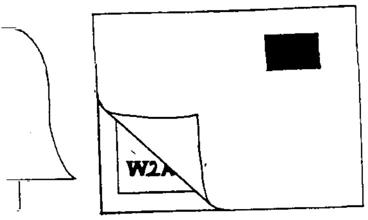
f back, (b) Laying protective cover
;, (d) Color swatch put on cover to



Choice of Color

olor that is pleasing to you and
-ntuate the design. If a white card
i, a dark color ink will give most
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s effect: dark blue ink on yellow
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:k is used, I suggest the ink selected
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:ond part of this article, techniques
:ions for creating two-color linecut
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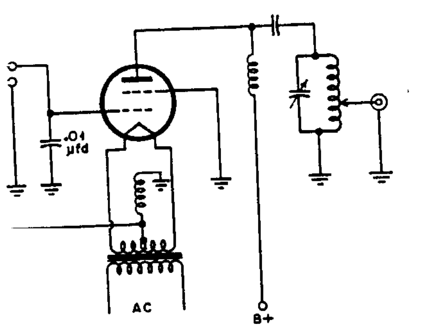
(to be continued)

r Noise



A typical grounded grid amplifier with method of eliminating final amplifier :ded. Ky$_1$ can be the spare contacts on e control relay of some commercial ex- -r a separate relay keyed simultaneously with the voice control relay

Increasing Tube Reliability

Supervisor, Electronics Design Branch, Mare al Shipyard, Vallejo, California.

Conversion of AM Transmitters to DSB Operation

C. A. West, W2IYG
Electron Tube Division,
Radio Corporation of America,
Harrison, N. J.

Are you becoming increasingly discouraged with phone operation because of crowded band conditions? Are heterodynes created by beating carriers breaking up your qso's in spite of your beam antenna and the addition to your receiver of double conversion, crystal filter, Q-multiplier, and other types of filters to sharpen your rf and if selectivity or notch your audio response? If your present final class C amplifier uses a pair of beam power, tetrode, or pentode tubes, you can easily convert your transmitter for double-sideband—suppressed-carrier operation and enjoy many of the advantages of sideband operation.

The conversion is quite simple. It consists basically of changing to a push-pull (grid-No. 1) input circuit and a parallel-plate output circuit and applying push-pull audio voltage plus some negative voltage on the screen grids (grid-No. 2). With the addition of a simple switching arrangement you can go back in seconds to your original AM and cw operation!

This article presents sufficient information of a general nature to help you convert your present transmitter or build and adjust a DSB amplifier, and describes in detail the conversion and adjustment of W2IYG's parallel 813 final operating at maximum ICAS class C telegraphy plate-voltage rating.

Circuit Conversion

The first step in the conversion of your present final amplifier is to re-wire it as shown in fig 1. The plate circuit is connected for parallel operation, and the grid-No. 1 circuit for push-pull operation. The screen grids are then connected to a step-up transformer having a center-tapped secondary. The negative screen-grid or grid-No. 2 voltage is connected at this center-tap. If a 500-ohm output winding is available from your audio amplifier, a 500-ohm line to the push-pull grid-coupling transformer should prove sufficient. Very little af power is required in the grid-No. 2 circuit because it is only necessary to supply sufficient af voltage for modulation to the proper amplifier power level. This subject is discussed further under adjustment.

When properly adjusted, this amplifier operates as follows: The grid-No. 1 input circuit operates in the normal class C fashion. When one grid is driven negative, the other is driven positive. Because the plates of the two tubes are connected in parallel through a common load, and because there is a normal 180-degree phase shift between the tubes, the instantaneous voltage at the plate of each tube is equal and opposite to that of the other tube. Under these conditions, voltages in the plate circuit cancel, and rf output is zero, causing complete carrier cancellation (at balance only). For a given dc plate voltage and rf grid-No. 1 voltage, the static or idling dc plate current therefore is influenced only by the value of negative dc grid-No. 2 voltage.

