MEGABOOSTER

Frequency Tripler Gives 432 MC Output with 144 MC Input

The Megabooster is a final amplifier designed for operation on the 430 to 450 megacycle band. No driving stages are incorporated, as the Megabooster may be driven by practically any 2 meter transmitter. The power output is sufficient for experimental work on the 3½ meter band. The Megabooster is easy to build and it may be modulated with any five to ten watt audio amplifier.

WHY CRYSTAL CONTROL

Because the 3½ meter band is so wide, it may seem unnecessary to use an MOPA or crystal controlled rig. However, definite advantages come from this type of transmitter. From the transmission standpoint, several watts of output from a modulated oscillator will go as far as the same power from a crystal-controlled rig. The main advantage in using crystal control is to give the receiver at the other end a chance to do a better job. If a relatively narrow band can be used, a 430 megacycle converter can be used with a regular receiver. This setup is much more sensitive than the usual wide band or generative receiver, which it would be necessary to use if a modulated oscillator were used. Of course, a special receiver, with a very broad i-f system could also be used.

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CIRCUIT CONSTANTS AND PARTS LIST

C1 = 12 mm/section butterfly condenser (Hammarlund BC-13)
C2 = Made of varnished cambric (see text)
C3 = Plate tuning condenser (see text)
C4 = Tank tuning condenser (see text)
J1 = 3 T No. 14 wire; 3/4 inch inside diameter
J2 = 4 T No. 10 wire; 1/2 inch inside diameter (see sketch)
L1 = 30 T No. 18 wire; 1/4 inch inside diameter; close wound
L2 = Plate lines (see sketch)
L3 = 1 T No. 10 wire; see photo
L4 = 30 T No. 18 wire; close wound on 100 ohm 1 watt resistor
R = 2300 ohm 3 watt
T = 6.3 V a.f. amplifier transformer
T1 = GL-2C43 tubes
T2 = S-10 D 1 X 3 inch cabinet
T3 = SO-239 Ampexmetal coaxial connectors
T4 = 1/4 inch shaft bearing
T5 = Octal sockets
Misc. brass and polyethylene as per sketches.

CIRCUIT DETAILS

The circuit diagram of the Megabooster is shown in Fig. 3. A pair of General Electric GL-2C43 Light- house tubes is used in a grounded grid tripler circuit. Grid drive is applied to the cathodes of the two tubes. This circuit is similar to the usual grid input circuit except that the center-tap of coil L3 is grounded instead of going to a bias supply.

The grids of the tubes are tied together and con- nected to ground through capacitor C1. The plate tank consists of a parallel line circuit, with a shorting bar for rough frequency adjustment and a tuning capacitor, C4, for fine frequency adjustment. Metering is accomplished by jacks J1 and J2; grid current being read in J1, and plate current being read in J2.

CONSTRUCTIONAL DETAILS

The main chassis (5 X 10 X 3 inches) as shown in Fig. 4 forms the base for the Megabooster, and the smaller 3 X 1 X 4 inch chassis acts as a shield for the plate lines and the output link, L4. The tubes are mounted under the chassis, with just the plate lead extending through the chassis deck. Fig. 5 shows in detail how the traps are mounted. Two three-quarter inch holes are cut in the chassis to match with the holes in the plate shown in Fig. 7E. A piece of varnished cambric 2 X 4 inches is placed between this plate and the chassis and forms capacitor C2. The grid ring in the GL-2C43 is flush against the plate and is kept from slipping by soldering a wire ring around the hole.
Fig. 3. Under-chassis View of the Megabooster

Fig. 4. Same view as Fig. 3, showing the plasma connectors.

Fig. 5. Input connector, C1, is mounted on the chassis.

Fig. 6. Postion of the components on the chassis.

Fig. 7. Constructional Details of Parts Described in the Text

Operating Adjustments

An output of 5 to 7 watts or that obtained from an ROC-121 transistor on 144 megacycles is ade-quate to drive the Megabooster. More driving power can be used as long as the coupling is arranged to provide the proper amount of power. Grid current to the two GL-243 tubes should run from 30 to 60 ma.

