

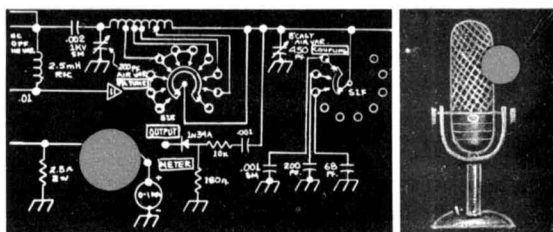
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focus
on
communications
technology . . .

ham radio

FEBRUARY 1968



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complete construction details





ham radio

staff

editor

James R. Fisk,
W1DTY

associate editors

A. Norman Into, Jr.,
W1CCZ/K2IEO
Nicholas D. Skeer,
K1PSR
James A. Harvey,
WA6IAK

roving editor

Forest H. Belt

art director

Jean Frey

publisher

T. H. Tenney, Jr.,
W1NLB

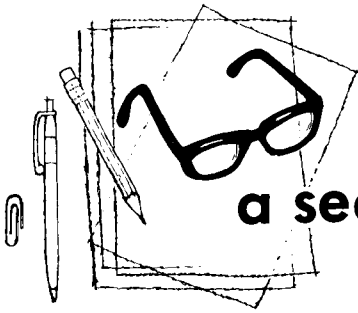
offices

Greenville, New Hampshire 03048
Telephone: 603-878-1441

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a second look

by jim
fisk

The birth of a magazine is a complicated process. It starts as an idea and develops through the coordinated efforts of authors, artists, typographers and pressmen. The ingredients are varied: articles, schematics, long-distance telephone calls, photography, advertising, subscriptions, public relations, paper and ink, all lovingly stirred together with prodigious amounts of midnight oil. Name: **ham radio**, born January, 1968.

Why **ham radio**? Very simple. The electronics and communications industry is moving forward at a tremendous clip, and so is amateur radio. Single sideband has largely replaced a-m, transistors are taking the place of vacuum tubes, and integrated circuits are finding their way into the ham workshop. The problem today, as it has always been, is to keep the amateur well informed. This doesn't mean that you have to impress your readers by printing every piece of state-of-the-art news that appears on the horizon.

Quite to the contrary. If you limit yourself to the state of the art, you'll get lost in a hurry. Advances are being made so rapidly, you just get tuned in and there's something new to worry about. And, since each new advance is built on what has been done in the past, if you don't get a clear idea of present techniques, you'll be hopelessly lost as time goes on.

Transistors have been with us for fifteen years, but it has just been within the last year or so that hams have started really thinking in terms of solid state. True, you usually wait

for that old vacuum-tube equipment to wear out before replacing it with solid-state gear, but many of the little gizmos around the shack that you've put together in the past few years should be transistorized. Are they? Probably not.

When vacuum tubes became practical devices, amateurs were among the first to use them in home construction. Likewise with semiconductor diodes. Not so with Transistors. Why? Because hams didn't have enough good **practical** information to go by. Unfortunately, transistors blow out a lot easier than tubes, and many amateurs who experimented with them in the early days were disillusioned by a row of "dead soldiers" on their bench.

What it amounts to is this. There is an awful lot of state-of-the-art practice which you've got to understand before you get into state-of-the-art design. If you're an engineer, fine, but not all hams are engineers. Most hams want practical circuits which they can adapt to their special jobs.

As an example of where this state-of-the-art phobia has taken us, consider single sideband for a moment. I would guess that at least 80% of the hams operating on our lower bands are using single-sideband equipment. But how many of them actually understand what goes on inside that box? Not nearly enough!

The problem here is that ssb appears to be a lot more complex than a-m. Certainly the gear required to generate a ssb signal is more complex than that old a-m rig, but under-

standing what makes it tick is not. The two modes are very closely related. Not particularly compatible, but related. The problem is that a simple, concise explanation of sideband has been lacking. Several excellent articles along this line were written in the early fifties, but many of the hams who have sideband equipment now have never seen them.

Ham radio is designed to fill this gap. It is designed to inform. It will be geared to the state of the art—the state of the art in practice. It will be a magazine which shows you how to use new devices and old. Although we will encourage the use of solid state, we will not discriminate against vacuum tubes for the sake of being modern. There are a lot of places where vacuum tubes are still very practical and desirable gadgets.

When new techniques and devices become available, look for a complete description of how to use them in **ham radio**. Our articles will run the gamut from the simple to the complex, but they will all be oriented to the practical approach—the amateur approach. Not all of you are interested in the same things, nor do you have similar electronic backgrounds, so the fare served up in **ham radio** will be varied.

We will have simple projects for the novice and the one-night-a-week experimenter, involved projects for the experienced ham who likes to work in his shop, practical design and theory articles for the fellow who wants to start from scratch, and the last word for the VHF'er, RTTY bug and ATV enthusiast.