When audio voltage is applied to the screen grids in a push-pull arrangement, one screen grid is driven positive while the other is driven negative. The tube with the positive-going screen-grid voltage begins to conduct, while the tube with the negative-going screen-grid voltage remains cut off. Each tube, therefore, produces power for only one half of the audio cycle. During the next half cycle tube operation is reversed, and the tube which was previously cut off begins to deliver power. Both sidebands are produced alternately by each of the tubes. The plate current in this case is influenced by the combination of negative dc voltage and af modulating voltage on the screen grid.

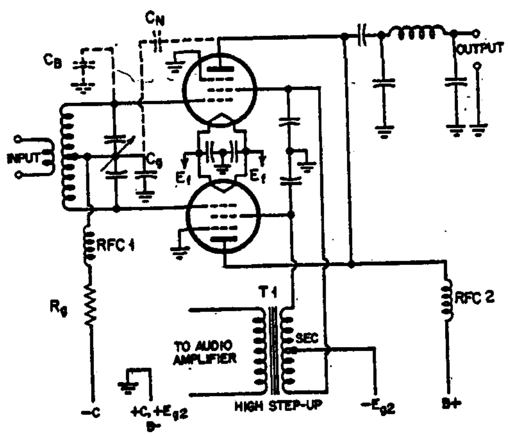
Another interesting feature is that the amplifier is *self-neutralizing*. As shown in fig 1, the grid-No. 1-to-plate capacitance of one tube acts as a neutralizing capacitor for the other tube. When one tube is conducting, the other is cut off. The tube which is cut off serves as the neutralizing capacitor in a conventional capacitive-neutralizing system for the tube which is conducting.

Adjustment

Adjustment of the DSB class C amplifier is straightforward. However, particular attention should be given to the following items: (1) The value of negative dc screen-grid or grid-No. 2 voltage, (2) amplifier balance, and (3) the value of af grid-No. 2 voltage.

DC Grid-No. 2 Supply Voltage

The negative dc grid-No. 2 voltage for proper operation of the DSB amplifier must be determined experimentally. A 90 volt 'C" battery may be used for initial tests. It is suggested that the plate-supply voltage be controlled with a Variac or that a 5000-ohm high-wattage resistor be used in series with the plate supply to provide tube protection during the initial adjustment of the screen-grid voltage. With full ICAS class C telegraphy, plate voltage, and normal rf drive to the input circuit, the grid-No. 2 voltage is adjusted for plate-current cutoff. The value of negative dc grid-No. 2 voltage is not critical. Numerous tests were run with negative voltages ranging from almost twice the plate-current-cutoff value to values at which static plate currents were high enough to cause almost full plate dissipation. Operation under these extreme conditions, however, is not recommended. At too high a negative screen-grid voltage, a pattern like the one shown in fig 2B is obtained. Because more af driving voltage is required for a given rf output with a high negative grid-No. 2 voltage, audio distortion is more likely to occur in the modulator as a result of operation at increased af gain. Operation at too low a negative screen-grid voltage is wasteful of dc input power.



C_N—NOT REQUIRED FOR DSB-SC AND HAS NEGLIGIBLE EFFECT WHEN LEFT IN, AS IS DESIRABLE FOR AM-CW OPERATION.
C_B—BALANCE CONTROL (SEE TEXT).

FIG. 1

After proper adjustment of dc grid-No. 2 voltage, the plate tank circuit is tuned to resonance with the aid of a sensitive rf galvanometer or field-strength meter. The circuit is tuned for a maximum reading on the rf indicator. This reading indicates the presence of carrier which may be strong enough to require suppression. A check with local sources will give this answer.