When the cathode circuit is properly driven, plate voltage can be applied. No installation is necessary because of the grounded-grid circuit. With the limit side of the small chassis removed, resonance may be indicated by a neon lamp held close to the plate lines. If the plate shorting bar is moved up and down when the neon lamp is at maximum brilliance, condenser C1 is used for fine adjustment.

With the line side of the small chassis replaced, it may be found necessary to resonate the coil. This will depend, in large part, on the antenna used. This latter adjustment may be made with the other side of the chassis removed. It is also convenient to adjust the line condenser, C2, from this side.

Plate current should be approximately 50 ma at resonance. Under these conditions a measured power output of three watts was obtained on the unit pictured. It is very important to match the output link to the antenna in order to get maximum output. It may be necessary to spend more time determining the proper size for the link and the plates of C2. They will depend on the line used and also the type of antenna used.

It was found that the addition of the shielding plug to the plates more than doubled the power output obtainable.

Plates in order to achieve maximum output. One side of the link soldered directly to the chassis, power conne-

Fig. 1. The Megabooster.

Fig. 2. The Megabooster with the chassis removed.

Plate 1

Plate 2

Plate 3

Plate 4

Plate 5

Plate 6

Plate 7
The screen grid is probably the most critical single element in modern high-gain tubes and yet it is un-derstood by most experimentalists. This is because most people look upon the screen grid as an element which is supposed to be frequency-constant, and because the screen seems to go no place in particular in the circuit he completely neglects it. He feels that once he has connected the screen voltage lead that he is through with that part of the circuit until the rig wears out. (The latest census lists 1,250,321 cases of parasites due to improperly bypassed and stabilized screen circuits. The adding machine broke down before the number of resultant key clicks was totaled—Editor's note.)

If the screen is important, let us see why. The best way to do this is to compare triodes and screen-grid tubes. A comparison on this basis brings out the following points.

(a) In a triode there is a large capacitance between grid and plate. If this capacitance is not taken care of by equalization, the resultant feedback voltage may vary with oscillation. In a screen-grid tube, the screen, if sufficiently bypassed, acts as an electrostatic shield between grid and plate and therefore materially reduces the feedback.

(b) The plate voltage (and grid voltage) in a triode determines the inverse of cathode current that flows. In a screen-grid tube, the plate voltage has a negligible effect in determining the amount of cathode current because the screen wire acts as a shield between plate and cathode. It is the screen voltage (and grid voltage) which controls electron flow in a screen-grid tube, just as the plate voltage controls the electron flow in a triode. Obviously then, if the current flow is to be held constant, then the screen voltage must necessarily be held absolutely constant.

Thinking now of an actual circuit using a screen-grid tube, what do the above two points mean? Let us assume a screen-grid tube in the final stage of our rig. With the antenna tightly coupled to the final tank, we find that the plate current isn't high enough to suit us. The link is therefore coupled tighter and we now get considerable more input. However, the plate current does not increase appreciably. At this point the average design decide that his bias won't load up properly. Actually all that happened was to be expected. In point "b" we stated that the current depended upon the screen voltage. Since such a screen voltage was not affected by increased loading, we found it difficult to change the plate current all that was required as increased loading was a decrease in power output, because the plate voltage being decreased as the loading was increased and the plate dissipation went up.

The other extreme of loading—too little load—we come to the exception in rule "b." That is, too little load will bring on a condition where the plate voltage will affect the cathode current. Practically this means that if the final is lightly loaded, the screen current will be high (even over rating), the plate current low, efficiency poor, and output low. This is the same condition we had above in the triode (using screen-grid tubes) will have a large voltage swing, and the maximum voltage on the plate will occur when maximum current should flow. With a low enough plate voltage, the electrons in the tube will not be attracted to the plate as strongly as usual. These electrons will therefore tend to collect on the screen-grid. This large increase in screen current may harm the screen, as it is a flimsy element in comparison to the plate, and is not capable of dissipating too much energy.

Many amateurs have found from first-hand experience that this last point is true. When an ECO is lightly loaded so that this effect takes place, a slight change in loading will change the frequency quite a good deal, whereas the same ECO, when heavily loaded, will be affected far more by a load change.

Adding up the information above we see that by which we may formulate four rules for operating screen-grid tubes that are to make them do the fine job they were designed to do.

1. Carefully bypass and install the screen circuit so that it acts as a good shielding device. This means that the bypass component leads must be properly placed. Also, external shielding should be used on the tube if such is recommended.