Amateur radio, just by its nature, is a very diversified hobby. Each ham follows his own special interests, whether home construction, public service, DX, traffic or a multitude of others. If you don't see an article that covers your particular plane of interest, it's because no one has taken the time to write it. If you have a little gimcrack that you've just put together, and think others would be interested in what it can do, draw a schematic, take some pictures and write it up. You don't have to be a professional writer to get your name in print; most of ours are not.

In addition to full-length feature articles, we are in the market for shorties for the **ham notebook**. If you have found a new and better way of doing something in the shack, have a new construction wrinkle, or have some small gem of technical information to convey, send it in to **ham notebook**. This monthly feature will cover everything from Antennas to Zener diodes, construction and design—technical tips that are useful around the shack and shop. You'll get paid for your efforts, and the rest of our readers will benefit from your ingenuity.

If you're interested in contributing something to **ham radio**, write for our "Author's Guide." This handy little pamphlet shows how to put your story together, the essentials of clear writing, the abbreviations we use, and what we need in terms of schematics and photographs. It also outlines our rates and payment policy.

Payments for manuscripts are generous and immediate. If we like your article, you'll get a check with our letter of acceptance, usually within a week of when you put it in the mail. After we accept it, it won't sit in our files for months or years waiting for publication. It will be put into print just as soon as possible. Articles that sit in the file are no good to the reader, to the author or to us. Nobody wants to read about (or build) a VHF converter today that was the hottest thing on two wheels when it was originally designed three years ago!

Ham radio will not stand still. We will always be looking for ways to improve because amateur radio is a dynamic hobby, always on the move. As the equipment, techniques and challenges of amateur radio change, so will we. We'll constantly try to make **ham radio** more useful to you as well as more interesting and stimulating. We can promise you now, we'll never become complacent, we'll always try to make **ham radio** better.

Jim Fisk W1DTY
Editor

here we are

a word from the publisher

Here we are! It's been a long trip since early October when Jim and I decided that there was definitely a place for **ham radio**. Where will the money come from? What will we call it? What will it look like? How will we get subscribers? How will we obtain advertisers? All of these questions, and many more, had to be answered one by one as **ham radio** began to take the final shape that you see here.

It has not been an easy road. We did not expect it to be. However, there have been many unexpected rewards along the way as many folks, both individual amateurs and those in industry, have given us valuable support and encouragement. We quickly found that there were many others who felt just as strongly as we that *our magazine* would be quite useful to the amateur community.

Can amateur radio really support a new magazine? We think it can, and here are some reasons why: Much has been said in recent years about what is wrong with *our hobby*, but altogether too little about what is healthy and right about it. We feel that amateur radio is a healthy patient and that it is going to be with us for a long time to come. Let's face it, we wouldn't be investing our time and money in this project if this were not the case.

In spite of what others may say, you need only look at the Call Book to see that the total number of licensees is continuing to grow. Admittedly, this growth may not be as fast as CB or other parts of the electronics industry, but still, we are growing. This growth could be, and should be, faster, but it is up to us in amateur radio to provide growth. No one else is going to do it for us.

There was, perhaps, a certain period of indecision during the incentive-licensing controversy. This issue has been decided, and the amateur knows exactly where he stands in the future. Home construction ideas and equipment purchases can now be planned with the full assurance that you'll be able to use this gear as intended. The potential newcomer need have no apprehension over what his

future operating privileges will be.

One of our major enemies is considered to be Citizens Band, and yet, it has been a failure. Even Chairman Hyde of the FCC has now suggested that major changes, including an increase in the license fee and a technical examination, should be considered as a means of improving this service. This could well have a very positive effect on amateur radio. The many youngsters who are introduced to radio each year via CB might well be channelled to our novice bands. Both radio services would benefit from this change in policy, as would the individuals involved.

A new outlook is necessary. If we continue to work with old ideas and concepts, we can hardly expect to maintain our traditional spot in the electronics world. We are a branch of one of the fastest moving areas of technology. If you have any doubts, look at the developments of the past few years in solid-state techniques or satellite communications. Amateur radio will have to look and act the part if we are to keep up.

Ham radio intends to take a very positive step in the advancement of amateur radio. As a start, this magazine looks years ahead of others because we have taken advantage of new techniques and ideas in technical publishing to bring you something very timely in appearance. Equally as much effort is going into the preparation of editorial material. A lot of work has been done to make the articles easier to read. Ideas have been more clearly organized, words and sentences have been carefully put together with professional techniques designed to make **ham radio** easier and more enjoyable to read!

We still have a lot to do. Our business is communications technology. This goes just as much for the printed word as for the latest integrated circuit. There will be many more new ideas in **ham radio** as the months go by. We think you'll like them.

Skip Tenney W1NLB
Publisher

Introducing



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homebrew 5-band ssb exciter

Here's
an all-band sideband
exciter that's simple,
straight-forward,
inexpensive and
easy to
build.

Fred Randall K1UKX, RFD 2, Blackstone Street, Uxbridge, Massachusetts 01569

Many opinions, both pro and con, have been expressed in regards to homebrew equipment. It is not my intent either to promote or discourage building equipment. I believe the only valid reason for a ham to build his station equipment is his own sincere desire.

