60–70 per cent and at half voltage it is 30–35 per cent. In a conventional a.m. system the carrier is always at half voltage, and so when no modulation is applied the efficiency of a properly-adjusted Class B r.f. amplifier will be in the order of 33 per cent. This need not concern the amateur running a single-sideband system with suppressed carrier, since his resting or no-modulation condition corresponds to zero signal input to the amplifier and he observes only the small resting d.c. input to the amplifier.

Amplifier Design

In a large majority of cases the design of a Class B linear amplifier will be rather simple, since most of the common power-amplifier tubes are rated for Class B audio work. In a case of this sort the proper plate voltage, bias voltage, load resistance and power output are given, and the sole job is to provide proper tank circuits and drive for the tubes. As an example, let us choose a tube of good reputation as a Class B audio amplifier, such as the GL-805. Typical operating conditions are given in Table I.

Fig. 1 is a schematic diagram of the usual Class B audio amplifier. Fig. 2 is a diagram of the amplifier changed over for use as a linear r.f. amplifier. Our first concern will be the design of the proper tank circuits for the grid and plate circuits. The subject of proper loading will be discussed under the section on practical adjustment.

Let us design the proper plate-tank circuits first. As in all r.f. amplifiers, this tank circuit should have a loaded Q of at least 12, if we want to have reasonable efficiency and low harmonic output. The loaded Q is defined in terms of the tank-capacitor reactance (equal to the tank-inductance reactance at resonance) and the load resistance by the equation

$$Q = R_L/X_C \qquad (1)$$

Rearranging, and substituting in the figures,

$$X_C = R_L/Q \qquad (2)$$

$$= 6700/12 = 560 \text{ ohms}$$

But we also know that

$$X_C = 1/2\pi fC \qquad (3)$$

If we choose the 75-meter 'phone band as our example of design, and hence substitute 4 Mc. for f and 560 ohms for X_C in (3), we will find the value for C to be approximately 70 $\mu\mu$fd. This is the value of the capacity across the tank, and we must double it to find the value for each section of our split-stator condenser, or 140 $\mu\mu$fd. per section. Note that this is the value of the capacity actually in use, and that for proper adjustment a capacitor with a rating of at least 150 (and preferably 200) $\mu\mu$fd. per section would be clearly indicated. The coils should be chosen or pruned until the proper amount of capacity is required to tune them to resonance, with the error if any on the low-inductance (high-capacity) side where it can do little harm. Many troubles in amateur transmitters can be traced to the use of too little capacity in the r.f. tank circuits. This is not a peculiarity of the Class B linear amplifier, but is equally true of the Class C, perhaps to an even greater degree.[3]

The calculation of the grid tank circuit is performed in just the same way as we calculated the plate tank. However, the loading of the grids, which must be substituted for R_L, is not given. Our present example, GL-805s, involves a pair of zero-bias tubes. Tubes in this class draw grid current even when very small signals are applied, and the equivalent loading of the grid tank is very nearly constant regardless of signal level. This will mean that a very nearly constant load will be reflected to the driving stage and only a small

TABLE I
Class B Audio-Amplifier Data
GL-805 Tubes
(Values given for two tubes)

D.c. plate voltage	1250 volts
D.c. grid voltage	0 volts
Peak grid-to-grid voltage	235 volts
Zero-signal plate current	148 ma.
Max.-signal plate current	400 ma.
Max.-signal driving power	6 watts
Max.-signal plate input	500 watts
Effective load plate-to-plate	6700 ohms
Max.-signal power output	300 watts

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[3] If you are having trouble with harmonics, TVI, or a touchy amplifier that won't take load properly, you might take a quick look at the chart on page 157, *ARRL Handbook*, 1949 edition. See if the L/C ratio is correct.

amount of loading or "swamping" will be necessary to insure that the driving signal is not distorted.

If, on the other hand, we choose tubes that operate at a normal bias of 50–60 volts (such as GL-810s) it is apparent that the grids will not draw any current at all until the driving signal exceeds this bias. In a case of this sort the grids load the grid tank circuit, and hence the driving stage, in a variable manner. Unless some further step is taken, this will result in distortion of the driving signal, and our amplifier system is not linear. This can be avoided if sufficient fixed loading is supplied for the driver stage, and if suitable impedance matching is done so that the variable grid loading is negligible. In any case, this will require that the driver be capable of supplying several times the listed value of grid driving power. A full discussion of the possible ways of impedance matching and controlling this variable grid loading is unfortunately far beyond the scope of this article. However, as a guide to those who care to delve into the subject, we can state that the necessary conditions which must be satisfied are two in number:

a) The load presented to the driving stage must be constant.

b) The voltage at the grids must have good regulation.