2. Make certain that the screen voltage is accurately held to the design value. If the circuit is keyed this may require a separate, stable source of voltage. It is also important that an accurate voltmeter be used. The voltmeter part of voltmeters, especially home-made units, may easily be off 20—30% if the voltmeter is an old instrument.

3. Make all loading adjustments carefully for maximum power output and maximum circuit efficiency. Loading an amplifier or final too lightly or too heavily will cause the circuit to operate inefficiently. Maximum power output will be obtained when the load is neither too light or too heavy.

4. Install a screen current monitoring position. A screen current meter, connected in the circuit at all times as is preferred. This will help to avoid accidental damage to the screen due to overload. Also, a screen current meter is an invaluable aid in the tuning-up process, as this meter is much more sensitive as a tuning indicator than the plate current meter.

When a screen-grid circuit is unloaded, plate current will be very low, but the screen-grid current will be high. As the loading increased the screen current will drop off as the plate current rises. A point will be reached where further increases do not affect the screen current. This is the approximate point of proper load. Further increases would be to the detriment of screen output as the loading was increased, and adjust the loading for maximum output—Lighthouse Larry.

**PARASITICS**

Fig. 4, page 3 of the May 1948 Ham News is in error. The load going from the top of Rs to C should be removed from C, and added instead to the bottom of the secondary of Ts. The grid from the bottom of the secondary of Ts, the C, and from the bottom of Rs to the top of Rs should be replaced with a shorted wire.
How many times have you built a piece of high-frequency ham gear, which had been described in glowing terms in your favorite radio publication, only to come to the conclusion that the author of the article probably never had it working either? You proceed to check and recheck the wiring, closely suspect the photographs to be correct, and your layout to be identical, measure the values of all components, and still it oscillates when it shouldn't, won't oscillate when it should, or just doesn't have the pep that the article led you to expect it to have.

Before you condemn the gadget and discard it, consider the one remaining factor in the construction, a factor which incidentally is not apparent from the circuit diagram and not always apparent from the photographs. That factor is the method of wiring, such as the placement of leads, the points of connection to the various components and the length of leads. Also to be considered is the type and characteristics of the components used. All of these points become increasingly important as higher frequencies are considered.

In a high-frequency circuit composed of resistances, capacitances and inductances, it is important that you use only resistances where such is called for, use capacitance only where a capacitance is specified, etc. This may sound obvious, but a resistor next to a lead, and the lead next to a capacitor, is not a capacitance series with the resistor and the lead has a capacitance to ground. Minus detail. Not at all sample. A one-inch length of No. 26 solid wire has an approximate inductance of .03 microhenrys. This means that one inch of this wire will resonate at 140 megacycles with parallel 60 uf. of capacitance. We can control the lead lengths of various component parts, but we cannot control the components themselves, except to select the best.

The small size one-half and one-quarter watt composition resistors are generally suitable for high-frequency circuits. In the capacitative line, sliver-mica button capacitors, high-capacity ceramics and regular tubular ceramic capacitors are available for bypassing in coupling and coupling applications.

Fig. 8 shows the circuit diagram of a typical mixer circuit using a 6AK5 miniature tube. This type of circuit embodies most of the principles of high-frequency wiring techniques. These same principles are of course applicable to radio-frequency amplifiers and oscillators. Fig. 9 is a photograph of this 6AK5 mixer circuit wired in two different ways. Circuit-W and the two methods are identical, but the layout on the left uses high-frequency components and high-frequency wiring techniques, while the right-hand layout illustrates the more common type of wiring technique which should be avoided at high frequencies.

With reference to Fig. 9, the tuning condenser, C9, is in the lower left section of both circuits with the grid coil directly above it. The I-f transformer is mounted in the upper-right portion, with only the six leads extending below chassis. The similarity in layout stops at this point. In the right-hand unit minia condensers are employed for bypassing. These condensers all go to ground at a common point, and the leads from these points are brought to the condenser leads. The coil leads on the right-hand unit are silvered-mica bus-bar condensers which are mounted around the tube socket so that each condenser is opposite the socket pin to which it connects. One end of the bus-bar condenser bolts to the chassis and the other end has a lug which ties directly to the socket lug. There are no leads added to these condensers and hence a minimum lead length is obtained.