Many of those who profess a desire to build their own ssb gear claim it is difficult or impossible because:

1. It is so complex that it takes an engineer to build it.
2. It is difficult to get parts; nobody stocks them, and they are too expensive.
3. A well equipped machine shop is necessary for the mechanical work.
4. Homebrew equipment looks shoddy or makeshift and is, usually, much larger and more bulky than commercial equipment.
5. No time.

The exciter shown on these pages is my answer to those who use any of the standard excuses. It was built in its entirety on a ham-shack workbench, using common hand tools and readily available, inexpensive parts. I can appreciate the time problem since I get home at 1:30 AM—this is when I can steal an hour or so to work on my little projects.

Building equipment is no bed of roses, and the subsequent debugging would try the patience of a saint. However, when the work is done and the bugs are exterminated, the satisfaction more than compensates for the barked knuckles, frayed nerves and gallons of coffee and midnight oil.

circuit description

A block diagram of the homebrew 5-band ssb exciter is shown in **fig. 1**. In this circuit a 6CW4 crystal oscillator generates a signal at either 453.5 or 456.5 kHz, depending upon which sideband is desired. This signal is applied to a germanium-diode ring modulator. One half of a 12AX7A is used as the speech amplifier. The other half is connected as a cathode follower to present the proper low-impedance audio signal to the ring modulator. The output of the modulator is a dsb suppressed carrier signal, which is transformer-coupled to the mechanical filter. The filter passes the chosen sideband and, for all practical purposes, eliminates the unwanted one.

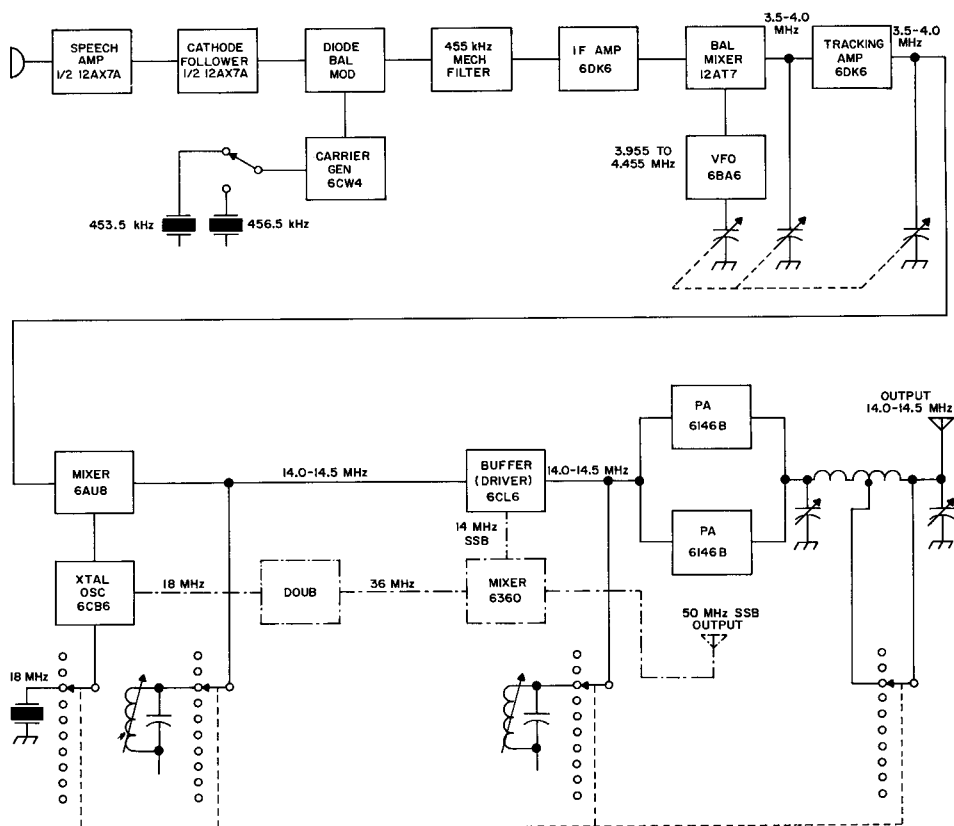
A 455-kHz i-f amplifier follows the filter; the output of this amplifier is fed to a 12AT7

fig. 1. Block diagram of the homebrew five-band ssb exciter with the bandswitch set to 20 meters. The components shown by the dotted lines may be added to provide six-meter capability if so desired, although the circuitry is not described here.

balanced mixer. The signal from the VFO, a Colpitts oscillator using a 6BA6, is also applied to this mixer. The VFO tunes from 3955 kHz to 4455 kHz—a 500-kHz tuning range. This signal is nulled out in the balanced mixer.

The output of the 12AT7 mixer is applied to another i-f amplifier. The input and output of this amplifier are gang-tuned by additional sections of the VFO tuning capacitor to the **difference** frequency (3500 to 4000 kHz). This tracking amplifier further eliminates the possibility of any VFO signal appearing at the output.