Carrier Suppression Adjustment:

After the reading on the rf indicator is noted, the ends of the grid coil should be touched one at a time. (If the wire is uninsulated, a piece of tape should be wrapped around your finger.) If there is no reduction in rf indication, the final is balanced. If there is unbalance, a small variable capacitor should be connected to the end of the grid tank which causes carrier reduction. This capacitor should be adjusted for minimum carrier. The final is now balanced. The balance must be checked, however, if you change bands. If the grid coils are symmetrical, one small variable capacitor of about 10 μμfd should prove suitable. If the plug-in strip is symmetrical and your coil can be plugged in either of two ways, mark the correct way for the coil to go in after it is balanced in the amplifier. For multi-band operation, a small balancing capacitor may be used in each grid coil as a padder across the tuning capacitor.

AF Grid-No. 2 Voltage:

The adjustment of af grid-No. 2 voltage must be made properly if serious distortion and excessive bandwidth are to be avoided. It is advisable to use an oscilloscope for this adjustment. The test setup is shown in fig 3. This test should be made before the transmitter is put on the air because it provides direct indication of transmitter performance. This test will be discussed in detail later. At this point it might be well to consider the development of the necessary af modulating voltage.

Because the screen grids represent a relatively high impedance load, very little audio power is required for modulation. The main requirement is that sufficient af voltage be available for modulation of the rf amplifier up to the point at which distortion and nonlinearity occur. At W2IYG an rms voltage of about 180 volts (per tube) was required for the 813's. Although no information is available regarding the exact af modulating voltage required for other tube types, an rms voltage (per tube) of about *twice* the value of the negative screen-grid voltage required for cutoff should be sufficient. Any 5- or 10-watt audio amplifier should be adequate provided it has a high transformer step-up ratio. Some experimentation may be required. (See the DSB article in last month's CQ.)

the Exciter:

It is *essential* that the VFO of your exciter be very stable! Otherwise, it becomes very difficult for your signal to be copied. Your "on the air" checks will show up instability immediately, so keep your VFO on zero beat.

Tune-Up:

Although output-circuit tune-up might appear to be a problem with this type of amplifier because of the suppressed-carrier feature, it is in fact very simple. With the input circuit tuned to resonance and normal flow of grid-No. 1 current, it is necessary only for you to whistle into the mike while resonating and loading the output circuit. Depending on your particular arrangement, the input circuit can easily be returned to parallel operation and B+ applied to the screen grids. At W2IYG this connection is made in seconds by a plug-in

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coil arrangement (fig 4A) and switch (fig 4B) which returns the amplifier to cw or AM service.

The very nature of this circuit provides excellent tube protection because, even with full plate voltage and no grid-No. 1 excitation, no plate current flows because of the negative grid-No. 2 voltage. Here is real foolproof operation!

Final Testing:

After the circuit and tube operating conditions have been established, one final test should be made with the aid of an oscilloscope to check the sidebands for distortion and nonlinearity.

With the transmitter under dummy load and a test setup similar to that shown in fig 3, tone modulation is applied and the rf pick-up link for the scope is adjusted until complete waveforms appear. If grid-No. 2 negative voltage is correct, af voltage is not excessive, and the amplifier is properly balanced, symmetrical waveforms such as those shown in fig 2A should appear. With excessive modulation, waveforms such as those shown in fig 2C and 2D will appear. Fig 2C shows "flat-topping" of an otherwise symmetrical waveform. When "flat-topping" occurs, the signal sounds distorted and begins to spread out and take up excessive frequency space. Fig 2D shows a combination of "flat-topping" and increased nonlinearity which creates serious interference. Fig 2E, with carrier showing, is caused by unbalance.

For those who do not own or have access to a scope, a low-range milliammeter (5 or 10 ma.) connected to read screen-grid current on one of the tubes will aid in the modulation adjustment. The screen grids should not draw current or distortion may occur. If there is doubt about the adjustment, the gain control should be kept low and some "on the air" tests made to determine the best setting of this control.

