Reduce the current. The color changes can be seen in seconds, so if it has not been dark for more than a few minutes, no harm has been done.

High current densities without circulation of the solution will result in lowered purity of the plated-out silver plus a chemical change in the fixer that will reduce the amount of silver you can reclaim.

When the silver has built up to a thickness of between 1/8 inch to 1/4 inch, remove the stainless steel bar holding the silver, rinse it in warm water, and let it dry.

To remove the silver, spread out a plastic or paper sheet, strike the plating sharply with a screwdriver, and it will crack. Simply chip off the plating until it is all removed. Return the stainless steel bar to the silver mine and continue.

Of course, this mine is not bottomless. The fixer solution will eventually become so low in silver content that it must be replaced with fresh solution. Fresh solution, in this case, means solution that has been used to process film and is no longer useful for fixing film because it is saturated with silver.

There are many methods to determine the useful plating life, i.e., silver content, of the fixer. The easiest but least accurate is the color of the solution. When it turns the color of medium strength tea, replace it. The more accurate method is to use the Kodak Silver Estimating Test Papers, cat. no. 1965466. When dipped in the solution, this test paper will turn from its normal yellow to some shade of brown. The darker the color, the higher the silver content remaining in solution. There is a color comparison chart on the back of the Kodak folder. I generally discard the fixer at a remaining silver level of 1 gram/liter.

To set up this simple silver mine, I used a carbon rod from a discarded D-cell battery, a 6-inch stainless steel rod, a 1-lb. plastic margarine container, and a battery, pot, and meter as previously described.

With no agitation of the solution, I maintain a current of 5 mA. I have been plating out approximately 3 ounces troy of silver per month. I am blessed with the availability of 12 gallons of fixer every 12 weeks that has a silver content of approximately 10 grams/liter. The amount of silver you recover per liter will depend upon its starting silver content, i.e., how much film has been processed through it and the average image content of the film.

The effect of the film image on silver content is that a very dark image has most of the silver left in the film. Conversely, a light image has had most of the silver removed. The Kodak test papers can be used to determine this silver content and, barring the probable contamination of the fixer with other chemicals, can be used as a guide to the useful life of the fixer.

The above method requires monitoring but twice daily and fixer replacement when required. If you have plenty of fixer and/or want a faster recovery rate, simply provide a means of gentle agitation. I have successfully used an old clock motor with a plastic shaft with a ½-inch by 2-inch paddle connected to the sweep second-hand shaft immersed in the fixer. This has yielded about an ounce a week. Larger electrodes, higher currents, greater agitation, and larger solution containers will of course increase the recovery rate.

So why throw good money down the drain? Dig into that silver mine and buy some more ham gear.■

✓See List of Advertisers on page 114

Fun-Equipment Revisited

Here are higher-band versions of the ever-popular Fun-Mitter and Fun-Amp. They are based on the Fun-Philosophy: cheap and simple.

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Home-brewing is alive and well! I reached this conclusion following the response to the publication of my series of "Fun" home-brew gear.[1-4] Response to the simple, low-cost home-brew units has been great, indicating that hams are still building at least some of their own gear. From nearly-Novices to long-time Extras, hams have built the Fun rigs and have discovered that building is easy, fun, and very rewarding.

Many requests have been received asking for different band coverage of the Fun-Mitter and its companions. This article is the result of those requests. It describes a simple CW transmitter for 15 or 20 meters operating off 24 volts and modification of the 20-Watt Fun-Amp for operation on the same bands.

The Fun-Ceiver and Fun-Oscillator are not included in this article on modifications due to instability problems at higher frequencies. Frequency stability is of prime importance with today's rigs and it is just too difficult to obtain the type of results desired on the higher frequencies and still maintain the objectives of the gear.

This second version of the Fun-Mitter is a five-Watt-output, crystal-controlled CW transmitter that uses either low-cost FT243 crystals at one-third the operating frequency or HC6U fundamental crystals on the operating frequency. If the variable crystal oscillator (vxo) capacitor is installed (C option), the frequency can be varied by as much as 10 kHz from the crystal frequency, using HC6U crystals.