A 6AU8A is used as a converter to heterodyne the 80-meter signal up to other bands. For 80-meter operation, the plate circuit of the 6AU8A pentode section is provided with a load resistor and operates as a low-gain amplifier. For 40- through 10-meter operation a signal from a 6CB6 crystal oscillator is applied to the triode section, and the plate circuit of the pentode section is tuned to the



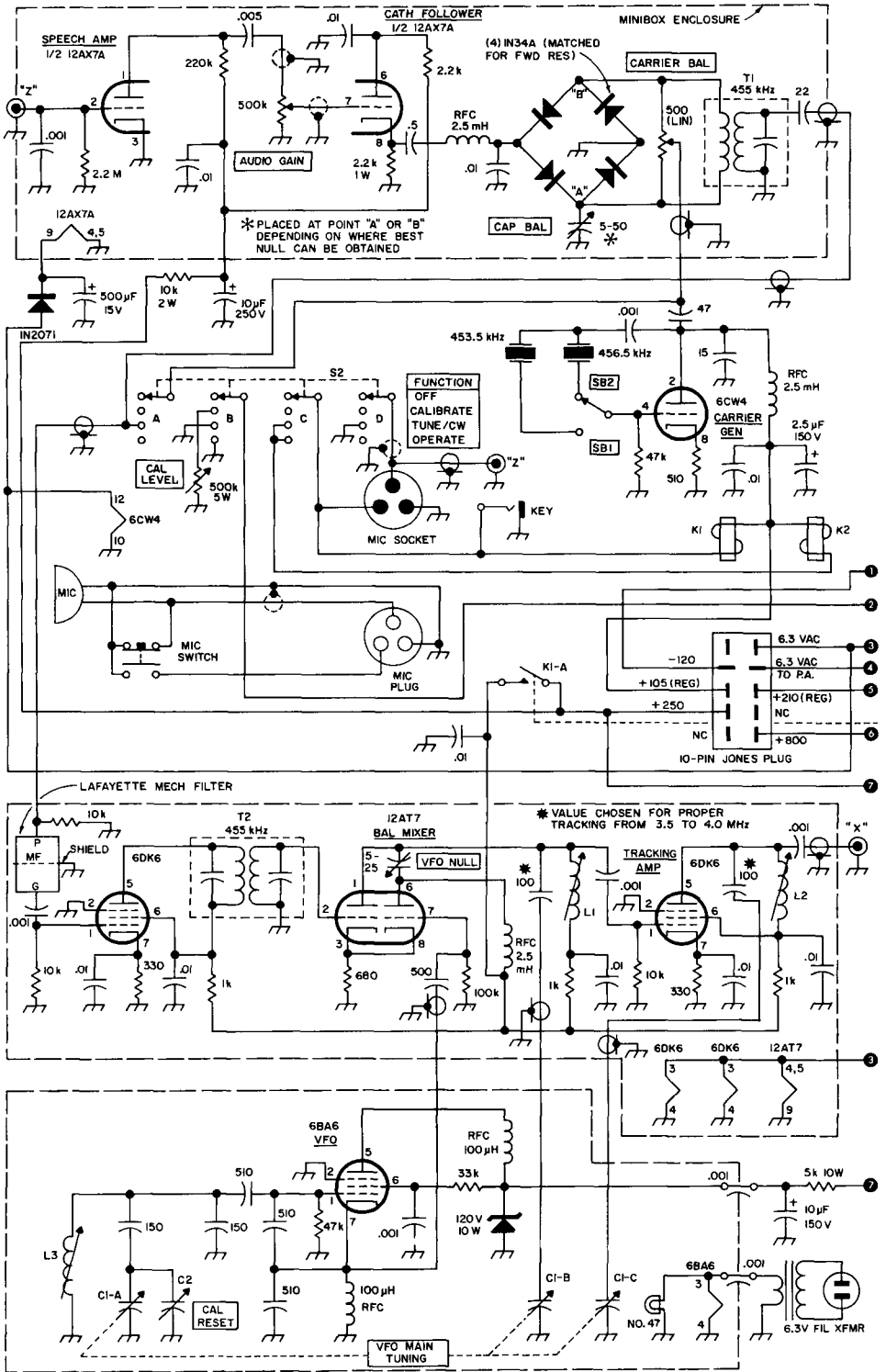
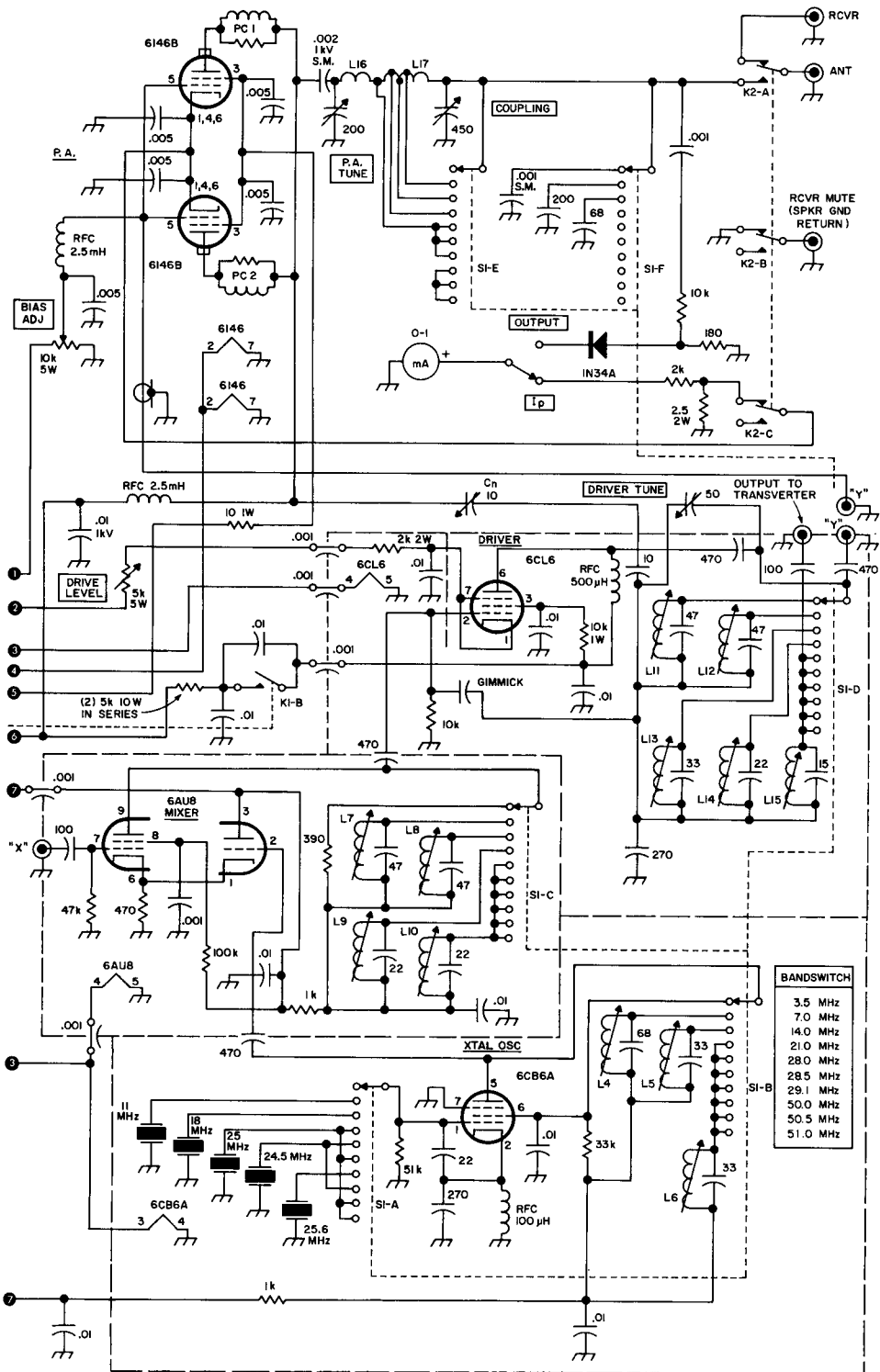