Typical Conversion

The test conversion made in one evening of the 813 transmitter at W2IYG was accomplished as follows:

The grid-No. 1 input circuit was converted for push-pull arrangement. This conversion was quite simple because plug-in coils were used in both the input and output circuits and a split-stator capacitor was being used. A push-pull input coil having a center link was constructed and the plug-in coil strip was rewired, as shown in fig 4. Conversion of the plate circuit was not necessary because of the original parallel arrangement.

Next, the grid-No. 2 (screen-grid) circuit was rewired as shown in fig 1. This operation involved only the disconnection of the positive screen-grid supply voltage and the removal of

[*Continued on page* 182]

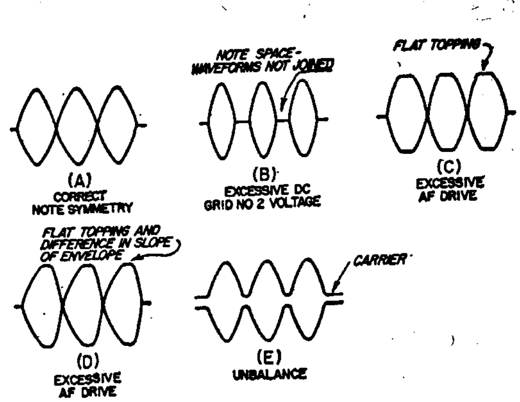

FIG. 2

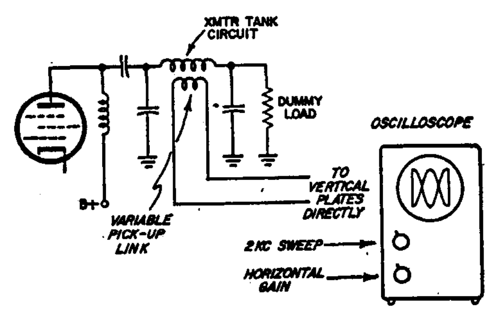

FIG. 3

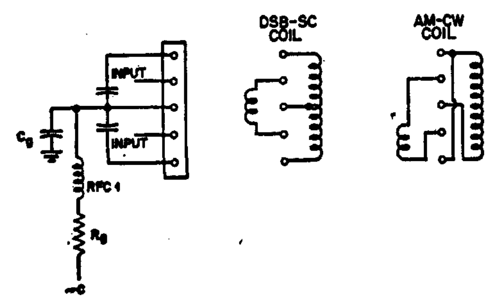

FIG. 4A

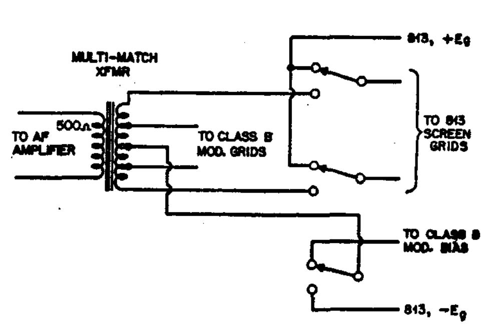

FIG. 4B

D S B [*from page* 51]

a jumper which tied the screen-grids in parallel.

Because this transmitter employed a 250-watt class B modulator, the af grid driving voltage to this unit could be utilized by connecting a pair of clip leads to the grids of the modulator tubes and pulling these tubes from their sockets. The secondary center tap of the modulator driver transformer was then connected to ground. This driver transformer was set for maximum step-up ratio, primary (500 ohms) to ½ secondary of 1:3. In the final setup, the push-pull 6V6 class AB1 amplifier produced more af voltage than was required.

