Low-Noise 220-Megacycle Converter

You have to hear "em before you can work "em, the saying goes. So here's a 220-megacycle "hearing aid" that will give the UHF old-timer a lift—and give the UHF tyro a good start. It's a 220-225-megacycle crystal-controlled converter that feeds a 10-15-megacycle signal into a communications receiver. Take a look, fellows.

--- Lighthouse Larry

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220-MEGACYCLE CONVERTER

CIRCUIT DESCRIPTION

This 220-megacycle converter uses 6AJ7 and 6AM6-type tubes developed by General Electric especially for high-frequency service. As shown on the circuit diagrams, two stages of radio frequency amplification are used. These are 6AJ7's in grounded grid service, rather than in cascade circuits because of the relative ease in getting the unit into operation. Performance does not seem to be impaired, because the noise figure was found to be between 3 and 6 db. In addition, the circuit is not critical to adjust.

A 12AX7 is used as a fixed oscillator, the first stage operating at 70 megacycles with an overdrive crystal in a Butler-type circuit. The second half of the 12AX7 triples to 210 megacycles, and this frequency is injected into the 6AM6's which are driven by means of a 1 micro-ohm cooled coupling capacitor. The resultant intermediate frequency varies from 10 to 15 megacycles, depending upon the frequency of the signal being received.

The 220- to 220-megacycle anode band then is covered by tuning the station receiver between 10 and 15 megacycles.

Two Butler-type circuits were built, both using a 70-megacycle overdrive crystal, and each oscillated separately. If it is desired to adjust the crystal frequency in use, it will be necessary to rewire the circuit and add another multiplying stage. In this event, a 777-megacycle crystal could be used in a stage which picks off its third overtone of approximately 23 megacycles and then multiplication continued to 210 megacycles as in the circuit described here. The oscillator circuits were set up initially with a grid-dip oscillator and required some later adjustment in tuning and coupling to optimize performance. The variable capacity available allow plenty of tolerance for circuit variations.

The 6AM6 mixer stage is a grounded cathode circuit. This tube has 96 grid pins, and no trouble was encountered in using any of these pins. The three unused grid connections were removed from the socket to minimize stray capacities. A first stage IF amplifier uses slug-tuned coils and a 6AJ7.

The 6AJ7 and 150 volts of B+ plus rated at 50 to 60 milliamperes and a 6.3-volt filament source that will handle 2.5 amperes. Both the filament and high-voltage leads are by-passed at the terminal block by feed-through capacitors (C9 and C10) to prevent possible interference from a strong station or transmitter. The 6.3-volt source might enter the circuit and great harm through the power connections. If such a station is nearby, it may be necessary to eliminate the 6.3-volt source in order to prevent possible harm on the chassis. Such precautions prevent frayed wires when trying to operate on 220 DC.

NOISE PERFORMANCE

As always at these frequencies, noise is an important factor, and this feature was closely examined in reducing this figure.

In the first place the UHF range the ultimate sensitivity of a receiver or receiver is limited by its noise figure. It is possible to reduce noise figure as long as possible. If the noise figure is reduced from 15 db (a common figure for A, 6, 6, 6, 6) then the same effect as raising by 10 times the power output of the station sending to the receiver. The 6AJ7 and 6AM6 tubes were designed to provide top performance at the UHF transmission design, but they perform beautifully at 220 megacycles.

A noise generator should be used to optimize performance. Both circuits have been described numerous times in amateur publications, and the circuit of the one unit to set up this converter is shown in Figure 1.

Fig. 1—Home-built noise generator uses a 0 to 2 ma meter

C—0.01 mfd ceramic disc or tubular
R—10,000-ohm potentiometer
R1—1 ohm, 1/4 watt
X—silicon diode (1N23 or 1N24)
M—0 to 0-2 ma d-c meter
B—2 cells

A silicon crystal diode must be used and the one shown here is a surplus 1N23 held into the circuit with a fuse clip and a pin taken from an octal socket. The time spent in constructing such a noise generator will be more than made up in optimizing performance of the converter.

The general procedure used for this converter was to first set its input maximum gain (as measured at the deflector of the station receiver) with a signal generator that will put out 1 volt on 0-2 ma meter. After this was done the noise figure of the converter was measured by a laboratory-type noise generator and found to be 9 db. The home-built noise generator was connected to the receiver, and adjustment made as described below until optimum noise performance was obtained.