Returning now to our original example, the GL-805s, we can calculate the loading effect of the grids from the known grid-driving power and known peak grid-to-grid voltage by means of the simple formula,[4]

$$R_{EQ} = E^2_{G\text{-}G}/2P_G \qquad (4)$$

Substituting the proper values of grid-to-grid voltage and grid driving power from the data in Table I gives an equivalent grid loading of 4600 ohms. To be conservative, we might well put a 5000-ohm damping resistor across the tank, so that the net effective resistance across the tank will be approximately 2400 ohms. Substituting this value in Equation (2), and the resultant value of reactance in (3), we find the necessary value of C to be 200 μμfd. across the tank or a split-stator capacitor of 400 μμfd. per section. A broadcast-receiver condenser of 420 μμfd. per section is readily available and will easily stand the low peak voltage on the grids.

Sometimes the value of capacity as calculated above will be so large as to be unreasonable for the frequency involved. In a case of this type the solution must be obtained in another way, as indicated when we spoke of variable grid loads. The same network rules will apply to the matching network in this case as applied in the case where the grids do not draw current over the entire cycle of excitation (use of negative bias).

Here again it may not be amiss to mention that the large value of capacity indicated is not a result of Class B operation, but in this case is purely a function of the tube chosen. For linear amplifiers it is necessary that the tanks be properly designed. If the Class C stage seems to be tolerant of errors in tank design, it is because few of us have given full consideration to the proper handling of our amplifiers and have been content to operate with the efficiency and the harmonic output accident has provided.

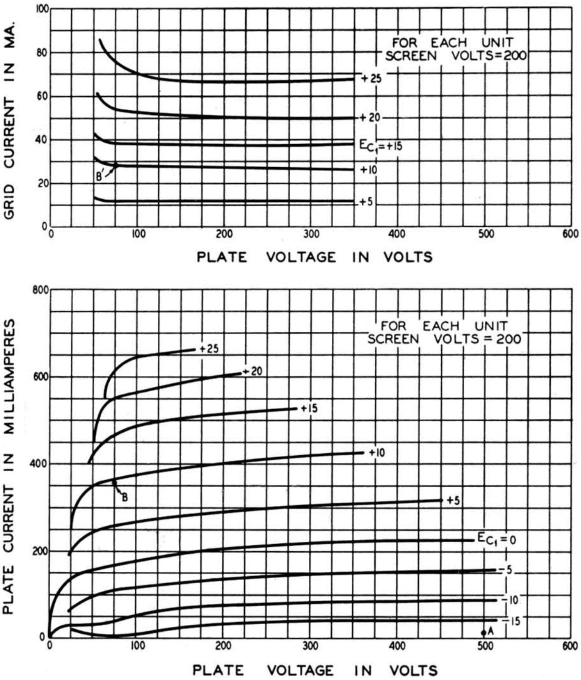

Fig. 3 — **Average grid and plate characteristics of the GL-829-B.**

Design from Tube Curves

There are actually very few power tubes which we might choose to use as linear amplifiers that do not carry a Class B audio rating. However, there are a few tubes, designed for v.h.f. use, which are not so rated. Such a tube is the GL-829-B, a compact tube roughly equivalent to a pair of GL-807s. This tube has recently been popular with the gang running 100 watts or less because it is so well shielded and so compact. If we care to use a tube of this sort we must determine the quantities equivalent to those given in Table I from the characteristic curves and a few formulae which have been worked out by the engineers. Fig. 3 shows the grid and plate characteristics of the GL-829-B.

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[4] The factor 2 in the denominator appears because we are using peak and not r.m.s. values.

As a first assumption, let us suppose that the plate-supply voltage is 500 volts. The proper bias is our next consideration, and one good rule of thumb in determining this is to choose the bias such that the resting plate current will produce approximately ⅓ rated plate dissipation. Bias determined in this way will usually allow better linearity (less distortion) than a bias chosen closer to complete cut-off. Since our GL-829-B has a rated dissipation of 20 watts per section, the proper bias will allow 6.7 watts resting dissipation per section. At 500 volts plate supply this means a resting plate current of 13.3 ma. per section. From the characteristic curves of Fig. 3 it will be seen that approximately 18 volts of bias will be required. The resting point is marked "A" in Fig. 3.

