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ham radio magazine

NOVEMBER 1971

automatic radiotelegraph translator and transcriber

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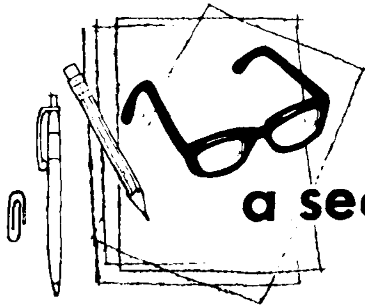

a second look

by jim fisk

The editor of a technically oriented magazine like *ham radio* wears several hats. I could use this whole page to describe the details that require attention to keep the magazine running smoothly, but I'd like to talk for a moment about one very important editorial task that means the difference between an interesting, accurate technical magazine, and one that isn't.

The articles in *ham radio* are written by authors not unlike you, the reader. They range from enthusiastic hams who want to share an idea, to fellows with engineering backgrounds (who also want to share an idea). I welcome the output of anyone who is interested in contributing something which will benefit all hams.

Budding authors often ask, "What kind of articles are you looking for?"

That question is difficult to answer since many new manuscripts arrive every day, but generally speaking, I am looking for simple construction projects that the average reader can put together in one or two weekends. Larger construction projects are also welcome, but the average *ham radio* reader must split his leisure time between amateur radio and other interests, so he doesn't have time to build a Chinese copy of a complex piece of gear.

When I read an article contributed to *ham radio*, the first thing I look for is interest value. If the manuscript passes this test, the next thing I look for is technical accuracy and attention to detail.

The contributed article doesn't have to be a literary masterpiece. If you have a good idea; if it's well documented; if the illustrations and technical discussion are clear and accurate – you may have a winner!

Don't feel too badly if your article is not accepted. Since we publish about twelve feature articles in every issue, to keep the production pipeline full, we purchase that same number of new manuscripts each month. This keeps the article backlog to a minimum and insures that the fare served up in each issue of *ham radio* represents the latest possible information on any given subject.

During an average month I receive about 45 or 50 new manuscripts. At some point during the month I sit down and go through each of the articles, rejecting those that are clearly not usable in *ham radio*; this narrows the stack of manuscripts down to 25 or so.

Now comes the most difficult part – deciding which of those remaining 25 articles are most desirable. Articles that are too long or need more polishing are returned to the author with suggestions for rewriting the article to our standards. The remaining material is further screened for technical accuracy and reader interest; this process continues, with comments from the staff (and sometimes, arguments), until we have decided upon the articles which will be published in *ham radio.*

If you prefer to read *ham radio*, rather than write for it, you can help by telling me the kind of article you like. If you have a pet project in mind, or an old project that could be updated with transistors or ICs, let me know about it; I'll pass the idea along to one of our regular contributors.

We are continually trying to improve *ham radio*, but we can only do that successfully if we hear from you, the reader, so keep those cards and letters coming in.

Jim Fisk, W1DTY
editor

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skip tenney
W1NLB

There seems to be a never ending discussion among both amateurs and those who cater to the amateur fraternity with goods and services as to whether or not amateur radio is growing. Most of the conclusions recently have been rather negative.

However, an interesting new twist has recently been introduced into arguments about this growth, or lack of it.

If you look at the total operator license figures from the FCC, they show a virtually stable figure since 1965, although growth was relatively constant until that time.

Does this mean that our ranks are not growing any longer? A number of people will disagree with this idea. Remember that, in 1964 a $4.00 fee was introduced for all but Novice licenses, while in 1969 this fee was increased to $9.00.

Unquestionably, there are former licensees who had been continually renewing their ticket when it came up for renewal every 5 years even though they never used it. If it was free – why not? The four-dollar fee probably dropped some of these people while the nine-dollar license stopped a good many more.

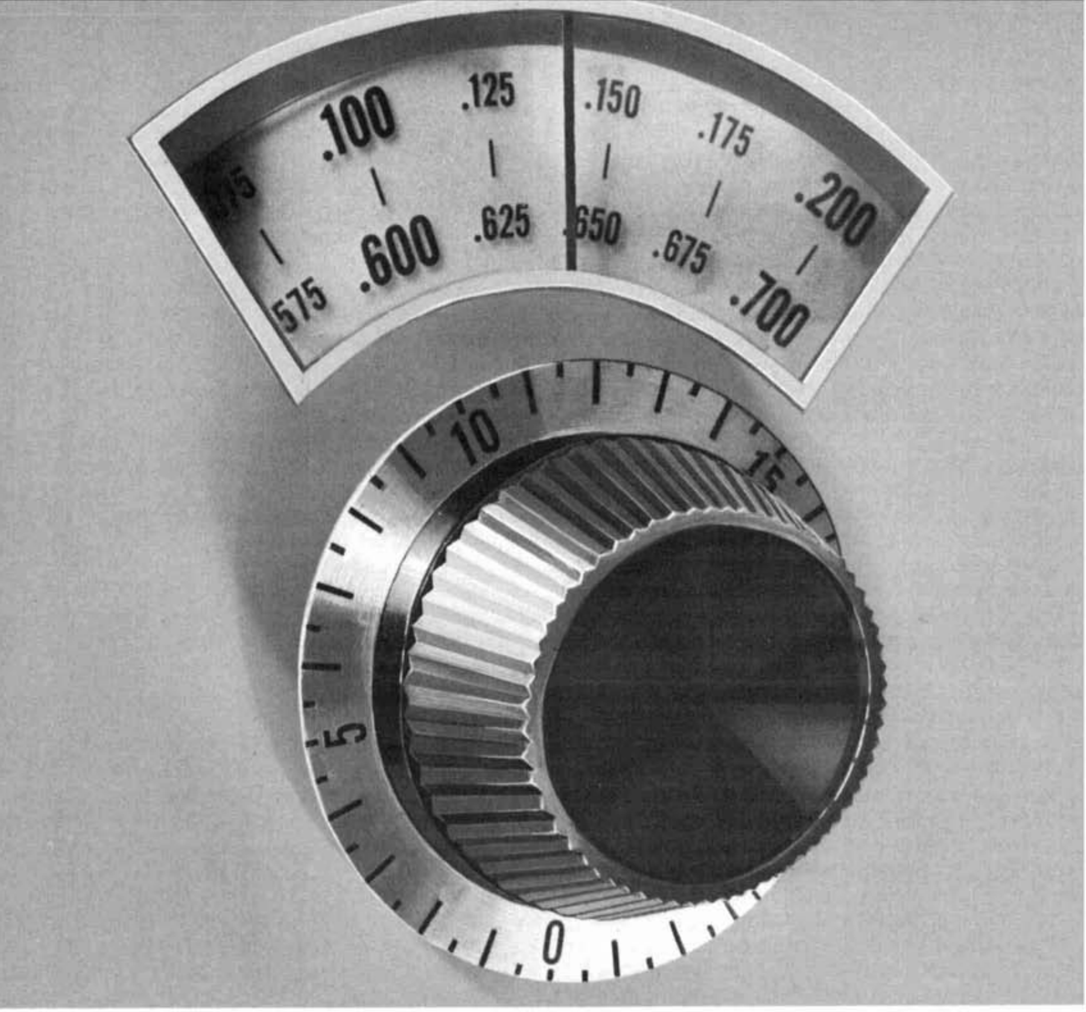
As these former licensees drop out, we are not losing active amateurs. They were amateurs in name only, but the new licensees who have come along to replace them are far more apt to put that shiny new ticket to work on the air.

Thus, the argument can logically be made that although the total of licenses outstanding has not grown, the actual number of active on-the-air amateurs has continued to increase.

This is a hard theory to prove or disprove because there have been many changes in our operating habits in the last ten years. Sideband has virtually replaced a-m on most high-frequency phone allocations, thus, permitting greater use of these frequencies. The explosive growth of vhf fm has also absorbed much activity in previously seldom-used portions of the amateur spectrum. Therefore, you cannot easily evaluate activity just by listening on our bands. We are using them more efficiently and are making room for added activity without necessarily having greater crowding (except possibly in a good pile-up on 20 meters).

The answer to the problem of growth is not found as simply as this editorial might imply, but it does show that amateur radio may be doing a good deal better than some people think.

Skip Tenney, W1NLB
publisher



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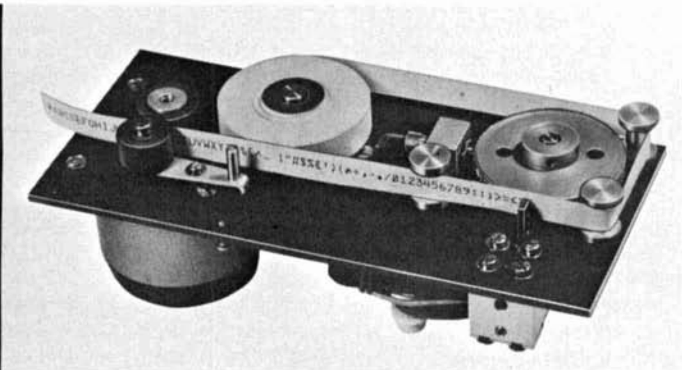


automatic radiotelegraph translator and transcriber

This automatic fist follower converts the CW output from your receiver into the printed word

Clarence Gonzales, W7CUU, Richard Vogler, K7KFA

In the past, amateur radio operators have devoted a lot of effort to making it easier to send perfect (or near perfect) CW signals. These efforts have progressed from the straight manual hand key to the semiautomatic bug, the electronic keyers, and finally, to the keyboard sender.[1] However, reception has been left to the ability of the human operator.

There have been a few techniques devised to aid the receiving operator, but most of these have been used to copy high-speed machine-sent Morse. One technique produces an inked recording of the high-speed CW transmission; the recording is fed through a photocell arrangement at greatly reduced speed to produce an audible tone that is translated by a human operator. Magnetic tape may be used in much the same way, but a human operator must still be used to translate the radiotelegraphic signals into the written word.

The idea of automatically translating and transcribing Morse code without a human operator is not new. Some time ago researchers at the Massachusetts Institute of Technology used a digital computer to recognize hand-sent Morse characters.[2] The computer program designed for this task was called MAUDE for Morse Automatic Decoder.

In the MAUDE program each *mark* and *space* was assigned a number that represented its duration. Then a sliding-window algorithm was used by the computer to identify the types of *spaces* and types of *mark* signals. The program provided for continuous adjustment based on the last six elements of each type; this resulted in automatic tracking of variations in hand-sent radiotelegraph signals. With this approach misinterpretation occured only about once in 10,000 times.

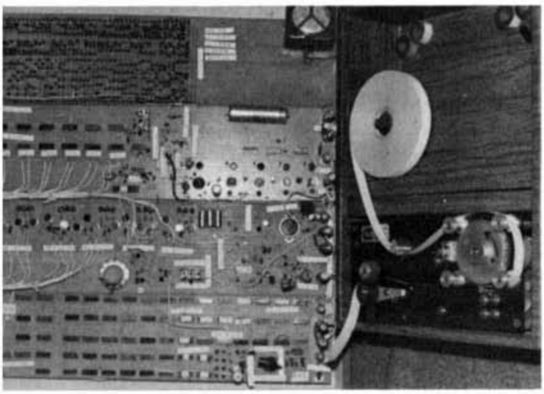
Although the MIT studies showed the feasibility of automatically translating hand-sent Morse code, unfortunately, the average radio amateur does not have his own digital computer for such activity.

automatic fist follower

The most practical and economic approach to automatic translation of Morse code would be to design a special purpose computer just for this function. The automatic fist follower (AFF) described in this article is just such a device. Although it uses an entirely different algorithm for its operation, it performs nearly as well as the MIT MAUDE computer system.

The automatic fist follower was originally conceived after reading Horowitz's article on the keyboard CW sender. However, we had to wait for the advent of inexpensive integrated circuits to make it technically practical and economically feasible for the amateur.

The automatic fist follower.



Nevertheless, the design was quite a challenge, and previous experience with computer logic design didn't hurt a bit. The ICs used in the AFF were scrounged from castoff vendor's samples and surplus computer circuit-boards. The discrete parts – transistors, diodes, resistors, capacitors – came from the junk box. The one item which had to be purchased new at considerable expense was the strip printer.

The automatic fist follower takes the audio output of a communications receiver that is tuned to a radiotelegraphic signal and translates it into letters, numerals, special symbols and spaces which are transcribed onto a paper tape by a strip printer.

The AFF will accept any code speed between 5 and 60 wpm. It would be a simple matter to extend the range to 300 wpm (the maximum speed of the strip printer) by increasing the frequency of the AFF's internal clock. However, in order to use a fairly large time constant in the signal filter to obtain good noise rejection the limit was set at 60 wpm.

The automatic fist follower will automatically track any reasonable variations in sending speed, dot length, dash length, weight, etc. In many cases it will track sending variations that are beyond the reception capability of a good human operator. All the operator has to do is tune in the sending station, set the approximate wpm control on the AFF and sit back and read the copy coming on the printer.

basic detection theory

Before discussing the functional block diagram of the automatic fist follower, it is desirable to explain the theory behind the detection of widely varying dots, dashes and spaces with which the AFF must cope. Of course, the easiest task for the AFF would be the reception of machine-sent Morse code, since this would be nearly perfect and free from variation with strict adherence to the standard definitions of dot length, dash length, element space, character space and word space. For example, if a dot is taken as a unit length, the standard definitions prescribe a length of 3 units for a dash, 1 unit for an element space, 3 units for a character space and 7 units for a word space.

Human operators *roughly* approximate perfect code; some operators deviate so far no one can interpret most of what they send. A convenient way of describing variations from perfect code is by a

Likewise, the number of clock pulses which occur in the interval between *mark* signals are counted. The frequency (wpm) control on the AFF is initially set so that most of the dots give a *mark* count of 6. The operator is assisted in this adjustment by the dot indicator light which flashes quite consistently when the setting is correct.

The typical dot will give a count of 6,

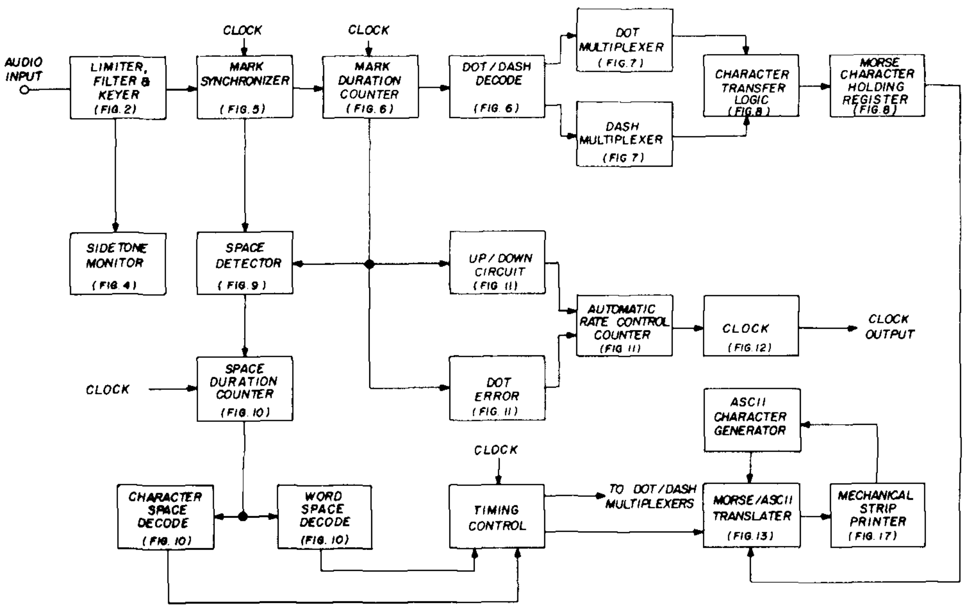


fig. 1. Block diagram of the automatic Morse code translator and transcriber.

parameter called weight. Weight is defined as *dot length* divided by *dot length plus element-space length.* Perfect code has a weight of 50%:

$$\text{weight} = \frac{\text{dot}}{\text{dot} + \text{space}} = \frac{1}{1+1} = 50\%$$

Light code has weight less than 50%; *heavy* code has weight greater than 50%.

The AFF uses a sampling technique to determine whether it is receiving a dot, a dash or a space element. Both the *mark* (dot or dash) and *space* (interval between *marks*) are sampled with a series of clock pulses. The number of clock pulses which occur during the *mark* signal are counted.

the typical dash a count of 18, the element space a count of 6, the character space a count of 18 and the word space a count of 42 (more if the last word was transmitted). These counts may vary by a large margin and still be recognized by the AFF. Any *mark* count between 1 and 12 is recognized as a dot. A *mark* count of 13 or more is treated as a dash. A *space* count between 1 and 12 is an element space, a count between 13 and 30 is a character space and any count of 31 or more is treated as a word space.

It is interesting to calculate the weight value limits which can be received and properly interpreted by the AFF. The lightest code it can handle is a dot length of 1 count and an element space length of 12 counts, resulting in:

$$\text{weight} = \frac{1}{1 + 12} = \frac{1}{13} = 7.7\%$$

The heaviest code the AFF can handle is a dot length of 12 and an element space length of 1, resulting in:

$$\text{weight} = \frac{12}{12 + 1} = \frac{12}{13} = 92.3\%$$

However, the AFF's automatic-frequency-control circuits will allow even greater variations in sending characteristics than this to be recognized. If the dot length varies from a 6-clock pulse count, a dot length error condition is detected and the frequency is automatically adjusted in a direction to bring the clock pulse count back to 6. Therefore, the AFF follows gradual changes in sending speed and will actually track the sender's fist through a wide range of variations.

theory of operation

The audio output from a communications receiver is fed into a limiter/clipper (see **fig. 1**). The radiotelegraph signal is shaped, and in successive circuits it is filtered and amplified so that it is suitable to trigger the keying circuit. The output of the keying circuit, which follows the on-off characteristics of the original signal, is synchronized with the AFF clock by the mark synchronizer.

The synchronized *mark* signal is used to control the start and duration of a count in the *mark* duration counter. This counter effectively counts clock pulses throughout the duration of the *mark* signal. At the end of the *mark* signal the count is terminated and a decision is made by the *dot dash decode* circuit as to whether the element is a dot or a dash. The appropriate indication is stored in the first stage of either the dot or dash multiplexer, and the *mark* duration counter is reset.

Each multiplexer is a five-stage shift register which performs the basic function of serial-to-parallel conversion. In other words, each element (dot or dash) of the character is successively stored in the multiplexer until all of the character has been received. All of the character elements are then available for translation prior to printout.

In addition, at the end of the *mark* signal, the space detector turns on the space duration counter which counts clock pulses throughout the duration of the *space* (i.e., until either the next *mark* signal begins, or until the counter has reached its maximum count, signifying a word space). At the completion of the *space* interval, the count is terminated and a decision is made by the character and word space decode circuits as to whether an element space, character space or word space has occurred.

If an element space is detected the mark duration counter again counts clock pulses during the next *mark* signal, and the space duration counter is reset. If a character space is detected the timing control circuit causes the dot/dash data in the multiplexer to be transferred to the Morse character holding register through the character transfer logic. The multiplexers are then reset for the next character.

If a word space is subsequently detected the timing control causes a *space* to be transferred to the Morse character holding register. In either case the next

SSO . . . SSO . . . SSO . . .
I wonder what that means?

mark signal causes the space duration counter to be reset.

As long as only element spaces are detected the dot/dash data continues to be shifted into successive stages of the dot/dash multiplexers. It takes the detection of a character space to cause the transfer of this accumulated data into the Morse character holding register.

Once the character is in the Morse character holding register the timing control supplies a character-ready signal which activates the Morse/ASCII code-translator. This translates the Morse representation of the character into the corresponding ASCII* representation which is used by the strip printer. The actual character passing under the print hammer is followed by the ASCII character code generator which is a counter that is sychronized with the positions of the characters on the print wheel. When the character under the print hammer corresponds to the translated Morse character the timing control activates the print hammer, thereby impressing the character on a paper strip located between the hammer and the wheel. The paper then moves to the next position for the next character. The Morse character holding register retains the old character until a new character is transferred into it.

*ASCII is the American Standard Code for Information Interchange. This is an eight-level code that is commonly used in computer printout devices and some teleprinters.

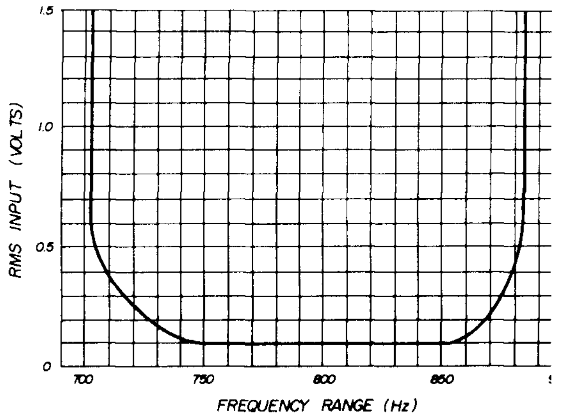


fig. 3. Bandpass characteristic of the 800-Hz active filter in fig. 2.

automatic frequency control

During the detection of dot information the dot error circuit indicates whenever a recognized dot element deviates

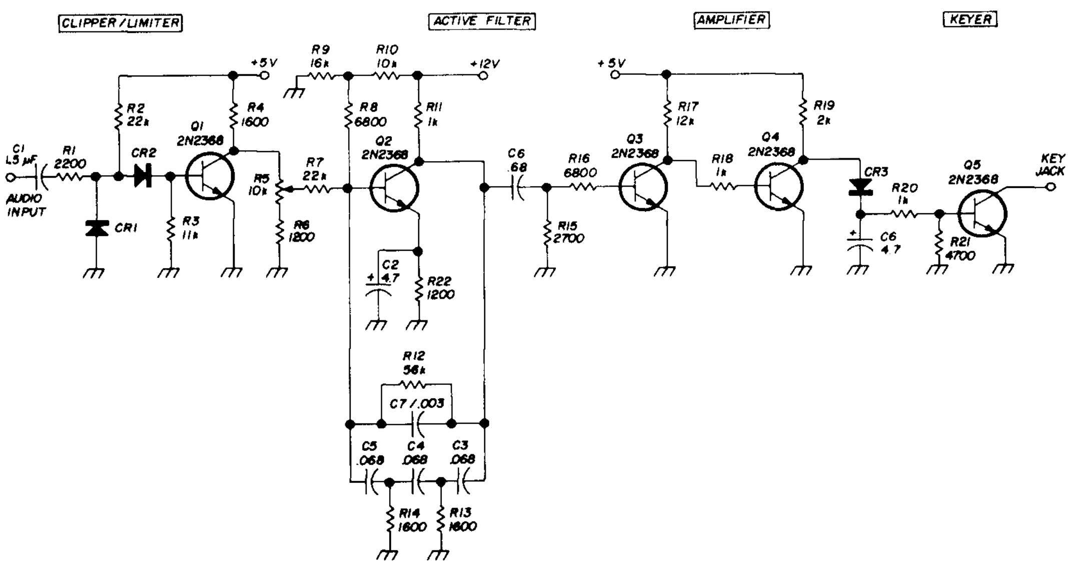


fig. 2. Filter and keying circuit. R12 and C7 provide negative feedback for improved filter skirt response.

from a perfect dot length of 6 counts. This error indication, in conjunction with the up/down circuit, causes the automatic rate control counter to either increase or decrease its count depending on the magnitude and direction of the dot error. The output of this counter is transformed into an analog signal by the analog error generator. This signal alters the AFF clock rate through the frequency control circuit so a dot generates a count of 6 in the *mark* duration counter. With this automatic following feature it is possible to track gradually changing sending speeds, up and down, to the limits of the clock frequency variation.

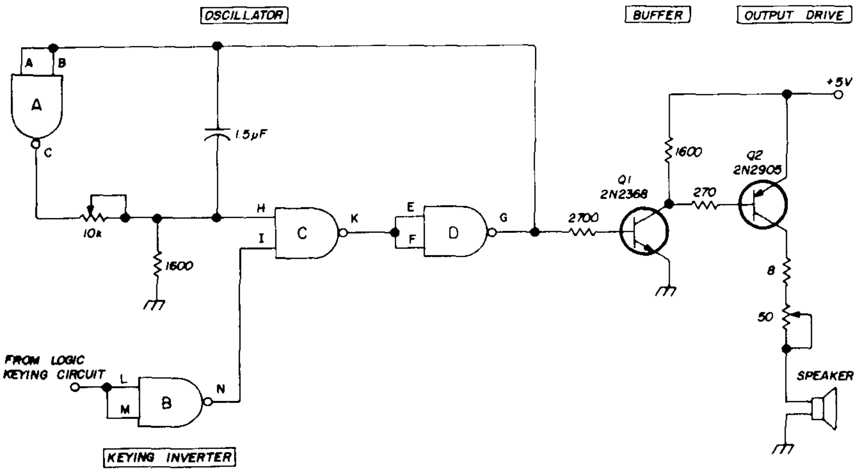


fig. 4. Sidetone generator. Suitable integrated circuits are Motorola SC2631, TI 16223 or Sylvania SG-220-07.

keying circuits

To translate radiotelegraphic signals with an automatic system the electronic circuits must be designed to perform the same elementary functions as a human operator to extract intelligence from the dot-and-dash impulses. It is a unique ability of the human ear and mind to concentrate on a desired CW signal and ignore static and interference.[3]

Although the circuits used in the AFF do not give complete immunity to static they do a good job of ignoring intruding voice and CW signals. With static down as little as 6 dB from the desired CW signal the AFF circuits efficiently imitate the performance of a human operator.

Although many single-stage circuits have been designed for audio frequency filters their overall performance is not optimum for the AFF. The circuit in **fig. 2** uses five stages to provide the needed functions of selecting the desired signal over a wide range of input signals (0.2 volts to 100 volts rms) along with the required frequency selectivity of less than 10 Hz to 1 kHz. Since complete theory of operation can be found in any textbook on selective audio filters only the general operation will be considered here.

circuit operation

Capacitor C1 blocks dc voltage from the input transistor Q1 yet allows the audio frequencies normal to amateur receivers to pass through. Diodes CR1 and CR2, along with resistor R1 clip and limit the input signals to Q1 between about −0.7 to +1.4 volts; R2 and Q1 biased on. All input signals cause the collector of Q1 to swing from near zero to +5 volts to provide constant-level signals to drive the 800-Hz center-frequency active filter.

Resistors R5 and R6 adjust the signal level (and bandwidth) to the base circuit of Q2. All signals at the base of Q2 are inverted 180° by Q2. Phase-shift elements

C3, C4, C5, R13 and R14 cause an additional shift of 180°; this signal is fed in phase with the input signal to the base of Q2, causing the circuit to oscillate. Signals not at the filter's operating frequency are out of phase and will not cause oscillation.

Transistors Q3 and Q4 amplify the low level output signal from the filter, shaping and squaring it to drive the keying detector diode CR3. The detector circuit has a charge time constant of about five milliseconds, requiring around five cycles of operation from the active filter before the base of transistor Q5 can be biased on. This provides some immunity to static.

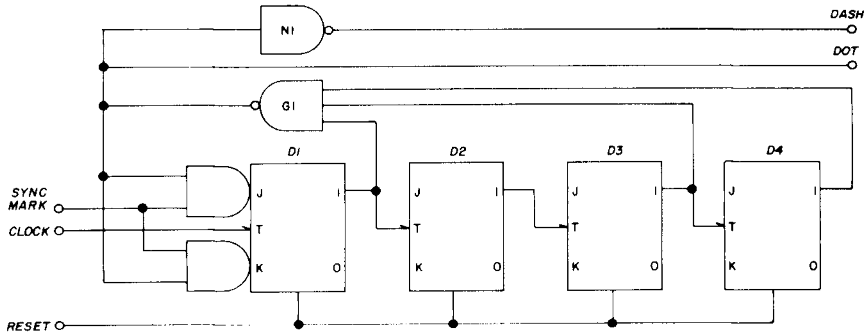


fig. 6. Mark duration counter and dot/dash decoder.

side-tone monitor

The side-tone generator (**fig. 4**) consists of a quadruple two-input positive TTL NAND gate driving two transistors. Three sections of the IC are connected as a three-stage ring oscillator; the fourth gate is used to invert the keying circuit which is grounded when keyed. Timing is controlled by the 10,000-ohm pot and the 1.5-μF capacitor. The squarewave generated by this circuit drives the amplifier transistors in the speaker circuit.

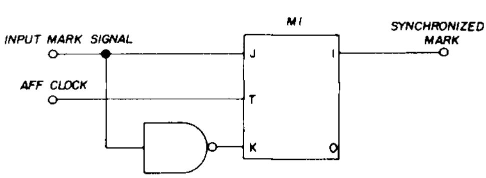


fig. 5. Mark synchronizer circuit.

mark synchronizer

The mark synchronizer (**fig. 5**) is merely a JK flip-flop which synchronizes the input signal from the keyer with the internal clock of the AFF. Synchronization is necessary to assure proper subsequent timing relationship within the AFF.

When the input *mark* signal goes positive the trailing edge of the next clock pulse sets the flip-flop to the *one* state. The flip-flop remains in this state until the input *mark* signal goes back to zero. At this time the trailing edge of the following clock pulse resets the flip-flop to *zero*. Thus, the flip-flop follows the input *mark* signal in synchronization with the AFF clock.

mark duration counter

Four JK flip-flops are used to form a sequential binary counter (**fig. 6**). This counter is used to count the number of AFF clock pulses which occur during the presence of a synchronized *mark* signal; the total count is indicative of mark signal duration.