While finally checked against a laboratory-type noise generator, the noise figure was between 5 and 6 db—decit Founder performance at 220 megacycles. It should be noted that optimum noise figure is not necessarily obtained at the point of optimum gain. Thus, in the absence of laboratory-type noise generators which can actually measure the noise figure, it is important to adjust for minimum noise figure on the home-built noise generator rather than for maximum gain.

PROVISIONAL CONSTRUCTION

Construction is not difficult, but should closely follow the layout and wiring of the model illustrated. The converter contains a total of 35 parts to be listed—45 collectors, reservoirs and coils. This average number of parts is included only five of the connections, but a number of them are particularly critical. The enclosed parts list has been carefully made with a view to assisting the reader in following the instructions in the above.

A 30x4-inch aluminum chassis should be laid out according to Figure 6—although slight variations are permissible to accommodate the actual parts the builder has gathered. It is wise to have on hand all the necessary parts—including the coils—before starting construction. They may be taken in drill notebook-mounting wire holes so that sockets will be properly oriented. All parts should be marked and the following parts can be mounted: HF connectors, terminal blocks, and feed-through capacitors, crystal socket, HF coil form, the 4-30 micro-ohm ceramic trimmer, the tubular ceramic trimmers, the variable air capacitor, and the four tie-points which support
the RF chokes and the 100-ohm dropping resistors. Miniature ceramic stand-off insulators made by Cambridge Thermionic Corporation are used for this last purpose in the model shown, but ordinary 1- or 2-point terminal strips will serve.

Before mounting the tube sockets, some of the unused lugs of the tube sockets of the first RF stage and the mixer stage are reduced to reduce stray capacity. In the first 6AK5 stage, tube socket lugs 1 and 3 should be removed, and in the 6AM5 stage tube socket lugs 3 and 8 should be removed. The tubes are completed by flattening the holding lugs in the tube sockets with a pair of long-nose pliers and then pushing them out through the top of the socket. When mounting the tubular ceramic trimmers (C1, C2, C3, and C4), note they should be oriented so their lugs can be soldered directly to the tube socket lugs. Small strips of copper about 3/16-inch wide are fashioned for soldering between pins 4 and 9 of the first 6AJ7 socket, and between pins 2, 3, 4, 6, and 9 of the second 6AJ7 socket. As shown in Figure 3, these shields are connected to the base sleeve of the socket.

COIL WINDING DATA

While coil specifications in the components list accompanying the schematic diagram are complete, it might be well to mention that L1 and L2 can be wound on any type form as long as the finished product, in the circuit, tunes the IF frequencies of 10 to 15 megacycles. After winding RFC, L1, and L2 on the thimbles of a 3/16-inch bobbin, it is possible to carefully unwind the bobbin from the coils without disturbing the spacing. It is wise to leave the leads longer than necessary until ready to wire the coils into the circuit.

WIRING DETAILS

The filament leads, RF chokes and high-voltage leads can be wired first. Wiring of the remaining components should follow—with the exception of C1, C2, and C4 and the input lead from the RF connector to the cathode of the first 6AJ7. Care should be taken to keep RF leads as short as possible. In wiring, note the placement of C1 and C2 on each side of pin 2 of the 6AM5 socket. Two capacitors are used here to reduce lead inductance. In the model shown (Fig. 5) two 200-ohm resistors are used for R2.

one connected to pin 2, the other to pin 7 (cathode pin) of the 6AM5. One 100-ohm resistor connected to either pin will serve, however.

Connection of C1, C2, and C4 and the RF input lead to their associated coils is somewhat critical for optimum noise figure and the adjustment procedure is described below.

ADJUSTMENT PROCEDURE

The home-bu!t crystal diode noise generator does not give noise figure in actual dB. It is a comparison device only, and merely tells the experimenter whether the adjustments he makes on his converter are in the right direction. With the particular crystal and components used in the home-built noise generator shown, it was found that 1 milliamperes of reverse current current—indicated on the noise meter meter—is equivalent to approximately 10 dB of noise when compared with a laboratory noise generator.

Unless the builder has access to such a laboratory instrument, he will not be able to measure precisely the noise figure of his converter. However, if the construction and adjustment instructions are closely followed, he can be sure that when he has attained optimum performance as indicated with his own home-built noise generator, the noise figure of his converter will be comparable to the converter described herein.