fig. 2. Schematic diagram of the low-cost five-band ssb exciter. Switch S2 (function) is in the tune-CW position,



switch S1 (band) at 3.5 MHz. Relays K1 and K2 are deenergized. The front-panel labeling is shown in boxes.

desired band. No direct coupling is used between the tube sections; sufficient mixing action is provided by inter-electrode capacity and by having the cathodes strapped together. The 6AU8A mixed is followed by a conventional class-A buffer amplifier and a bandswitched final using class-AB₁ 6146B's.

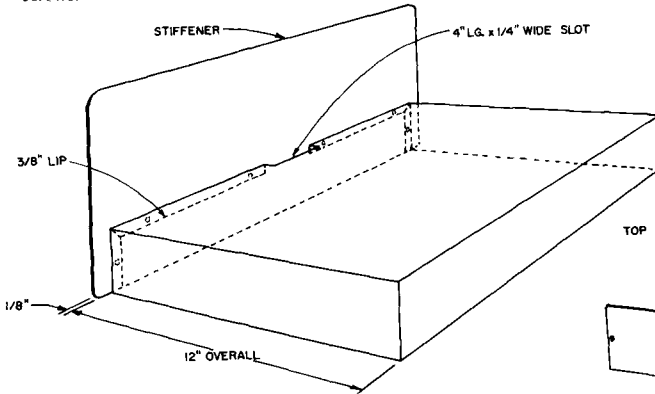
The rule I use in anything I build is to use what I have available, rather than to try and locate and purchase what I don't have on hand.