When the synchronized *mark* signal goes positive the trailing edge of each successive clock pulse causes stages D1 through D4 to count up. When, and if, the counter reaches a count of 13 (D4, D3, D2, D1=1101), the output of gate G1 goes to zero and freezes the counter at this total. The counter is reset when the *mark* signal goes back to zero and after a decision is made as to whether the total count represents a dot or a dash.

You may recall that any mark count up to and including 12 is detected as a dot. Any count of 13 or more (always represented by a counter state of 13) is

whether the previous *mark* signal is a dot or a dash a shift pulse is generated and stores this indication by storing a one in flip-flop T1 if a dot and in flip-flop H1 if a dash. If the next *mark* signal is part of the same character the following shift pulse stores this indication in T1 or H1 as appropriate. At the same time it shifts the

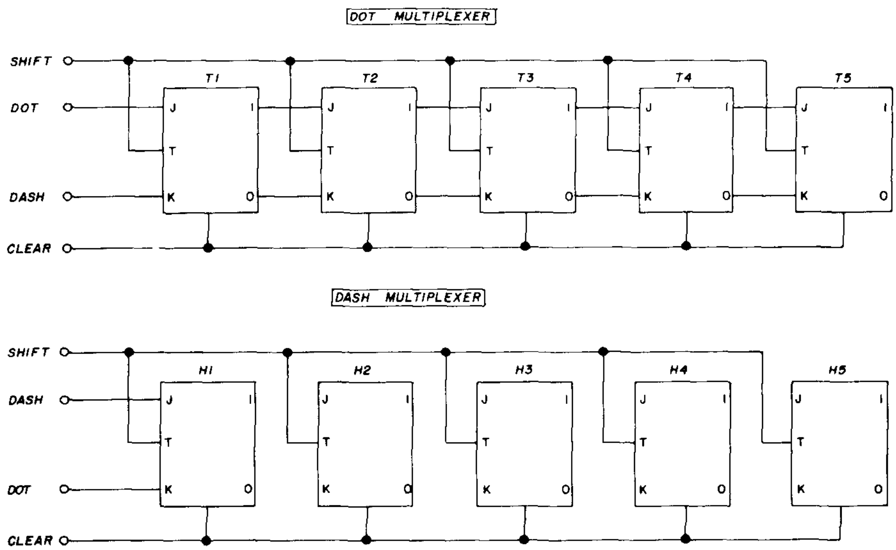


fig. 7. Dot and dash multiplexer circuits.

detected as a dash. The adjustable oscillator is initially set so a typical dot will give a count of six.

Note that when the binary counter has terminated its count the output of gate G1 (when positive) indicates a dot. The output of inverter N1 (when positive) indicates a dash.

dot and dash multiplexers

When a dot/dash decision has been made by gate G1 and inverter N1 at the conclusion of a *mark* count some means must be provided to remember this decision. This is accomplished in the case of a dot by the dot multiplexer; in the case of a dash the dash multiplexer is used. Each of these multiplexers consists of a 5-stage shift register composed of JK flip-flops (see **fig. 7**).

After the decision is made as to

previous indications in T1 and H1 into T2 and H2, respectively. Likewise, the previous indications in T2, H2 are shifted into T3, H3; those into T4, H4, and into T5, H5.

Up to five successive dot/dash character elements can be stored in the multiplexers. If a character is composed of six elements (e.g., the special symbols), the first element is shifted out of T5, H5 and lost at the time that the sixth and last element is shifted into T1, H1. However, the special symbols can still be decoded since a chopped-off five element representation of them can be uniquely identified.

A flip-flop is capable of representing two states and could therefore represent either a dot or a dash. However, there are actually three states to be represented: dot, dash and null (neither). As an example, suppose that a Morse code "W" is

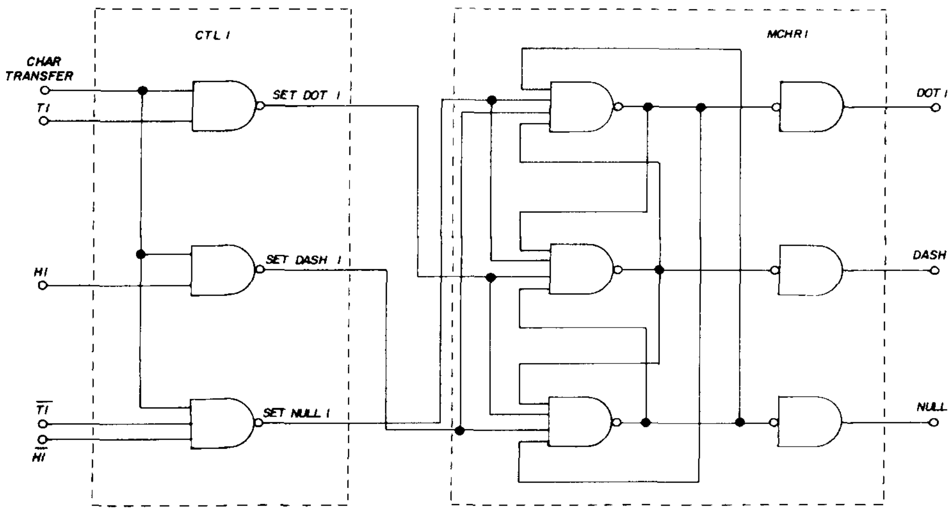


fig. 8. Character transfer logic (CTL) and Morse character holding register (MCHR).

stored in the multiplexers. In the dot multiplexer T1 is zero (reset), T2 is zero, T3 is one (set), T4 is zero and T5 is zero. In the dash multiplexer H1 is one, H2 is one, H3 is zero, H4 is zero and H5 is zero. This is interpreted as follows:

null is stored in stage 5 since both T5 and H5 are zero (reset)

null is stored in stage 4 since T4 and H4 are zero

dot is stored in stage 3 since T3 is one (set) and H3 is zero

dash is stored in stage 2 since T2 is zero and H2 is one

dash is stored in stage 1 since T1 is zero and H1 is one

(Stage 1 always contains the last element of the Morse character.) Note that it is not permitted to set both flip-flops in the same stage (such as T1=1 and H1=1) since that would mean that the same element was indentified as *both* a dot and a dash. The dot/dash multiplexers are cleared after their data is transferred to the Morse character holding register upon the occurrence of a character space.

morse character holding register

There are five stages comprising the character transfer logic and Morse character holding register (**fig. 8**). This illustration shows a typical stage (in this case, stage 1) made up of a portion of the character-transfer logic (CTL1) and a three-stage latch (MCHR1) which holds element number 1 from the dot-dash multiplexers.

When a character space is detected the transfer-character pulse is generated which transfers the dot-dash data in the multiplexers to the Morse character holding register. The multiplexers are then cleared so they are ready to receive the next character. The MCHR holds the character until it can be translated and printed out.

It can be seen from **fig. 8** that if T1 (dot indication) is present at the time of the transfer character pulse the CTL1 circuit causes the *set dot-1* output to go negative, causing MCHR1 to latch in the *dot-1* state. That is, the *dot-1* output goes positive while the *dash-1* and *null-1* outputs go negative. Similarly, if H1 (dash indication) is present during the transfer pulse, MCHR1 latches in the *dash-1* state. If neither T1 nor H1 is present during the transfer pulse, MCHR1 latches in the *null-1* state.

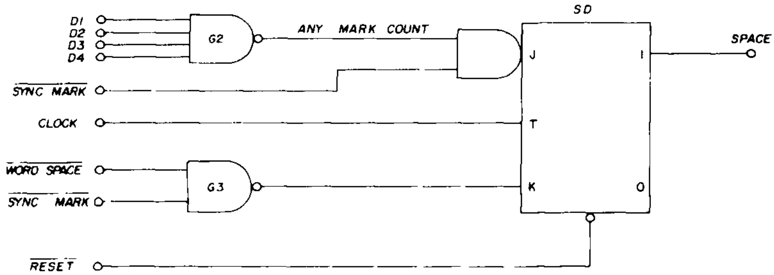


fig. 9. Space detector.

The outputs of MCHR1, together with the outputs of the other four stages of the Morse character holding register, are connected to the input of the diode matrix which performs the Morse to ASCII character translation. This must be done to get the character in a form suitable for printout.

space detector

The space detector (**fig. 9**) is a flip-flop that is set at the beginning of each interval between *marks* and reset at the beginning of the next *mark* if this *mark* occurs before a word-space is detected. If not, the space detector is reset upon the detection of the word-space.

Flip-flop SD is initially in a reset state. If the *mark* duration counter has any count in it the output of gate G2 is positive. At the completion of the *mark* signal *sync mark* goes positive enabling the set side of flip-flop SD. On the next clock pulse SD is set. The flip-flop will remain set (signifying a *space* condition) until the output of gate G3 goes high. This is caused either by the occurrence of a new *sync mark* signal or the detection of a word-space. If either of these conditions should occur flip-flop SD is reset on the next clock pulse. This signifies the end of the space interval.

space duration counter

The space duration counter (**fig. 10**) is a 5-stage serial binary counter composed

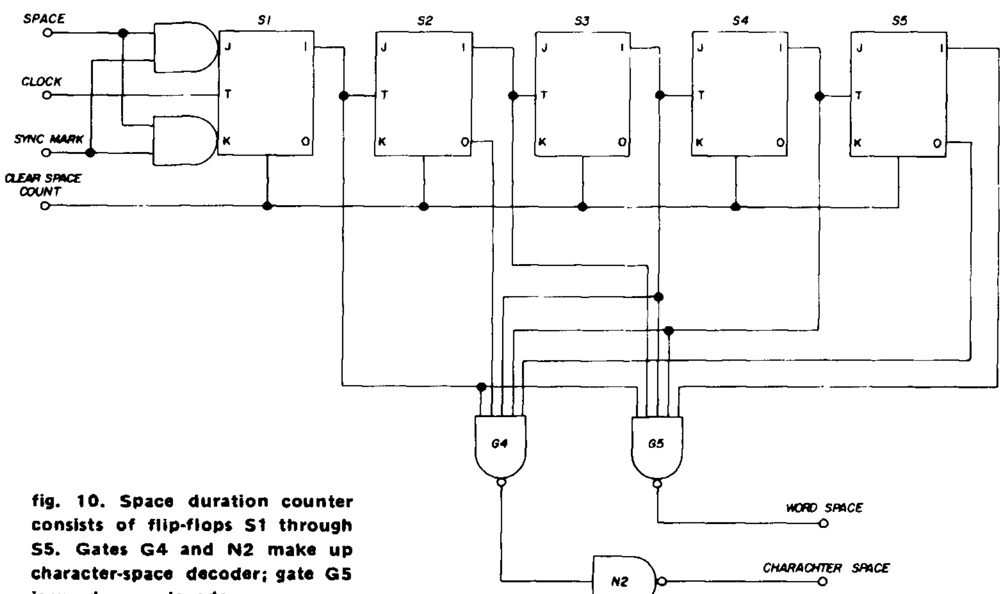


fig. 10. Space duration counter consists of flip-flops S1 through S5. Gates G4 and N2 make up character-space decoder; gate G5 is word-space decoder.

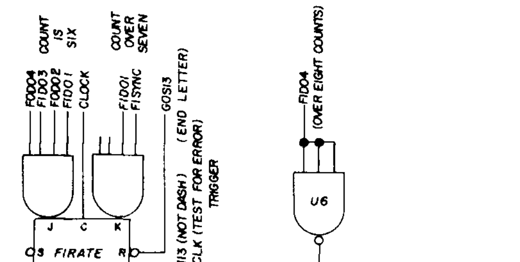
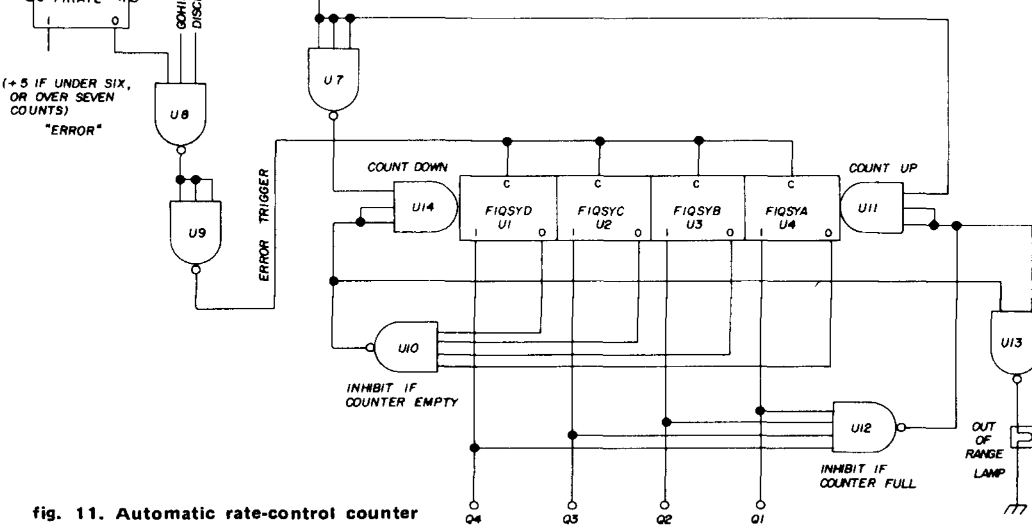



fig. 11. Automatic rate-control counter includes up/down circuit and dot error trigger.

of JK flip-flops. It counts clock pulses during the period that the *space* flip-flop is in a set state. This counter is reset either at the beginning of the next *mark*, or upon the detection of a word-space. Note that whenever a *sync mark* signal occurs it inhibits the input gates of the first stage (S1) of the counter. At the same time the clear-space-count signal is formed to clear the counter.

The character space decoder (gate G4 and inverter N2) detects the occurrence of a count of 13 in the counter. At this time the output of inverter N2 goes positive to indicate a character space. This indication is sent to the timing control logic where a transfer-character pulse is formed, and later, a print pulse.

The word-space decoder (gate G5) detects the occurrence of a count of 31 in the counter. The output of gate G5 goes negative at this time to indicate a word-space. This indication is also sent to the timing control logic where a transfer-character pulse is formed, and later, a step-paper signal to the printer. The word-space signal is also instrumental in clearing the space detector and the space duration counter.

The master oscillator and automatic frequency control circuit in **fig. 12** provides the clock signal for the AFF. This circuit was designed to maintain the *mark* count of 6 as the speed of the operator changed to track the sending operator.

The outputs from rate-control flip-flops F1QSYA, B, C and D in **fig. 11** drive the summing gate transistors Q1, Q2, Q3 and Q4. As these transistors turn on (or off) resistor R16 (82k), R17 (39k), R18 (20k) and R19 (10k) are connected (or disconnected) across shunt resistor R20. Resistors R5, R6 and R20 form a network that controls the current into the base of the current-charging transistor Q5. Unijunction transistor Q6, current generator Q5 and capacitor C1 form a relaxation oscillator which controls the basic frequency of the clock.

The rate at which the voltage across capacitor C1 rises is a function of the

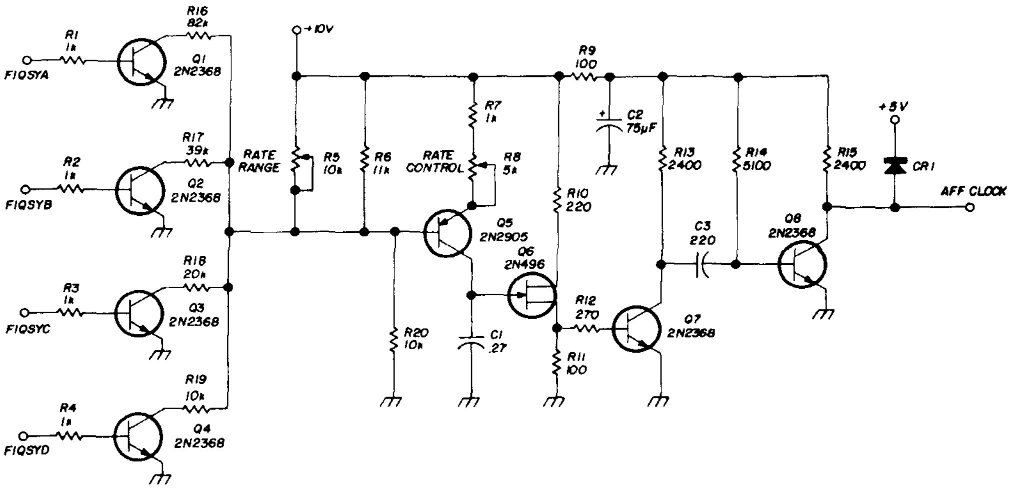


fig. 12. Adjustable oscillator and automatic frequency control circuit. Inputs to Q1, Q2, Q3 and Q4 are from automatic rate-control counter in fig. 11.

current generated by Q5 and the time required until Q6 fires at about 6.5 volts. This master clock signal controls the pulse-shaping single-shot multivibrator (Q7 and Q8) which generate a one microsecond clock pulse.

As the *mark* duration counter counts the clock pulses a feedback control signal is sent to the rate-control flip-flops (**fig. 11**) and updates the stored count if the dot length is more or less than the ideal six count; if it is six counts no change is made.

The value in this counter controls the summing network current and the clock frequency so a count of six is maintained in the *mark* generator. Since the control circuits in the automatic rate control counter will not respond to a dash signal (count over 13) the wpm rate changes only in relation to the average dot length.

translator

The heart of the automatic fist follower lies in its Morse/ASCII translator; this circuit is nothing more than a diode matrix network which compares the desired Morse code character with that of

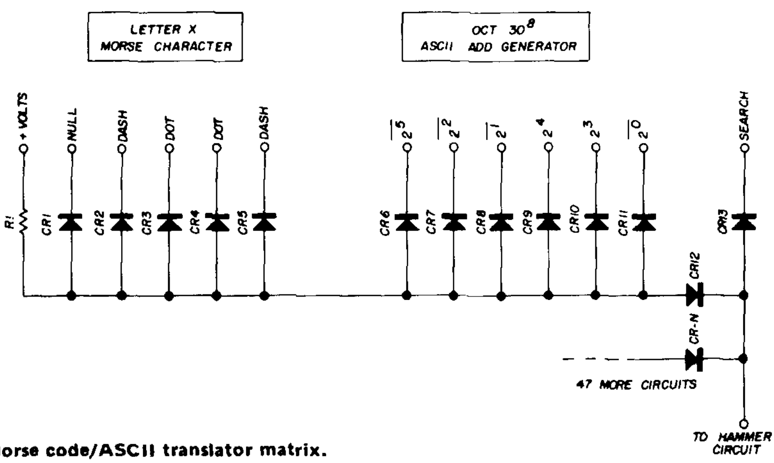


fig. 13. Morse code/ASCII translator matrix.

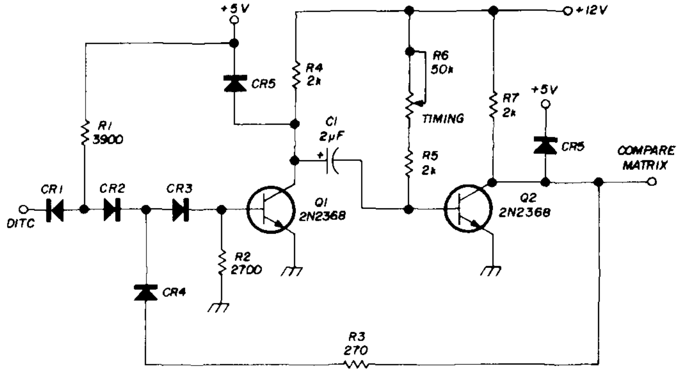


fig. 14. Print single shot is adjustable from 3 to 80 milliseconds; set to 40 milliseconds.

the corresponding letter on a print wheel. The position of any given character on this print wheel is detected by comparing, in a diode matrix, the value of the octal address generator with that of the desired character.

The operation of *one* compare line will be described with the aid of **fig. 13.** The eleven diodes in **fig. 13** are connected in a logic AND circuit. Five are connected into the Morse code character detect circuit; six diodes are connected to the ASCII address generator. Forty-eight such circuits are connected as OR logic circuits to AND with CR13 to generate the compare signal.

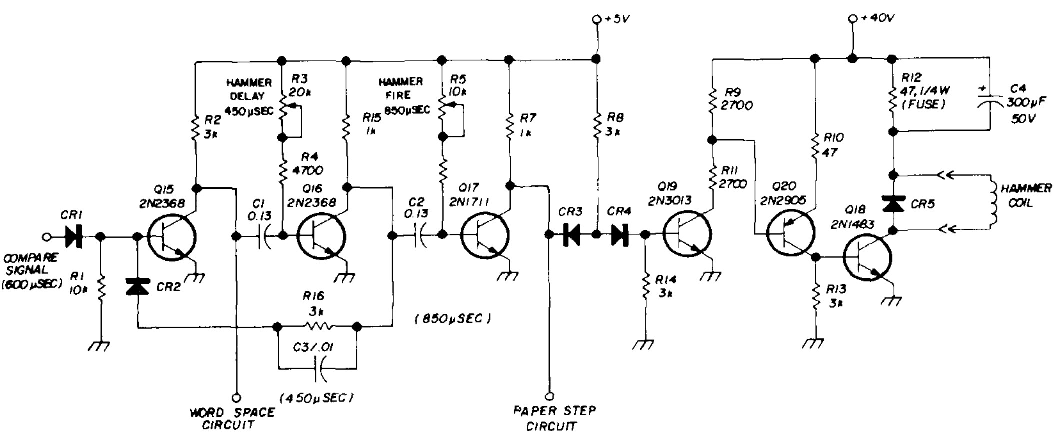
This compare signal (the result of all diodes in one line being at +5 volts) starts the hammer drive circuit. Only one of 64 combinations will be true at any one time for those diodes (CR6 through CR11) connected to the ASCII code generator. The generator is nothing more than six flip-flops connected to count from zero to 63 and repeat.

As the ASCII generator counts, it searches for those diodes which are at +5 volts. Since all diodes are at +5 volts at compare time, the compare line goes to +5 volts (through R1) and starts the hammer circuit. The received and decoded Morse code character comes in to diodes CR1 through CR5. As each new character is decoded by the AFF it is printed out through this translator.

print single-shot

The print single-shot (**fig. 14**) is a two-stage transistor circuit whose timing is enabled with a positive input trigger pulse applied to diode CR1. The positive pulse, from the Morse code translator

fig. 15. Hammer delay circuit. All diodes are 1N914s except CR5 which is a 1N4000.



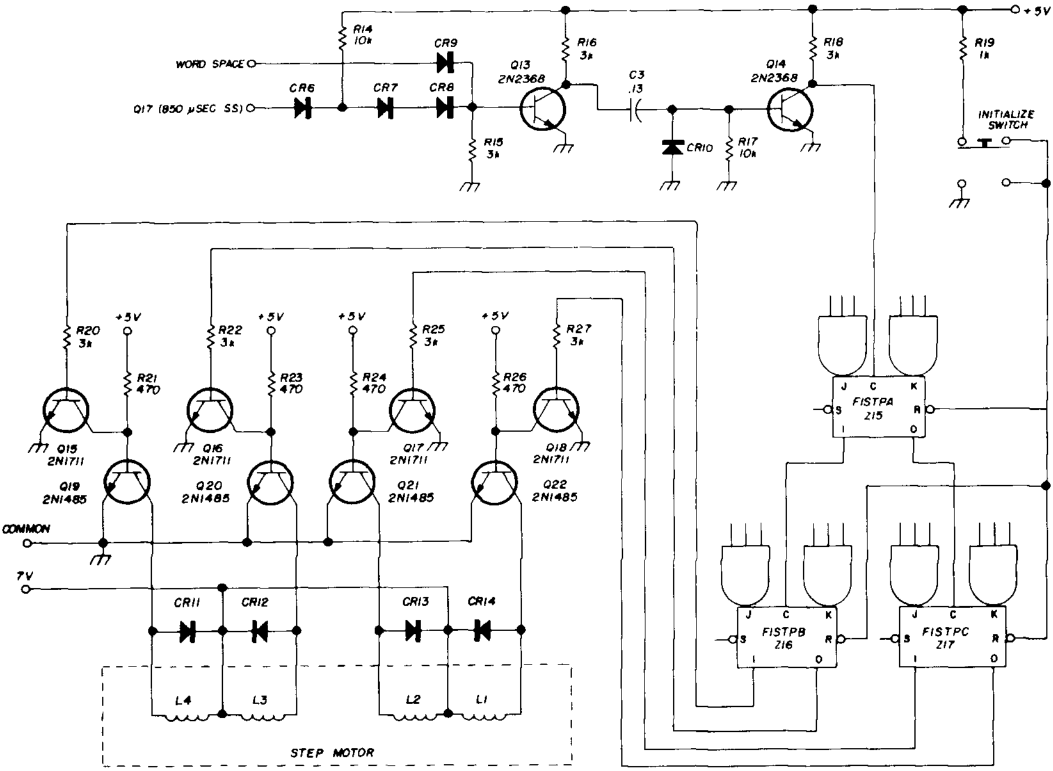


fig. 16. Paper-step control. Diodes CR11 through CR14 are type 1N4000. Integrated circuits Z15, Z16, and Z17 are Sylvania type SF200-08. Diodes CR6 through CR10 are 1N914s.

(character and word-space detector) logic, triggers transistor Q1 on. With Q1's collector clamped to ground, capacitor C1 starts to discharge through resistors R5 and R6. The rate of discharge is determined by their time constant. With the base of transistor Q2 below ground, a positive voltage is applied from the collector of Q2 through R3, CR3 and CR4 to the base of transistor Q1, keeping Q1 turned on until the charge across C1 decreases to a level that allows transistor Q2 to turn on.

This action occurs each time a character is formed. R6, the timing resistor, is set to give a 40-millisecond pulse output from Q2. This drives the Morse code to ASCII diode compare matrix. It is during this time that the print wheel will complete one revolution, allowing the desired Morse character to be synchronized with the comparing ASCII character on the print wheel.

print control

Control of the mechanical functions within the printing mechanism requires very precise timing signals. Three single-shot circuits were developed for controlling this basic timing. Single-shot circuits of standard design include two or more stages for each timing function; this circuit (**fig. 15**) uses five stages to generate the three separate timing signals.

The first section of the timing circuit allows time for the print wheel to synchronize the desired character (embossed on the face of the rotating print wheel) with the print hammer impact interval. The compare signal from the Morse code/ASCII translator signals the approach of the desired character toward the hammer impact point.

A positive pulse at diode CR1 turns on transistor Q15; this clamps one end of capacitor C1 to ground and starts the timing cycle for R3, R4 and C1. The cycle ends when C1 charges and allows transistor Q16 to return to the on state in approximately 450 microseconds.

The end of that timing cycle causes C2 to be clamped to ground by the collector of Q16, which starts the hammer *on* drive signal. The output pulse from Q17 drives not only transistor Q19, but also starts the delay time for the stepping-motor trigger.

At the time when Q17 was positive, transistor Q13 was biased on, and capacitor C3 was discharging through diode CR10. Upon the termination of the print hammer pulse transistor Q13 is switched off, allowing R16 to drive current into the base of transistor Q14. Transistor Q14 is normally biased off by R17 holding its base to ground. When Q14 turns on, a fast negative-going pulse is generated to trigger the JK flip-flop Z15 in the step-motor control circuit which advances the paper tape.

The step motor is controlled by three JK flip-flops, Z15, Z16, Z17 (see **fig. 16**). The four control states are: 1010, 1001, 0101 and 0110. These control states enable the field currents within the stepping motor and control the direction of rotation, one step for each input trigger. Transistors Q15, Q16, Q17, Q18 and Q19 through Q22 serve only as current amplifiers. **Fig. 17** shows a functional block diagram of the basic strip printer and control.

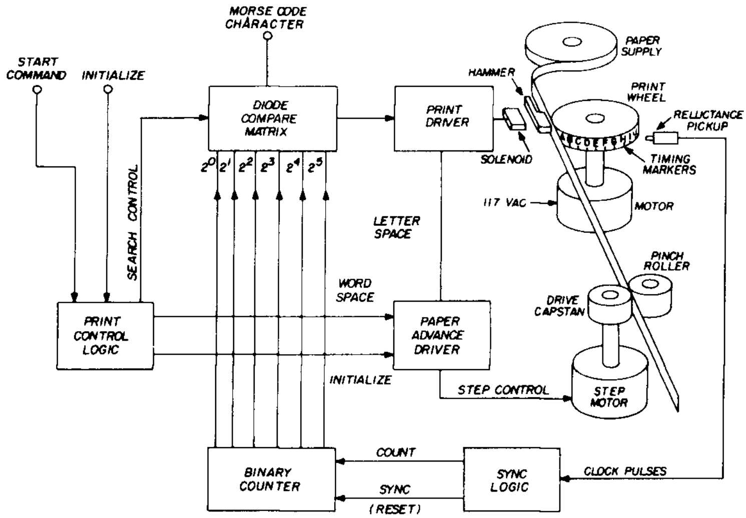


fig. 17. Block diagram of the basic strip printer.

construction

The photograph shows an overall view of the four circuit breadboards with the strip printer in the foreground. Nearly any method of construction can be used as long as the interconnecting wires are not over one foot long. This is because the TTL logic chips are very fast and noise would trigger them.

The first board has all of the AFF logic and those transistors and components which make up the master oscillator and automatic rate control.