This coverage allows enough flexibility to provide plenty of frequencies with only a few crystals. Crystals are cheap, easy to obtain, reliable, and very stable. They make simple transmitters easy for all of us to build!

Philosophy

An early objective with the Fun-Mitter and Fun-Amp was to design simple gear that was easy to build with parts that could be obtained from Radio Shack. The Mark II versions of these rigs follow the same objective with only the crystal and its socket not being found at Radio Shack. Other objectives: costs of less than $25 each, no tuning adjustments, and same size PC boards (2¼" × 3").

These objectives are continued in the higher-band versions. A twenty-meter transmitter and amplifier can easily be built in an afternoon and put on the air without adjustments. (The reader is strongly urged to review the articles on the Fun-Mitter and Fun-Amp for detailed construction and design descriptions.)

Circuit

The circuits remain unchanged from the original designs. The resonant circuit and filter values, however, must be changed to allow operation on the higher frequencies. Radio Shack rf chokes and disc ceramic capacitors again were used.

The Fun-Mitter schematic is reproduced in Fig. 1. The Pierce oscillator operates on the operating frequency using either third overtone or fundamental crystals. (A third overtone is simply three times the value marked on the crystal.) For example, to operate the transmitter on 14.060 MHz, either a 14.060-MHz fundamental crystal can be used or a 4.383-MHz crystal can be operated on its third overtone. (This allows the use of cheaper FT243 crystals in the Fun-Mitter.) Also, on fifteen meters many of the same crystals used for forty meters, when operating on their third overtone, will provide the frequency coverage desired.

Fundamental mode crystals in an HC6U holder do, however, have the advantage of more frequency range when used with the vxo capacitor (C option). I have had several HC6U crystals, however, that do not provide a stable, clean oscil-

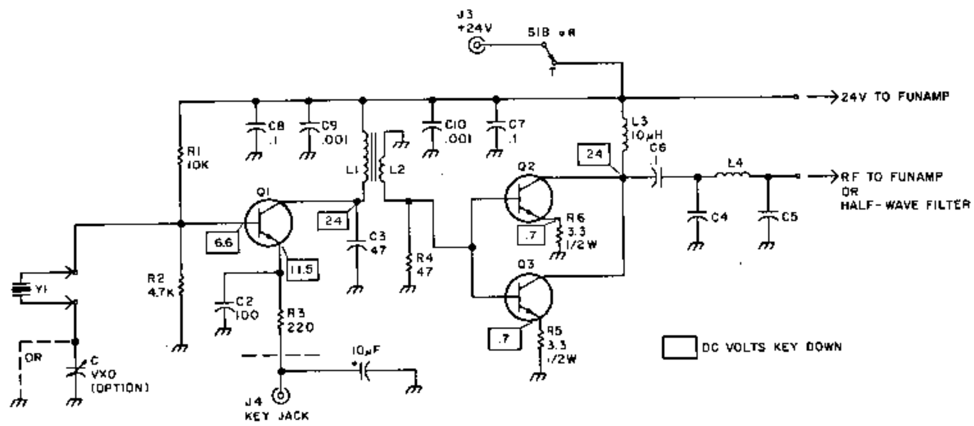

Fig. 1. Schematic of 15/20-meter Fun-Mitter. Reference designators remain the same as in the original Fun-Mitter article in order to match the parts locator for the PC board. Capacitance values less than 1 are in uF.