The adjustment procedure for obtaining the best noise figure involves moving the connections of the RF input lead, L1, C1, and C2. Of course, before these adjustments can be made, these components must be soldered in to check against and set the converter up for maximum gain. It is suggested that as a starting point the socket of the 6AM5 be soldered directly to the cathode pin of the socket of the first 6AJ7. The connections of C1, C2, and C4 and the input lead from the RF connector to the cathode of the first 6AJ7 can be made at the center of L1. Then C1 can be soldered from a point about a half-turn down from the plate end of L1 directly to pin 9 of the 6AM5. C2 can be connected between grid pin 4 of the mixer tube and tapped down about a half turn from the plate end of L1. With these connections made, the first step is to use a signal generator as mentioned above—a fellow ham's 270-ohm transmitter—and make the usual adjustments of the tuned circuits to get minimum gain. Once this is accomplished, the objective of subsequent ad-
Fig. 4—Chassis Input

Fig. 5—Bottom view of 230-megacycle converter. RF input at top left, second RF amplifier at bottom left center; mixer tube and slug-tuned plate coil (C) at bottom center; and IF amplifier and final tank coil (L) at bottom right. At top right is crystal socket, the 12AX7, C0, C1, and other components associated with the oscillator circuit. The 6L6G4 plate resistor and by-pass are hidden under the inner lip of the chassis. In this view most of the parts can be identified by checking their connections to tube pins.
REPAIRING CRACKLE FINISH

Top of metal cabinets often become dingy and un-
sightly with age. These surfaces are not readily cleaned with water or furniture polishes. A few experiments in my ham shack have resulted in a simple solution to this problem. Apply with a cotton cloth a few drops of mineral oil to the dull crackle finish. Wick off excess oil by hard rubbing with a clean cloth. Automotive oil such as Mo. 20 or 30 is excellent for this purpose. The original sparkle and uniformity of the finish will thus be obtained. Try it and you'll be amazed.

-By E. Burnett, W7TV

HOW TO GET G-E HA.M NEWS
The G-E HA.M NEWS may be obtained free from G-E tube distributors—$1 per year to Q.E. will mail G-E NEWS in your house. Write to: G-E HA.M NEWS, Tube Department, General Electric Co., Schenectady 5, N. Y.

PARASITICS

In the schematic diagram for the VTVM Adapter described in the July-August, 1954, issue of G-E HA.M NEWS (Volume 8, No. 5) a chassis-ground connection in the negative (black) lead circuit was not indicated. While this omission will not affect the dc operation of the adapter, the user will want to provide a return path for RF when using the RF probe with the chassis-grounded connector included.

"TRICKS & TOPICS"

flour, providing there is a 500-ohm output tap. Ordinarily, an 8-ohm audio output will provide enough voltage to measure conveniently.

Now the noise generator should be connected to the left side of the filter and the meter. The output of the receiver and converter turned on. With the noise generator at a level that is too low to be heard, the noise is set at a point where internal noise registers about 3 microvolts on the output meter. The noise is then filtered through the receiver. After this reference level is established, the receiver sensitivity controls should not be touched again during the noise performance adjustment pro-
cedure.

The next step is to turn on the noise generator and adjust its potentiometer so that the generator meter reads about mid-scale. (On the noise generator shown this would be 1 milliamperes.) Now note the percentage of increase in the output meter reading as compared with its reading when the noise generator is off.

From here on the object is to make changes in the converter's input and coupling circuits which will re-
sult in this same percentage increase in the output meter reading as compared with its reading when the noise generator is off.

The first adjustment to make on the converter to improve noise performance is to find the best point on L-1 to attach the input lead from the generator. The best point is that point on L-1 where the percentage of increase in the output meter when the noise generator is turned on is the same as it was before the adjustment procedure was started. If the coil tap adjustment is made in the right direction, the noise generator potentiometer adjustment should reduce the reading of the output meter. If, however, obtaining the same percentage of increase is accomplished by increasing the noise generator cur-
nent, the coil tap adjustment was a step in the wrong direction.

The next adjustment to make is the tap on L-2. The lead from L-2 will be soldered on the coil at various points—each time realigning the noise generator potentiometer to see if the noise generator current goes down when obtaining the same increase on the output meter. The same principles as before will be followed. The success of the output tuning is observed in ac-

2. Adjustment of C2 did not seem to make much dif-
ficence in noise performance in the converter shown. However, it might be worth while trying tapping the leads of this capacitor at different points on L4 and L5.
Several people have remarked, after reading about the Edison Radio Amateur Award season and the contests-up who received special citations, that they know someone who also rendered an outstanding public service. In each case, however, they took the trouble to nominate the amateur in question. Thus, this work went unnoticed by the judges of our Award. As in most such awards, one of the biggest jobs is hosting for Award candidates. This is especially true with amateur radio awards because for the most part amateurs are modest individuals. So if you know of an amateur you feel worthy of the Edison Radio Amateur Award, be sure to nominate him. The rules of the Award are given in our advertisements in the September and October issues of both CQ and QST magazines.