The second board holds the auxiliary lamp display. This is not needed for operation of the AFF logic and was used as a display until the printout control was designed.

The third board holds the electronic circuits required by the printer. The fourth board contains the diode compare circuits. Not much can be said about the matrix diode board except that it's awkward, takes a lot of room, and we wish it wasn't needed.

During construction, there is one point that you should be aware of: use care in the ground and voltage supply lines. They must be short. Number 24 awg was used on the prototype with bypass capacitors (1.5 μF disc) every six inches or so.

adjustment

Operation of your receiver with the AFF is not unlike its normal operation in the CW mode. The only special consideration is that the audio beat note produced by the desired CW signal must fall within the bandpass of the 800-Hz active filter.

With the prototype unit tests showed that with 200-Hz bandwidth tuning on a Drake TR-4 was nice and smooth, allowed good QRM rejection yet received CW speeds up to 100 wpm without dropping data due to frequency rolloff.

The only other requirement is that the receiver's output level be at least 0.2 volts rms and above the noise level to trigger the active filter.

Operation of the AFF's logic is perhaps the easiest of all. You have only to tune in a CW signal, set the *run/calibration* switch to *calibrate,* adjust the rate control until the dot lamp starts to flash, then turn the switch back to *run.*

This technique should have you receiving automatic Morse code with the drudgeries left to the AFF machine. You can sit back and read the copy.

Even with the automatic tracking ability of the machine there is always some guy with a lead foot – a lid who can do things with Morse code even old man Morse did not know about. You don't have to give up; simply go to manual operation (calibrate position) and ride the rate control till the copy is clear. The dot lamp may not always light, due to the idiosyncrasies of this type of sending, but the copy should be readable.

We put a sign over our machine which reads, "This machine cannot think! It can copy Morse code."

The results of several months of on-the-air operation with the AFF were very enlightening. Machine-sent Morse code, even at speeds exceeding 100 wpm, was duck soup for the AFF. Surprisingly, even quite poor hand-sent Morse code was copied almost solidly due to the automatic tracking feature of the unit.

The major cause of errors was due to signal fading below the noise level or extremely strong interference right on top of the signal. This pointed up the extreme importance of the shaper, filter and keyer sections in the front end. More time was spent arriving at the optimum design for this area than any other portion. The bandpass was narrowed as much as possible while still allowing fairly high speed code to pass through the filter.

Limiting the maximum code speed to about 60 wpm is reasonable for amateur use and allows a sharp narrowband filter. However, the prototype AFF has an adjustable bandpass circuit that allows reception of very high speed code when desired.

The AFF was built with the fairly expensive high-speed transistor-transistor-logic (T^2L) integrated circuits because they were readily available. However, these are not necessary; the lower cost, low-speed ICs are ideal for this application since they are less susceptible to noise and less critical in operation. The same logic functions are available in these low-cost circuits, so substitution is quite straight forward.

The AFF prototype performs very well. It is a simple step from here to a low-cost version. In addition, the output interface can be adapted to a teleprinter or visual display. The age of ICs and automation is truly with us and it is starting to have considerable impact on amateur communications.

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2. Selfridge and Neisser, "Pattern Recognition," *Scientific American,* August, 1960.
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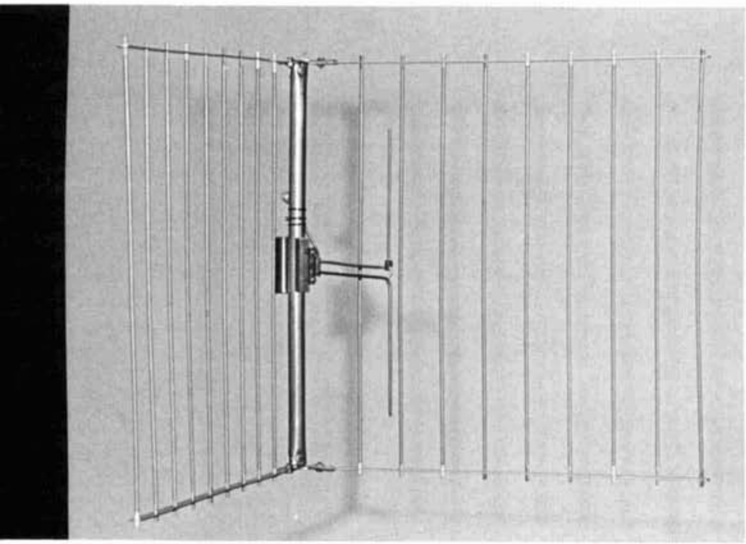
ham radio



432-MHz corner-reflector antenna

This miniature 7-dB antenna may be used by apartment dwellers, or as a reference for antenna measuring

Fred Telewski, WA2FSQ

Here is a small 432-MHz antenna which will suit the needs of apartment dwelling amateurs or those who want a standard gain reference antenna. This 7-dB antenna makes a nice portable window unit as well as an excellent comparision antenna for larger arrays.

Antenna contests have shown that many complex arrays (both amateur and commercial) do not perform as expected. This is due in part to the fact that many gain measurements are made via E- and H-plane pattern integration that assume a lossless structure. This is often not true because the structures are lossy. In addition, directivity is a prerequisite for gain but gain is not required for directivity. Since the corner reflector described here is simple and foolproof it will provide a good reference for large arrays.

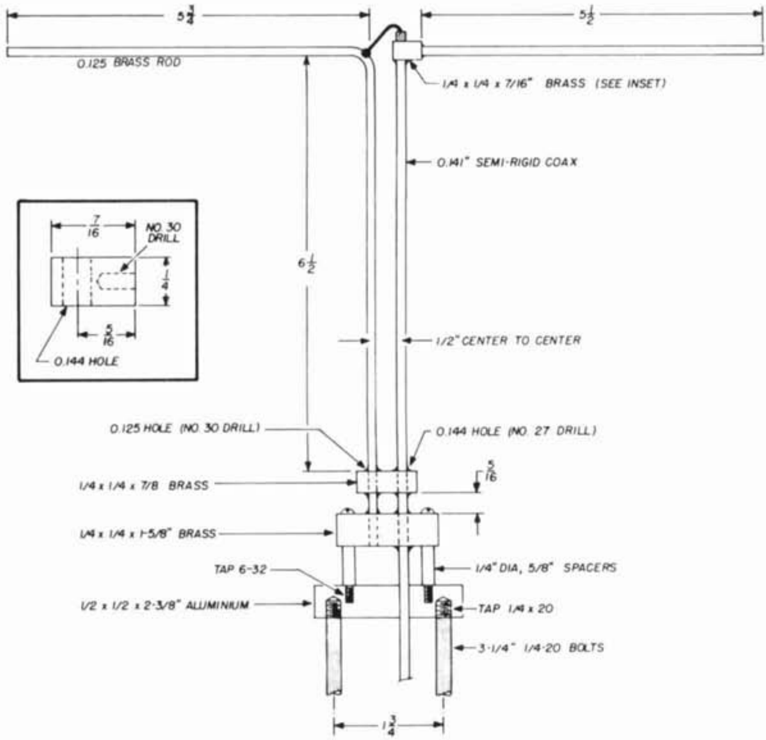
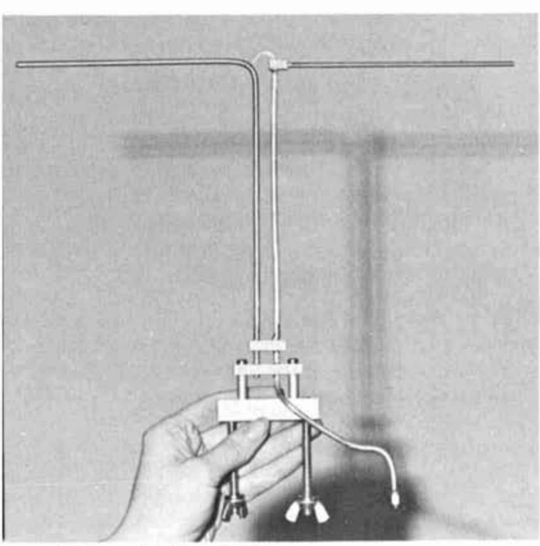


fig. 1. Construction details for the driven dipole element of the 432-MHz corner reflector antenna. Reflector is built from commercial uhf-tv antenna.

the reflector

The corner reflector is a modified JFD uhf television antenna which is priced at around $5.00. Start modifying the antenna by removing the U-bolt and saddle clamps; drill out the rivet which holds the bow-tie assembly in place. Discard the bow-tie and replace it with the driven dipole described in **fig. 1.** The original bow-tie will not function properly at 432 MHz.



Driven dipole assembly.

For a completely collapsible antenna, drill out the spring-loaded rivets which hold the reflector panels to the back bar and replace them with 8-32 screws and wing nuts.

driven dipole

The driven dipole consists of a coaxial line (Phelps-Dodge 0.141-inch semirigid line*), a balancer and a dipole. A variety of connectors for the semirigid line are available from Phelps Dodge Corporation;

*Phelps Dodge Communications Corporation, 60 Dodge Avenue, North Haven, Connecticut 06473.

the one recommended here is a BNC female type PDM 952-001. If you don't want to purchase a special connector, you can make one out of a BNC type UG-88/U connector by making a bushing which will adapt 0.141-inch line to the rear nut and soldering it in place.

The driven dipole parts should be soldered with a 250-watt iron. Clean the parts carefully with fine sandpaper or steel wool and apply flux before soldering. Do not use a torch; the excessive heat may cause the Teflon to expand and burst the outer conductor of the semirigid line.

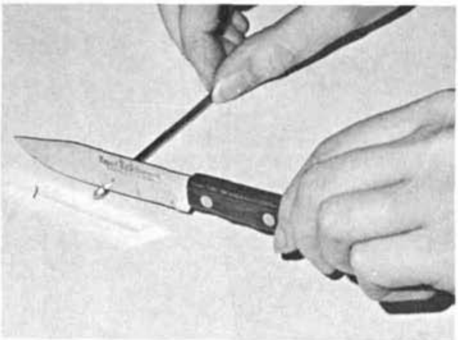


fig. 2. First step in preparing semi-rigid coaxial line is to score the outer conductor with a sharp knife.

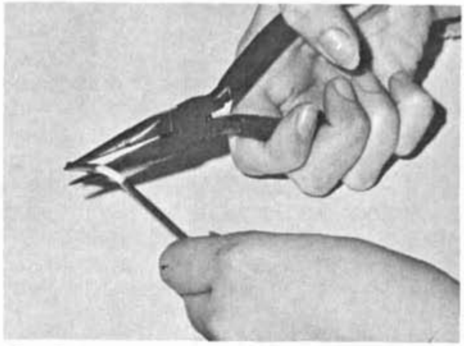
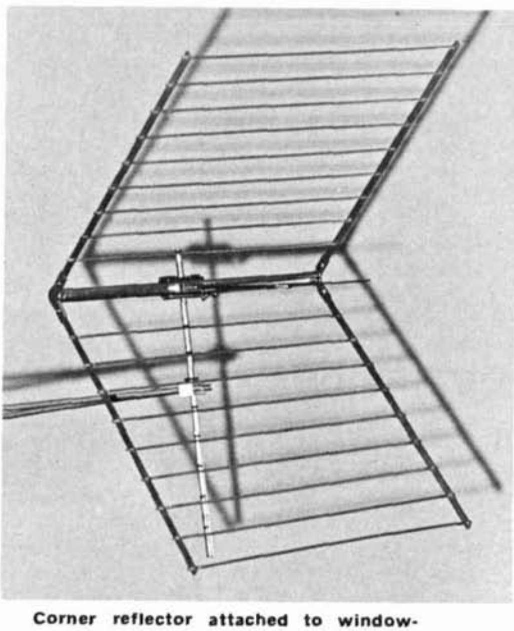


fig. 3. Break the outer conductor by grasping the end with pliers and rocking it back and forth.



Corner reflector attached to window-mounting bracket.

A few hints are in order for working with the semirigid coaxial line. This cable may be prepared by scoring the outer conductor with a sharp knife (see **fig. 2**). When the score is complete, grasp the end lightly with a pair of pliers and rock from side to side (see **fig. 3**). This separates the outer conductor from the Teflon dielectric. Now the outer conductor may be removed. Carefully score the Teflon (do not nick the center conductor) and remove it to expose the center conductor (see **fig. 4**).

performance

This antenna will deliver approximately 7 dB gain over a dipole. This design should yield a vswr of 1.2:1 or less if the dipole is carefully constructed. The 0.141-inch semirigid line will handle 200 watts of rf output power quite easily. For higher powers (500 to 600 watts) use 0.250-inch semirigid coaxial line.

radiation hazard

The potential hazards of rf radiation should always be considered when working in close proximity to vhf and uhf antennas. In general, it is good practice not to stand directly in front of any vhf-uhf antenna excited with 10 watts or more of rf. At these frequencies the rf energy causes thermal heating of body tissue which may have undesirable effects

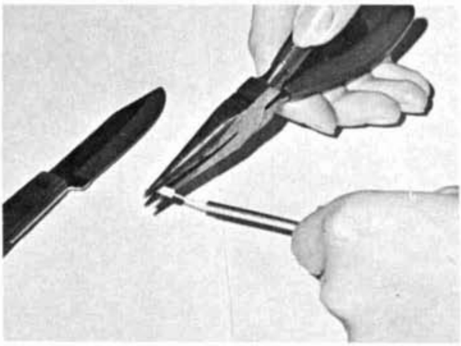


fig. 4. Score the Teflon dielectric and remove. Be careful not to nick the center conductor.

on body organs, notably the eyes. Since rf radiation effects are dependent on the average power dissipated by the tissue, a-m and fm are potentially worse than CW or ssb. This is due to the continuous high-level carrier associated with a-m and fm.

With 100 watts of rf delivered to this antenna, the field strength 6 feet in front of the antenna is well below the 10 mW/cm^2 safety standard commonly accepted in America. Radiation off the sides and back of the antenna is less than 0.1 mW/cm^2. (These measurements were conducted with a calibrated power meter and a Narda microwave radiation monitor, model B86B3.)

The antenna may be mounted out a window and swung from side to side without any significant rf field concentration in the building. The window brace shown in **fig. 5** is useful for mounting the antenna in an apartment window.

reference antenna

Amateurs who want to use this antenna as a reference might wonder why you would use a gain antenna as a reference instead of a dipole. This is because of the serious errors often introduced with a dipole reference because the dipole is prone to picking up reflections from the back, as well as ground reflections from the front.

In many cases the comparison antenna can be made to look like a champ or a dud by simply moving the reference dipole two or three feet in one direction or another so that reflections are arriving in or out of phase. Therefore, a reference antenna with some gain and a single major lobe is desirable. It eliminates back-lobe contributions so the major reflections which effect the antenna are the forward ground type; the effects of these may be determined by moving the antenna in the vertical plane.

In general, measurements with respect to this type of reference antenna are a good deal more consistent than those made with respect to a dipole. Since the amateur is not usually concerned with the absolute gain of his system but rather

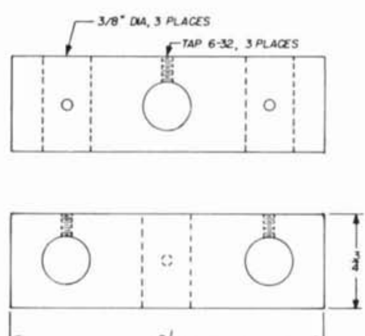


fig. 5. Window mounting blocks are made from 3/4" aluminum bar stock. Mounting rods are 3/8" aluminum tubing, 2-feet long. Complete installation requires 2 mounting blocks and 3 rods.

whether he has made an improvement or not, consistency in the measurement technique is most desirable.

In conclusion I would like to extend my thanks to Ted Miller of Phelps Dodge for his cooperation. I would also like to acknowledge R. Knadle, K2RIW, for his help and comments.

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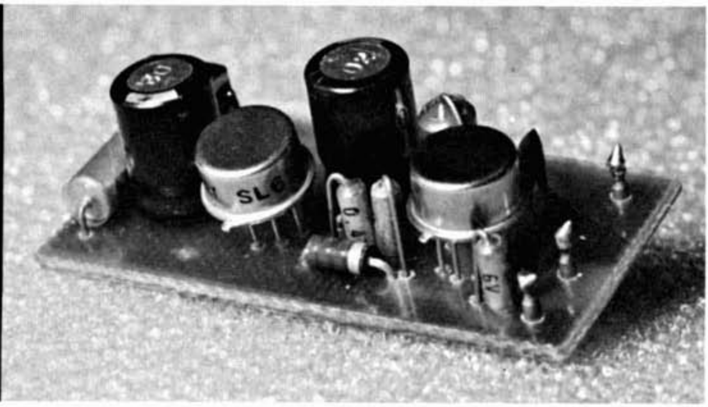


miniature microphone preamplifier with agc

An integrated-circuit speech preamplifier that features nearly constant output with large variations in speech input

James M. Bryant, 29 Arle Gardens, Cheltenham, England

For many applications it is convenient to be able to reduce the dynamic range of an audio signal. The modulation depth of a transmitter is best kept quite high; a constant value of modulating signal is useful to prevent overmodulation. Also, if speech is being taped at low tape speeds too low a signal will result in a poor signal-to-noise ratio; too large a signal will produce distortion.

This article describes a speech amplifier system with agc which will provide an rms output stable within 2 dB for nearly 40 dB input range. The circuit uses two integrated circuits and only ten discrete components, and occupies a printed circuit measuring only 22 x 47 mm (0.8 x 1.8 inch) on which there is also room for a miniature microphone.

An ideal speech agc system must adapt quickly to an input level and follow a

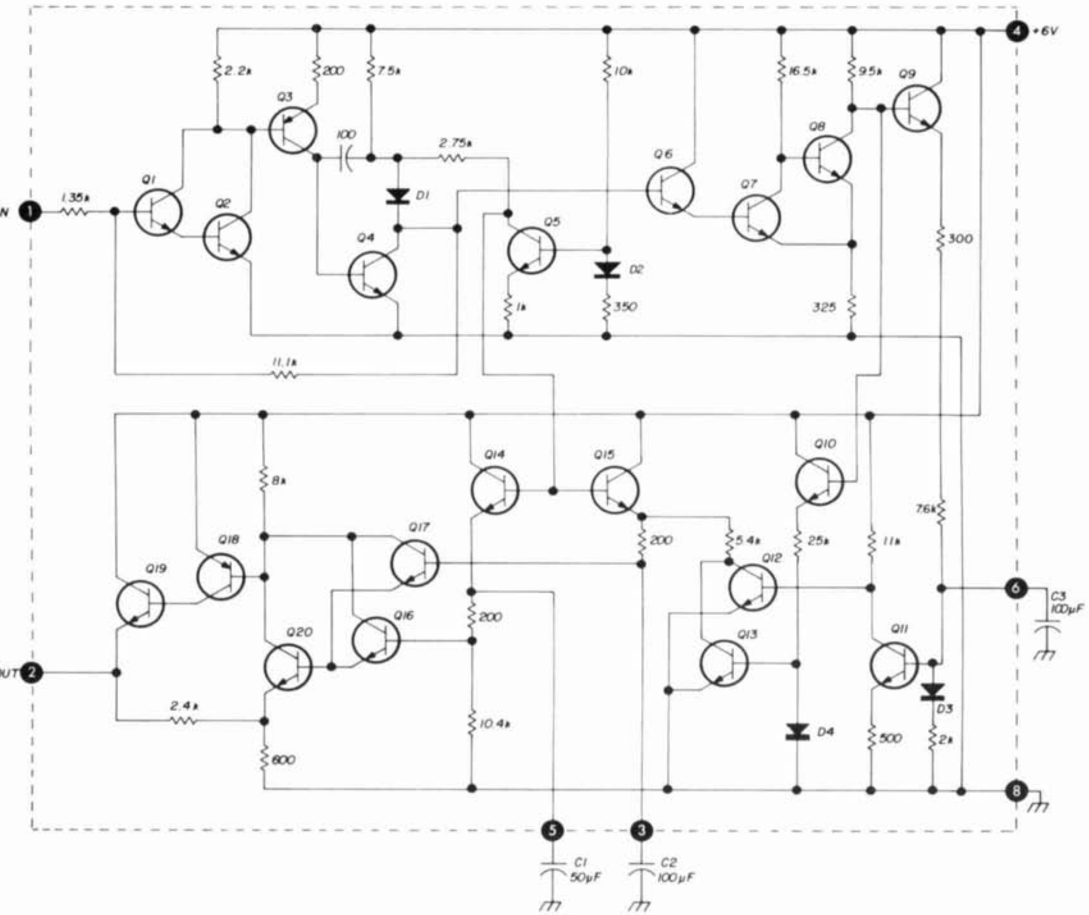
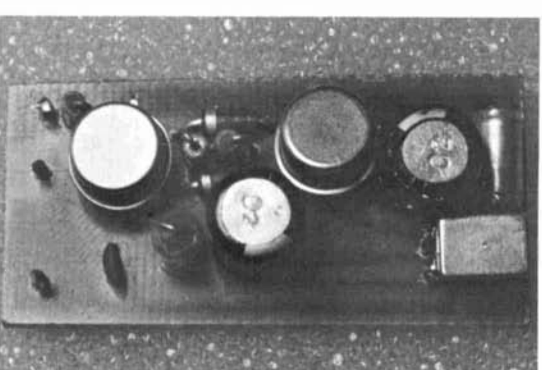


fig. 1. Internal circuit diagram of the Plessey SL620C agc generator.

fading signal but *remember* its level if speech suddenly stops as it does in pauses between words. However, if the pause becomes too long the system must quickly revert to full gain.



agc generator

The Plessey SL620C agc generator* meets the requirements detailed above and will also produce short pulses of agc to suppress short noise bursts while remembering the agc level at which it was operating when the noise burst first arrived. A circuit diagram of the SL620C is shown in **fig. 1**; its response to a varying audio signal is plotted in **fig. 2.** Capacitors C1, C2 and C3 are connected externally.

Circuit operation is as follows: the incoming signal is amplified by an af amplifier using transistors Q1 to Q4; its

*Plessey integrated circuits may be purchased from Plessey Electronics Corporation, 170 Finn Court, Farmingdale, Long Island, New York 11735.

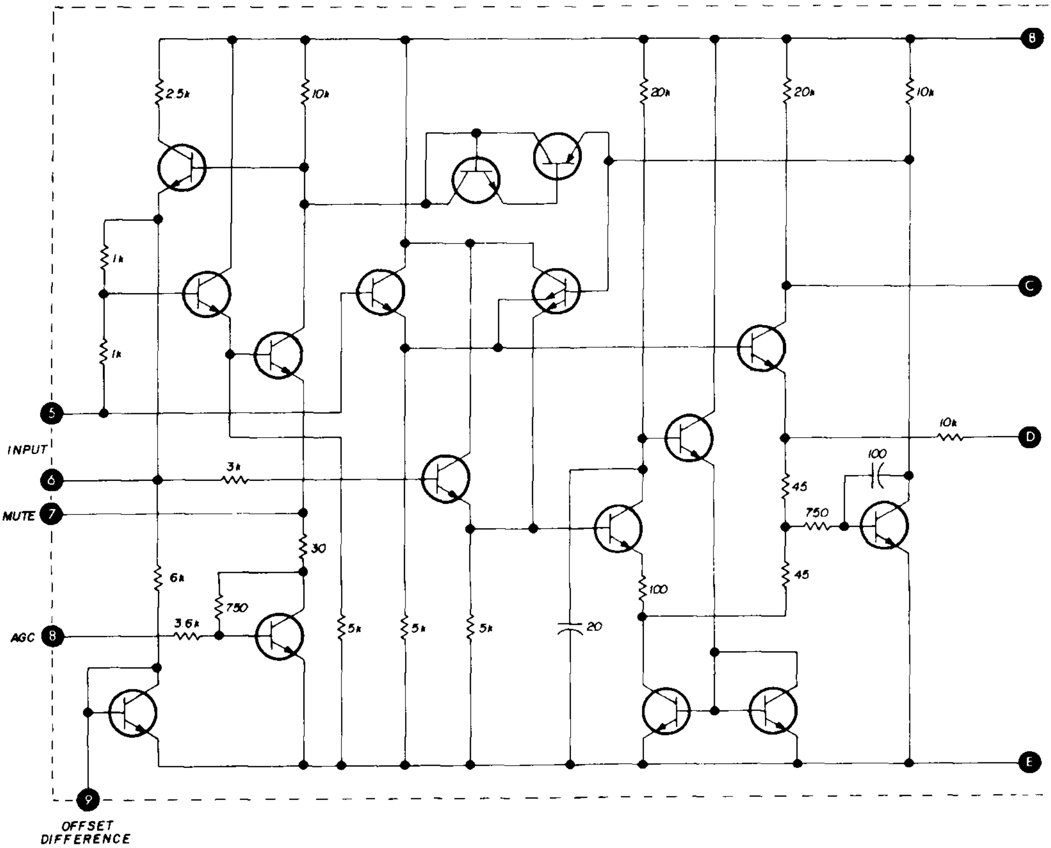


fig. 3. Circuit diagram of the Plessey SL630C audio amplifier.

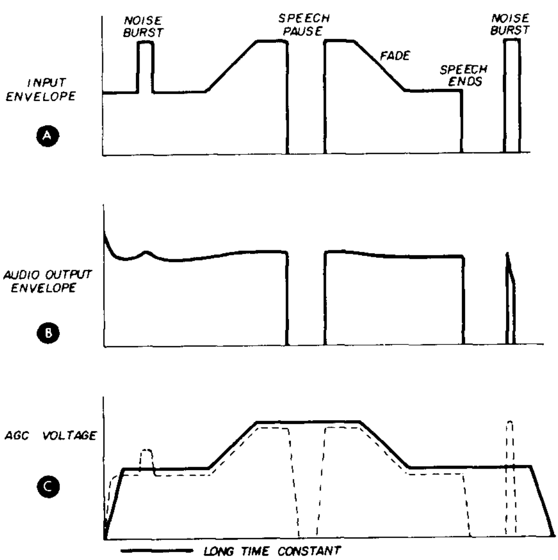
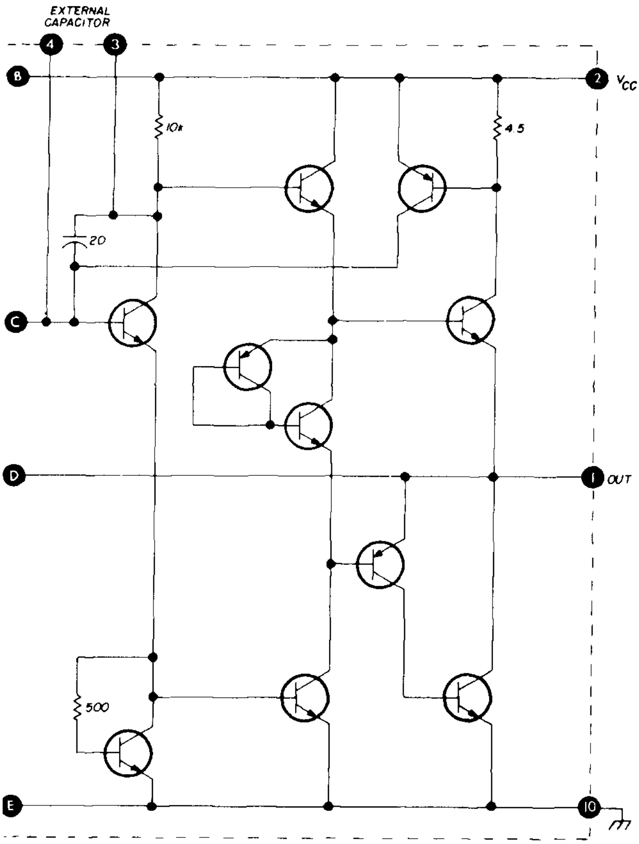


fig. 2. Response curves for the SL620C.

dc level is shifted by Q5 and applied to two detectors, Q14 and Q15. These detectors charge C2 and C2 respectively. Capacitor C1 has a short charge and discharge time constant; C2 has a longer one. Both of these capacitors drive a dc output amplifier (Q16 to Q20); this dc output amplifier is connected so that whichever capacitor has the larger potential controls the output.

If both C1 and C2 have the same charge, a slight offset ensures that C2 will control the output. Thus, the incoming signal will quickly establish an agc output via Q14 and more slowly establish a charge across C2 via Q15.

If sufficient signals are present at the input to the SL620C the trigger circuit (transistors Q6 to Q8) will operate to provide a fast discharge path for C2 via Q10 and Q13. This allows the input signal



to fade up to 20 dB per second and still be tracked by the agc. However, if the input signals are too small the trigger stops operating and C2 is not discharged. This enables the agc signal to *remember* its original level during pauses in speech.