Another interesting point is the grid coil and condenser combination. In the right-hand unit the coil leads connect to the condenser and then two long leads of wire go from the condenser (C9) over to pin No. 1 and the other to ground. These long leads have inductance which is in series with the condenser coil combination. Note how this series inductance is eliminated in the left-hand unit. The top coil lead goes directly to pin No. 1 and the condenser is connected to pin No. 1 through a piece of one-eighth inch wide copper strap. This strap has very little inductance. The lead from the grid to the coil has inductance but it forms a part of the coil inductance. The other two leads ground directly to the chassis, the

Fig. 8. Circuit diagram of mixer circuit described

Fig. 9. Wiring technique—high-frequency construction on the left, usual construction on the right
How did you solve that last problem that almost had you stumped? Be it about tubes, antennas, circuits, etc.—lightening Lord would like to tell the rest of the gang about it. Need I tell each "brick" publisher you with $10 worth of 0.125 starboard tubes. No return required. Many thanks for your cooperation and send your "love-letter" for and at Lippincott, Lerry, Take Division, Dept. 309, General Electric Company. Salutations—To all from Canadian General Electric Company, Ltd., Toronto, Ontario.

PLUG-IN VARIABLE LINK
A medium and high power transmitters a variable link with plug-in coil is highly desirable to meet a wide variety of impedances, frequencies and loads. Also, for the suppression of harmonics, it is desirable to ground the center of the link.

With these thoughts in mind and a view to simplicity of construction and availability of material, the plug-in variable link (Fig. 18) was designed. Some dimensions such as the tank coil diameter, distance from center of tank coil to center of shaft, and width allowed in tank coil for link will be determined by each individual case. Other dimensions as used by the author are suggested. A piece of mica 1 in. thick and 2 in. long was used to mount the coil. Its width depends on the space available in the tank coil. These holes are drilled and tapped for 3-32 machine screws. Screw in tightly three small brass banana plugs. Cut off the two outer screws flush with the top and allow the center one to stick up about 15 in. A small hole just large enough for the wire is drilled near one of the outer plugs. A coil is made up of two, four or six turns so that the center tap can be added to the top of the screw of the center plug. The ends of the coil are brought through the two holes, bent over and soldered to the base of the plug. The coil will be self-supporting if correctly wound. It will be noted that an odd number of turns was used because it is not affected by the beat of the similar link.

The arm is composed of another similar piece of mica, a piece of mica 1 in. x 3 in. x 1/8 in. The mica discs have three holes drilled in it at the same time that the coil is wound. One support and two position holes are drilled with a 3/8 in. drill and the center with a 1/8 in. drill. In the tap hole, brass jam nuts are inserted and the nut run down to within one turn of being tight. The lead wire is then soldered to both the nut and the jack. This allows the 15 in. dia. Jackson to be used in the 1/8 in. holes, to compensate for mechanical controls, and will give good contact with both jacks.

For the center jack a 1 in. X 1 in. copper or brass sheet was used. Shape is not necessary. The other two jacks are supported on the back of the mica and will provide the proper connections to three of each. It is drilled hole up in the middle of the brass jack with the head being drilled out further to accommodate the base of the plug. The pins are then drilled lengthwise and tapped for the 3/32 in. machine screws. When this has been screwed down firmly, drill a hole through the side of the bakelite arm passing through the 1/8 in. screw and tap for 3-32 screw. This provides the ground connection. Lastly drill the hole for the shaft at the desired distance from the center of the jack and provide one or two set screws to hold it in place in ferrule. —W. P. H.

NOISLESS SLIP RINGS
Continuous rotation of large antennas is highly desirable especially in cases where the antenna cannot be viewed from the shack to check "winding" feeders. Coaxial rotary joints are available but open wire or twisted pair type of feed lines usually require a difficult slip ring and brush assembly. With reference to Fig. 115, the rings are 15 in. wide bands shaved from large diameter aluminum tubing. They are supplied around the mass by multiple sectors which also act as guides for the stationary contacts. These contactors consist of loops of braided copper shielding slightly larger than the rings. The loops are held tight by small springs and make contact over approximately 270° of the ring surface. This unusually large contact area permits absolutely noiseless reception and transmits power distribution quite well. With rings 10 in. thick spaced 1 in. between centers and standard 15 in. braided shielding, no mismatch was apparent in a 300 ohm tuned feeder system. Clear spacing would suit 15 ohm line and wider spacing would be used for open wire lines. —W. D. F.