This general rule was followed in building this exciter. The crystals and mechanical filter had to be purchased of course, but they were available "off the shelf" at Lafayette.* The 455-kHz i-f cans are available at any radio store or they may be removed from an old broadcast radio.

All of the circuits used in this exciter were obtained from various sources and adapted for use with components I had. It may be possible to further optimize the circuits, but the values I used work very well.

The carrier crystals and heterodyning

fig. 3. Construction of the chassis and front panel. The chassis is cut down from a Bud AC419 to 12 1/4" deep. When the 3/8" lip is formed around the front, the overall depth is twelve inches. A four-inch slot, 1/4" wide, is cut out along the front of the chassis for dial clearance and lead routing. The completed chassis is mounted to the 1/4"-thick stiffener plate (sub-panel with countersunk screws.



crystals as well as the VFO frequency match the Lafayette HA-350 Receiver in use at K1UKX. For this reason, transceive operation is quite practical, with only slight modifications to the receiver.

* Lafayette Radio Electronics, 111 Jericho Turnpike, Syosset, L. I., New York 11791. Order replacement part for HA-350 receiver, \$12.95.

Because both summing and differencing heterodyning is used to obtain the various bands, the tuning direction, as well as the selected sideband, changes with the band in use. This is a small inconvenience which you soon become accustomed to, and allows simpler and less expensive construction. The chart in **table 1** shows the tuning direction and normal sideband in use on the 80-through 10-meter amateur bands.

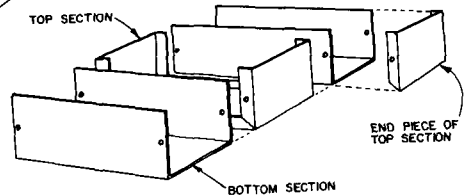
chassis and cabinet

A good starting point is the cabinet. I used an LMB* CO-1; price \$20.00. One point which bears mentioning at this time is that when you use a decent appearing foundation for construction projects, it goes a long way toward encouraging the builder to complete them.

The dial bezel is cut from 1/4-inch thick stock. I used plexiglass, but wood would be

* Available from Newark Electronics Corporation, 500 North Pulaski, Chicago, Illinois 60624. Catalog number 91F1192, \$19.95 plus postage.

fig. 4. Method used for making shielded compartments for the bandswitch using two 1 1/2" x 2" x 4" miniboxes. The circuits are built into each compartment, tested, and then assembled into a complete unit.



a perfectly acceptable substitute. After cutting and filing it to shape, I sprayed it with machine-gray Krylon. While still tacky, the bezel was given a "dusting" coat of the same paint from about three feet away. This gives an attractive sandblast matte finish which blends well with the cabinet. The dial windows are cut from 1/8-inch plexiglass and

cemented to the rear of the bezel. A hairline is scribed in the center of the left-hand window.

The chassis consists of a front sub-panel cut from rack panel material and a commercial chassis, Bud AC419. The chassis is cut to size with a hacksaw or nibbling tool, bent to shape and bolted to the front panel using recessed-head screws. The use of a double panel permits a face plate completely free of unsightly screw heads. It also provides the rigidity necessary for mechanical stability of the VFO. The VFO compartment side plates are also cut from rack-panel material. These plates are bolted to the chassis and front panel after construction of the VFO. The rear panel of the cabinet is cut away to provide access to the chassis apron.

The front panel lettering is done with Walsco decals. After they are in place, the panel is given a coat of clear Krylon. A light dusting coat is then applied to return the panel to a semi-gloss finish. This seals the decals and completely hides their edges, giving the appearance of silk-screen lettering.

speech amplifier and balanced modulator

The speech-amplifier and balanced-modulator circuitry is built as a unit in a small mini-

fig. 5. Front finish panel for the five-band SSB transmitter. A full-scale template is available from K1UKX for 25c to cover postage and handling. Lips are formed at the top and bottom of panel as shown in fig. 6.