After a long pause capacitor C3, which is charged by the trigger circuit via Q9, will discharge and allow Q12 to conduct, rapidly discharging C2 and allowing the agc signal to drop, thus restoring full gain to the controlled amplifier. If a burst of noise occurs the short time-constant system consisting of Q14 and C1 will briefly control the system to reduce its level.

audio amplifier

The Plessey SL630C audio amplifier circuit is illustrated in **fig. 3.** In addition to its agc connection (pin 8) it has a mute terminal (pin 7) and a reference (pin 9) which is used in conjunction with a linear potentiometer to provide logarithmic volume control when manual gain control is required. This is shown in **fig. 4.** The amplifier is muted when the mute

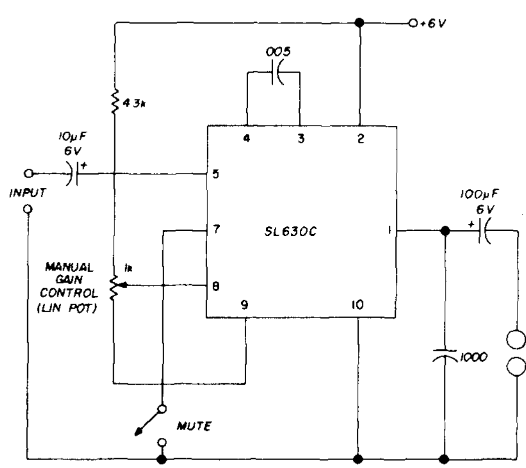
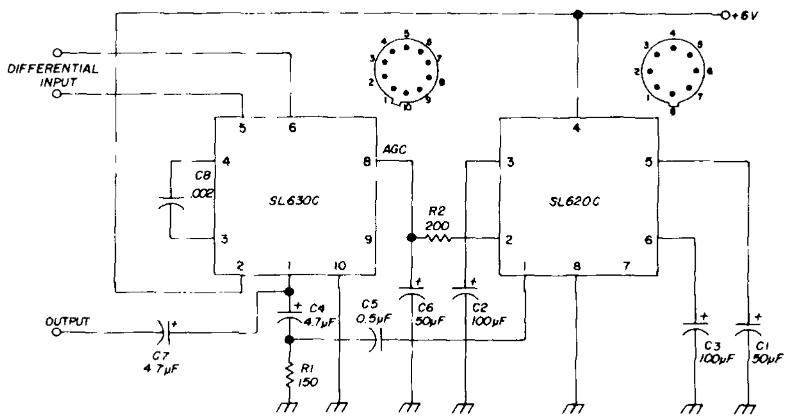


fig. 4. Practical circuit for using the SL630C as an amplifier with manual gain control.

terminal is grounded. With mute control two or more SL630C devices may be connected to a common output without extra loading as long as all but one are muted at any one time.

The SL630C audio amplifier has an internal 20-pF capacitor which provides 6-dB per octave rolloff above 800 kHz. However, in normal operation this capacitor is shunted by an external generator. If this happens low-frequency feedback will occur and low-frequency oscillation or motorboating will take place. This will not occur if the indicated component values are used for C4, C5 and R1.

The agc amplifier is built on the miniature printed-circuit board shown in **fig. 6.** *To use this board the smallest* possible components must be used. When



C1,C6	47-μF, 6-volt, subminiature tantalum	C5	0.47-μF, 35-volt, subminiature tantalum
C2,C3	100-μF, 6-volt, electrolytic	C8	0.0022-μF, subminiature ceramic
C4,C7	4.7-μF, 10-volt, subminiature tantalum	R1	150-ohm, 1/8-watt
		R2	220-ohm, 1/8-watt

fig. 5. Practical speech preamplifier circuit features wide dynamic range. Output is 80 mV rms.

capacitor (connected between pins 3 and 4) to provide a lower frequency 3-dB point at a frequency defined by the formula

$$C = \frac{10^9}{2\pi f}$$

where C is in pF and f is the frequency in Hz.

agc amplifier

The complete audio agc amplifier is shown in **fig. 5.** Since the SL630C has some gain between the agc input point and the output, care must be taken so low-frequency signals from the SL630C do not reach the input of the SL620C agc preparing the printed-circuit board particular care must be used because the conductor widths and separations are very small.

Except for the power supply and output connections, all holes in the printed-circuit board should be 1/32 inch. The holes for the power supply and output terminals should be the correct size for the terminals you use. All soldering should be done as quickly as possible with a small soldering iron and fine rosin-core solder. Before you install the ICs, pin 7 of the SL620C and pins 7 and 9 of the SL630C should be cut off as close to the can as possible. These pins are not used.

Before connecting the agc speech amplifier to a power supply double check that all devices are properly connected and have the correct polarity. Also check to see that there are no solder bridges between the conductors of the circuit board. The power supply should be 6 volts ±0.5 volt. If you use a battery connect a 500-μF decoupling capacitor across it.

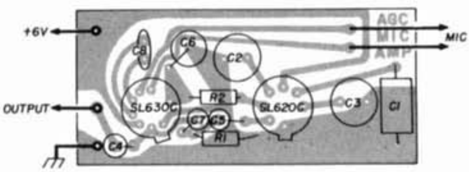


fig. 6. Full-size layout of miniature printed-circuit board for the speech preamplifier.

operation

The finished agc amplifier system should deliver about 80 mV rms for a wide range of inputs. The microphone I used, a microminiature Knowles Electronics type 1590 which measures only 4 x 6 x 8 mm, is mounted on the circuit board. The complete unit is small enough to mount easily in a small microphone case. Microphones with output impedances below about 5k ohms and output of a few millivolts or more may be used with this preamplifier.

If single-ended input is required, it should be connected between ground and pin 5 of the SL630C through a capacitor not larger than 1 μF. In this case pin 6 should be left open. However, this arrangement is not recommended because instablity can result.

To test the agc preamplifier use an ac voltmeter (vtvm or oscilloscope) and an audio oscillator to check that output remains constant as input is varied. Otherwise, you can connect a pair of headphones to the output and alternately shout and whisper into the microphone while an assistant in another room listens for changes in volume.

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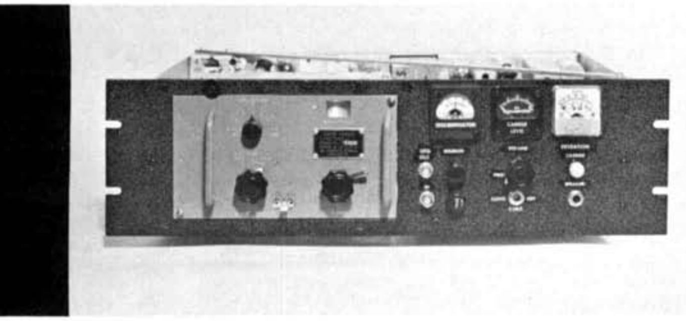


tunable vhf fm receiver

This tunable vhf fm receiver is based on the use of surplus building blocks

David M. Stahley, K8AUH, 6401 Brookside Drive, Cleveland, Ohio 44144

The tunable fm receiver described in this article provides good vhf fm reception by simply adding a suitable converter. The basic tuning range of the receiver is 8 to 16 MHz. Therefore, the overall tuning range with a 2-meter converter is 142 to 150 MHz, and with a 6-meter converter, 48 to 56 MHz. With the addition of a vhf converter, the 8- to 16-MHz tuning range becomes the first i-f; the second i-f is at 455 kHz.

The sensitivity of the receiver is 0.6 microvolt for 20-dB quieting (first i-f) and 0.35 microvolt for 20-dB quieting (with the 2-meter converter). Image rejection is more than 70 dB (with the 2-meter converter).

Some of the optional features of this tunable vhf fm receiver are carrier-operated relay (COR), deviation meter, relative carrier meter, crystal control and automatic frequency control (afc).

construction

The tunable fm receiver is fairly easy to put together since it consists of commercially built and tested units as shown in **fig. 1.** As I am interested in 2-meter fm, I use an Ameco CN-144 converter ahead of the tuning unit.

The 8- to 16-MHz tuning unit is a tuning drawer from a surplus AN/FRR-49 series receiver made by TMC. The original receiver was also known as the AN/FRR-502. Several different tuning drawers are available for this receiver; a list of the more useful units for amateur use is given in **table 1.** These are available on the surplus market. In addition, a large number were released to Navy MARS a few years ago.

The tuning drawers consist of two tunable rf amplifiers, a mixer and oscillator. A reactance tube is included in the oscillator circuit for afc. The oscillator may also be crystal controlled. These features, including a crystal socket, are available on the front panel of the tuning drawer.

In the original receiver the main FRR-49 chassis contained the power supply, 455-kHz i-f amplifier and audio circuits. The main chassis is known as the FRR-2 or R-5007/FRR-502. If you have patience you can find mating connectors for the tuning drawers on the surplus market; if you're in a hurry they can be purchased from an industrial electronics distributor — Cannon part number DPD-1204-34P.

The i-f strip used in the tunable fm receiver described here was originally part of a Motorola LO4AB uhf base-station receiver. The actual i-f strip I used is a Motorola uhf type TA-183 designed for

fig. 1. Block diagram of the tunable vhf fm receiver.

service in the 404- to 420-MHz range. For my use I removed the rf sections, mixer, first and second i-f stages and local-oscillator chain from the chassis. This left only the audio, squelch and third i-f at 455-kHz. Since the circuit included a 455-kHz bandpass filter this was included in my finished receiver.

A few items were added during assembly including a zero-center microammeter to allow comparison of stations on channel. Another microammeter is used to indicate relative carrier strength, and a deviation meter is helpful in setting up fm

table 1. FFR tuning units most suitable for amateur use.

frequency range	tuning unit	alternate part no.
2.0 — 4.0 MHz	FFRD-5	TN-5010/FRR-502
4.0 — 8.0 MHz	FFRD-6	TN-5011/FRR-502
8.0 — 16.0 MHz	FFRD-7	TN-5012/FRR-502
16.0 — 32.0 MHz	FFRD-8	TN-5014/FRR-502

transmitters. A carrier-operated relay is used to operate a signal lamp or key a tape recorder for logging; this circuit is the standard Motorola type.

The relative carrier meter simply reads the first-limiter grid current. The deviation meter consists of an amplifier/buffer

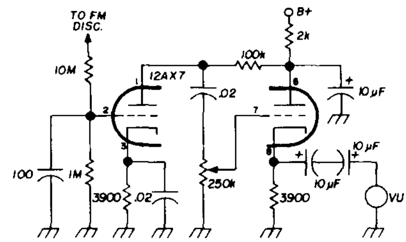


fig. 2. Deviation meter for the tunable fm receiver.

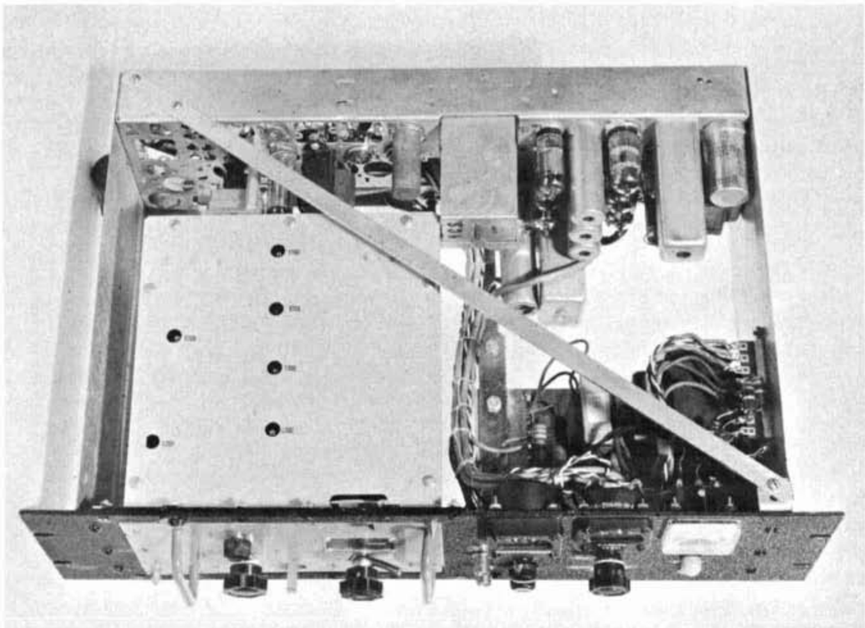
and meter driver shown in **fig. 2.** Discriminator response was plotted by using a signal generator, frequency counter and vtvm. A 1-kHz tone was then inserted at an appropriate level (taken from the response curve) and the meter trim potentiometer adjusted for proper meter indication.

Although I didn't use the afc provision it is available if you want to use it. In some cases you may find that the correction voltage from the discriminator has the reverse sense. In this event reverse the connections to the plates of the dis-

*Complete schematic diagrams of the FFRD-7 tuning head, Motorola TA-183 i-f/audio system and power supply are available for $.25 from *ham radio* magazine, Greenville, New Hampshire 03048.

criminator tube or use an IC operational amplifier as an inverter.

The power supply for the tunable fm receiver was designed around an old tv power transformer. The B+ supplies for the various receiver sections were tailored to the requirements. The i-f strip requires 200 volts at 70 mA and 6.3 Vac at 2 amps; the surplus tuning drawer requires 250 volts at about 20 mA, 150 volts regulated at 30 mA and 6.3 Vac at 1.4 amp. The Ameco two-meter converter needs 100 to 125 volts at 25 mA and 6.3 Vac at 0.9 amp.



Top view of tunable vhf fm receiver shows surplus tuning drawer to left. Modified Motorola TA-183 i-f strip is at rear. Power supply is next to the front panel on the right.

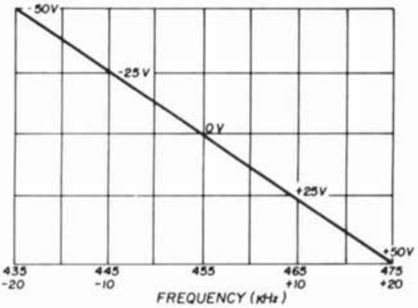


fig. 3. Discriminator response of the Motorola TA-183 i-f strip.

vhf converters

Since 2 meters is my primary interest, I used an Ameco CN-144 converter ahead of the 8- to 16-MHz tuning drawer. The converter was set up for output at 10 to 14 MHz. The rf gain control on the converter was adjusted to the point where first-limiter grid current just started to increase: overall sensitivity of the receiver was 0.35 microvolt for 20-dB quieting at 147-MHz input.

summary

There are many variations to the basic receiver discussed here. It is especially nice to be able to use existing items from around the station to build a useful, quality performer as described here. I have found this tunable receiver to be very useful in setting up my station fm equipment and netting it to frequencies used in my home area. In addition, I can monitor any channel I want without disturbing my regular fm equipment or spending the money for an additional crystal.

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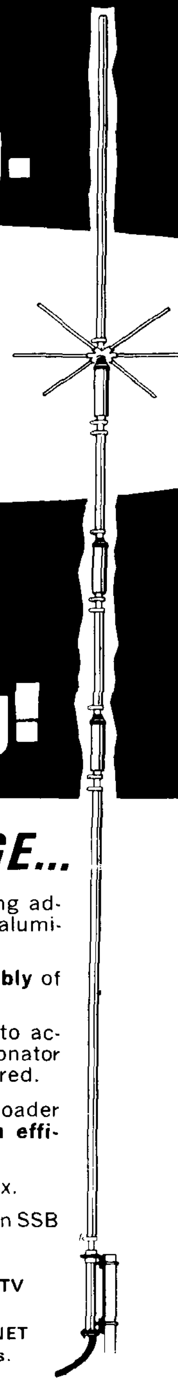

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More Details? CHECK—OFF Page 110

six-meter conversion of the Heathkit SB200 linear amplifier

The SB200 can be converted into a high-efficiency linear for 50-MHz in less than two hours

Louis E. Savioe, K1RAK, 29 Hillsdale Road, Holbrook, Massachusetts 02343

Most 50-MHz conversions of high-frequency rf power amplifiers involve modifications to the existing tank circuit. In most cases the number of turns on the 10-meter coil is reduced so the circuit will tune in the 50-MHz range. The 6-meter Heath SB200 conversion described here uses a tank circuit that is designed specifically for 6 meters. This provides maximum plate-tank circuit efficiency through the use of optimum L/C ratios, constant load to the exciter and maximum tuning ease.

design parameters

This six-meter conversion was based on two essential ground rules: nothing was to be done that would change the front panel, and the unit must be left in such a condition after the conversion that it could be easily restored to its original condition. Both of these aims have been realized.

Only three items must be purchased for this conversion: two pi-network tuning capacitors and 16-inches of copper tubing. The complete conversion can be completed in about two hours and requires no special tools.

step-by-step conversion

1. Remove the amplifier from the enclosure and remove the top shield cover.

2. Remove the two T160/572B power tubes and store in a safe place.

3. Unsolder both parasitic suppressors (PC1 and PC2) from the 1000 pF blocking capacitor (C24). Remove one turn from each suppressor and place aside. Unsolder the lead from plate choke RFC1 to C24.

4. Unsolder and carefully remove L7 (10-, 15- and 20-meter coil). Be careful not to break the switch connections on wafer B of the bandswitch.

5. Unsolder the connections from L6 (80- and 40-meter coil) to wafer A and B of the bandswitch. L6 may be left in the rf compartment if you wish. I chose to remove it.

6. Unsolder C26 (100 pF) from wafer A of the bandswitch and dismantle from C25.

7. Unsolder the heavy bus bar connections which connect both halves of C28 (loading capacitor). Remove the

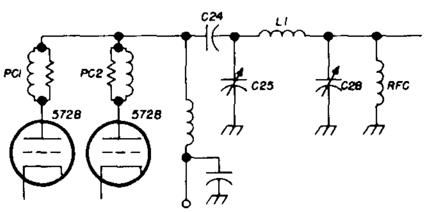
heavy bus wire connection which comes from wafer B on the top side of the chassis to C28 on the underside of the chassis (marked X in **fig. 2**).

8. Remove RFC3 (1.1 mH). Remove the RG-58/U cable between the relay and C28.

9. Unscrew all mounting hardware from C28 loading capacitor. To remove this capacitor from the chassis, it is necessary to loosen the hardware holding the front panel; following removal of C28 secure all panel hardware.

10. Remove the mounting hardware from C25 plate tuning capacitor and remove it from the chassis.

11. Install the new E. F. Johnson 154-1 air variable (C28). Use the front mounting hole of the original loading capacitor as a guide and drill and tap a 6-32 hole to match the mounting bracket of the new loading capacitor. Install the capacitor using star washers on all hardware.



C25	9-38 pF air variable (E. F. Johnson 154-11)
C28	12-244 pF air variable (E. F. Johnson 154-1)
L1	4 turns 3/16" copper tubing, 1¼" diameter, spaced 3/16" between turns (see fig. 3)
RFC	Ohmite Z-50
PC1,PC2	parasitic suppressors

fig. 1. Modified plate circuit for the 6-meter SB200.

12. Select the new E. F. Johnson 154-11 capacitor (C25), and using the front mounting hole of the original capacitor, drill a 6-32 hole to match the bracket of the 154-11. Install the capacitor.

13. Install the tuning knobs and tighten all front-panel hardware. Align the knob markings with the left edge of the tuning indices with both capacitors fully meshed.

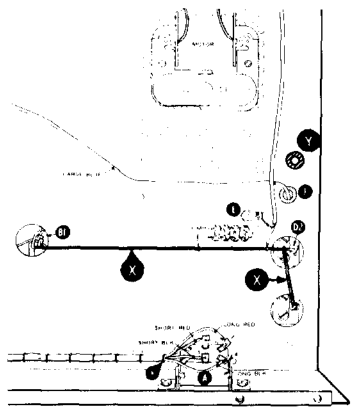


fig. 2. Under-chassis modifications to the SB200. Remove wires marked with X. Drill new 3/8" hole at position Y.

14. Install the plate coil and the 1000 pF coupling capacitor as shown in **fig. 4**. Use a 6-32 x ¾-inch threaded brass or aluminum standoff between the tuning capacitor and the 1000 pF coupling capacitor. Be sure to use star washers on all mechanical connections.

15. Install a 6-32 solder lug on the 1000-pF capacitor. Connect the 1000-pF capacitor to RFC1 with solid number-12 copper wire.

16. Install parasitic suppressors PC1 and PC2 and plate cap assemblies to RFC1.

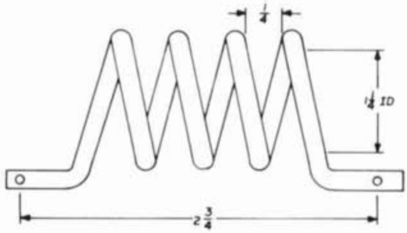


fig. 3. Construction of the plate-tank coil for the 6-meter SB200. Material is 3/16" copper tubing. Two small holes at ends are drilled for 6-32 screws.

17. Install a 6-32 solder lug on the rear stator plate of C28 – nearest the shield wall. Use a star washer.

20. Drill a 3/8-inch hole in the chassis (location Y in **fig. 2**) just above grommet F. Install a ½-inch rubber grommet.

21. Cut the RG-8/U exactly 9½-inches long. Strip 2½-inches of the unstripped end.

22. Unravel the braid and twist securely. Trim to a length of 1½ inches.

23. Using the 2½-inch stripped end of the RG-8/4 cable, attach and solder the braid to solder lug K (**fig. 2**).

24. Strip ½ inch of insulation from the inner conductor of the cable and solder it to lug 7 of the relay.

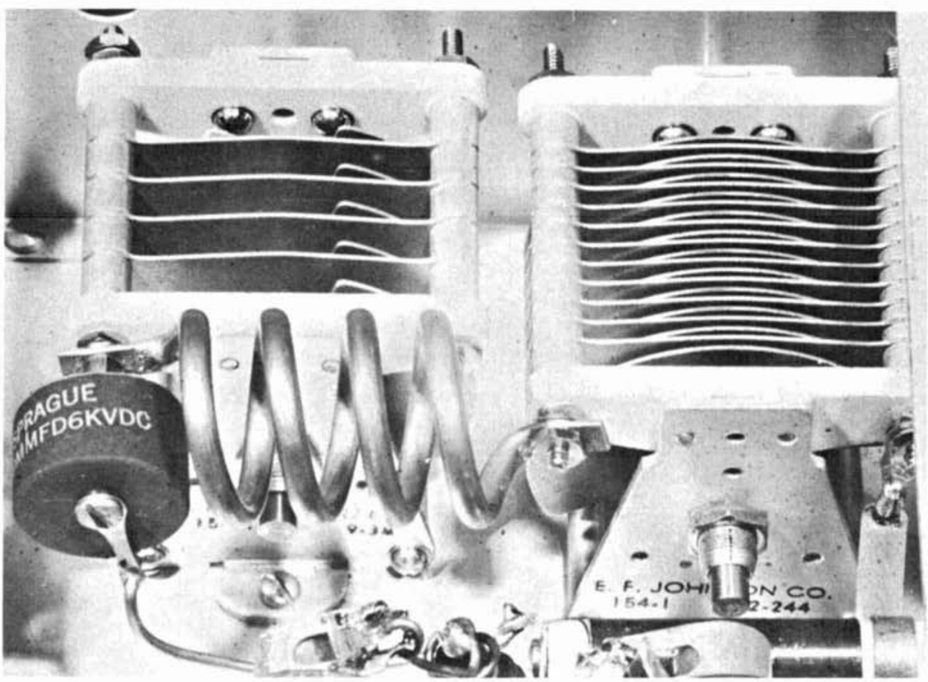


fig. 4. The plate-tank coil is mounted between solder lugs mounted on the pi-network capacitors. The 1000-pF coupling capacitor is mounted on a threaded metal standoff.

18. Strip 6 inches from one end of a 20-inch length of RG-8/U.

19. Unravel the shield braid and cut the braid 1½-inches long, measured from the end of the vinyl jacket. Twist and tin the braid.

25. Solder the shield braid at the other end of this piece of RG-8/U to solder lug E (**Fig. 2**).

26. Strip ½ inch of insulation from the inner conductor and push this end of the cable through the grommet at Y.

27. Solder the inner conductor to the empty solder lug on loading capacitor C28.

28. *Install an Ohmite Z-50 RF choke* between the solder lug in step 27 and the ground solder lug located on the rear mounting bolt of loading capacitor C28.

This completes the modifications in the rf compartment. Install the T160/572B power tubes and attach the plate caps. The only steps remaining are those necessary to modify the input circuit. Refer to **fig. 5.**

1. Disconnect and remove the 68 pF capacitor from coil CA to the ground lug at AE.

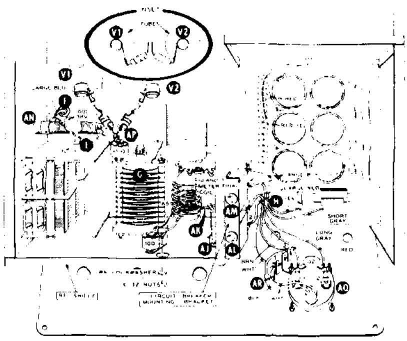


fig. 5. Above-chassis construction of the SB200 before modification.

2. Connect a 15 pF capacitor between lug 2 or CA to the ground lug at AE.

alignment and tune up

1. Connect the amplifier to the exciter; connect the keying line.

2. Set the bandswitch to the ten-meter position (this is now the permanent six meter position).

3. Set the load capacitor knob to 2 on the dial.

4. Set the plate tuning capacitor at half mesh.

5. Turn on the exciter and the linear amplifier. Allow three minutes for both to warm up.

6. *Place the meter switch of the amplifier to the plate current position.*

7. Key the exciter and apply enough drive to show 300 mA on the meter.

8. Adjust the tune (plate) control for a dip.

9. Increase exciter drive and adjust the amplifier for a dip at 500 mA plate current (use both plate tuning and loading controls). On this amplifier the dip occurs with the plate tune control at 40% mesh and the load control at 2½ on the dial.

10. Change the meter switch to the *rf out* position and adjust the *Sensitivity* control for half-scale indication.

11. Adjust the plate tuning control slightly for a maximum rf output indication.

Note: During all tuning and adjusting do not allow a key down condition for more than 30 seconds at a time.

12. Key the exciter and apply drive for a plate meter indication of 200 mA.

13. Adjust coil CA for maximum plate current indication.

This completes the 6-meter modifications to the SB200. This linear can be driven with any exciter which has an output of at least 35 watts. The unit in the photographs belongs to WA1LVF; Roy is driving it with a Heathkit SB110A. Tests conducted with Bird Thruline wattmeters on both exciter and linear, loaded into a Heath Cantenna, showed 60 watts output from the SB110A and linear amplifier output of 600 watts.

No instability has been experienced with this conversion. If you should experience instability, a stub neutralizing rod located between the power tubes, mounted on a ceramic feedthrough and connected to the bifilar choke with a 2-turn link should stabilize the amplifier.

optional modification

The small motor and fan used to circulate air around the power tubes leaves much to be desired for my tastes; I prefer lots of air around power tubes. The miniature Pamotor muffin fan can be purchased from most supply houses for about $10. In some areas it may be available as surplus.

Remove the original fan and fan motor. Use a nibbler tool or a fine coping saw to cut out a square hole to fit the outside dimensions of the Pamotor fan. Be sure to leave enough metal on the diagonal corners to accommodate the mounting ears. Mount the fan on the underside of the chassis; don't worry, there is just 3/16-inch of clearance between the fan and the bottom edge of the chassis.

Mount a 2-lug terminal as shown in **fig. 6.** Connect the black wires which went to the original fan motor to the tie points and the Pamotor fan leads to the same tie points. When the fan is installed in the SB200 cabinet there is more than enough room from the bottom of the fan to the cabinet. All SB-line enclosures are perforated, and this really helps air circulation. With the installation of the muffin fan air circulation has been improved by a factor of at least five. The fan motor is very quiet.

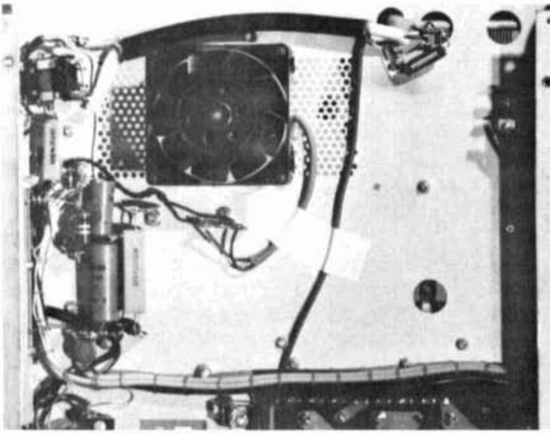
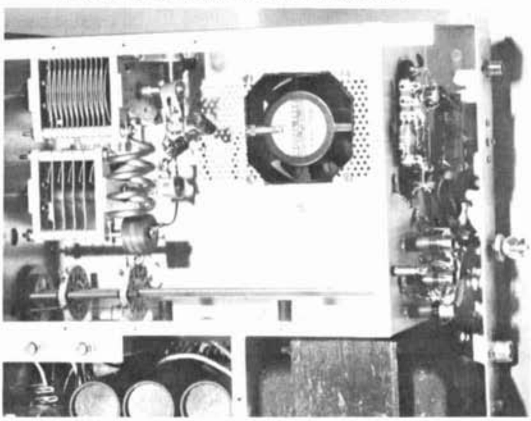


fig. 6. The Pamoter muffin fan is mounted directly below the plate area of the final tubes. The 2-lug tie point is mounted to the right of the fan motor.

Top view of the completed SB200 conversion including the new circulation system.



conclusion

The cost of the conversion is, to my mind, most reasonable. The two capacitors in the pi-network were ordered directly from E,F. Johnson for $15.63 including postage. The Pamotor fan was $9 locally and the copper tubing was 45c at the local hardware store. With the exception of the 15 pF capacitor, the new grommet and the length of RG-8/U cable, all other parts were salvaged from the original circuitry.