QSL CARD DISPLAY
The usual method of mounting QSL cards on the wall results in a rather messy looking wall, with thumbtacks being used on each card. However, if the QSL cards are connected together (see Fig. 15C) with staples, a neat and compact display card up which will require only two thumbtacks for mounting —W. D. S. B.

EYELET HOLDER
In dismantling war surplus equipment and making changes in existing equipment, it is sometimes necessary to remove eyepins or rivets. The usual procedure is to drill into the side of the eyebolts with some advantage to the drilled part or rivet is removed. This work is nicey, except that, the rivet is usually a set in position and a 1/16 in. drill which is fixed in the war. This prevents the eyepin from turning. It may be necessary to experiment to get the right drill size, and in some cases it may be necessary to drill a small pilot hole on the underside so that the fixed drill can bite into it. —V. D. N.

![Fig. 10. W. D. F.'s Variable Link, W. D. F.'s Slip Rings, W. D. S. B.'s QSL Card Display](image-url)
STAND-BY OPERATION

Question: If a ham transmitter is not used for an hour or so, between contacts, is it better to leave the filament voltage on, or should it be reduced, or should the filament voltage be turned off entirely?—WKEB

Answer: High power S-band-ranger filament transmitting tubes should be operated at eighty per cent of normal filament voltage during stand-by periods of less than two hours and shut down entirely for longer periods. For transmitting tubes of less than 250 watts plate dissipation the filament voltage may be removed for stand-by periods greater than fifteen minutes. There should be no reduction of filament voltage for periods of less than five minutes. However, the filament voltage may be reduced to eighty per cent during stand-by periods greater than five minutes, if desired.

Transmitting tube filaments should not be kept on unnecessarily, because in throtled-upaged filament tubes, the rate of deterioration of the filament goes down as the sater rate goes down. Therefore, if the plate-voltage is off as long as the plate voltage on.

Grid-casted filaments or cathode junctions should be operated at normal filament voltage during stand-by periods. If these periods exceed two hours the filament voltage may be shut off—Lighthouse Larry.

STORING SPARE TUBES

Question: Do receiving and transmitting tubes deteriorate in storage? What precautions should be used to keep spare tubes in the best condition?—C. R. New

Answer: As a usual thing, high vacuum transmitting tube filaments change slowly while being stored. However, to insure that tubes used as spares are in as good a condition as possible, it is advisable to put them in the equipment in which they are intended to be used and operate them for a few minutes. The test should normally be performed at three-month intervals and the conditions of operation should be within the tube manufacturer's specifications. However, if the tube cannot be operated in the actual equipment for any reason, some test may be obtained by operating it stastically using sufficient d-c load to prevent excessive electron currents or discharges. In all such cases care should be taken to ensure that the voltage is not exceeded.

Receiving tubes may be handled in a similar manner. It is desirable to check them in the actual equipment every three months. In the event that such equipment is not available the receiving tubes may be checked in a regular tube tester.—Lighthouse Larry.

FREQUENCY FOR TYPICAL DATA

Question: When controlling information to be published as "typical operation" data for RF power amplifier tubes, are data made at any specific standard operating frequency or is the published data an average of tests at various frequencies? Grid driving power, for example, as listed in technical information sheets, could not be regarded as a constant for a wide range of frequencies. If there is a standard frequency, where is it published?—N.A.

Answer: When the design work on a transmitting tube has been completed, the engineer usually knows the approximate frequency at which the tube is capable of operating for a full rating. The tests are then made on the tube at various frequencies near the approximate maximum frequency. From this data the engineer determines the exact frequency for operation at full ratings. This frequency is called the "absolute maximum frequency." Let us assume for purposes of discussion that this frequency is 12 megacycles. It is then possible to determine the approximate condition which will apply for any frequency up to and including 30 megacycles. In addition, the engineer may further put additional on the tube, for operation at frequencies above the frequency for maximum ratings. These higher frequency ratings are normally lower than the lower frequency ratings, and usually these ratings are expressed as a percentage of the low frequency ratings. For example, if 25 megacycles is the frequency for maximum ratings, two other frequencies such as 80 and 100 megacycles may be selected. The maximum permissible percentage of rated plate voltage and plate plate current for class C. Telegraphy service could be 100% at 30 megacycles, 75% at 80 megacycles, and 50% at 100 megacycles. The tube data will usually give information of this sort, or, if lower ratings for higher frequencies are not recommended, then the data sheet will give the frequency for maximum ratings.—Lighthouse Larry.