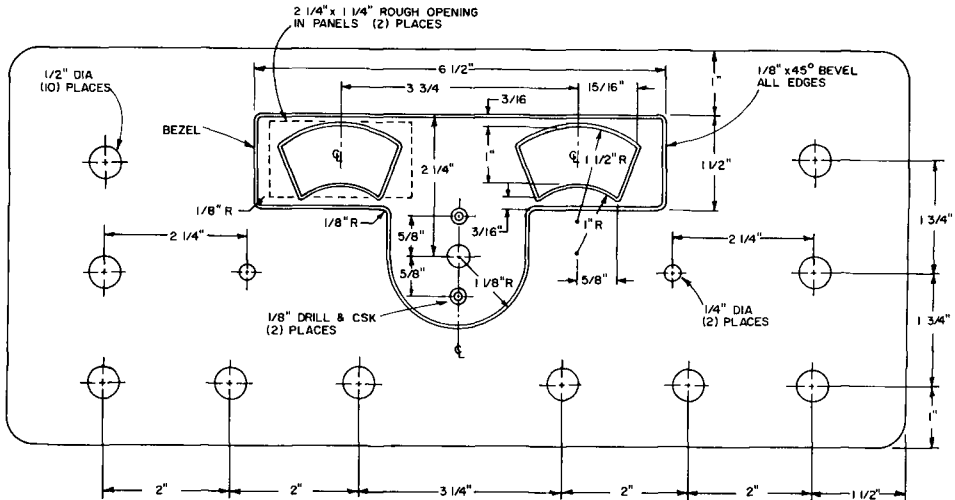


table 1. Parts list for exciter

- C1 — ARC-5 receiver tuning capacitor
- C2 — ARC-5 receiver antenna-trim capacitor
- L1, L2, L3 — 40 turns #26 enameled on 1/2" slug-tuned form.
- L4 — 12 turns #22 enameled on 3/8" slug-tuned form.
- L5 — 10 turns #22 enameled on 3/8" slug-tuned form.
- L6, L9 — 8 turns #22 enameled on 3/8" slug-tuned form.
- L7 — 22 turns #22 enameled on 3/8" slug-tuned form.
- L8, L13 — 15 turns #22 enameled on 3/8" slug-tuned form.
- L10 — 6 turns #22 enameled on 3/8" slug-tuned form.
- L11 — 65 turns #30 enameled on 3/8" slug-tuned form.
- L12 — 18 turns #22 enameled on 3/8" slug-tuned form.
- L14 — 9 turns #22 enameled on 3/8" slug-tuned form.
- L15 — 4 turns #22 enameled on 3/8" slug-tuned form.
- L16, L17 — Pi-Dux 820-D-10 with 4 turns removed from the 10 turns-per-inch end; replaced with 5 turns B&W 3006 mounted at right angles as shown in photograph. Tapped at the junction of the Pi-Dux unit and B&W 3006 and at 34, 41, and 44 turns from the coupling-capacitor end.
- K1, K2 — 4PDT, 15 kilohms, 110 Vdc, (Allied Control T163X-25).
- PC1, PC2 — 6 turns 1-16" thick, 1/8" wide copper strip wound around 39-ohm, 2-watt resistors.
- S1, S2 — Built up from Centralab index section and wafers.
- T1 — 455 kHz i-f transformer (Workman TF11 although others will work) with primary winding and tuning capacitor removed and replaced with 50 turns #32 enameled, scramble wound next to secondary.
- T2 — 455 kHz i-f transformer (Workman TF11).

box. The balance potentiometer is located in front of the minibox with an extension shaft through to the front panel. The audio-gain control is located on a bracket attached to the minibox by the nut that retains the

balance pot. Wiring to the gain control is accomplished with small shielded cable; power and signal leads come out through a hole in the bottom. It might be well to mention here that this method of construction not only provides excellent shielding, it makes for more pleasant building—you don't have to horse a big chassis all over the bench during construction. It also allows individual testing of sub-assemblies, a procedure which I highly recommend because it's much easier than aligning the whole exciter at one whack.

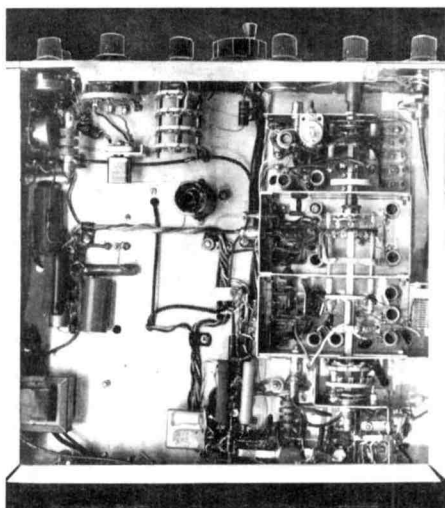
carrier generator

The 6CW4 carrier generator tube is located in the small space between the minibox and the front panel on the left side of the chassis as shown in fig. 6.

filter-mixer i-f amplifier

These stages are built into another minibox. Small sheet-metal protrusions provide room for the use of full-size 1/2-inch tuned coils on the input and output circuits of the tracking amplifier. All the leads from the box, as well as the coil leads to the ARC-5 tuning capacitor, are shielded. Access to the balanced-mixer nulling capacitor is available from the bottom of the main chassis through

Below-chassis view of the five-band ssb exciter. The VFO tube and carrier generator crystals are in the upper left center; the bandswitch is to the right.