Because some operational tests appeared to be in order at this point a dummy load consisting of two 100-watt lamps in parallel was connected to the amplifier output. The exciter was tuned up in the 40-meter phone band, and the 813 amplifier input circuit was tuned and adjusted for *normal class C operation*. The final amplifier plate voltage was gradually applied to the plate circuit. At 2200 volts the static plate current was too high, about 200 milliamperes. Negative voltage was then applied to the screen grids (about –90 volts). This voltage cut the plate current off completely. Next, the speech amplifier was turned on and, with the plate tank tuning capacitor and loading capacitors set near their normal tune-up values, the gain control was advanced while the writer whistled into the microphone. The final amplifier plate current gradually increased, and the plate tank circuit was resonated. With loading, the dummy load lamps came to brilliance at a plate current of about 125 milliamperes. An "on the air" check with the SB group produced exciting results. All reports were readability 5, all the way to the West coast. Critical reports indicated excessive carrier, unbalance in the sidebands, and some distortion. Because of the encouraging results obtained with only one evening's work, further work on the system was continued for several weeks. During this period, numerous adjustments and measurements were conducted, and "on the air" tests were made almost regularly with the same group of SB stations. The results of this investigation supplied most of the information contained in this article including the typical operation values for a pair of 813's shown in Fig. 5.

DC Plate Voltage	2250 volts
DC Grid-No. 3 Voltage	0 volts
Grid-No. 2 (Screen-Grid) Voltage:	
DC*	—90 volts
AF° (rms, per tube) approx.	180 volts
DC Grid-No. 1 (Control-Grid) Voltage*	—150 volts
Peak RF Grid-No. 1 Voltage (per tube)	275 volts
DC Plate Current:	
For zero af grid-No. 2 signal, approx.	0 ma
For max. af grid-No. 2 signal, approx.	125 ma
DC Grid-No. 2 Current	#
DC Grid-No. 1 Current $	20 ma
Grid-No. 1 Driving Power, approx.	8 watts
Average Power Output, approx. (total for two tubes)	210 watts

* At W2IYG, —90 volts obtained from common fixed supply. Additional —60 volts for grid No. 1 obtained from resistor of 3000 ohms.

° AF signal of 2 kc.

\# Negligible

$ DC grid No. 1 current drops 10 to 15% under maximum af signal conditions.

FIG. 5

The following chart clearly shows the power-saving advantage of DSB operation over AM operation:

AM Versus DSB Power Comparisons
(Values are for 813 transmitter at W2IYG under max. af signal conditions

	AM	DSB-SC
DC Plate Input Power (Final)	500	281 watts
DC Grid-No. 2 Input Power	32	0 watts
Grid No. 1 Driving Power	8	8 watts
Carrier Power	375	0 watts
Total Sideband Power (Average) for Sine-wave modulation	187	210 watts
DC Modulator Plate Input (including modulator driver)	353	20 watts
Total DC Input Power to Final and Modulator	885	301 watts

Note that the *AM* transmitter requires more than 3 times the total dc input power of the DSB transmitter for *about the same* sideband power! When filament and bias power requirements are included for the AM modulator stage, the figure is closer to 4.

On the Air Operation

For those who have never tuned in a suppressed-carrier signal, double-sideband or single-sideband, your present AM-CW receiver can demodulate a suppressed-carrier signal only when a carrier of sufficient strength and frequency is present at your receiver. To supply this carrier it is only necessary that your BFO be turned on. First, however, the sideband station should be tuned for maximum response. Keep the rf gain *low*, and the af gain high. Turn on the BFO and adjust the pitch control until the signal becomes readable. Adjust the main tuning dial for maximum intelligibility. Slight re-adjustment of the rf and af gain controls and BFO will produce complete readability with no "Donald Duck" effects. This final frequency is the one at which you zero-beat your vfo. The use of a crystal filter or Q-multiplier to improve receiver selectivity aids in the rejection of one of the sidebands and reduces phasing effects. The ideal solution is to add a sideband adapter to the receiver. Stand by until there is a lull in the conversation, then break in with your call. Keep your pencil handy because, if your experience turns out to be like the writer's, you'll have more qrmless qsos in a shorter period of time than you have ever had before. You're on your own! Happy "carrierless" hunting! ■