Since the maximum signal efficiency is going to be in the order of 65 per cent, we can now determine the maximum input power. The 35 per cent power loss must equal the maximum plate dissipation, which is 40 watts (both sections) for our GL-829-B. Therefore, the total power input (100 per cent) must be 115 watts maximum, or 57.5 watts per section.

Dividing the maximum power input by the plate voltage will give the maximum signal plate current. In this case the total current will be 115/500 = 0.230 amp. = 230 ma. This is 115 ma. per section d.c. plate current at maximum signal.

The plate-current pulses of each tube of our Class B linear amplifier are half sections of a sine wave, such as might have been produced by a half-wave rectifier. In such a waveform, the peak current is 3.14 times the value read by a d.c. meter, and this permits us to find the peak current flowing through the tube. Since the d.c. input per section is 115 ma., we know then that the peak current through each section should be 115 × 3.14 = 360 ma.

Returning to Fig. 3, we see that 360 ma. will flow on the crest of the cycle if the grid is driven up to +10 volts on the peak and the plate is not allowed to swing lower than 75 volts. Since the grid starts from −18 volts (the bias), this will be a peak r.f. grid swing of 28 volts, or a peak grid-to-grid voltage of 56 volts.

The grid driving power may be calculated from the peak grid-to-grid voltage and the grid current that will flow at the operating point "B." This is marked as B′ on the grid current curves in Fig. 3. The grid driving power is one-quarter[5] of the product of this peak grid current and the peak grid-to-grid voltage, or 0.39 watt in this case.

The power output of this amplifier may now be calculated by the aid of the formula

$$P = 0.78\ (E_{\mathrm{B}} - E_{\mathrm{Pmin}})\ I_{\mathrm{d.c.\,max}} \qquad (5)$$

Substituting the value of minimum plate voltage, the plate-supply voltage and the maximum-signal d.c. plate current we find the output power to be 0.78 (500–75) 0.23 = 76 watts.

TABLE II
Class B Audio or Linear R.F. Amplifier Data—GL-829-B
(Values given for both sections)

D.c. plate voltage	500 volts
D.c. grid voltage	—18 volts
Peak grid-to-grid voltage	56 volts
Zero-signal plate current	27 ma.
Max.-signal plate current	230 ma.
Max.-signal driving power	0.39 watts
Max.-signal plate input	115 watts
Effective load plate-to-plate	4800 ohms
Max.-signal power output (audio or peak r.f.)	76 watts

As a double check we subtract this from the power input of 115 watts and find 39 watts plate dissipation for both sections. The actual efficiency is 66 per cent, a bit higher than assumed at first.

The plate-to-plate load resistance is readily obtained from the formula:

$$R = 2.6\ (E_{\mathrm{B}} - E_{\mathrm{Pmin}})\ /I_{\mathrm{d.c.\,max}} \qquad (6)$$

Substituting the same values used with Equation (5), we find the plate-to-plate load resistance to be 2.6 (500–75)/0.23 = 4800 ohms.

Collecting all the values calculated, we can now make up a table similar to the one given for the GL-805s which will apply to the GL-829-B. This is shown in Table II.

The calculation of the specific amplifier will now be the same as the case of the GL-805s, since we have determined all the significant values.

General Considerations

Before going into detail on the adjustment and loading of the Class B linear amplifier, a few general considerations should be kept in mind. If proper operation is expected, it is essential that the amplifier be so constructed, wired and neutralized that no trace of regeneration or parasitic instability remains. Needless to say, this also applies to the stages driving it.

The bias supply to the Class B linear amplifier should be quite stiff. The Class C stage thrives on grid-leak bias, but for really good operation the Class B should be supplied from a very stiff source, such as batteries or some form of voltage regulator. If nonlinearity is noticed when testing the unit, the bias supply may be checked by means of a large electrolytic capacitor. Simply shunt the supply with 100 μfd. or so of capacity and see if the linearity improves. If so, rebuild the bias supply for better regulation. *Do not rely on a large condenser alone.*

Adjustment of Amplifiers

The two critical adjustments for obtaining proper operation from the linear amplifier that has been correctly designed are the plate loading

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[5] Approximate value commonly used for design purposes.

and the grid drive. Since these adjustments are preferably made with power on, it is a matter of practical convenience to have both controls readily available, at least during initial tune-up.