V-RUBE JUMPERS

Question: What is the purpose of the jumper lead (pins 3 and 7) in the V-Rube tubes such as the GL-OA/ VR31 and the GL-OGB/VR90 and WMBVR?—WKB

Answer: Voltage regulator tubes are used in circuits when it is necessary to supply a constant voltage to a load. In most cases the circuits would be so arranged that the plate voltage or the grid bias would change to a higher voltage. This would, of course, affect the grid current and, at a certain point, the tube unit would turn on when the V-Rube tube was not in the circuit. To prevent this the tubes GL-OA/VR31 between pins 3 and 7 in the base of the GL-OA/ GL-OGB/VR90, GL-OGB/VR91, GL-OGB/VR140. This wire connects, in no way, with any of the plate voltage tubes and it is inside the envelope. The circuit is therefore wired so that this jumper is in series with the primary of the transformer which supplies d-c voltage to the V-Rube tube. Taking out the V-Rube cut of its socket through the transformer. The two miniature tube voltage regulators, the OA2 and the OGB, are also made so that a jumper connection can be used. However, certain precautions are necessary. In the case of the OZA and the OGB the jumper connection is inside the tube. If 115 volts a-c were to be applied to these jumper connections, a gas glow might occur in place of the a-c voltage. This glow would probably injure the tube, or at least prevent it from operating properly. Also, when the jumper is arranged in the tube so that it is connected to the anode and the plate, for example, in the OA2 and the OGB, pins 3 and 5 are sending con- entropy from the power supply is con- nected to pin 3 and the lead to the load is connected to pin 5, then the load will be removed if the tube is "removed from its socket."—Lighthouse Larry.
condenser being connected through its lug to ground and the coil being soldered directly to the metal base of the Millics slug-tuned form. Making all ground leads to one point has long been a favorite wiring trick, but in high-frequency work it is usually far better to ground to chassis at the clearest point. Incidentally, make sure that the chassis is clean and bright before tightening the ground lug. In some cases, where grounds are made at random, it may be necessary to shift the grounding point slightly, although usually this will not be necessary.

A solid copper strap as shown will always give a lower inductance lead than a wire lead, and is even better than tinned brass, according to tests by the writer. However, the strap as shown was used at 146 mc. on broad and solid copper of the same cross-section showed that the solid strap had a Q two and a half times as high as the Q of the copper lead. This great decrease in FR loss is a definite help at three frequencies.

Another good point is to place a portion of the IF transformer tuning capacity at the plate pin of the tube. In the right-hand unit the plate lead (pin No. 5) goes directly to the IF transformer. This long lead has inductance and is liable to cause a high-frequency parasitic, even though the IF transformer works at a relatively low frequency. The left-hand unit shows a capacitor from pin No. 5 to ground. (The resistor-like component with the five color bands is this capacitor.) As long as this capacitor is in the order of 10 to 20 mmf., most high-frequency oscillation voltages will be short-circuited. In effect this capacitor (not shown in Fig. 8) is in parallel with Cg. It would be even better if the padding capacitor in the IF cap were to be removed and wired in tight at the socket.

The last point is the proper use of the two cathode connections on the 6AK5 tube. As shown in the circuit diagram, juts 1 and 7 are both bypassed to ground. This reduces the impedance of the grid and is definitely desirable. If the ultimate in proper bypassing is to be used, then the double cathode load would be used differently. The original idea in making two cathode leads available was to prevent a common coupling impedance. This is done by wiring the grid returns to one cathode connection, and the plate and screen returns to the other cathode connection. In this system, only one side of the cathode is bypassed to ground. Inasmuch as this latter system is not always a convenient method, the wiring as shown in the diagram may be used and will be perfectly satisfactory except for the most critical cases.—Lighthouse Larry.