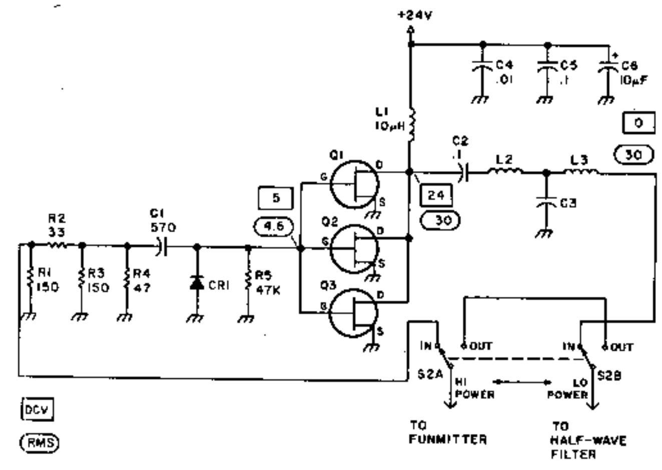

Fig. 2. Schematic of 15/20-meter Fun-Amp.

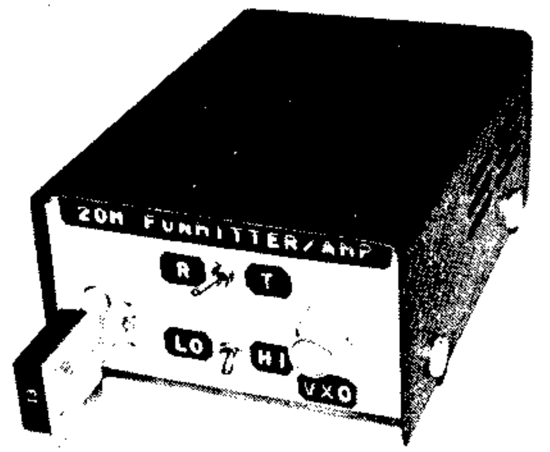

Photo A. Front view of twenty-meter version of Fun-Mitter/ Fun-Amp.

lator signal, probably due to the higher-than-normal power used in the Fun-Mitter oscillator stage. Although the FT243 will have a range of only approximately 1 kHz with the vxo, it will provide better and more reliable operation. (FT243 4.3- or 7-MHz crystals for use on twenty or fifteen third overtone will not oscillate on exactly three times the marked frequency. Depending on the crystal, they may be as much as 10 kHz lower than the marked frequency. Keep this in mind when ordering.)

L1 and C3 determine the resonant frequency of the oscillator. If L1 is constructed correctly, the oscillator should oscillate with no adjustments. A three-turn winding (L2) over L1 operates as a transformer to match the collector impedance of Q1 to the base impedance of Q2, Q3 and provide drive. Q2 and Q3 operate in parallel as a class C amplifier which provides good efficiency.

These 2N3866 transistors, Q2 and Q3, are being pushed to their limits in the Fun-Mitter circuit. Under some load conditions, some hams have discovered that Q2 and Q3 can be destroyed. To avoid this, either reduce the supply voltage to 20 to 22 volts or increase the value of R5 and R6 to 4 to 5 Ohms. Also, the 2N3866 part can be replaced with the much more rugged 2N3553. The only other components needing change are C4, C5, and L4 which, together, comprise a pi-network filter. Component values are given in the Parts Lists.

The Fun-Amp schematic is reproduced in Fig. 2. Using the Fun-Amp on other frequencies is even easier than using the Fun-Mitter on other frequencies. Only L2, L3, and C3 need to be modified. The input circuit remains completely un-

Parts Lists

Fun-Mitter—Fig. 1

C1-C10	Ceramic disc	272-xxx
C3	20m—47 pF 15m—47 pF	
C4,C5	20m—220 pF 15m—160 pF (2 220 in series, 1 47 in parallel)	
C option	Broadcast variable (any small variable with maximum capacitance of 100 to 300 pF will work)	
J3	Phono jack	274-386
J4	Phone jack	274-252
L1	20m—20 turns removed 15m—24 turns removed	273-101 273-101
L2	3 turns wound over Q1 end of L1	
L3	10 μH	273-101
L4	20m—25 turns removed 15m—27 turns removed	273-101 273-101
Q1	RS-2009	276-2009
Q2,Q3	RS-2038	276-2038
R1-R4	¼ Watt	271-1xxx
R5, R6	Each is three 10 Ω, ½ W 271-001 in parallel	
S1	DPDT toggle	275-1546
Y1	Crystal—FT243, HC6U	