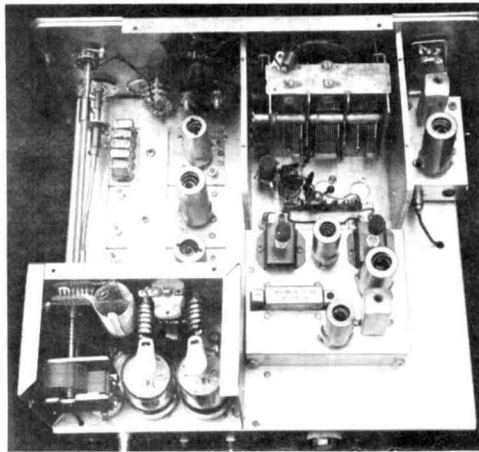
photos by Ted Woolner WA1ABP

a small access hole. Proper tracking is established by juggling capacitor values in series with the ARC-5 variable capacitor sections. I trimmed some plates from my unit, but by proper choice of series capacitors, this should be unnecessary.

variable frequency oscillator

The VFO is a standard Colpitts oscillator using a 6BA6 tube. The tube is located under the chassis and all circuitry associated with

Inside the five-band ssb exciter. Power amplifier compartment to the lower left.



the VFO is contained in a shielded compartment. The 6BA6 is provided with a separate filament transformer and the heater runs as long as the exciter is plugged in. A number 47 bulb, which is used to keep the VFO compartment warm, is also connected. These provisions make warm-up drift negligible and no temperature-compensation circuitry is required.

Plate and filament voltage to the VFO is run through feed-through capacitors from under the chassis. The VFO plate voltage is zener regulated at 120 volts. A small 10-pF variable capacitor is connected in parallel with the main tuning capacitor and provides about ± 10 kHz variation for tuning-dial calibration. This capacitor was removed from the same ARC-5 receiver that yielded the main-tuning capacitor. It is placed between the tuning capacitor and the face plate; this is a tight squeeze but it fits after careful positioning.

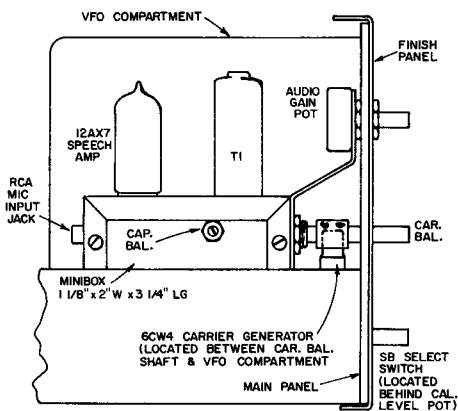
The center section of the main-tuning capacitor is used for the VFO. The remaining sections are used to tune the tracking ampli-

fier. Note that a capacitor is placed in series with the main-tuning capacitor—this limits the tuning range to 500 kHz, and makes the dial calibration extremely linear.

final amplifier

The final amplifier is a conventional neutralized circuit using a pi-network output. The two 6146B tubes are connected in parallel and are provided with regulated grid bias and screen voltage. The cathode pins on the tube sockets are bent inward toward the center and strapped together with a tinned-copper strip. Flat copper strips are also used for the plate parasitic suppressors, and many of the connections in the bandswitch assembly make use of the same material.

fig. 6. Side view of the chassis showing the position of the mechanical filter compartment on the left-hand side of the chassis. Note the lips at the top and bottom of the front finish panel.



control functions

Most of the control functions are either self-explanatory or discussed elsewhere in the text. A few functions, perhaps, require further explanation.

The **calibrate** position of the function switch permits the operator to “talk” himself on frequency, or, if desired, the carrier may be inserted and a conventional zero beat can be accomplished. In either case, the push-to-talk switch (or key) must be depressed to energize the transmitter. The **calibrate level** control sets the spotting signal to a comfortable listening level.

In the **tune-CW** position of the function switch, the balanced modulator is bypassed to provide a CW carrier when the key or push-to-talk switch is depressed. Full break-in CW permits maximum operating convenience. This is accomplished through the use of high-speed relays.

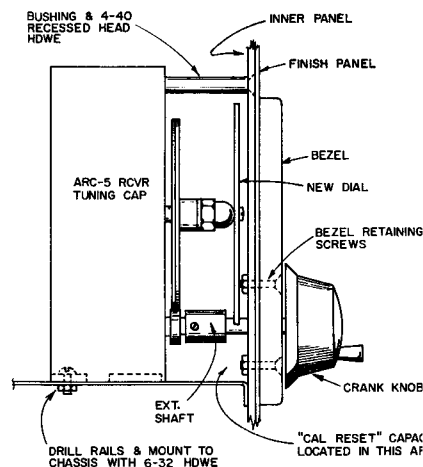
The meter is switched to read either final cathode current or output. Antenna change-over and receiver muting are built in, as is push to talk. Any power supply that will provide the indicated voltages at the power-plug terminals may be used.

No tuning or alignment instructions are given here since it is assumed that anyone with the necessary skills to build an exciter such as this one will be thoroughly familiar with the proper techniques.

It is not expected that anyone will build an exact copy of this transmitter. However, some of the construction methods and circuits used here should be of interest to other appliance operators who prefer, as I do, to build their own appliances.

ham radio

fig. 7. Construction of the driving mechanism for the ARC-5 tuning capacitor. The dial scale is mounted to the original dial retaining nut with a 4-40 screw.



References

1. ARRL, **Single Sideband for the Radio Amateur**, American Radio Relay League, Newington, Connecticut, Third Edition, 1962.
2. D. Stoner, **New Sideband Handbook**, Cowan Publishing, New York, 1962.

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