All adjustment procedures will be described in terms of oscilloscope pictures. The 'scope can show misadjustment at a glance and will greatly facilitate all adjustments. In addition, it is the most reliable instrument for observing modulation amplitude and, once used, is likely to become the most nearly essential instrument in the shack. Nothing elaborate is needed. One manufacturer regularly advertises a suitable instrument complete and ready to run in an attractive case for $24.95. If you prefer, build a unit such as shown on page 477 of the *ARRL Handbook*, 1949 edition, or the unit described by J. L. Hollis, W0JET, in the Sept., 1948, *QST*. Using one of the small war-surplus cathode-ray tubes, the cost will be less than a good multimeter.

The proper adjustment procedure for the linear amplifier used with an a.m. system can be covered very briefly. First of all, the driver stage, which will very likely be the modulated stage, may be checked by observing the modulation pattern on the oscilloscope when the driver is loaded by a dummy load (which simulates the input circuit of the linear amplifier). Pages 290–295, Chapter 9, *ARRL Handbook*, 1949 edition, gives the story on the use of the oscilloscope so well that it need not be repeated here. After the driver has been adjusted for proper operation into the dummy load, it may be coupled to the linear amplifier. The linear amplifier should now be coupled to a suitable dummy load (not the antenna). With no modulation applied to the driver, the drive and the output loading of the linear amplifier should be adjusted so that plate current is approximately one-half of the maximum signal plate current. Then 100 per cent modulation should be applied and the output of the linear amplifier observed on the 'scope. If the positive peaks of modulation are flattened, the loading of the linear amplifier is too light, or the driver is limiting. If the flattening of the positive peaks is caused by the amplifier load being too light, it will be possible to clear up the pattern by temporarily detuning the amplifier plate circuit. In this case, tighter output coupling and probably looser coupling to the driver are indicated. Always maintain the initial plate current by balancing the drive and output coupling. On the other hand, driver overload will usually mean that the driver is undercoupled and the linear amplifier is too heavily loaded. The object of the whole loading procedure will be to adjust the amplifier to a point where, with normal input, the output circuit is just on the verge of flattening the positive peaks at 100 per cent modulation. In an ideal system, the adjustment finally reached will give simultaneous overload on the driver stage and the linear amplifier. In the practical case it is probably better to have the linear amplifier overload first. If the output-coupling and grid-drive adjustments are available as suggested, this procedure can be followed in less time than it takes to tell, with a few glances at the plate current thrown in as a double check. The antenna may now be coupled and checked.

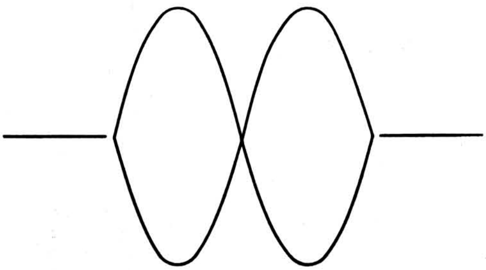

Fig. 4 — **Oscilloscope pattern obtained with a two-tone test signal through a correctly-adjusted linear amplifier.**

Single-Sideband Procedure

If the amplifier is to be used with single-sideband transmitters, a modification of the above test procedure is helpful. With single sideband, 100 per cent modulation with a single tone is a pure r.f. output with no modulation envelope, and the point of flattening is difficult to observe. However if the input signal consists of two sine waves of different frequencies (for example, 1000 c.p.s. difference) but equal amplitudes, the output of the single-sideband transmitter should have the envelope shown in Fig. 4. We have called this a "two-tone" test signal to distinguish it from other test signals. Its first advantage lies in the fact that any flattening of the positive peaks is readily discernible, which makes the adjustment of the linear-amplifier drive and output coupling as simple a procedure as that described for a.m. systems. Indeed, the procedure will be the same, except that there is no carrier-level adjustment to be made initially.