WeNAPA apparently found there are no secrets in a ham wedding—what with mobs all over the place reporting every movement. "Rolley HAM," published by the Ark-Bar-Bee Radio Club (W4QBO), with mobs stationed at the church and at the happy couple's "hidd'n" get-away car.

A note in "Sparky," published by the Brandon (Mississippi) Amateur Radio Club, informs us that VE4PA visited VE5CW and VE5OH and "spent a couple of intense hours watching the interchange on the air and listening to the ham talk. VE4PA is quite happy over these and a half minutes of transmission from Melbourne a week ago last Sunday—oh, oh, oh! Anyway it's a nice plee of furniture." Some of us in the "more advanced" TV locations are wondering if the lads up that way know really how well off they are?

"Show me a man who has a hobby and I'll show you a conscientious and enthusiastic public servant and effort is always above average. Of all the hams, it is safe to say that radio is the most complete politically and technically. No other hobby can be as much enjoyed publicly with as much enjoyment as can ham radio. Probably no other hobby has as many jalousie commercial interests exciting our assets. No other hobby can or has helped the advance of electronics as ham radio has done."

Thus we read in "Mare Sparky," published by the Michigan Amateur Radio Club (WPAEB). He adds that none of these achievements can or could be accomplished without the co-operative efforts of individual hams organized into clubs. Individually, he points out, we are but persons with hobbies; collectively, we constitute a power that can help not only ourselves but our community, our nation and the world. And I might point out all this is in addition to the fun and fine friendships club activities can bring.

Our first Bound Volume was so popular, we are getting a lot of requests for a second Bound Volume. The first volume contained all the issues of QST published from 1946 to 1949. We plan to make up another bound volume at the end of our second five-year period of publication. Thus our second Bound Volume will contain all issues published in the years 1951 through 1955.

We' re sorry it is so long between Bound Volumes, but publishing bi-monthly as we do, it takes long to accumulate sufficient issues to make binding worthwhile. If by any chance any of you wish to make reservation at this early date for the second Bound Volume of QST, we' d be glad to keep your name and address on file until the back is ready. But please do not send any money now! We sell the Bound Volumes at the cost of binding and handling (the first one cost $2 per copy) and we cannot tell at this time just what binding will cost a year and a half from now.

The editor was looking over ARRL's bibliography of TVI literature the other day and reminded us to remind you that we will have some back copies of the issues of QST which describe our TVI filters. In fact, we still have a few left. This highly effective filter by a home-brew amateur was designed to fit the MW-2 tube, and is described in the March 1951, issue of QST (Volume 6, No. 2). We'll be glad to send you a copy, if you want one. Incidentally, one of the fellows who read one of these little filters reported it was highly effective as a flare when lighting struck his TV line. He said the filter just seemed to evaporate. He couldn't find more than a few droplets of copper left. But the TV set was still there. He didn't recommend the filter as a substitute for normal lightning arresting precautions, however.

—Eightball Terry
A. R. KOCH, W2RMA

Art Koch, W2RMA—designer of the 220-megacycle converter described in this issue of G-E HAM NEWS—makes G-E UHF klystrons tick during the day. Then he goes home and makes UHF ham radio tick. He's a design engineer at the industrial and transmitting tube plant in Schenectady and has supervised the installation of UHF klystrons in a number of the nation's most progressive TV stations.

G-E's 12-kilowatt klystrons come in six types—each covering a segment of the 470 to 890-megacycle UHF TV band. They are tunable within their ranges and are triple-resistor type tubes. Klystrons stand up to heavy loads—consistently giving 75,000 volts at 3.5 amperes at 5.5 volts, and require 17,000 volts d-c at 3 amperes. Driving power averages 25 watts—and most stations use a 6X10 as driver. Two klystrons are used in a UHF-YF system—one to amplify the visual signal; the other to amplify the sound—and the two are mixed in a "Fitter" before being fed into the antenna.

Art, shown here setting up some gear to test a klystron, is the designer of one of the UHF cavities illustrated in the APRL Handbook, and the Super 140 (G-E HAM NEWS, Volume 8, No. 4).