Fun-Amp—Fig. 2

C1-C5	Ceramic disc	272-xxx
C1	570 pF (470 and 100 in par.)	
C3	20m—250 pF (2 47 pF in series, 1 220 in parallel) 15m—160 pF (2 220 pF in series, 1 47 pF in parallel)	
C6	10 μF, 35 V dc	272-1013
CR1	1N914 small signal silicon	276-1122
L1	10 μH	273-101
L2	20m—26 turns removed 15m—28 turns removed	273-101 273-101
L3	20m—24 turns removed 15m—26 turns removed	273-101 273-101
Q1-Q3	VN67AF VMOS FET	276-2071
R1,R3	150Ω, ½ W	271-013
R2	33Ω, ½ W	271-007
R4	47Ω, ½ W	271-009
R5	47kΩ, ¼ W	271-1342
S2	DPDT toggle	275-1546
	TO-220 heat sink (3)	276-1363
	Case	270-252
	Hardware	64-3012 64-3019
	Wire	
	Coax	

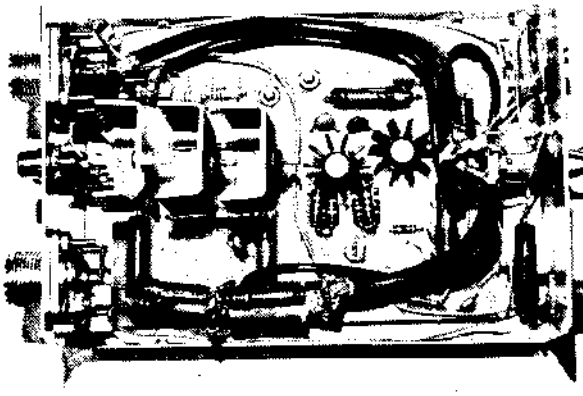

Photo B. *Inside view of twenty-meter version of Fun-Mitter/Fun-Amp. The coil shown connected between the crystal and C (optional) does not exist in the final version of the Fun-Mitter.*

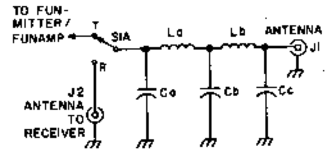

Fig. 3. Half-wave filter for 15/20-meter Fun-Mitter/Fun-Amp. The filter reduces any harmonic radiation to below acceptable levels. It is wired using point-to-point wiring between the antenna connector and S1. The filter provides receiver filtering by placing it before the receiver antenna connector. Values are as follows: use 273-101 10 uH rf choke with turns removed; 272-xxx series ceramic caps.

	20m	15m
Ca	220	150 (100 & 47 in parallel)
Cb	440 (2 220 in parallel)	320 (100 & 220 in parallel)
Cc	220	150 (100 & 47 in parallel)
La	26 turns removed	28 turns removed
Lb	26 turns removed	28 turns removed

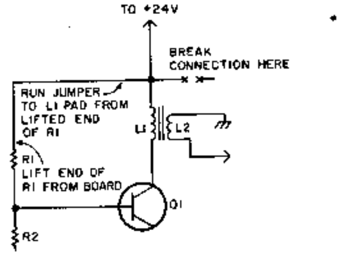

Fig. 4. Modification to allow "spotting" of transmitter (use when using PC pattern from the February, 1981, 73).

changed. This circuit operates very well at 15 and 20 meters due to the excellent frequency characteristics of Q1-Q3. A detailed circuit description is given in the Fun-Amp article.

Two additions have been made to the higher-frequency versions of the transmitter and amp. Fig. 3 shows a half-wave harmonic filter which reduces harmonic radiation. Also, a 10-µF capacitor (272-1013) has been added at the key jack (J4) to shape the keyed waveform and eliminate any key clicks.

Construction

Even though the Fun-Amp and Fun-Mitter are "goof-proof" projects, care and thought must be put into their construction. Although the fifteen- and twenty-meter versions are as simple as the earlier models, it might be helpful to review some pitfalls to watch for.