The SB200 has been a very popular linear amplifier and now, with the introduction of the SB220, they should be more plentiful on the used market. This conversion provides very respectable power output from a table-top linear which uses inexpensive tubes. I will be glad to answer inquiries if accompanied by a sase. My thanks to Roy Colella, WA1LVF, for furnishing the SB200 to experiment on and to Dick McGinn, WA1IMS, for the photographs.

ham radio

More Details? CHECK—OFF Page 110

weak-signal reception in cw receivers

Suggestions for controlling receiver-generated noise, with some interesting test results

E. R. Cook, ZS6BT, 32 Grove Road, Gardens, Johannesburg, South Africa

Much has been written about weak-signal reception. It is well known that a cw contact can be maintained long after signals using other modulation modes have become too weak to resolve. The limiting factor in copying weak signals is usually the noise generated within the receiver. Noise from external sources is also a problem, but even this noise may be minimized by using the correct approach in receiver design. It is the purpose of this article to demonstrate methods of reducing internally generated noise so that really weak signals may be copied under "quiet" conditions.

receiver noise

One method of assessing the capability of a receiver to receive weak signals is to replace the antenna with a dummy load and adjust the audio-noise output to a measured value, say -10 dB, when the receiver is adjusted to maximum sensitivity. A signal is then applied that will increase the audio output by 10 dB. The injected-signal level, in microvolts, is then a measure of the limiting signal-to-noise ratio. A receiver with a 1-microvolt sensitivity under these conditions is considered average; a sensitivity of ¼ microvolt is excellent.

The noise at the receiver audio output under dummy-load conditions is caused in a tube-type receiver by the tubes. It's usually stated that most of the noise comes from the *first* tube in the receiver; one good reason for this statement is that the tube furthest from the audio has the most amplification behind it. Sensitivity, therefore, is to some extent a matter of rf amplification versus rf tube noise. Because two tubes make more noise than one, we need really high amplification from a single rf stage.

Receiver noise, finally, increases with amplification. This is why so little noise accompanies a strong signal. We reduce the gain; and the noise, being weaker, disappears first. It's when we are working at the limit of amplification that noise intrudes, and any reduction of noise is tantamount to increasing the level of the incoming signal.

There are various ways of reducing noise in relation to signal. One is to reduce the number of tubes — there is nothing quieter than a one-tube "blooper!" Another is to improve the rf stage sensitivity. A third way is to narrow receiver bandwidth.

Noise covers a wide frequency range. Any reduction in receiver audio-frequency bandwidth will reduce noise. For cw reception a very narrow frequency bandwidth is desired. If the audio amplifier is designed to attenuate all frequencies except that which responds to the received signal, then unwanted audio frequencies and attendant noise will be reduced. Such reduction in bandwidth not only reduces much receiver-generated noise; external noise, such as that from power leaks and auto ignition, will also be reduced.

gain control

An important consideration in design of a receiver for weak-signal performance is that of gain control. An enormous amount of amplification is needed to increase a 0.1-microvolt input signal to a 1-milliwatt audio level. Without an effective gain-control system, receiver overload will occur when receiving very weak signals in the presence of powerful signals or local noise. A sensitive rf stage and its associated mixer, for example, will seldom overload in the presence of a powerful signal, so this part of the system requires neither manual nor automatic gain control (agc). Early i-f stages, on the other hand, are subject to overload in the presence of strong signals and require efficient gain control circuits.

Agc circuits have been developed for cw-signal reception, but they are more complex than those for phone signals. In a cw agc system, the agc voltage must be derived from a rectifier isolated from the beat oscillator, otherwise the rectified bfo voltage will reduce receiver gain even in the absence of incoming signals. Therefore, most amateurs use the audio-gain control; but this control has its limitations.

An audio-gain control is an input attenuator. The audio amplifier runs at full gain all the time, but its input is limited by the audio-gain control. When a strong signal is received, the product detector may be overloaded because audio attenuation occurs after the product detector. Clearly, some form of i-f gain control is the answer; and for weak-signal cw reception, this may be in the form of a bias control in the final i-f stage.

Also not to be overlooked is the fact that a product detector is a mixer (by definition a nonlinear device), and the less noise or excess signal presented to it the better. The gain of the incoming signal, therefore, should be reduced before the signal reaches the product detector.

A receiver designed for truly weak-signal reception must reduce the strongest signal to near zero amplitude while providing sufficient amplification to obtain usable audio response from a weak signal.

tests

I ran some tests to determine ways of improving signal-to-noise performance. A block diagram of the receiver configuration for these tests is shown in **fig. 1.** Note that the rf stage has neither manual nor automatic gain control but has regeneration control available. The buffer and 465-kHz i-f have agc plus an overriding manual control; the main control operates on the cathodes of the two 85-kHz i-f amplifiers, which have no agc. Two audio filters are also available.

Five controls are shown. Details of each are given together with information concerning the 85-kHz channel and the audio-output meter.

control 1. The rf stage is regenerative to the point of oscillation at maximum setting. At minimum setting regeneration ceases, and the amplifier operates at normal gain.

control 2. This control replaces the usual rf gain control. It provides cathode-bias control for two stages, both of which may be controlled by agc. Control 2 normally runs wide open but is adjusted to attenuate strong signals. (An rf stage and its mixer are seldom overloaded; the stages following the first mixer are those susceptible to overload.)

control 3. This control can take the Q multiplier into oscillation. The Q multiplier is used as a peaking device rather than a selectivity control. The 1.5-kHz bandwidth of the 85-kHz i-f channel provides the i-f selectivity.

control 4. Cathode bias for the two 85-kHz i-f stages is controlled by this pot, which replaces the usual audio gain control.

control 5. This is a 2-pole 3-position switch that enables either one or both audio filters. The filters are toroid LC tuned circuits, one in the product-detector output and the other in the grid circuit of the first audio stage. Resonant frequency is 1 kHz, and the filters provide considerable gain. A suggested schematic is shown in **fig. 1.**

audio-output meter. The audio-output meter is designed for a 600-ohm receiver output; zero dB represents 1 mW. The lowest-scale reading is -20 dB (10 microwatts). The point of zero signal with sensitive headphones is about -7 dB. It is necessary to calculate responses below -20 dB, as we shall see.

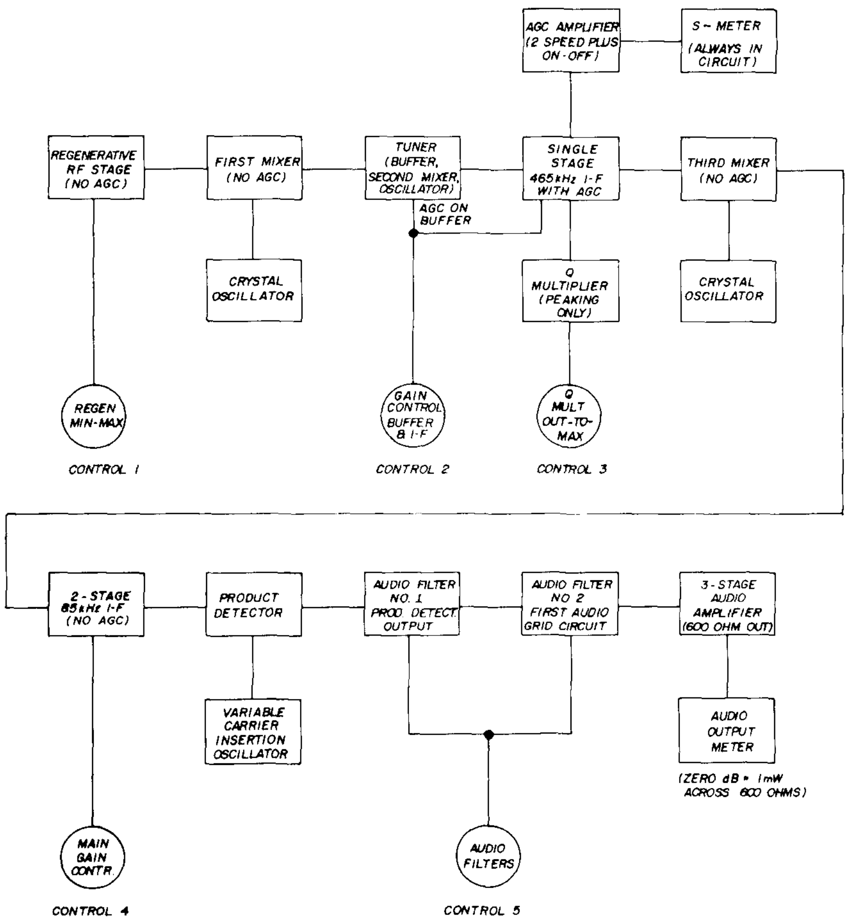


fig. 1. Low-noise receiver that produced the test results in table 1. Control functions are described in the text.

85-kHz i-f channel. The input to this channel is two cascaded i-f transformers. A total of four undercoupled transformers give a bandwidth of about 1.5 kHz.* The carrier-insertion oscillator is variable from 83 to 87 kHz and is adjusted to the audio-filter requirement.

*The 85-kHz i-f strip can be a BC-453 war-surplus aircraft receiver (tuning range 190-550 kHz). The shape factor of this strip is quite good: 1.5 kHz at 6 dB down and 6.5 kHz at 60 dB down. It is still available; try G & G Radio Electronics Co., 45-47 Warren St., (2nd Floor), New York, N. Y. 10007. Price used is $16.95 complete with tubes. The set can be easily transistorized. **editor.**

preparation for tests

Instead of a signal generator I used a live signal via the antenna. The signal source was a shielded low-power oscillator located clear of receiver and antenna. The output was adjusted for a signal 10 dB over the *basic* internal noise level. The signal showed no level variation at either the S meter or audio output.

The antenna was arranged so I could switch from receive to dummy load to compare signal level with noise at each setting. Noise via the antenna was not taken into account, but on the preliminary test I noted that, in the absence of a signal, the noise increased by less than 5 dB when changing from dummy load to receive.

basic adjustments

Agc was switched off, and control 2 was set to maximum. Regeneration was at Minimum, the Q multiplier was OFF, and both audio filters were OUT. The output meter was placed on the scale -20 to +17 dB, and control 4 was adjusted (dummy-load position) to give a noise output of -10 dB. When switching to receive and tuned to the test signal, the output increased to zero dB; in fact, the test signal was adjusted to produce this level.

At this point, the receiver compared well with an average communications receiver. A check over the cw band showed a lively response. The test-signal level, in microvolts, is not known. It is irrelevant to the tests, but it certainly did not exceed 1 microvolt.

test objectives

It was desired to start with basic adjustments approximating those of an average good receiver. A fade-free signal would be available to produce exactly 10 dB above receiver internal noise. A record would be kept of the following effects on receiver operation:

1. Audio filtering.
2. Regeneration.
3. Q multiplier.
4. Combinations of the above.

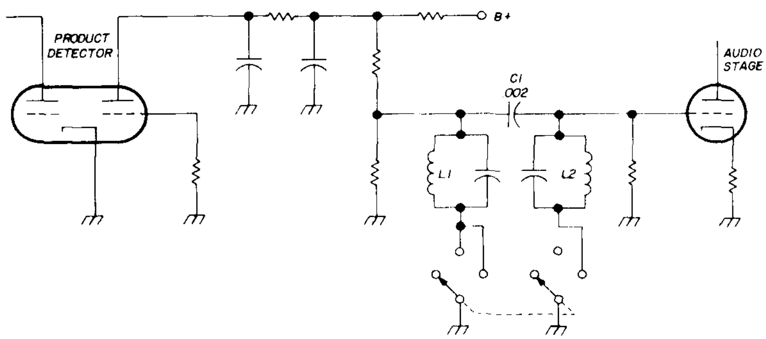


fig. 2. Suggested audio filter. L1, L2 may be 88 mH toroids or preferably 300 mH, which have a better response curve and higher gain. C1 should be as shown if it is now larger in your receiver.

test results

Results of the tests are shown in **table 1.** I was surprised by the data even though I'd had considerable experience with the receiver and knew its capabilities. A study of **table 1** leads to the following conclusions:

audio filtering. A 20-dB improvement for one audio filter proves that audio filtering really reduces noise. The fact that the second filter gave only 5 dB additional improvement indicates that the filter skirt-width doesn't greatly improve after the first big bite at the apple.

regeneration. The 8-dB improvement shows that the signal does increase faster than the noise when regeneration is used. The increase in sensitivity is worthwhile.

Q multiplier. This is really a form of highly stable i-f regeneration. Selectivity measurements have shown that passband sharpening is completely nullified if the band being sharpened is wider than a subsequent channel. The 465-kHz i-f channel, even with the Q multiplier in use, is wider than that of the 85-kHz channel. Nevertheless, the 3-dB improvement is most effective, as shown in the next paragraph.

regeneration + Q multiplier. An improvement of 20 dB is identical to that obtained with a single audio filter. The difference between the two conditions is merely one of bandwidth. However, it is desirable to retain this improvement because it's not always necessary to use audio filters. The receiver is invariably used with both regeneration and Q multiplier at maximum.

regeneration + Q multiplier + filters. With the noise reduction already obtained, it is obvious that audio filters would have less work available. In fact, the single filter now contributes only 7 instead of 20 dB, and the second filter adds a mere 3 dB improvement. At the same time, the *total* improvement is a very worthwhile 30 dB.

analysis of test results

The tests show that improved sensitivity reduces noise because less subsequent amplification is required – in other words, the gain may be reduced. Also, restricting audio bandwidth is of great assistance. Moreover, it is clear that a multi-tube receiver can be made virtually noise-free. The actual amount of noise may be estimated from the following discussion.

table 1. Test results using a "live" signal from the antenna. Signal source was an oscillator adjusted to produce a signal 10 dB over the basic internal noise level of the receiver. See fig. 1 and text for control position.

rf regeneration	out	out	in	in	out	out	in	in
Q multiplier	out	in	out	in	out	out	in	in
first audio filter	out	out	out	out	in	in	in	in
second audio filter	out	out	out	out	out	in	out	in
noise level (dB)	-10	-10	-10	-20	-20	-20	-20	-20
test signal level above noise (dB)	10	13	18	30	30	35	37	40
improvement (dB)		3	8	20	20	25	27	30

For headphone reception an audio output of 100 microwatts is more than adequate; 1 to 2 milliwatts will drive a speaker for use in a small room. If we convert the dB numbers into audio power, we obtain a better perspective **(table 2).**

Working from **table 2** and referring to **table 1,** we can back off the gain control (in theory) until the test signal is 100 microwatts (-10 dB) and estimate the amount of noise that will be present. At the *basic* setting, with the signal at -10 dB instead of zero dB, the noise level will still be 10 microwatts – a considerable amount.

For a 20-dB improvement, the noise will decrease to 0.1 microwatt, at which level it barely intrudes on the ear. For a 30-dB improvement, the noise will be a mere 0.01 microwatt. However, if we back off the gain until the signal is 10 microwatts (-20 dB), the noise will be

0.01 microwatts for a 20-dB improvement and 0.001 microwatts for a 30-dB improvement.

Until now, we've considered a signal which was, basically, only 10 dB above the noise – really an S1 signal. Let's now consider a signal 20 dB above the noise, improved 30 dB and reduced to produce 10 microwatts. The noise is now -70 dB or 0.0001 microwatt.

Now we'll add one point for good measure: a 0.1-microwatt signal from a loudspeaker is barely audible at 6 feet, but a 10-microwatt signal can be *copied* at 30 feet or more.

table 2. Data for estimating improvement in receiver response to noise based on the combinations in table 1.

audio meter (dB)	output power (μW)	remarks
0	1000	very strong on headphones
-10	100	strong headphone signal
-20	10	comfortable headphone signal
-30	1	weak headphone signal
-40	0.1	a tolerable noise level
-50	0.01	an excellent noise level
-60	0.001	noise barely noticeable
-70	0.0001	virtually zero noise

conclusions

Admittedly the tests involved only signal versus internal noise and the results will be degraded by external noise. However, the use of audio filters narrows the audio spectrum so that external noise is greatly reduced.

The fact that a triple-conversion receiver was used is incidental. Communications receivers have an rf stage, and many have a Q Multiplier. Audio filters may be used with any receiver that has an audio stage. Triple conversion doesn't offer much advantage over a double-conversion receiver if sharp i-f filtering is available, but triple conversion does permit rejection of the audio image without filters (giving single-signal response); and triple conversion permits agc voltage generation and the use of an S meter at the second i-f while bfo/cio injection and gain control follow the third i-f stage.

The amount of audio amplification provided doesn't appear to affect noise too greatly because we seldom use all the audio amplification, although we use much more on weak signals. Nevertheless, we should remember that the audio amplifier has little or no internal noise – in the sense that noise from audio tubes is not amplified to the same extent as that from earlier tubes, and there is less loading of the product detector where adequate audio amplification is available.

Although 1 to 2 milliwatts of audio usually suffices for cw operation, it is advisable to consider the potential audio outputs available from a sensitive low-noise receiver. Based upon an output of 1 milliwatt for zero-dB, +10 dB is 10 milliwatts and +30 dB is 1 watt, with +40 dB increasing to 10 watts!

Where noise level stands at -20 dB, a signal 20 dB above noise is a mere 1 milliwatt, but at 40 dB above noise we have 100 milliwatts. If this is the type of output we expect from a 1-microvolt input (see **table 1**) what can we expect from a local signal some 60 dB stronger? This would be 100 dB above the noise; a potential output of one *kilowatt* of audio for -40 dB of noise! To reduce such a signal to 1 milliwatt calls for the noise to go back to -100 dB; i.e., to one ten-millionth of a microwatt. This is the measure of gain reduction we need if our receiver is *really* sensitive with low-noise response.

Even a regenerative rf stage will handle the 60-dB increase (from say 0.1 microvolt to a volt or two); but the agc and/or rf gain must reduce early amplification considerably; and finally we need considerable attenuation later in the receiver. We can, however, visualize the amount of signal passing through the product detector if we rely on an audio-input attenuator running almost closed off to limit the audio to 1 milliwatt or less, even after reducing the rf gain.

There is nothing more pleasing to the cw DX man than a really weak signal producing a 1-milliwatt audio signal with an absolutely quiet background.

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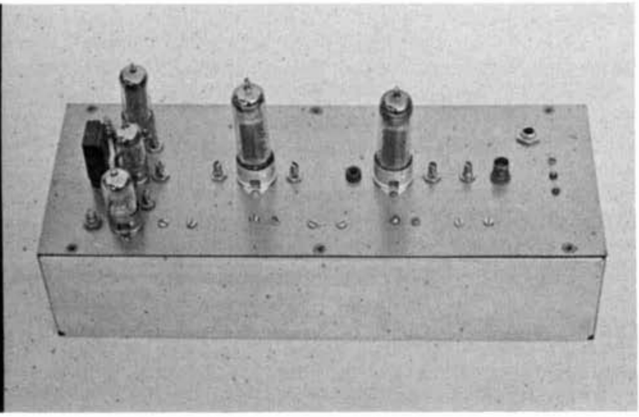


low-cost 220-MHz exciter

This simple crystal-controlled exciter for 220-MHz provides several watts CW output — the final stage may be modulated if desired

Martin Beck, WB6DJV, 1637 Hood, Wichita, Kansas 67203

When an amateur contemplates 220 MHz the first thing that enters his mind goes something like this, "If I build a decent exciter for 220 a lot of hard work and time will very likely go down the drain; I have a pal with a surplus RDZ and he says there's nothing going on up there anyway." Well, there *is* activity on 220. And the RDZ doesn't have a low-noise 2N4416 front end. As to the matter of the exciter troubles – here is a little gem that uses a minimum of components, does not have to be neutralized, keys like a dream and uses five garden-variety tubes.

The exciter consists of a 6AQ5 oscillator stage, followed by three triplers and a 220-MHz power amplifier (**fig. 1**). I chose 6C4s for the first two triplers because they are low cost, and RCA rates them as 5-watt oscillators at 144 MHz; they are extremely efficient at 24 and 72 MHz.

construction

When you wire the tripler sections you will need a small soldering pencil to work in the cramped quarters (I used a Weller WPS). Don't be discouraged by the compactness of the first three stages. Lay in the heater and B+ wiring first, then install the bypass capacitors. Next install all resistors and capacitors. Don't cheat by using wire; you will only need the component leads.

When you have the first three stages wired, plug in the 6AQ5, a suitable 8-MHz crystal,* apply power, set the oscillator tuning capacitor half open and screw in the L1 coil slug until you hear the oscillator signal on a general-coverage receiver. Now plug in the first 6C4 tripler, set the plate-tuning capacitor half open, and adjust the L2 tuning slug for maximum 24-MHz signal indication. Plug in the second 6C4 tripler and go through the same procedure, tuning for maximum signal at 73 MHz. These initial settings will put you in the ballpark when you are ready to line up the last two stages.

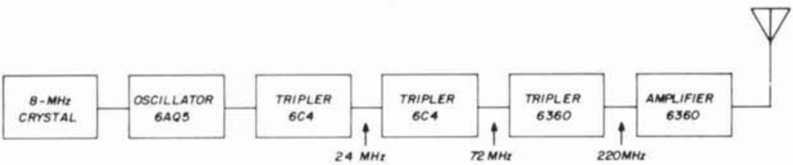
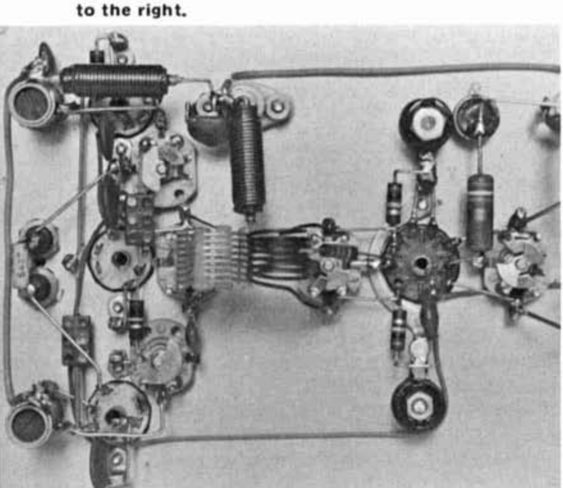


fig. 1. Block diagram of the simple 220-MHz exciter.

Bottom view of the exciter showing the crystal oscillator and 6C4 tripler stages to the left; 73- to 22-MHz 6360 tripler is to the right.



photos by M. McConnell

Turn off the power, remove the three tubes, and wire the third tripler and final power amplifier stages. After checking your wiring for errors mount the coils on the variable butterfly capacitors. To tune up these stages the coils are set on frequency by either pinching them shut or spreading them apart (with the tuning capacitors half open). If you use 222.5 as your tuneup frequency the variable capacitors will cover the entire 220-MHz band.

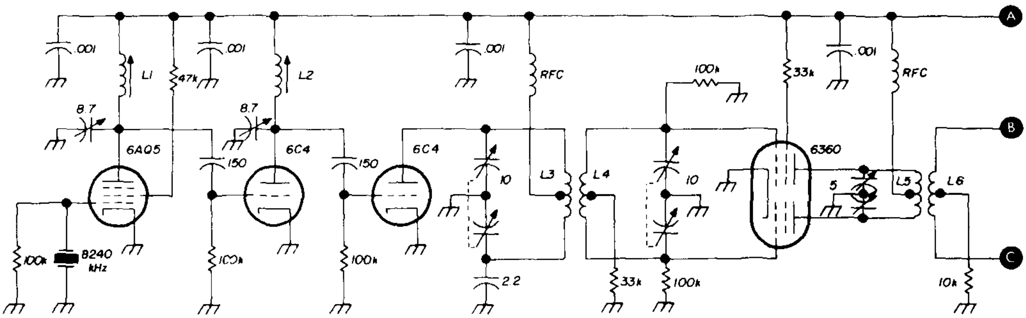
Do not change the value of the 6360 screen resistors. With the values shown in **fig. 2** you will not have to measure plate current as power input is within safe limits when the circuit is tuned to resonance. In rigs of this type I have always preferred to read the grid current of each stage except the final power amplifier. If you want to put in meters and meter switches, fine, but it's certainly not a necessity.

final tuneup

When tuning up the 6360 power amplifier, open the B+ line to *both* the screen and plate. When you have obtained maximum possible final grid drive, turn

*For output on 222.5 MHz, select a 8.240 MHz crystal; the first tripler will be at 24.720 MHz and second tripler, 74.160 MHz. For 220 MHz use a 8.148-MHz crystal; a 8.333-MHz crystal will put output at 225 MHz.

the power off and reconnect the plate and screen voltage. Apply power again, tune the plate circuit for maximum 220-MHz output, using both the butterfly color whatsoever. If *one* of the tube plates begins to show color turn off the power and check your tank-circuit wiring for symmetry. Make sure the mechanical



C8,C10,C13	10.8-pF butterfly (E. F. Johnson 160-211)	L5	5 turns no. 16, 3/8" diameter, 1¼" long
C11	5.1-pF butterfly (E. F. Johnson 160-205)	L6	5 turns no. 16, 3/8" diameter, 1-3/4" long
L1	16-29 μH (J. W. Miller 4407)	L7	5 turns no. 16, 5/16" diameter 1" long
L2	3 μH (J. W. Miller 4608)	L8	1½ turns no. 18 enameled, closewound, 7/8" diameter
L3	8 turns no. 18 enameled, 5/8" diameter, 1/2" long		
L4	7 turns no 18 enameled, 1/2" diameter, 3/8" long		

fig. 2. Low-cost 220-MHz exciter uses 8-MHz crystal oscillator, three frequency triplers and power output stage. No neutralization is required.

and series-link capacitors.

Now, turn off the room lights and carefully observe the plates of both 6360 tubes. There should be absolutely no layout of the 6360 stages is symmetrical; electrical symmetry will follow. If you find you must neutralize the 6360 final, you did something wrong.

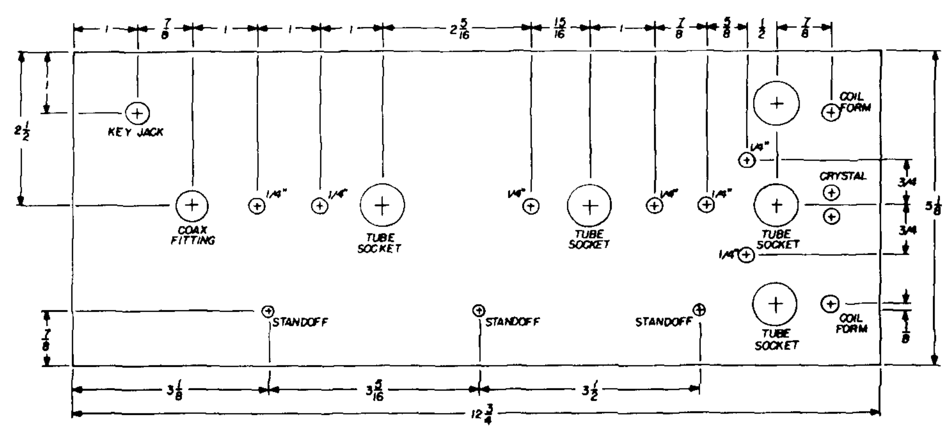
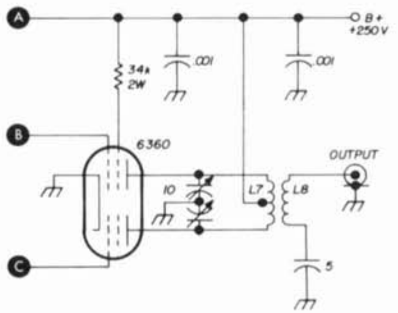


fig. 3. Layout for the 220-MHz exciter.

circuit hints

The bias on the 6C4 and 6360 control grids is provided by drive from the previous stage. If drive fails every tube in



the line will be quickly destroyed. This has never happened to me but I'm always on the lookout for drive failure. You can put a fuse in the B+ line, but if you tune slightly off-resonance you'll lose the fuse – which can be annoying, and always happens at the worst possible time. Obviously, a separate bias supply is the best approach, but this little rig was designed for utter simplicity and low cost, so none was included.

If you're a CW man as I am you're all set with a few watts out on 220 MHz. If you want more power you can build the 220-MHz power amplifier described in an earlier issue of *ham radio.*[1]

reference

1. Martin Beck, WB6DJV, "An RF Power Amplifier for 220 MHz," *ham radio,* January, 1971, page 44.

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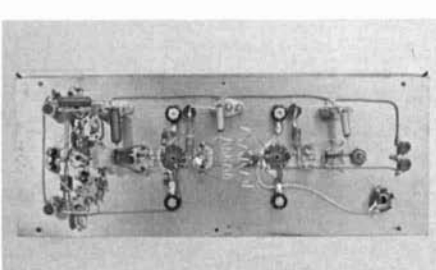

Bottom view shows layout of the exciter.

the simplest
cw audio filter

This most simple of all cw audio filters series tunes the built-in inductance of your headphones

Gene Hubbell, W7DI, 6633 East Palo Verde Lane, Scottsdale, Airzona 85251

For the simplest possible cw audio filter all you have to do is put a capacitor in series with your high-impedance headphones. Lower impedance headphones may require additional inductance, but in most cases a series capacitor will resonate the headphones to a convenient audio frequency.

I have used this effect for some time, and recently set up the test circuit in **fig. 1** to determine the proper capacitance values for various types of headphones. I used an old Western Electric audio signal generator with 600-ohm output into a 500:3.2-ohm audio transformer. A sensitive vtvm across the headphones measures circuit voltage. For low-impedance headphones a surplus 88-mH toroid inductor may be switched into the circuit.

With the headphones connected directly to the 3.2-ohm winding of the transformer the voltage was approximately 0.22-volt rms. With a series capacitor, and the audio generator tuned to the resonant frequency, the voltage across the headphones increased to as much as 0.7 volt; this represents considerable audio gain.