Those experimenters using the filter method for obtaining single-sideband signals can obtain such a test signal by mixing the output of two audio oscillators of good waveform. The experimenters using the phasing method of single-sideband signal generation will recognize the pattern as that obtained when a single test tone is applied to one of their balanced modulators. For this latter group a two-tone test signal may be readily obtained by disabling one of the balanced modulators in the exciter and applying a single input tone. Other variations are possible in different exciters, and the final choice of any one operator will be dictated by convenience.

Let us suppose that the linear amplifier has been coupled to a dummy load and the single-sideband exciter has been connected to its input.

By observing the oscilloscope coupled to the amplifier output, it will be possible to adjust the drive and output coupling so that the peaks of the two-tone test signal waveform are on the verge of flattening. The peak input power may now be checked. This is readily possible, for with the two-tone test-signal applied, the peak input power will be 1.57 times the d.c. power input to the linear amplifier. Should this be different from the design value for the particular linear amplifier, the drive and loading adjustments can be quickly changed in the proper direction (always adjusting the loading so that the peaks of the envelope are on the verge of flattening) and the proper design value reached.

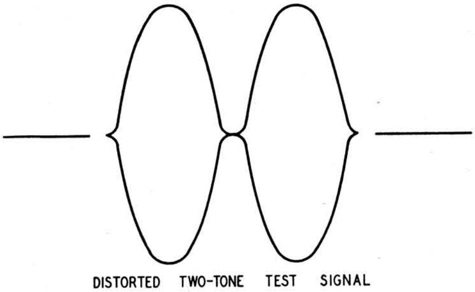

Fig. 5 — **The distorted two-tone test-signal pattern obtained when the bias voltage is incorrect.**

As a final check, before coupling the linear amplifier to the antenna, the single-sideband operator will do well to check the linearity of the system, since distortion in the linear amplifier (for that matter, in any of the r.f. amplifiers) probably will result in the generation of sidebands on the side that was suppressed in the exciter. Here again the two-tone test signal will be of great help, since distortion of the signal will be readily recognized. A check of the bias supply has already been recommended. The next most likely form of distortion will be caused by curvature of the tube characteristic near cut-off, and will be recognizable from a two-tone test pattern that looks like Fig. 5. A slight readjustment of bias (or applying a few volts of positive or negative bias, in the case of zero-bias tubes) will usually straighten out the kink that exists where the pattern crosses the zero axis. Make this adjustment with special care, however, because the dissipation of the tubes with no input signal will be very sensitive to this adjustment. There are a few tubes that will not permit this adjustment to be carried to the point where the kink is entirely eliminated without exceeding the rated plate dissipation.

The antenna may now be coupled to the linear amplifier until the plate input with the excitation as determined above is the same as that obtained with the dummy load. The operator can now feel

(Continued on page 94)

HAMFEST CALENDAR

CALIFORNIA — The San Joaquin Valley Radio Club is staging its Seventh Annual Hamfest on Saturday, May 7th, at the Belmont Inn, ten minutes from downtown Fresno. The program starts promptly at 9 A.M., and includes entertainment, contests, speakers and an evening banquet. The ladies will have their own activities during the afternoon under the direction of W6QVK. There will also be a breakfast for DX men on Sunday morning, with W6KUT officiating. Registration is $3.75 per person, and can be made through Ken Woodyatt, W6JWK, 3044 Thorne Ave., Fresno, Calif.

ILLINOIS — The Annual Hamfest of the Peoria Amateur Radio Assn. will be held on Sunday, June 12th, at Woodland Knolls, which is located east of Peoria on Route 116, about 4½ miles from McCluggage Bridge. Contests, entertainment and a good time for all are promised. Bring your own lunch. For particulars address Secy. H. E. Callander, PARA, 211 E. McClure, Peoria, Ill.

MISSISSIPPI — All amateurs, XYLs and YLs are cordially invited to the Jackson Amateur Radio Club Hamfest, being held in that city on Saturday and Sunday, May 28th and 29th. A gala program has been arranged, and further particulars may be obtained by writing to President J. P. Brown, JARA, 1108 Central St., Jackson, Miss.

NEW YORK — A bang-up time is assured hams who attend the Rochester Amateur Radio Association Hamfest on Saturday, May 14th, at the Powers Hotel, Rochester. A special program has been arranged for the ladies, so bring the YF or YL. Tickets are $3.50 in advance, $3.75 at the door.