For best results, use of a PC board is strongly recommended.[5] Refer to the earlier articles for the patterns and component locators. The 2¼" by 3" format shown in Photo B is small enough to allow mounting flexibility. I would suggest that this format be followed. Combining several bands, amplifier, transmitter, etc., on one board can lead to problems, particularly if you are inexperienced in homebrew.

Before building, develop a plan as to how you will load the boards, assemble the unit, and test. After the plan is developed, proceed carefully. Most problems are due to misloaded parts, poorly soldered connections (rosin-core solder is a must!), faulty components, and hasty build-and-test. Most of these problems can be avoided by developing a plan and carefully and thoughtfully following it.

Radio Shack rf chokes are used as inductors by removing turns as necessary. Fifteen- and twenty-meter circuits require less inductance and, therefore, the coils will have fewer turns. In constructing the coils, be sure that the exact number of turns is removed and that insulation is scraped from the end of the wire that will be resoldered to the coil form. The three-turn Fun-Mitter coil (L2) that is wound over L1 should be wound in the same direction as the turns of L1. Also, wind it over the end of L1 that is mounted nearest Q1. The excess wire cut off when the turns are removed is excellent for wiring L2. Refer to Photo B for a view of the coils.

It is best to construct a single band in one box rather than combining bands. This is slightly more costly due to duplication of some parts, but it eliminates switching problems completely.

An advantageous modification to the Fun-Mitter is to allow a "spotting" function. This is helpful when finding your frequency on your receiver without transmitting on the air. This is accomplished by continuously applying 24 V to the oscillator stage. To do this, break the connection between L1 and L3, then connect L1 directly to 24 V. Also, one end of R1 is removed from the circuit board and a wire from it run to the 24-V side of L1. With this modification, pressing the key will produce a note in the receiver with the send/receive switch set to receive. See Fig. 4 for details of the modification.

Crystals can be obtained very easily. After deciding on either FT243 third overtone or HC6U fundamental, both crystals and sockets can be ordered from a supplier such as CW Crystals or Jan Crystals.[6]

Adjustment

Adjusting the high-frequency Fun-Mitter and Fun-Amp is just as easy as with the low-band versions. Again by thinking carefully through the process, the rig can be set up without problems in a short time.

If possible, find a VOM to use at this stage. Although not absolutely necessary, it is much more helpful and educational to see what is happening during tune-up. Begin by ensuring that you do indeed have a 24-V source (either lantern batteries or the Fun-Mitter power supply). Measure the voltage. With +24 V disconnected, measure the resistance at the voltage-input connector to ensure that no shorts exist to ground (use Ohms scale).

It is essential that a dummy load be connected to the antenna connector at all times during tune-up. For the Fun-Mitter/Fun-Amp combination, a dummy load capable of dissipating 20 Watts will be needed. Without a load, the transistors will be destroyed quickly.

The final step in tune-up is to attach an ammeter and begin testing! Connect an ammeter capable of measuring at least 1.5 Amps in series in the +24 line going to the gear. Set the T/R switch (S1) to "transmit." With the Fun-Amp switched out, the meter should read around 300 mA with the key pressed. Switching the Fun-Amp in should produce a reading of around 1.2 Amps with the key down, indicating a power input of around 30 Watts.

As can be seen, there are no adjustments to be made. This is one of the beauties of the gear. After building the units carefully, they should work the first time with no adjustments!

If trouble is encountered, check the following:

1. Isolate the problem to a stage—Fun-Mitter, Fun-Amp; if Fun-Mitter, does oscillator work?

2. Measure voltages at collectors and drains of transistors with T/R switch in T position (should read 24 V).

3. Check for wiring errors.

4. Check soldering.

Operating

The thrill of home-brew construction comes in the actual operation. Making contacts with gear you built yourself is fun! The high-frequency Fun-Mitter and Fun-Amp easily will produce worldwide contacts. Twenty Watts on 15 or 20 meters can bring in contacts from all continents easily.