At frequencies below resonance response falls off rapidly due to increasing capacitive reactance. Above resonance the voltage drops slowly to the 0.22-volt level. However, when the 88-mH toroid is in the circuit response drops much more sharply at frequencies above resonance.

High-impedance headphones work best in this simple circuit. Medium-impedance headphones do fairly well, and low-impedance headphones (6 to 8 ohms) exhibit little, if any, series-resonance. You can get an idea of the impedance range of your headphones by measuring their dc resistance. If the dc resistance is 1000 ohms or more they can be classified

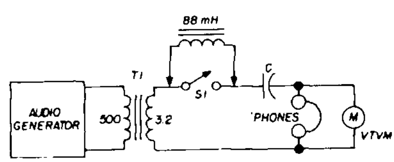

fig. 1. Test circuit for checking resonance of series-tuned headphones.

table 1. Performance of various headphones with series-resonant capacitors.

headphones	peak frequency (Hz)	capacitor (μF)	peak voltage
Western	580	.015	0.62 V
Electric	750	.01	0.62 V
type 194W	800	.0075	0.60 V
(2000 ohms dc)	1150	.005	0.55 V
Murdock Signal	600	.05	0.55 V
Corps type R-14	700	.02	0.50 V
(1700 ohms dc)	1000	.015	0.65 V
	1200	.01	0.68 V
	1350	.0075	0.66 V
Telex	750*	.22	0.37 V
(225 ohms dc)	800	.32	0.40 V
	900	.15	0.40 V
	950	.22	0.40 V
	1050*	.1	0.40 V
	1150	.15	0.40 V
	1300	.1	0.37 V
Murdock type	750*	.22	0.35 V
P-23 CAATC	900*	.22	0.37 V
(130 ohms dc)	1050*	.15	0.45 V
	1300*	.1	0.45 V

*88-mH toroid inductor in circuit. Note dual resonance of Murdock P-23 headphones with 0.22-μF series capacitor.

as high-impedance types; 150 to 300 indicates medium 500- to 600-ohms impedance. The dc resistance of low-impedance headphones will usually be much less than 100 ohms.

Some of the results I obtained are shown in **table 1.** The Western Electric 194W (antiques) and Murdock Signal Corps R-14 headphones are high-impedance types: the Telex and Murdock P-23 headphones are medium impedance. The resonance effect of the 88-mH inductor is evident in the two tests made with the Telex headphones.

Since most of the headphones used by amateurs were not originally designed for flat response one or more peaks usually show up as you change the audio signal frequency. If the series capacitance is chosen carefully the tuned peak can be made to coincide with a natural signal peak, thereby accentuating the cw filtering effect.

ham radio

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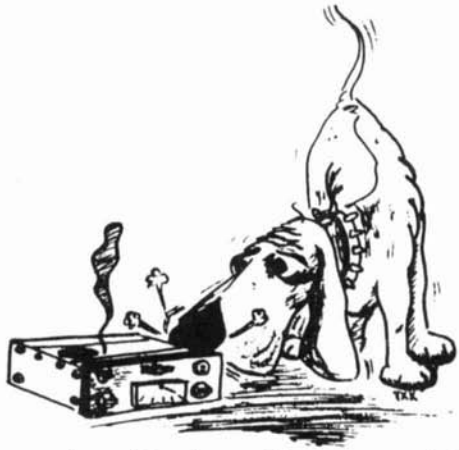

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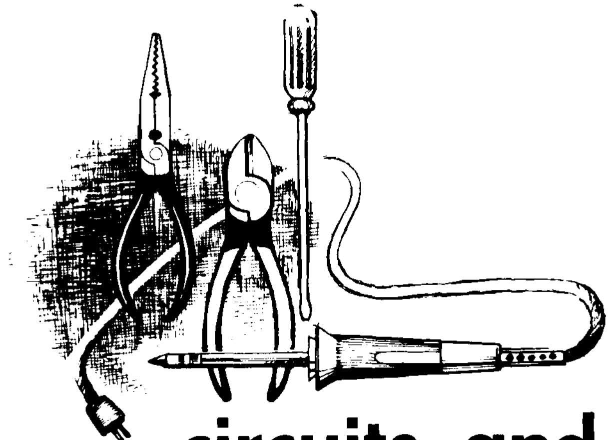


circuits and techniques

ed noll, W3FQJ

direct conversion receivers

Solid-state direct conversion is encouraging receiver construction; simplicity, low cost and good performance are its virtues. QRP fans are properly enthused because these receivers match the size, cost and battery-drain limitations of their low-power operations. It is not unusual to work other hams operating with substantial transmitter power but receiving on a small direct-conversion receiver.

Watch out for considerable commercial activity too; this mode of reception is a specialty of the Ten-Tec Company. Direct-conversion receivers match and often out-perform many of the commercial receivers in the $75 and $175 class, especially if these are single-conversion types.

theory of operation

In a direct-conversion receiver the signal is applied directly to the detector along with a locally generated carrier of similar frequency. The output circuit emphasizes the difference-frequency components, these being the modulation on the incoming signal. A direct conversion is made from signal frequency to modulating frequency. A more exact definition for a direct-conversion receiver would be a receiver that converts directly to the modulating frequency by heterodyning.

The demodulation is handled by a product mixer. In the mixing and multi-

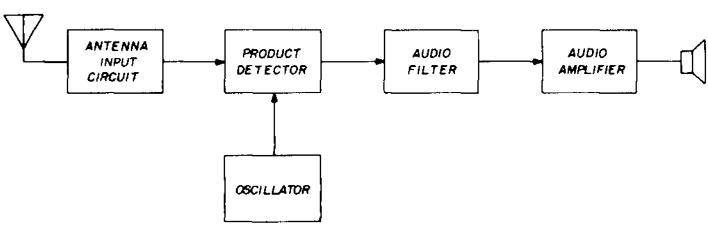


fig. 1. Essential details of a direct-conversion receiver.

plying of signal and oscillator frequencies many frequencies are produced in the output. The one of concern is usually the difference frequency. When the signal and oscillator frequencies are the same, a special form of product mixer, the product detector, is used.

Leo Gunther, VK7RG, in the April 1970 issue of the *Australian EEB*, states it this way, "The oscillator frequency in the product mixer need not be the same as that of the signal; though it is when used as a product detector."[1]

Inasmuch as the product detector form of linear mixer produces a family of output frequencies, the output circuit must include an audio filter that filters out undesired components and emphasizes the original modulating frequencies. Finally, the power level of the demodulated audio must be increased to drive a headset or loudspeaker.

The gain of the receiver is determined by the gain of the audio amplifier. If good signal-to-noise ratio and sensitivity are to be obtained, a low-noise high-gain audio amplifier is essential.

A single-sideband signal is demodulated by tuning the oscillator frequency to the absent carrier frequency of the incoming signal. A CW signal is demodulated by off-setting the receive oscillator frequency from the incoming carrier frequency. A conventional a-m signal is demodulated by tuning the oscillator frequency to the incoming carrier frequency using the same zero-beat technique used when demodulating an a-m signal with a sideband receiver.

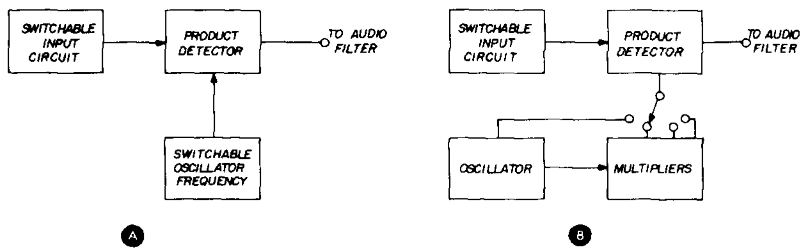


fig. 2. Two schemes for multiband operation of direct-conversion receivers.

what constitutes good direct-conversion practice?

The conversion should be linear. A balanced detector circuit with good linear performance over sufficient dynamic range is preferred. Hot-carrier diodes with their low noise content and low intermodulation distortion are popular. The field-effect transistor (both dual-gate and dual-fet types) is attractive for the same reasons. However, as VK7RG points out, the low signal levels at which the normal product detector operates in a direct-conversion receiver is an important factor in the low cross modulation performance.

The usual direct-conversion receiver includes no rf stage. None is required when the product detector itself has a very low noise level. Selectivity is determined by the output audio filter. Any rf stage ahead of the product detector has a marginal influence on the overall selectivity. An overpowering local station may give some trouble, although its effect is likely to be less than in the usual solid-

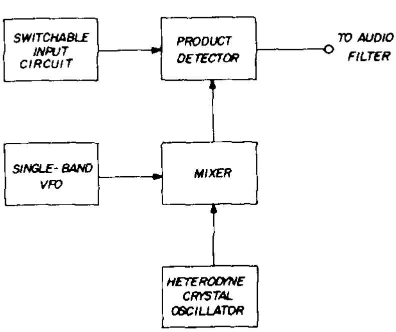


fig. 3. Using heterodyning to obtain multiband operation with a direct-conversion receiver.

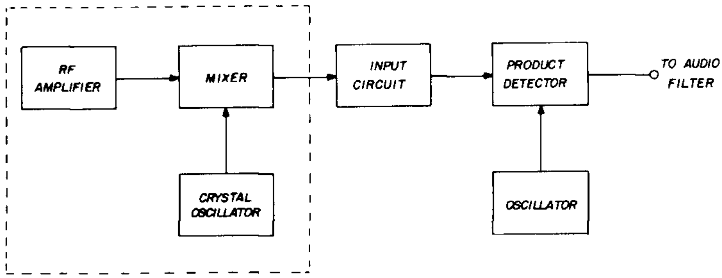


fig. 4. An outboard tuner can be used with a direct-conversion receiver to provide multiband operation.

state superheterodyne receiver. A narrow-band filter is appropriate for CW; wider band (300-2500 Hz), for ssb reception.

Presently the audio filters used in direct-conversion receivers are relatively simple types. The inclusion of audio filters with better shape factors is just a matter of time.

Sensitivity is influenced by the overall gain of the audio amplifier and the noise content of the detector and audio input stage. A low noise fet input stage seems expedient not only because of its low noise content but also because its high impedance permits the design of a more simple good-shape audio filter.

The oscillator must be very stable. However, this requirement is now old-hat because the same order of stability is needed in more conventional sideband receivers and in transmit or transceiver vfos.

There are three ways of adding bands to a basic single-band direct-conversion receiver. The obvious procedure is shown in **fig. 2**. In example A, a multiband oscillator is used. You need only to switch oscillator frequency and antenna input resonance to change bands. An alternative to this scheme is to use a stable low-frequency oscillator and a switchable multiplier chain that generates the harmonics needed for operation on higher-frequency bands.

An idea used by C. F. Dorey[2] employs a stable vfo and one or more crystal oscillators, **fig. 3**. A mixer selects either the sum of difference frequency to obtain an appropriate injection frequency for the desired receive band.

The final method,[3] shown in **fig. 4**, changes the direct-conversion receiver over to a superhet for reception on other bands. In this case individual band converters are placed ahead of the product detector. These outboard tuners can consist of a crystal oscillator-mixer combination or an rf amplifier and mixer-oscillator.

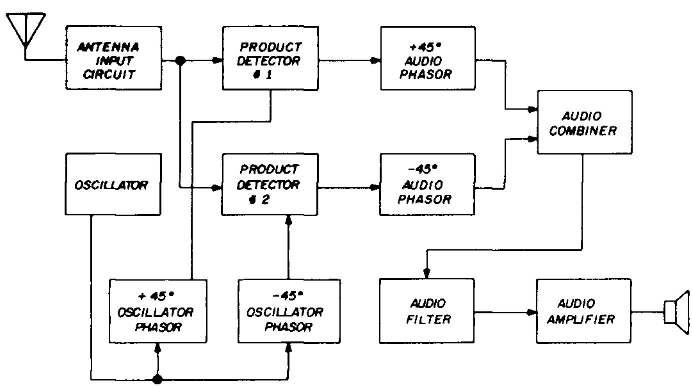


fig. 5. Two-phase direct-conversion receiver.

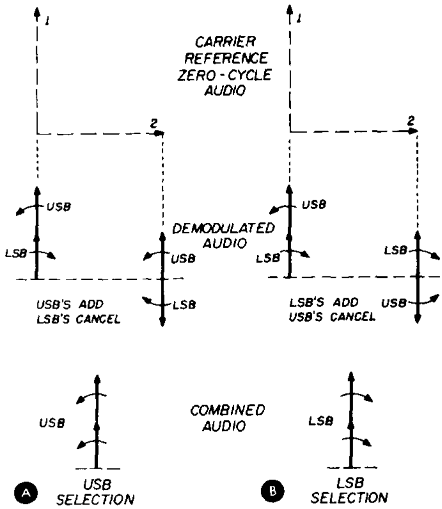


fig. 6. Vector diagrams of two-phase direct-conversion receiver signals.

adjacent channel interference

The conventional sideband receiver, be it used for CW or sideband reception, includes a sideband filter that rejects carrier and undesired sideband spectra. The usual direct-conversion receiver has no such facility. If you are tuning in a lower sideband signal, an adjacent channel signal may beat with the oscillator frequency to produce audio difference components that fall in the upper sideband spectrum. These will be heard in the output. Radio-frequency selectivity is of little use in rejecting these opposite-side audio images. Good audio filter selectivity is of some help but this can be carried to the point at which the desired modulation loses intelligibility and/or imposes an impractical pinch on oscillator stability.

two-phase direct conversion

A double-balanced product detector[4,5] with appropriate phasing can be used to cancel out image-side components. This adds complexity as shown in **fig. 5**. However, integrated circuits are good devices for designing double-balanced systems with little increase in weight and size. The added stages are worth the effort if you strive for performance that will match more conventional high-quality sideband receivers.

In the two-phase system the incoming signal is applied in phase to both product detectors. Oscillator components are applied 90° out of phase. The two demodulated audio signals are then made 90° related with an audio phase-shift network. Next the two signals are combined prior to application to the main audio filter and a follow-up audio amplifier. What happens is shown in the vector diagrams of **fig. 6**. When adjusted for upper sideband reception the audio frequency components demodulated from one side of carrier frequency are additive. Conversely, any audio frequency components demodulated from the other frequency side of carrier are subtractive.

Incorporated switching selects either upper or lower sideband reception. Switching can take place in the combiner by a change-over between difference or sum operation. Two-phase operation may be the next general forward step in direct-conversion techniques.

cw transceive

Direct conversion is just fine for transceive operation. One oscillator (crystal,

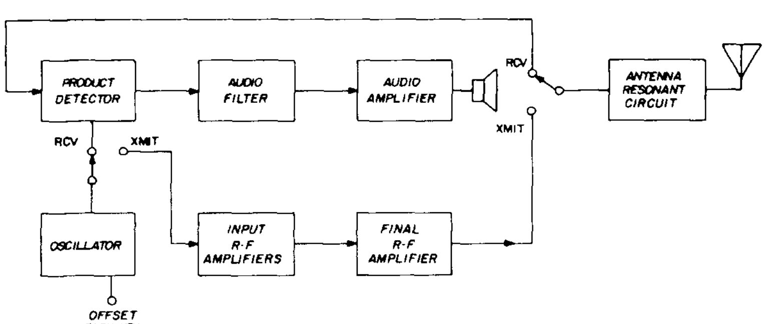


fig. 7. Transceiving with direct conversion.

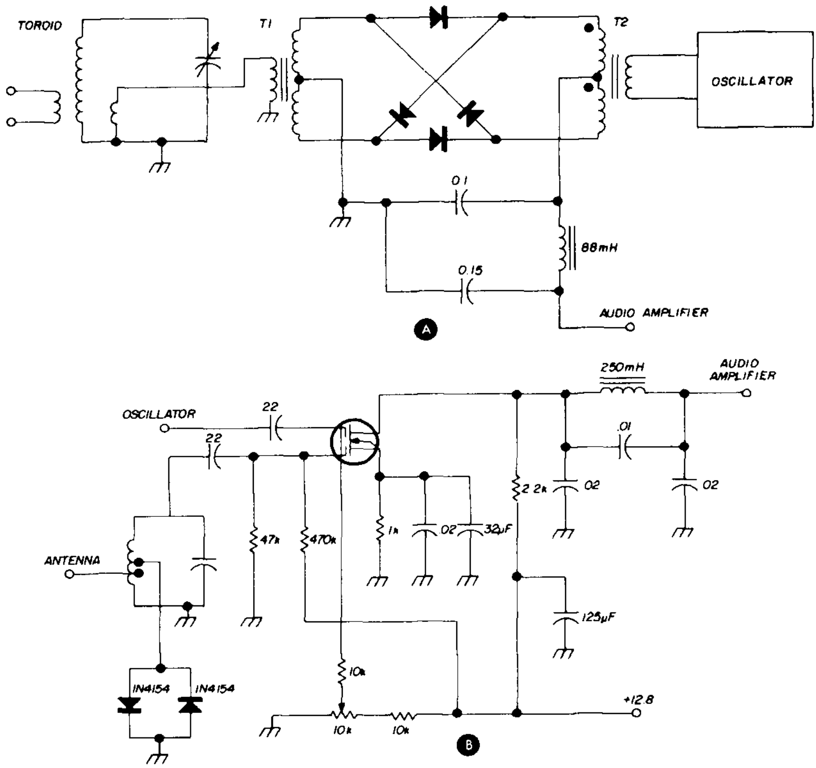


fig. 8. Two popular product detectors. Hayward-Bingham circuit is in (A). Transformers T1 and T2 are trifilar-wound toroids. Circuit in (B) is used in the Ten-Tec RX10 direct-conversion receiver.

vxo or vfo) serves both receiver and transmit modes, **fig. 7**. There is a slight difference between the transmit oscillator frequency and the desired offset frequency operation of the oscillator for CW reception. A correction can be a part of the transmit-receive switching[6, 7, 8, 12] in the oscillator circuits. You can then adjust the tone of the demodulated CW without changing the frequency of the

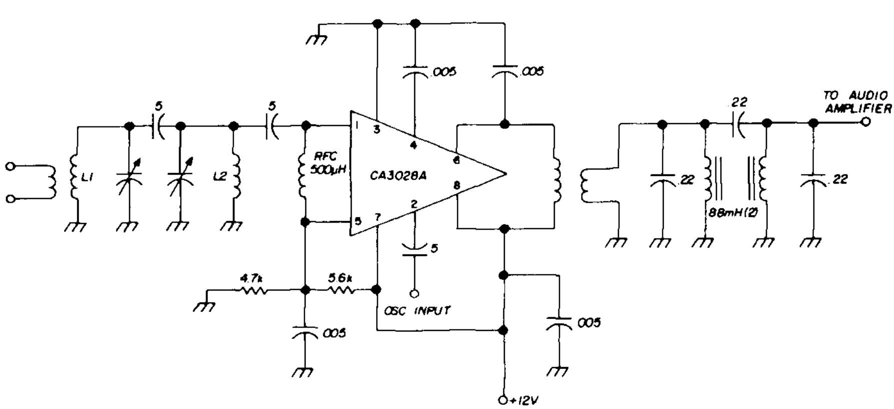


fig. 9. Integrated-circuit product detector uses RCA CA3028A. L1 and L2 are mutual-C coupled toroids.

transmit oscillator. The same preset switching arrangement also compensates for any change in oscillator frequency that may result from loading shifts in switching between transmit and receive.

typical circuits

The product detector is the key stage of a direct-conversion receiver because of its influence on distortion, cross modulation, noise and sensitivity. Low-noise devices and a balanced circuit keep noise and cross modulation at a low level. If the product detector is somewhat less than the best it can be preceded by an fet amplifier that will improve the signal-to-

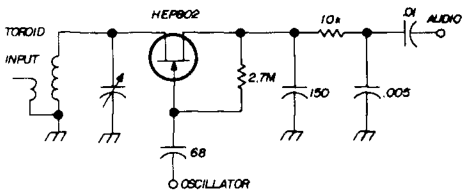
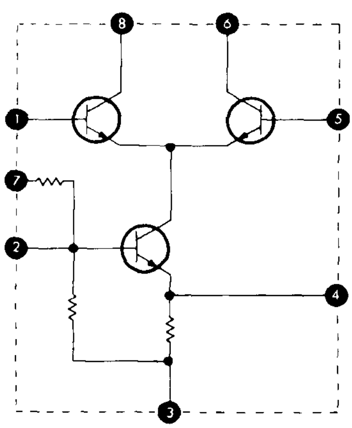


fig. 11. Simple product detector and audio filter used in receiver designed by K1BQT.

noise ratio and, to a limited degree, the selectivity as well.

The two most popular forms of product detector are shown in **fig. 8**. Example A is the common balanced-ring arrangement using the low-noise hot-carrier diodes.[9] This circuit customarily

fig. 10. Circuit diagram of the CA3028A differential-amplifier ic.



uses two broadband trifilar input and output windings. Link coupling is used between the input of product detector and the antenna resonant circuit.

Other types of low-noise diodes are used and perform well. For single-band

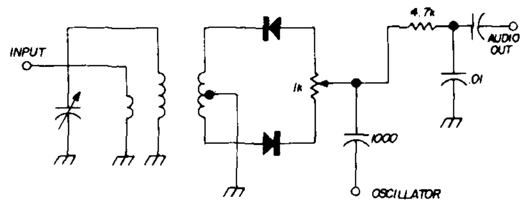


fig. 12. Simple two-diode product detector devised by PAØKSB.

operation a resonant input circuit can develop a higher output and improve the signal-to-noise ratio.

The dual-gate mosfet provides a fine low-noise and minimum cross modulation product detector. The circuit of **fig. 8B** is used in the popular Ten-Tec RX10 direct-conversion receiver. One gate is for signal injection; the second gate, for oscillator injection. A switchable resonant input circuit permits operation on four bands, 15 through 80 meters. A 2-kHz audio filter is located between the drain and the input to the audio amplifier.

Low-pass LC audio filters are common although simple resistor-capacitor combinations are sometimes found. Surplus 88-mH telephone toroid coils are often used in the audio filter, **fig. 9**. This arrangement uses an integrated circuit as a product detector. The RCA CA3028A integrated circuit is a simple differential amplifier with a means of applying an oscillator signal to the base of the constant-current emitter-bias circuit of the differential pair (**fig. 10**). Note in **fig. 9** that the incoming signal is applied between terminals 1 and 5; the oscillator to terminal 7. Demodulated audio is taken from pins 6 and 8.

An fet product detector[10] is shown in **fig. 11**. The input signal is applied to the source; oscillator, to the gate. A simple resistor-capacitor filter passes the audio products of the drain circuit to the fet audio-input state.

Probably the simplest product detector is that used by PAØKSB,[11] **fig. 12.** A two-diode balanced mixer is followed

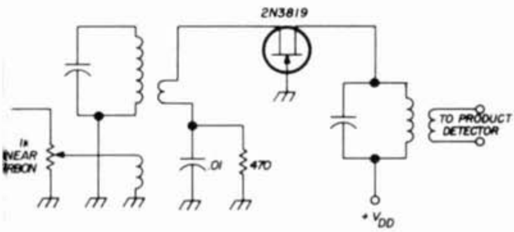


fig. 13. G3EJF's common-gate fet rf amplifier for use with direct-conversion receivers.

by a resistor-capacitor audio filter and a two-stage audio amplifier for headset operation. For these simple detectors a good low-noise fet input rf stage is a definite benefit. A grounded-gate stage from G3EJF[7] is shown in **fig. 13.**

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ham radio

the ham notebook

component marking

There are several types of typing correction tape that are ideally suited for marking printed-circuit boards, transistors and other components. I use the type that is about 1-inch wide and comes in a dispenser (Sterling Type-White or Dixon Taperaser). Place the correction tape over the surface to be marked and letter directly on the back of the tape. For best results use a sharp pencil or ball-point pen. The white correction-tape pigment is transferred easily and legibly.

Because of the stark whiteness of the pigment, readability is excellent, even on light-colored printed-circuit boards. To protect the letters dab a little lacquer or synthetic varnish over the lettering. The white pigment is not especially solvent in lacquer-based materials, but it does have a tendency to smear a little.

W. H. Fishback, W1JE

calibrator crystals

In recent years there have been many items published on the subject of improving the accuracy and reliability of receiver crystal calibrators. Some hams have provided external transistor oscillators, thus tending to limit the temperature range of the unit compared with one exposed to tube heat. Others have gone to external oven-controlled crystals. There remains much interest in improving the internal calibrator, hopefully without modifying the receiver.

The performance of the trimming capacitor in the receiver can be improved by adding parallel and series N750 and npo capacitors to restrict the trimmer range and to obtain better temperature compensation.

There has been little comment, if any, upon the simple approach – replacing the internal calibrator crystal with a better one.

Herb Blasier, W6EF, points out that the usual receiver has an inexpensive E-cut 100-kHz crystal, but this cut has a very small range of temperatures for which it has minimum drift. This crystal may be replaced with a DT-cut crystal for 100 kHz, or for 1 MHz. The DT cut has a long, flat curve, and is little affected by reasonable changes in operating temperatures. For 50 kHz, a useful frequency for calibrators, the NT cut is desirable.

Bill Conklin, K6KA

low-value voltage source

Although zener diodes are available in a wide veriety of voltages, values below about three volts are not as common as other values. Such regulating voltages are sometimes needed and can be built from only a few discrete components. The circuit in **fig. 1B** is a transistorized equivalent of a zener diode. The breakdown voltage is adjusted by resistor R2. This circuit has been used to obtain regulating voltages from less than 1 volt up to 10 volts.

Circuit operation is quite simple. When the voltage across R1 reaches approximately 0.5 volts, Q1 begins to conduct, causing Q2 to conduct. Q2 draws only enough current through load resistor R_L to maintain conduction in both Q1 and Q2. This voltage is the breakdown voltage V_Z. If the supply voltage is increased Q2 will conduct more current but V_Z will be maintained.

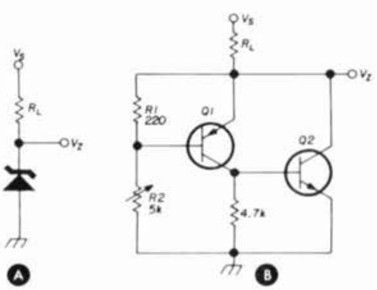


fig. 1. Circuit in (B) is transistor equivalent of circuit in (A). Output voltage can be adjusted from less than 1 volt up to 10 volts.

The regulating voltage, V_Z, is the equal to:

$$V_Z = 0.5\left(\frac{R1 + R2}{R1}\right)$$

The value of the load resistor R_L is determined as in the conventional zener-diode circuit in **fig. 1A**:

$$R_L = \frac{V_S - V_Z}{I}$$

where I is the current through zener and the load.

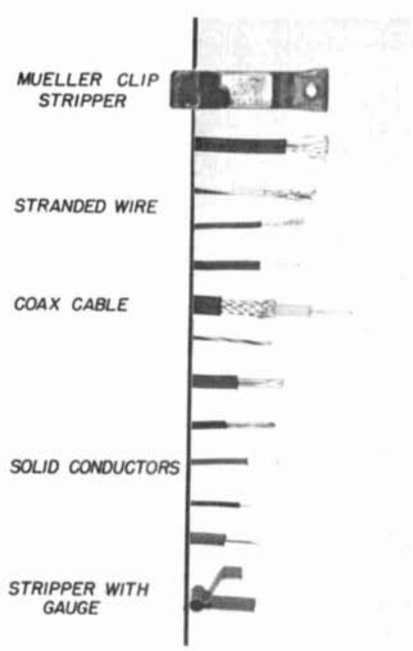
This circuit can be used in almost any application that a regular zener diode can be used, but it has one advantage that can often be very useful to the experimenter – the regulating voltage can be adjusted to precisely the required value.

Transistors Q1 and Q2 should be low-leakage silicon transistors. The power rating of Q2 determines the power rating of the equivalent zener. Another advantage now becomes apparent: an expensive high-power zener diode can be replaced if an appropriate power transistor (low cost) is used for Q2!

James McAlister, WA5EKA

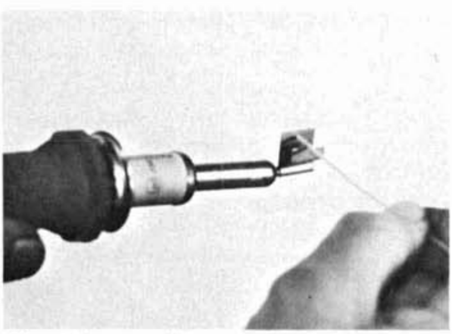
hot wire stripper

The wire strippers shown in the photographs permit consistently better stripped wires when building electronic equipment. I use two different versions with great success. Both use a hot knife edge to melt the insulation in a thin line around the wire, permitting clean removal of insulation without damage to the conductor. Cut strands or nicks are completely eliminated. The stripper can be used on various sizes of solid conductors, stranded wire or coaxial cable. It is especially useful on very small gauge stranded wire. On coaxial cable clean cuts can be made through the outer jacket and, after moving the braid out of the way, through the insulation around the center conductor.



Hot-wire strippers and samples of stripped wire and cable.

For the first version of the hot wire stripper remove the screw from a Mueller battery clip, flatten this end and file to a dull knife edge. Clip to the tip of a soldering iron (100 watts or less) and when the edge is hot enough to melt the plastic insulation the stripper is ready for use. Place the knife edge against the insulation and rotate the wire between your fingers until a clean cut is made to the conductor. The insulation will slide off cleanly.