NEW YORK — The Annual Dinner and Hamfest of the Westchester Amateur Radio Association will be held on Friday, May 6th, at the Scarsdale Casino, Central Ave., Scarsdale, N. Y., starting at 7:30 P.M. Bill Leonard, W2SKE, CBS commentator, will be master of ceremonies. Tickets will be $3.75 per person at the door, or may be obtained in advance for $3.50 from David Bulkley, W2QUJ, 405 Weaver Street, Larchmont, N. Y.

TEXAS — The Annual Convention of the South Texas Emergency Net — "largest emergency net in the world" — will be held in Cuero, Texas again this year, on May 28th and 29th. Each year the convention has become a more important event, with the attendance last year numbering between 400 and 500. It is a real hamfest with emphasis on emergency and net operation. All amateurs, XYLs and interested parties are invited to attend. On Saturday, May 28th, there will be a special mobile contest on the way to the convention beginning at 7 A.M. Work as many stations as you can. Registration will begin at the Legion Hall in Cuero at 9 A.M. and programs will begin at 1 P.M. On both days there will be good entertainment as well as technical information interspersed with lively contests. The YLs and XYLs will enjoy special programs arranged for them. The FCC inspector will be present and those who wish to take the examination for their amateur license may do so on Saturday. A Sunday-noon highlight will be the barbecue in the city park especially prepared by Police Chief Taylor. Tickets may be obtained in advance from B. B. Thorn, W5CIX, Cuero, Texas; price $2.50 each.

WISCONSIN — Presently celebrating 30 years of affiliation with ARRL, the Milwaukee Radio Amateurs' Club, sponsors of last year's ARRL National Convention, is resuming its series of famous QSO Parties. The next affair will be held in the Elizabethan Room of the Milwaukee Athletic Club on Saturday evening, May 28th. Dinner will start promptly at 6:30, and will be followed by top-notch entertainment, technical talks and free beer. Since May 28th begins the Memorial Day week end, make up a party and have a real good time. Advance registrations at $5.00 per person will be accepted if letters are postmarked prior to midnight, May 21st. Registration at the door will be $6.00. Send only the *short* ticket, with cash, or check or money order payable to Milwaukee QSO Party, to H. E. Saxton, 709 East Sylvan Ave., Milwaukee 11, Wis. Bring the *long* ticket with you.

Simple Gear for 420 Mc.

(*Continued from page 14*)

tapped r.f. choke, *RFC*$_1$, should be checked by the same method as recommended for the transmitter. The nodal point is that at which little or no change in the receiver's operation is noticed as the line is touched. As with the transmitter, this point will be near the middle of the line. This test should be made with the receiver set near the middle of the band.

Results

Just as with simple lower-frequency gear, it should not be expected that this one-watt transmitter and three-tube receiver will set the 420-Mc. world on fire. They are presented as examples of just about the simplest sort of gear with which practical communication can be carried on — on this or any other band. The beginner in this field will find them good enough to provide a lot of fun, particularly if there are several other amateurs within a radius of a few miles with whom to work. Not much beyond line of sight can be expected from such a low-powered transmitter, but even line of sight may include some pretty good distances if the rig is used for portable operation from high locations.

The receiver does surprisingly well, for such a simple layout. To be sure, it has all the disadvantages of the superregen — radiation of an interfering signal, somewhat critical tuning, and the characteristic superregen hiss — but the discrepancy between its performance and that of most superhets for 420 is not so great as is experienced on lower frequencies. The shortcomings of the superregen are somewhat alleviated by the inherent characteristics of the 420-Mc. band, and the advantages of this old stand-by of the v.h.f. experimenter show up well in this design. It is fully selective enough for present conditions on the band; its simplicity and low cost are a welcome change from present trends in receiving equipment; and its performance, in a tube-for-tube comparison, is hard to beat.

Linear R.F. Amplifiers

(*Continued from page 20*)

that the system has been adjusted for optimum performance, and enjoy the fruits of his labor.

The design and adjustment techniques described in this article have been somewhat different from those which apply to the more common Class C amplifier. However, it is the author's sincere conviction that most difficulties which may arise in the design or handling of the Class B linear amplifier will be due to lack of familiarity with it, and that as the Class B linear amplifier comes into more common use, the amateur will soon handle it with the same ease as he does his other equipment. This has certainly been true of several amateur stations with which the author is familiar, and where linear amplifiers have been installed recently.