With the capability of 15- through 80-meter operation with the Fun gear, WAS, WAC, and DXCC are all within reach. Good luck! ■

References

1. "The Fun-Mitter—A Goof-Proof Rf Project," 73, February, 1981.
2. "The Fun-Ceiver," 73, July, 1981.
3. "The Fun-Oscillator," 73, February, 1982.
4. "The Fun-Amp," 73, May, 1982.
5. PC boards may be obtained from the author for $7.00 ppd. each. (For both originals and modified.)
6. CW Crystals, 570 N. Buffalo St., Marshfield MO 65106; Jan Crystals, 2400 Crystal Drive, Ft. Myers FL 33906.

✓ See List of Advertisers on page 114

Frank R. Portune N6BW
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Pasadena CA 91107

The Ultimate Breadboard

There used to be two styles of prototypes—rat's nest and cramped. Now there is a third style—simple.

There are at least a dozen different boards on the market intended for prototyping and one-of-a-kind construction projects. Most that I have used in my ham activities, in the classes at Los Angeles Access, and professionally have either been lacking in flexibility and ease of construction or are difficult to circuit trace.

Of the commonly-available types, the wire-wrap board, for example, is extremely difficult to circuit trace, especially when the component density reaches a certain point. This is complicated by the fact that components must be placed in IC header plugs.

The widely-used perfboard-type with general-purpose foil pads is much too cramped, lacks definite locations for ICs, is too difficult to circuit trace, and is prone to solder bridges.

The third common type, consisting of many small squares, works reasonably well for small projects. However, it becomes entirely too large for bigger circuits. It also lacks definite locations for components, especially ICs.

Forming a short jumper from bare wire using a small round tool and the end of your finger.

The board shown here solves many of the problems by combining a number of the good features of all systems into one, all contained on a standard 4½"×6½" 22-pin edge-connect card. The connector may be cut off easily if it is not used.

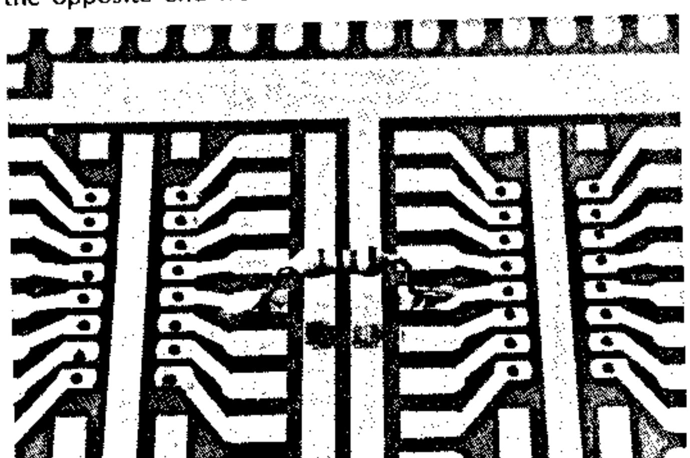
The basic features of the board are sixteen 16-pin DIP patterns for small ICs and one 40-pin pattern for larger ICs such as microprocessors, UARTs, etc. Alternately, the larger pattern will accommodate two additional 16-pin ICs.

Two continuous power rails run throughout the board and are available on both sides of all IC patterns. There is also a set of pads and a foil area for a 3-terminal tab-type regulator. On the opposite end from the edge connector are a number of small pads for switches or indicator LEDs.

Locating Components

Components may be mounted on either side of the board. In some cases, #60 holes will have to be drilled in the plain pads for this. For experimenting, however, all components including the ICs are best placed on the foil side. This leaves the entire circuit in view without turning the board over. In this way, the circuit is much easier to visualize.

For more permanent projects, some of the larger components and the ICs are best placed on the non-foil side. Buses of many wires are also better on the back to keep them out of the way during testing and repair. Resistors, small capacitors, and most interconnecting wires should be on the foil side.



A component properly formed and soldered to the board.