Wire stripper with gauge installed on 37-watt Ungar soldering iron.

The second version, for use with a 37-watt Ungar soldering iron, has a built-in stop to gauge the length of insulation to be stripped off the wire. The dimensions are not critical, and materials used are available from scrap. The stripper shown in the photograph was made from a steel metal strap used for banding cardboard cartons. It is .010-inch thick and ½ inch wide, bent around a nail to the shape shown in the photograph. Both ends are filed to a dull knife edge. The stop should extend about 1/8-inch beyond the other knife edge to permit insulation of any length to be stripped. To use this feature place the end of the wire against the stop and rotate the wire between your fingers until a clean cut is made. When stripping thick insulation or on coax cable, using either stripper, roll the cable on your bench with a small amount of pressure on the stripper.

Carl Yeager, W8DWT

cleaning tape heads

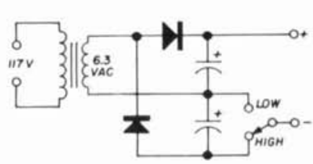
Sound recorders are used widely by amateurs, many of whom are not experienced audiophiles. After awhile, a recorder may fail to record at a suitably high level until the recording and erase heads are cleaned. In my case, I had purchased a bottle of cleaner, and also tried rubbing alcohol which did not correct the loss of recording volume.

One salesman said later that it was necessary to use an almost pure alcohol, not a 70% rubbing alcohol. The instruction book recommended using carbon tetrachloride, which has some serious toxic effects if much is used in a closed space and is impossible to buy in some states. However, in checking with users of commercial recorders and computers, it was found that Ampex No. 087-007 head cleaner consists of another somewhat toxic material, less than 11 percent Trichlorethane. A little of this on a Q-tip quickly corrected the recording volume.

Bill Conklin, K6KA

dual-voltage power supply

Many home construction projects involving the use of transistors call for a 9-volt power supply. Once in a while you may want a bit higher voltage, say 18 volts. Here's a circuit for getting either of those two voltages from a power supply using a transformer with a 6.3-volt ac



secondary, the size that lives in almost every junkbox. The wiring diagram in **fig. 2** tells about all that can be said. The transformer, rectifiers and capacitors are those that are available. The spdt switch selects either of the two available voltages.

Carl Drumeller, W5JJ

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24 PAGES, crammed with Gov't Surplus Electronic Gear – the Biggest Bargain Buys in America! It will pay you to **SEND 25¢** for your copy – Refunded with your first order.

R48/TRC-8 UHF FM RECEIVER 230 to 250 Mc. Variable tuning, one band. 115/230 V 60 cy. Complete with speaker, phone jack, squelch circuit 2-1/2" meter for circuit testing; includes 15 tubes: 8/6AG7, 9002, 5U4, 6V6, VR-150, 6N7, 6SN7, 6AL7. Size 20 x 19 x 16". Weight 75 lbs.
NEW............................ **$44.50**

TV-10 UHF TRANSVERTER 28V DC
Made by Aircraft Radio Corp. Couples UHF Antenna to VHF transmitter and VHF receiver. Uses 6 tubes: 4/5763 and 2/6201. Includes 8 crystals ranging from 233.8 Mc to 257.8 Mc. Size: 11x 4-1/2x4-5/8". Wt 5-1/2 lbs.
LIKE NEW, with tubes and crystals..... **$9.95**

R-20 RECEIVER
Made by Aircraft Radio Corp, works on 28 V, inclues 4 tubes: 2/12AW6, 12AX7, 12AT7. Size: 6-1/2x4-1/2x4-5/8".
LIKE NEW......................... **$7.50**

HANDMIKE
Rugged, heavy-duty carbon handmike with press-to-talk switch. Equipped with 4-ft cord & phone plug. SPECIAL
NEW, boxed....... Each **$1.88** 2 for $3.25

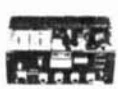
2" DC VOLTMETER
Mounts in 2-1/8" hole. Flange diameter 2-5/8" Two scales: 0-15 and 0-600. Calibrated for use on steel panel. Standard brand. SPECIAL
NEW, boxed....... Each $1.75 2 for $3.00

BC-733 RECEIVER Receives radio signals being transmitted by US satellite on approx. 108 Mc. AM, crystal-controlled on 6 preset freqs. in 108.3 to 110.3 Mc range. Operates on 12/24 V DC & 220 VDC 80 Ma. Complete with 10 tubes. Can be converted to FM Receiver 80 to 108 Mc. Exc.Used............ **$5.95**
BC-732A Control Box for above, NEW... 1.75

T-41 / APS - 18 TRANSMITTER
ANTENNA UNI designed for 115 V 800 to 1400 cps. Tubes included are two 15E and one 15R. Complete with shock mounts and blower motor. 7x8x18", NEW.... **$8.95**

BC-223AX TRANSMITTER 25 Watt, CW, MCW, Voice, Crystal control on 4 pre-selected channels, range 2000 to 5200 Kc by use of 3 plugin units, included. Complete.
BRAND NEW..................... **$27.50**

APN-1 FM TRANSCEIVER 400-450 Mc. Freq. modulated by moving coil transducer. Easily converted for radio control or 70 cms. Complete with 14 tubes, dyn.
BRAND NEW...................... **$9.95**



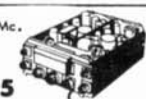
IP-69A/ALA-2 INDICATOR 3" scope.
Front panel controls: Vertical Pos.;horizontal pos. intensity, focus, gain, width, center freq. Pan. Operates on 115 V 380 to 1000 cps.
Complete with tubes. LIKE NEW...... **$27.50**

TG-5B TELEGRAPH SET for code communications or code practice. Portable, with hinged lid. Two or more units operate up to 25 miles apart. Bell call system, 1000 cycle howler, key, headpiece, canvas case, book.
Size 5-1/2x5-1/2x10". NEW........... **$8.95**

TELEPHONE TYPE RELAY
Made by J.H.Bunnell, has adjustable sensitivity. 150 ohm coil. NEW...... **$3.45**

AN/APR - 4Y FM & AM RECEIVER "FB" for Satellite Tracking!
High precision lab instrument, for monitoring and measuring frequency and relative signal strength, 38 to 4000 Mc. in 5 tuning ranges. For 110 v 60 cycle AC. Built-in power supply. Original circuit diagram included. Checked out,
Perfect. LIKE NEW.................. **$88.50**
All tuning units available for above. P.U.R.

BC-645 TRANSCEIVER 15 tubes, 435 to 500 Mc. Easily adapted for 2 way voice or code on Ham, Mobile, Television Experimental, and Citizens Bands. With tubes, less power supply in factory carton, BRAND NEW..... **$16.95**



TRANSMITTER has 4 tubes: WE-316A, 2-6F6, 7F7
RECEIVER has 11 tubes: 2-955, 4-7H7, 2-7E6, 3-7F7
RECEIVER I.F.: 40 Megacycles
SIZE: 10-1/2" x 13-1/2" x 4-1/2". Shpg wt 25 lbs.

SPECIAL PACKAGE OFFER: BC-645 Transceiver, Dynamotor and all accessories, including mounting, UHF Antenna Assemblies, control box, complete set of connectors and plugs.
Brand New **$26.95**

HEADSET Low impedance. With large chamois ear cushions. 4-ft cord and plug. Reg. $12.50. Our Special Price **$2.95**
Less ear cushions.................. $1.95
High impedance adaptor for above... $ .69

SCR-274-N, ARC-5 COMMAND SET HQ!

Freq. Range	Type	Exc. Used	Like New	BRAND NEW
RECEIVERS.	**Complete with Tubes**			
190 - 550 Kc	BC-453	$16.95	$23.50	$27.50
6 - 9.1 Mc	BC-455	—	—	$22.50
1.5 - 3 Mc	R-25	—	$19.50	$21.50
TRANSMITTERS.	**Complete with Tubes**			
4 - 5.3 Mc	BC-457	$8.95	—	$11.95
5.3 - 7 Mc	BC-458	$8.95	—	$11.95

TG-34A CODE KEYER, self-contained, automatic, reproduces code practice signals from paper tape. 5 to 12 WPM Built-in speaker. Brand new with tech manual. takeup reel and AC line cord. ... **$24.50**
Code practice tapes for above P.U.R.

BC-1206-C RECEIVER Aircraft Beacon Receiver 200 to 400 Kc. Operates from 24V DC 1.5A. Continuous tuning, vol control, on-off switch and phone jack. Very sensitive. Compact.
Complete with tubes, NEW............. **$12.50**

BC-604 FM TRANSMITTER 20 to 27.9 Mc. Output approx 30 watts. 10 crystal controlled channels. Complete with tubes.
NEW.......................... **$12.50**

ARC-R11A Modern Q-5 Receiver 190 - 550 Khz $10.95
ARC-R22 540 - 1600 Khz Receiver with tuning graph $15.95
R-4/ARR-2 Receiver 234-258 Mhz, 11 tubes, NEW $8.95

BC-605 INTERPHONE AMPLIFIER, NEW $3.45 EXC.USED.... $1.95
TELEPHONE HANDSET, W.E. type............LIKE NEW $2.95
SCR-522 TRANSMITTER-RECEIVER, with 18 tubes. LIKE NEW $32.50

AM-300/AIC PUSHPULL AMPLIFIER
4-tube PP power amplifier with dynamotor, works on 28 VDC. Automatic gain control.
Shpg wt 15 lbs. LIKE NEW.............. **$3.95**

DUAL AMPLIFIER has two input circuits each feeding a single 6SN7GT twin triode amplifier. Complete with 115V 60 cy. power supply using 6X5GT rectifier. NEW.......... **$5.95**

AM-26/AIC PHASE INVERTER AMP.
4-tube pushpull power amplifier. Carbon mike input, hi-lo imp. output. Works on 24VDC. Easily converted to dandy 9-watt amplifier. Complete with tubes and dynamotor
LIKE NEW **$5.95**

WILLARD 2-VOLT STORAGE BATTERY
Rated at 20 Amp.-Hours. Model 20-2. Rechargeable. Compact nonspill construction. Lightweight polystyrene container, 3x4x5 1/2". Shipped dry, uses standard electrolyte. Shipping Weight 3 lbs. NEW, each............. **$2.79**

TERMS: 25% Deposit with order, balance C.O.D. -or- Remittance in full. Minimum order $5.00 F.O.B. NYC. Subject to prior sale and price change

G&G RADIO ELECTRONICS COMPANY
45-47 Warren St. (2nd Fl.) New York, N.Y. 10007 Ph. 212-267-4605

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new products

power supplies

The *Scrubber* is a solid-state aid to noise-free CW reception. It also serves as a station speaker and code practice oscillator. The *Scrubber* contains a *Fritch*,* a sharp, solid-state, active filter which "scrubs" the audio output from the receiver. The filtered signal is rectified and used to drive a dry-reed relay. The relay contacts are used to key an internal audio oscillator, whose tone and volume are selected by the operator. The code output matches the received signal but is isolated and free of noise.

The filtering and oscillator keying functions are performed by the Douglas Randall *Fritch* frequency responsive switch. The *Fritch* provides a contact closure when a 1000-Hz signal is received from the receiver audio section; the contact closure is used to key the *Scrubber* oscillator.

The *Scrubber* contains a matching transformer input, *Fritch,* monitor oscillator, communications quality speaker and power supply. A rear panel terminal strip provides connections for receiver audio and practice key. Provisions are made to match 3.2-, 8-, 600- and 1000-ohm receiver outputs. A rear panel adjustment sets the proper signal input level to the *Scrubber.*

In operation, a CW signal is tuned in with the *scrub* switch *out*. When the desired signal peaks on the front panel meter, the *scrub* switch is thrown to *in.* The desired audio signal will then key the internal oscillator in step with the received signal. The extremely high degree of isolation between the actual audio signal and the regenerated signal eliminates all unwanted static and noise. The *Scrubber* will pass signals in a very narrow audio passband and reject all others.

Like any filter, the *Scrubber* cannot distinguish between multiple signals in its passband. However, rough or chirpy signals are reproduced as clear T9 notes. The better the receiver selectivity, the easier it is for the *Scrubber* to separate signals. SWLs and novices will find that the *Scrubber* will improve copy from homebrew and less expensive receivers and will eliminate distracting QRN. Ear fatigue from static crashes is eliminated.

The wide dynamic input range of the *Scrubber* helps to compensate for fading signals. The use of a reed relay allows faithful reproduction of the original signal at speeds in excess of 25 words per minute.

The Scrubber is housed in a handsome wood-grained cabinet and can also be used as a station speaker, CW monitor or code-practice oscillator. The unit is priced at $94.50. For more information, use *check-off* on page 110, or write to Douglas Randall Division, Walter Kidde and Company, Inc., 6 Pawcatuck Avenue, Pawcatuck, Connecticut 02891.

*Fritch is the registered trade mark for Douglas Randall frequency-responsive switch; patent pending.

More Details? CHECK—OFF Page 110

printed-circuit kit

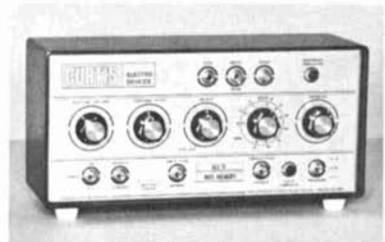
At one time building an electronics project was hard work because it involved drilling, cutting, reaming and deburring a metal chassis. Now Injectorall Electronics Corporation has taken the sweat out of electronics and put pleasure back in. With Injectorall's new no. 650 photo-etch printed-circuit kit, anyone, beginner or professional, can make professional printed circuits the first time, every time. Injectorall's 650 is a completely packaged kit (nothing else to buy) using a photosensitive method for producing professional quality printed circuits. It can be used with assurance by engineers developing a prototype or an amateur who is building a home-lab project.

With Injectorall's Kit 650 you don't need a darkroom, and you can completely eliminate commercially made boards. If *ham radio* has a drawing you want to use, Kit 650 has materials included to let you make negatives from the printed page. Hobbyists and professionals alike have found it ideal for solid-state and integrated circuitry.

Kit 650 contains two photo-sensitized 3 x 4-inch copper-clad boards, a photographic test negative and an ultraviolet light source. It also contains an exposure glass, clamps, developer, etchant, trays, resist remover, drill and complete instructions. This low-cost easy way of making quality printed circuit boards is now available at all major distributors and retails for only $10.80.

For more information, use *check-off* on page 110, or write to Injectorall Electronics Corporation, 4 North Road, Great Neck, New York 11024.

programmable electronic keyer



Curtis Electro Devices has announced an unusual new electronic keyer designed to raise contest scores while adding to the enjoyment of CW operation. A 256-bit MOS integrated-circuit read-write memory has been incorporated into the basic Curtis keying circuitry to provide "canned" CW sequences for repetitious portions of CW traffic such as used during CW contests. This frees the operator for logging and provides a moment of relaxation. The following is a typical Field Day program set:

A. 5NN SCV DE W1DTY/1
B. CQ FD CQ FD DE W1DTY/1
C. DE W1DTY/1

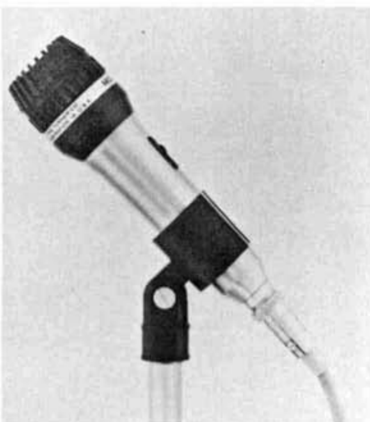
These three programs are *written* into the MOS memory merely *by sending* on the keyer paddle while the instrument is in the *write* mode. The sequence may be written and rewritten as often as desired for any contest or call letters in only the time it takes to send the Morse characters. An internal battery automatically supplies current to the memory in the event power is removed. The memory may be programmed at any convenient speed. Playback, initiated either by a panel push-button or an external switch, exactly follows the manual speed and weight characteristics in use by the operator and is indistinguishable from manual sending. Memory reset is instantaneous when manual sending is started.

The all IC EK-402 Programmable Electronic Keyer incorporates the features required in a professional keyer including calibrated speed, variable character weighting, sidetone pitch and volume, a variable repeat cycle, tune-up switch,

More Details? CHECK—OFF Page 110

iambic or standard keying action and dot memory. Speaker and 110 Vac power supply (220 Vac optional) are built-in. The reed relay output will key any grid-block, cathode keyed or solid-state amateur transmitter. The keyer is priced at $289.95 FOB factory, complete with cables, connectors and memory battery. For more information write Curtis Electro Devices, Box 4090, Mountain View, California 94940, or use *check-off* on page 110.

turner microphones



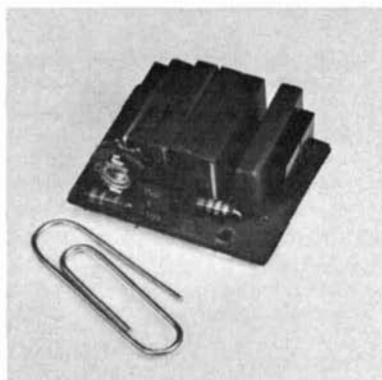
The medium-priced Turner 600 cardioid dynamic microphones now include a detachable cable with professional connector, and the guarantee has been extended to five years at no increase in price. The Turner 600 series ($70 list) has excellent unidirectional cardioid pick-up characteristics and a smooth wide-range response. The units feature die-cast zinc alloy cases, Cycolac fronts, on-off switches and are available as a Model 600 high impedance (40,000 ohm) or Model 602 low impedance (150 ohm). Response covers the 50-15,000 Hz range with discrimination typically 20-25 dB over the entire range.

Effective immediately, the permanently attached cord on the 600 Series microphones is replaced by a 20-foot detachable cord, including an Amphenol MC2M connector. The new cable is single-conductor, shielded, on high-impedance models, and two-conductor, shielded, on low-impedance models.

The guarantee on the 600 series microphones has now been extended to five years, longest in the microphone industry. If, at any time within five years of purchase, the microphone fails, it may be returned to Turner, prepaid. If the failure is due to faulty materials or workmanship, the microphone will be repaired or replaced, at no charge, and returned to the sender, postage paid.

The Turner Division of Conrac Corporation, located at 909 17th Street N. E., Cedar Rapids, Iowa 52402, is one of the world's leading manufacturers of microphones for broadcast, sound systems, amateur radio and other applications. For more information use *check-off* on page 110.

sub-audible tone module



Alpha Electronic Services has announced its new SS-80J integrated-circuit sub-audible tone module. Measuring less than one square inch, including the new TN-91J frequency determining module, the SS-80J is the smallest non-reed CTCSS device available. The unit was designed especially to offer high reliability by the elimination of mechanical and contactless reeds and still be small enough to be installed in hand-held transceivers and pocket page receivers.

Under development for two years, the SS-80J has been subjected to a rigorous

More Details? CHECK–OFF Page 110

testing program to establish long-term reliability. Extremely stable, the unit meets or exceeds all applicable EIA Specifications and is available in standard or special frequencies from 20.0 cps to 250.0 cps. Special configurations are available for easy mounting in most handheld and portable units along with instruction manuals that clearly outline step-by-step installation. For additional information write to Alpha Electronic Services Inc., 8431 Monroe Avenue, Stanton, California 90680, or use *check-off* on page 110.

instrument knobs

International Rectifier Corporation has introduced a family of all aluminum, quality instrument knobs at prices ranging from 56 cents to $1.19. The knobs are designed specifically to upgrade the appearance of instruments built by hobbyists achieving a custom, precision look.

In the International Rectifier Diamond line, the company will offer three styles of individually machined knobs in a total of 11 sizes. These include a *silver* aluminum knob style with knurled sides and recessed spin top. This style is also available in skirted configuration. The third series is gold anodized aluminum with recessed tops and wood-grained inserts.

All three styles are individually packaged with a 1/8-inch adapter to make the standard ¼-inch shaft fit all sizes. Each knob has a set screw to assure secure fit. Knob sizes range from approximately ½ inch to 1¼ inch in diameter. Available at your local electronics distributor; for more information use *check-off* on page 110.

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gonset portable vhf receiver

The Gonset Division of Aerotron recently announced its new model 6RP highband vhf personal portable receiver. The Gonset 6RP is a high-performance, true fm narrow-band pocket-type receiver, with built-in antenna for monitoring the range of 146 to 160 MHz. The 6RP may be powered with replaceable mercury cells or rechargeable nickel cadmium batteries; other options include two-frequency capability, and signal-to-noise ratio squelch which is adjustable from the outside of the unit. The Gonset 6RP may be used for monitoring amateur fm, police, fire, industrial, CD and many other land-mobile services.

For more information on the new Gonset 6RP vhf-fm receiver, use *check-off* on page 110 or write to Aerotron, Inc., Post Office Box 6527, Raleigh, North Carolina 27608.

second-class radio-telephone license handbook

The emphasis of this new edition, authored by Edward M. Noll, is placed on two-way radio since this is the major field of activity for the second-class radio-telephone license holder. Completely updated, the discussions of the latest solid-state two-way communications

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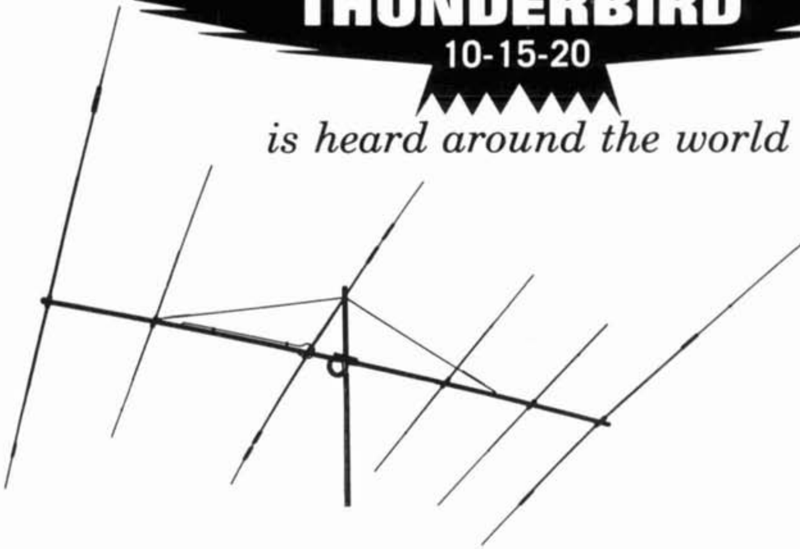
The voice of

HY-GAIN'S

THUNDERBIRD

10-15-20

is heard around the world



Here's why Thunderbirds outperform all other tri-banders:

- **Thunderbird's "Hy-Q" traps** provide separate traps for each band. "Hy-Q" traps are electronically tuned at the factory to perform better at any frequency in the band—either phone or CW. **And** you can tune the antenna, using charts supplied in the manual, to **substantially** outperform any other antennas made.
- **Thunderbird's superior construction** includes a new, cast aluminum, tilt-head universal boom-to-mast bracket that accommodates masts from 1¼" x 2½". Allows easy tilting for installation, maintenance and tuning and provides mast feed-thru for beam stacking.

  Taper swaged, slotted tubing on all elements allows easy adjustment and readjustment. Taper swaged to permit larger diameter tubing where it counts! And less wind loading. Full circumference compression clamps are mechanically and electrically superior to self-tapping metal screws.
- **Thunderbird's exclusive Beta Match** achieves balanced input, optimum matching on all 3 bands and provides DC ground to eliminate precipitation static.

- 25 db front-to-back ratio.
- SWR less than 1.5 to 1 on all bands.
- 24-foot boom . . . none longer in the industry.
- Extra heavy gauge, machine formed, element to boom brackets, with plastic sleeves used only for insulation. Bracket design allows full mechanical support.
- Interlaced, optimum spaced elements for higher gain and better pattern control.
- 3 active elements on 20 and 15 meters. 4 active elements on 10 meters.

New 6-Element Super Thunderbird
Model 389
Suggested retail price, **$179.95**

Improved 3-Element Thunderbird
Model 388
Suggested retail price, **$144.95**

Fabulous 3-Element Thunderbird, Jr.
Model 221
Suggested retail price, **$99.95**

Popular 2-Element Thunderbird
Model 390
Suggested retail price, **$99.95**

Buy one today at your favorite Hy-Gain distributor!

HY-GAIN ELECTRONICS CORPORATION

P.O. Box 5407-WK, Lincoln, Nebraska 68505

More Details? CHECK—OFF Page 110

equipment are included in this revised edition.

The first five chapters cover FCC rules and regulations, operating procedures for radiotelephone communications, transmitter tuning and adjustment, etc. Chapters 6 through 14 are study guide chapters that contain questions and answers on Elements I, II and III of the FCC exam. Each of the study guide chapters include a self-examination, with the answers provided.

Chapter 15 contains two 100-question tests to simulate the FCC examinations. These tests are presented in the multiple-choice form of the FCC tests. The answers to these tests are also given. Finally, the book has appendices which contain extracts from the FCC Rules and Regulations. These extracts contain valuable information that can be used as reference material.

Second-Class Radiotelephone License Handbook will help the reader acquire a license, and will continue to serve as reference material once he is licensed. Published by Howard W. Sams & Company. 360 pages, softcover. $6.50 from Comtec Books, Post Office Box 592, Amherst, New Hampshire 03031.

vhf fm transmitter kit

The new two-meter five-watt vhf fm transmitter kit from RMV Electronics features 4-channel capability. The kit is furnished with step-by-step instructions and is built on a double-sided 3- x 7-inch glass-epoxy board. The circuit uses 16 transistors and 9 diodes and has a separate oscillator for each channel, capable of remote selection. The transmitter uses plug-in HC-18/U crystals in the 9-MHz range.

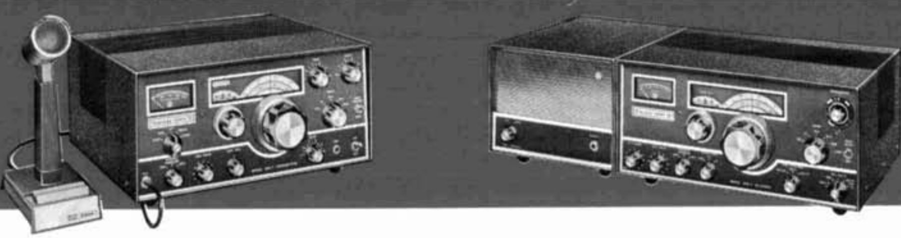
The completed transmitter is easy to tune up with a 50 μA meter and provides 5 watts (typical) output with a 13.6-volt power supply. Priced at $59.95 less crystals, microphone, meter or power source from RMV Electronics, Box 283, Wood Dale, Illinois 60191; add $1.00 for postage in the U. S. A. For more information use *check-off* on page 110.

More Details? CHECK–OFF Page 110

More Details? CHECK—OFF Page 110

INTRODUCTORY OFFER FROM SWAN*

15 DAY TRIAL ON SWAN 600R RECEIVER, AND 600T TRANSMITTER



We'll give you a 15 day trial on either or both the 600R and 600T. If you are dissatisfied with them in any way, you can return them to the Swan factory and we'll refund your money immediately, with no questions asked.

This is an unusual offer, but the 600R and 600T are such unusual products that we feel you should have the opportunity to try them in your own shack at no risk, to convince yourself that the 600R and 600T are the finest amateur receiver and transmitter values you can own. You can order the units separately or as a pair, with or without accessories . . . any way you wish.

600R RECEIVER
SSB-CW-AM and FSK superheterodyne receiver. Covers 10 through 80 meters. **$395**

600R CUSTOM
With I.F. noise blanker, and IC audio filter factory installed. **$495**

600T TRANSMITTER
SSB-CW-AM self-contained transmitter with 600 watts P.E.P. input, 500 watts CW, 150 watts AM, and 100 watts continuous AFSK. Provides full coverage from 10 through 80 meters. **$535**

600S STANDARD SPEAKER
With tone switch and headphone jack. **$18**

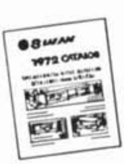
600SP DELUXE SPEAKER
Includes Swan phone patch, tone switch, and headphone jack. **$ 59**

SS-16B Super selective filter . . . . add **$60**

CW FILTER with 600 cycle bandwidth . . . . **$ 22**

AM FILTER wih 6 kc bandwidth . . . . **$ 29**

*Offer requires payment in advance for units desired. 15 day trial period begins upon your receipt of the units. If during the 15 day period you are dissatisfied with any of the units you ordered, return them to the factory, freight prepaid, and we will mail you a refund check for the full price of the units. Dealer participation in this program is optional. Offer expires December 31, 1971.



SWAN ELECTRONICS
A Subsidiary of Cubic Corporation

SWAN FACTORY
305 Airport Road
Oceanside, CA 92054
Phone: (714) 757-7525

EASTERN OFFICE
P.O. Box 2288
Ocean, N.J. 07712
Phone: (201) 531-4114

Please send me the following Swan Equipment on your 15 day Introductory Offer.

☐ 600R @ $395
☐ 600R Custom @ $495
☐ 600T @ $535
☐ 600S @ $18
☐ 600SP @ $59
☐ SS-16B
☐ AM Filter @ $29
☐ CW Filter @ $22
☐ 1972 Catalog

I enclose $________.

California and New Jersey residents add 5% sales tax.

BankAmericard #____________________.

Master Charge account #__________________.

Interbank #____________________.
(4-digit number above name)

Name________________ Call________

Address________________________

City________ State________ Zip________

More Details? CHECK—OFF Page 110

MODEL 600R

The perfect receiver for your ham shack, whether your interest is in phone, CW, DX, or rag chewing. With its tremendous sensitivity, selectivity, stability, and rugged construction, the 600R outperforms anything else on the market.

The 600R can be interconnected with its matching twin, the 600T Transmitter, or with a Swan 500C, 500CX, 270, or 270B Transceiver. The 600R will also operate with any other transmitter, requiring only antenna and muting connections.

MODEL 600T

600 WATTS, 10-80 METERS, SSB-AM-CW

A complete, self-contained, high power transmitter. When combined with the matching 600R Receiver, you'll have the finest and most versatile station available at any price. The 600T may also be used with any other receiver. All necessary muting and frequency spotting circuitry is included.

Special Features: Highly stabilized frequency control with ultra-smooth tuning system; the famous Swan high quality audio, single conversion design, producing fewer spurious byproducts.

SWAN
ELECTRONICS
A Subsidiary of Cubic Corporation

Write for your 1972 Swan catalog today.

600R SPECIFICATIONS:

- SSB, CW, AM and FSK superheterodyne receiver
- Frequency range with built-in tuning system: 3.4 to 4.4 mc, 6.7 to 7.7 mc, 13.8 to 14.8 mc, 20.9 to 21.9 mc, 27.5 to 30 mc
- With external tuner, Model 330: general coverage from 3 to 30 mc
- Tuning system: 80 through 15 meters are covered by Bandspread Dial in 200 kc segments with 2 kc calibration. 10 meters is covered in 500 kc segments with 5 kc calibration
- With external oscillator, Model 510X: 3 to 24 mc, 10 crystal position. These external oscillators plug directly into the 600R
- Ultra-smooth vernier tuning, with large knob and dial, gives you the incomparable feel of a Swan tuning system
- Sensitivity: ¼ microvolt at 50 ohms for 10 db signal plus noise-to-noise ratio
- Selectivity: 2.7 kc bandwidth with 1.7 shape factor is standard
- Options include 0.6 kc CW filter, 6 kc AM filter, and SS-16B super selective filter
- Crystal calibrator with 25 and 100 kc selection
- Hybrid design: 7 tubes, 8 transistors, 12 diodes. Transistors used where they provide definite advantage. Tubes used where they still provide superior performance
- Features: Swan's exclusive single conversion design, with fewer spurious responses than multi-conversion designs
- Fully compatible with 600T Transmitter, providing transceive operation as well as separate frequency control. Also compatible with Swan 500C, 500CX, 270, and 270B Transceivers
- Both models have built-in AC power supply
- Dimensions: 15 in. wide, 6½ in. high, 12 in. deep. Weight: 23 lbs.

600T SPECIFICATIONS:

- Power rating: 600 watts P.E.P. input. 500 watts CW, 150 watts AM, 100 watts continuous AFSK
- Pi-network output for 50 or 75 ohm coax
- Frequency range: same as 600R. With Model 510X, the 600T may be crystal controlled for MARS and NET operation. 510X has 10 crystal positions and plugs directly into the 600T
- When interconnected with the 600R matching Receiver, the 600T VFO may be used for transceive operation, and may be calibrated with 600R crystal calibrator
- Solid state VFO, highest stability, temperature and voltage compensated
- Suppression: carrier 60 db, unwanted sideband 50 db (standard filter). Third order distortion approximately 30 db
- Audio response: plus or minus 3 db from 300 to 3000 cycles
- Includes built-in AC power supply
- Dimensions: 15 in. wide, 6½ in. wide, 12 in. deep. Weight 32 lbs.

THE MOST POPULAR TRANSCEIVER IN THE WORLD

SWAN 500CX

550 Watts — 5 Bands. SSB-CW-AM Transceiver

Because of its reputation for reliability and unsurpassed performance, the Swan 500CX has become the world's most popular transceiver. Not only is the 500CX the ideal rig for your ham shack, it also provides unparalleled high performance in mobile operation. The 500CX features single conversion which results in greatly reduced image and spurious response, made possible by the unique combination of a high frequency I.F. system and a highly stable multi-range variable frequency oscillator.

Sensitivity of the Swan receiver circuitry is second to none. Using the best vacuum tubes available for the R.F. amplifier, signal to noise ratios run as high as the state of the art permits, without the inherent overload problems found in solid state receivers.

Selectivity . . . Swan's 5.5 mc 2.7 kc bandwidth design produces the optimum shape factor, steepest skirts, and greatest ultimate rejection available. The result is maximum readability of voice under conditions of noise and QRM, making operating a pleasure.

Price, less power supply . . . . **$489.**

SPECIAL FEATURES:

- 550 Watts P.E.P.
- Amplified automatic gain control circuit. Fast attack results in exceptional receiver control with no "pumping" effect.
- Built-in 25/100 kc solid state crystal calibrator.
- Sidetone oscillator for CW, pleasant sounding sine wave.
- Amplified Automatic Level Control for maximum "talk power" and less critical Mic Gain adjustment.
- Shifted carrier CW—eliminates "leap frogging" when operating CW.
- High stability solid state VFO.
- Single conversion design for fewer spurious responses.

GENERAL SPECIFICATIONS:

Frequency range: 3.5-4.0 mc, 7.0-7.45 mc, 14.0-14.45 mc, 21.0-21.45 mc, 28.0-29.7 mc. Extended frequency coverage for MARS operation with plug-in crystal oscillator accessory, Model 510X • 5.5 mc quartz crystal filter. Finest in the industry • 2700 cycle bandwidth, 1.7 to 1 shape factor at 6 and 60 db, more than 100 db ultimate rejection • Selectable upper and lower sideband • Solid state VFO, highest stability, temperature and voltage compensated • 13 vacuum tubes 7 transistors, 11 diodes.

TRANSMITTER SPECIFICATIONS:

Power rating: 550 watts P.E.P. input, 360 watts CW input, 125 watts AM input. Two 6LQ6 tubes • Suppression: unwanted sideband down more than 50 db, carrier down more than 60 db, third order distortion down approximately 30 db • Audio bandpass: 300 to 3000 cycles, ±3 db • Output circuit: wide range Pi, coarse and fine adjustment • Amplified ALC, increased voice power • Automatic voice controlled transmit with plug-in VX-2 accessory • CW keying, grid-block system, off-set transmit frequency • Semi-break-in CW operation with plug-in VX-2 accessory.

RECEIVER SPECIFICATIONS:

Sensitivity: requires less than 1/2 microvolt at 50 ohms for 10 db S + N/N ratio • Precision tuning: velvet-smooth dual ratio, zero backlash. The finest tuning system on the market • Audio fidelity: 300 to 3000 cycles, ±3 db • Amplified AGC, fast attack, no pumping, controlled decay • S-Meter circuit functions automatically in receive mode • Automatic noise limiter, with panel on-off switch • CW sidetone circuit for monitoring CW keying.

ACCESSORIES:

Model 117XC AC Power Supply . . . . $ 99
Model 14-117 DC Power Supply $129
Model VX-II Vox Unit . . . . $ 35
Model 510X Crystal Control Unit . . . . $ 49
Model 508 External VFO $129
SS-16B Super Selective 16 Pole Filter, add $ 60
I.F. Noise Blanker Accessory Kit . . . . $ 89
IC Audio Filter for notching or peaking . . $ 59
Model FP-1 Phone Patch . . . . $ 44

Write for your 1972 Swan catalog today.

SWAN
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THE IDEAL TRAVELING COMPANION

A complete station in one complete package.

SWAN CYGNET 270B

260 WATTS—5 BANDS—SSB TRANSCEIVER
WITH BUILT-IN AC POWER SUPPLY AND LOUDSPEAKER

The lightweight, compact design of the Deluxe Cygnet makes it an ideal traveling companion. It contains all the features required for home station operation with enough power to work the world. Simply plug it in, connect an antenna, and you're on the air.

The Deluxe Cygnet also makes the perfect mobile rig. Simply attach the 14A DC Converter, connect to a 12 volt supply or cigarette lighter, and you're on the air. Perfect for traveler or vacationer. **$429**

SPECIFICATIONS:

• Power input: 260 watts P.E.P. SSB, and 180 watts CW • Frequency range: 3.5-4.0 mc, 7.0-7.3 mc, 14.0-14.35 mc, 21.0-21.45 mc, 28.0-29.7 mc • 5.5 mc Crystal Lattice Filter, same as used in the Swan 500CX. 2.7 kc with 1.7 to 1 shape factor. Ultimate rejection exceeds 100 db • Unwanted sideband suppressed 50 db. Carrier suppressed 60 db. Third order distortion down approximately 30 db • Audio response: flat within 3 db from 300 to 3000 cycles in both transmit and receive modes • Pi antenna coupler for 50 to 75 ohm coaxial cable • Grid block CW keying with offset transmit frequency • Solid state VFO circuit temperature and voltage stabilized • Receiver sensitivity better than 1/2 microvolt at 50 ohms for 10 db S + N/N ratio • 100 kc crystal calibrator and dial-set control • S-meter for receiver, P.A. cathode meter for transmitter tuning • Improved AGC and ALC circuit • Separate R.F. and A.F. gain controls • Sideband selector • Provision for plug in of VOX unit, external VFO, headphones, and Cygnet Linear • Tube complement: 12AU6 VFO amp., 12BE6 trans. mixer, 6GK6 driver, 6LQ6 pwr. amp., 6BZ6 rec. R.F., 12BE6 rec. mixer, 12BA6 1st I.F. amp., 12BA6 2nd I.F. amp., 12AX7 prod. det. A.F. amp., 6AQ5 A.F. output, 12AX7 mic. amp., 6JH8 bal. mod., 12AV6 AGC-ALC amp., 12BA6 xtal. cal. • Voltage input: 117 volts 50-60 cycles. Available on special order for 208-220-240 volts • For 12-14 volt DC operation, a plug-in converter, Model 14A, is available. This unit is only 1½ x 3 x 4 in., and plugs into the back of the 270B in place of the AC power connector • Dimensions: 5½ in. high, 13 in. wide, 11 deep • Net weight: 24 lbs.

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ACCESSORIES:

Model 14A 12V DC Converter .... $ 39
Model VX-II Vox Unit .... $ 35
Model 510X Crystal Control Unit .... $ 49
Model 508 External VFO $129
Model FP-1 Phone Patch .... $ 44
SS-16B Super Selective 16 Pole Filter, add $ 60
I.F. Noise Blanker Accessory Kit .... $ 89
IC Audio Filter for notching or peaking . . $ 59

SWAN
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NO COMPROMISE 2 METER PERFORMANCE

SWAN FM-2X
10 WATTS—12 CHANNELS

The low price of this exceptional 2 meter rig was achieved through Swan's Value Engineering. There was no compromise in performance, quality, or design. The FM-2X is without doubt the finest value in 2 meter transceivers on the market today. Its low price includes microphone, built-in speaker, AC and DC operation. Features include automatic protection of the output transistor, and individual trimmers on each transmit and receive crystal. Just compare the FM-2X with the others; you'll agree it's the best. **$259**

FM-2X SPECIFICATIONS:

• Frequency coverage 144-148 mc • Number of channels: 12 • Crystals installed for 3 channels as follows: Channel 1: transmit and receive 146.94 mc; Channel 2: transmit 146.34, receive 146.94 mc; Channel 3: transmit 146.34, receive 146.76 mc. Modulation: frequency modulation (phase type) • Transmitter control: push to talk on microphone • Power source: AC 117 volts, 50-60 Hz, DC 13.5 volts ±10% • Dimensions: 8¼" x 7" x 3". Weight: 8¼ lbs • Furnished with unit: dynamic microphone, antenna connector plug, spare fuses and lamps, AC power supply, DC power cord with fuse holder.

TRANSMITTER:

• Fully solid state • RF power output 10 watts nominal • Frequency deviation adjustable to ±15 kc; factory adjusted to approximately 5 kc • Frequency stability: ±.001% • Spurious radiation: —60 db below carrier • Frequency multiplication: 12 times.

RECEIVER:

• Circuitry: crystal controlled double conversion superheterodyne • Input impedance: 50 to 75 ohms • Intermediate frequencies: 10.7 mc and 455 kc • Sensitivity: 0.5 μv for 20 db quieting, 0.5 μv for 12 db Sinad • Intermodulation: more than 60 db down • Audio output: 1 watt to internal speaker.

VHF-150

150 WATT 2 METER AMPLIFIER
12 VOLTS DC—117 VOLTS AC

Here in one package is a complete 150 watt 2 meter amplifier, requiring only 2 watts drive to provide full 150 watts input. This amplifier will operate in class "C" for FM or CW, or in class "B" for SSB or other modes requiring linear operation. Designed for continuous operation. And by adding a 14C DC Converter you have a powerful mobile combination.

Write for your 1972 Swan catalog today.

VHF-150 with built-in 117 volt AC power supply **$279**

14C Converter **$65**

VHF-150 SPECIFICATIONS:

• Power rating: 180 watts P.E.P. input SSB; 150 watts DC input on CW or FM • Frequency range: 143-149mc • Uses 5894B twin tetrode • Drive requirements: approximate.y 2 watts for full output • Meter selector: reads plate current and relative output • Includes transmit and receive relay control for simple operation with a transceiver • Output coupling adjusted at factory for 50 ohms • Power supply: built-in 117 or 230 VAC input with proper line cord • Also DC operation with addition of 14C DC Converter • Dimensions: 13 in. wide, 5½ in. high, 10¾ in. deep • Weight: 23 lbs.

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SWAN LINEAR AMPLIFIERS

Maximum Power . . . Maximum Quality . . . Through Value Engineering

MARK II 2000 WATT LINEAR

The Mark II Amplifier provides your SSB, CW, or AM station the full legal power limit, with full frequency coverage of the amateur bands 10-80 meters, and also MARS frequencies. All controls are easily accessible on the front panel which allows you to tune the Mark II quickly and accurately.

The matching power supply is a separate unit which may be placed beside the Mark II or, with its 4½ foot connecting cable, on the floor. Component quality is of the highest caliber. Silicon rectifiers deliver 2500 volts DC in excess of 1.2 amperes. Computer grade electrolytic filters provide 40 mfd capacity for excellent dynamic regulation.

Mark II, complete with tubes and power supply **$599**

SPECIFICATIONS:
MARK II LINEAR AMPLIFIER

• Two Eimac 3-500Z zero bias triodes in grounded grid circuit • Conservative power ratings: 2000 watts P.E.P. input, 1000 watts CW, AM and RTTY input • Full frequency coverage of amateur bands 10-80 meters plus MARS frequencies • Wide range Pi network in output tank circuit • Drive requirements: 100 to 300 watts • Includes antenna changeover relay • Ceramic insulation on all tuning capacitors and RF switches • Planetary vernier drives on both plate and loading controls • Low RPM, high volume fan operates almost silently • Dimensions: 13 in. wide, 8 in. high, 14 in. deep • Weight: 20 lbs.

POWER SUPPLY SPECIFICATIONS:

• Input voltage may be either 117 or 230 volts AC, 50-60 ∿ (230 VAC operation recommended) • Silicon rectifiers deliver 2500 volts DC in excess of 1.2 amperes • Computer grade electrolytic filter capacitors. 40 mfd net capacity • Self-contained fan for cool, continuous operation • Dimensions: 9 in. wide, 8 in. high, 14 in. deep • Weight: 35 lbs.

MARK 6B 2000 WATT LINEAR FOR 6 METERS

Essentially the same as the Mark II, except that it provides coverage of the six meter band from 50-54 mc. Mark 6B, complete with tubes and power supply **$599**

MODEL 1200W

1200 WATT LINEAR AMPLIFIER, 10-80 METER COVERAGE WITH SELF-CONTAINED AC POWER SUPPLY

We built this as a matching linear for the Swan Cygnet 270B Transceiver, but with its low price, the 1200W has gained great popularity on its own. Utilizing a grounded grid super-cathode drive circuit, both efficiency and linearity are exceptionally high **$219**

SPECIFICATIONS:

• Power rating: 1200 watts P.E.P. input, 700 watts CW input, 300 watts AM input • Covers 10, 15, 20, 40 and 80 meters • Four 6LQ6 tubes operating as grounded grid triodes • Third order distortion down approximately 30 db • Pi output tank for 50 or 75 ohm coaxial antenna feed • Computer grade electrolytic filter capacitors • Silicon diode rectifiers • Complete with interconnecting cables, ready to plug into the 270B and operate, 117 volts, 50-60 ∿ input. Available on special order for 208-220-240 volts • Dimensions: 5½ in. high, 13 in. wide, 11 in. deep • Weight: 25 lbs. (Carrying handle included.)

Write for your 1972 Swan catalog today.

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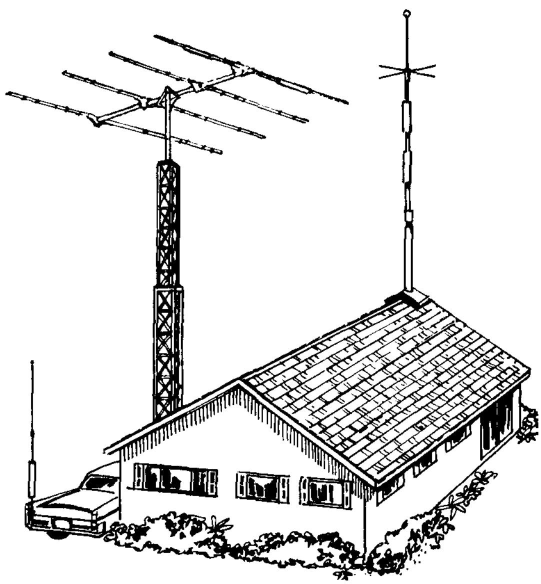
SWAN HIGH PERFORMANCE MULTI-BAND ANTENNAS

Swan has earned its high reputation in the ham radio market by offering top quality equipment with maximum performance and reliability at a most reasonable cost, backed up by the best customer service in the industry.

The Swan antennas of course include these same factors. Our antenna products are the best you can buy. The exclusive patented traps used in Swan antennas explain why they consistently give superior performance. Ask any ham who is using a Swan antenna, or better yet, check his signal on the air.

Impedance Match: Swan antennas are designed for a near perfect match on each band with 52 ohm coaxial cable. Standing wave ratio will be as low as 1.2 at band center, and only slightly higher at band edges, resulting in extremely low transmission line losses.



MODEL 1040-V HIGH PERFORMANCE TRAP VERTICAL

For 10, 15, 20 and 40 meters with optional 75 meters add-on-kit.

Model 1040V **$49**

75 meter add-on-kit **$29**

SPECIFICATIONS: SWAN TRIBAND BEAMS

All Swan Multiband Antennas are rated for 2000 watts, and require 52 ohm coaxial feedline.

**Heavy duty models.*

	Forward Gain	Front to Back Ratio	Boom Length and Diameter	Longest Element	Turning Radius	Maximum Wind Survival	Wind Load @ 80 MPH	Wind Surface Area	Net Weight Assembled	Price
*TB-4H	9 db Average	24-26 db	24' x 1½"	28' 10"	18' 6"	100 MPH	148 lbs	6 sq. ft.	54 lbs.	$129.00
*TB-3H	8 db Average	20-22 db	16' x 1½"	28' 2"	16'	100 MPH	110 lbs	4 sq. ft.	44 lbs.	$109.00
TB-3	7.5 db Average	20-22 db	14' x 1½"	28' 2"	14' 11"	80 MPH	100 lbs	3.8 sq. ft.	39 lbs.	$ 94.00
TB-2	5 db Average	16-18 db	6½' x 1½"	27' 8"	14' 3"	80 MPH	60 lbs	1.8 sq. ft.	18 lbs.	$ 79.00

HIGH Q—MAXIMUM PERFORMANCE MOBILE ANTENNAS

SINGLE BAND MODEL 35

Top section, 5 ft. whip **$12.00**

15 meter coil **$22.00**
20 meter coil **$24.00**
40 meter coil **$26.00**
75 meter coil **$28.00**
18 inch base section .... **$ 8.50**
36 inch base section .... **$ 9.00**
48 inch base section .... **$ 9.50**

5 BAND MANUAL SWITCHING MODEL 45

Covers 10, 15, 20, 40 and 75 meters with no coil changing. Gold plated contacts on the patented vertical switch provide 5 stops for full coverage of the 75 meter phone band. 1000 watts P.E.P. power rating. **$69**

5 BAND REMOTE CONTROL MODEL 55B

Our most deluxe model for the band hopping operator. Control box under the dash permits instant band changing while driving. The new control unit in the 55B stops automatically at the selected switch position. Covers 10, 15, 20, 40, and 75 meters with the same patented electrical and mechanical design as the manual Model 45, but with motor drive and remote control. 1000 watts P.E.P. **$99**

EXTRA KWIK-ON CONNECTORS for quick removal of Model 45 or 55 .... **$ 6**
Deluxe Bumper mount **$24**

Write for your 1972 Swan catalog today.

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More Details? CHECK—OFF Page 110

More Details? CHECK—OFF Page 110

flea market

■ **RATES** Commercial Ads 25¢ per word; non-commercial ads 10¢ per word payable in advance. No cash discounts or agency commissions allowed.

■ **COPY** No special layout or arrangements available. Material should be typewritten or clearly printed and must include full name and address. We reserve the right to reject unsuitable copy. **Ham Radio** can not check out each advertiser and thus cannot be held responsible for claims made. Liability for correctness of material limited to corrected ad in next available issue. Deadline is 15th of second preceding month.

■ **SEND MATERIAL TO:** Flea Market, Ham Radio, Greenville, N. H. 03048.

VHF NOISE BLANKER — See Westcom ad in Dec. '70 and Mar. '71 Ham Radio.

AUTOMATIC MORSE CODE Copying Machine. Featured in Ham Radio Magazine November 1971. Copy up to 120 wpm without knowing Morse code. Simply hook to your receiver's audio and read printout. Send $14.95 for detailed construction plans. VMG Electronics, 2138H West Sunnyside Phoenix, Arizona 85029.

TELETYPE PICTURES FOR SALE. Vol. 1 $1.00. Vol. 2 $2.00. Vol. 3 $1.50. All for $4.00. Perforated tapes available. 200 different pictures. W9DGV-B, 2210-30th Street, Rock Island, Illinois 61201.

SAVE MONEY on parts and transmitting-receiving tubes. Foreign-Domestic. Send 25¢ for giant catalog. Refunded first order. United Radio Company, 56-HR Ferry Street, Newark, N.J. 07105.

RESISTOR KIT. Semi-Precision Deposited Carbon. Superior to composition types. ½ watt, 5% tolerance. Most will check within 2%. Highly stable. 5 each of 61 standard value between 10 ohms and 1 megohm. Total of 305. Ideal for Labs. $12.00 postpaid in U.S. W3TUD, 6854 Alcoma Drive, Pittsburgh, Pa. 15235.

SELL HAMMARLUND SP-600JX with crystal control unit, manual, outstanding condx $300.00. Looking for 51J4 or R290A. WA2WYQ, Stephen Elko, Box 91, Angola, Indiana 46703.

TELETYPE #28 LRXB4 reperforator-transmitter "as is" $100: checked out $175. Includes two 3-speed gearshifts. Alltronics-Howard Co., Box 19, Boston, Mass. 02101. 617-742-0048.

SURPLUS MILITARY RADIOS, Electronics, Radar Parts, tons of material for the ham, free catalogue available. Sabre Industries, 1370 Sargent Ave., Winnipeg 21, Manitoba, Canada.

TOROIDS! LOWEST PRICE ANYWHERE. 40/$10.00 POSTPAID (5/$2.00). Center tapped, 44 or 88mhy. 32KSR page printer, reconditioned, perfect $225. MITE UGC41KSR page printer, reconditioned, $250. Model 28 sprocket to friction kit, $25. Model 15KSR, $65. Matching RA87 P.S. unused, $5. Sync motors, $7. 14TD 60 speed, $25. 14DPE tape punch, $15. HP 200CD audio oscillator, $75. 11/16" reperforator tape, 40/$1.00. Model 33ASR complete, $650. Stamp for listing. Van W2DLT, 302H Passaic, Stirling, N. J. 07980.

WANTED R389, R390, R390A, R391, R220, Racal and 51S1 receivers. SWRC. P. O. Box 10048, Kansas City, Missouri 64111.

"DON AND BOB" New Guaranteed Goodies. Monarch KW SWR inline bridge 8.88 plus 1.50 postage/handling; Amphenol PL259, SO239 3.95/10; Ham-M rotor 99.00; TR44 59.95; PB KHP17D11, D13 24-48V 4PDT relay 1.95 ea; Westinghouse fullwave bridge 300A/200V 29.95; Raytheon 6LQ6/6JE6C 3.50; #14 antenna wire 1.95/C; Coax: RG6A/U 10¢/ft; RG22B/U 20¢/ft; RG63/U 10¢/ft; RG213 15¢/ft; quote new discontinued tubes; Industrial surplus list; quote Drake, Galaxy, Hy-Gain, Mosley, Tri-Ex, 2 meter transceivers. Tempo Kenwood dealer. Prices collect. Mastercharge, Bank-Americard. Warranty guaranteed. Madison Electronics, 1508 McKinney, Houston, Texas 77002. (713) 224-2668 .

QSL'S — BROWNIE W3CJI — 3111B Lehigh, Allentown, Pa. 18103. Samples 10¢. Cut catalogue 25¢.

CHRISTMAS IS COMING. Subscriptions to Ham Radio are the perfect gift idea. Be sure to see our special holiday offer.

WORLD QSL BUREAU — See ad page 108.

METERS AND T.E. REPAIRED or calibrated. Write Hortons Repair Center, 1132 Connway, Heath, Ohio 43055.

FOR SALE MINT NCL 2000 linear $325. FDFM-2 10w 2m FM transistorized 6 channel transceiver with mobile mount and AC power supply $185. W7YHS, 319 N. 26th St., Billings, MT 59101.

UHF FM RECEIVER; ARW-56 receiver, covers 404 to 550 MHz, with any 10 crystal-controlled channels. 28 vdc input, good condition with copy of manual and all schematics. $25.00 FOB, Richard Solomon, 19 Pierce Road, Watertown, Mass. 02172.

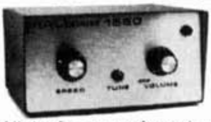
SAROC Seventh Anniversary January 6-9, 1972. Advance Registration $9.00 per person entitles registrant to SAROC Special room rate $12.00 per night plus room tax, single or double occupancy, effective January 4 thru 12, 1972; tickets for admission to technical seminars, **Ham Radio Magazine** and **SAROC** Happy Hour Thursday, **Swan Electronics** and **SAROC** Social Hour Friday, **Hy-Gain/Galaxy Electronics** and **SAROC** Champagne Party Saturday, Buffet Hunt Breakfast, Sunday. Ladies who register will receive transportation for shopping tour, luncheon and Crazy Hat program at the New Union Plaza Hotel downtown Las Vegas, Saturday. Advance Registration, with Flamingo Hotel mid-night show, two drinks, $14.50. Advance Registration, with Flamingo Hotel Dinner Show (entrees Brisket of Beef or Turkey) no drinks, $17.50. Tax and Gratuity included except for room. Frontier Airlines SAROC group flight package planned from Chicago, St. Louis, Omaha, Denver, send for details. Fifth National FM Conference, ARRL, WCARS-7255, WPSS-3952, MARS, meetings and technical sessions scheduled. Accommodations request to Flamingo Hotel, Las Vegas, Nevada before December 15th. Advance Registration to SAROC, Southern Nevada ARC, Inc., Box 73, Boulder City, Nevada 89005, before December 31st.

"NIXIE" TYPE READOUTS (w/internal point) $2.90, sockets 55¢; 7441A drivers $2.50; 7490 or 7493 counters $1.75; 7475 latches $1.50; most 7400 series gates 35¢. DIP/IC sockets 1.2¢/pin. Everything brand new. SASE full info. WA1HSJ, Box 1, Corinth, Vermont 05039.

I STILL HAVE more used radio and electronic books to sell. List for SASE. James Fred, Cutler, Indiana 46920.

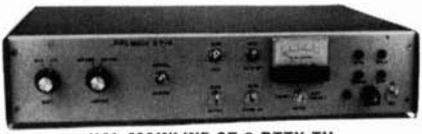
TELL YOUR FRIENDS about Ham Radio Magazine.

HAL DEVICES



HAL DEVICES MODEL 1550 ELECTRONIC KEYER

All the features of previous **HAL** keyers and more. TTL circuitry. Optional identifier for sending call letters. DX and RTTY ops, take notice. Transistor switching for grid block **AND** cathode keying. Rugged crackle cabinet with brushed aluminum panel. Designed for ease of operation. Model 1550 only $64.95. With ID $89.95.



HAL MAINLINE ST-6 RTTY TU

Complete parts kit for the W6FFC ST-6 now includes all parts except cabinet. Only 7 **HAL** circuit boards (drilled G10 glass) for all features. Plug-in IC sockets. Custom transformer by Thordarson for both supplies, 115/230V, 50-60Hz. $135.00 kit. Screened table or rack cabinet $26.00. Boards and manual $16.50. Shipping extra. Wired units available.

HAL TOUCHCODER II KIT $55.00

Complete parts kit, excluding keyboard, for the W4UX CW code-typer. All circuitry on one 3 x 6" G10 glass PC board. Plug-in IC sockets. Optional contest ID available, $35.00. Watch for announcement of the new **HAL** code-typers, both Morse and RTTY.

HAL ARRL FM TRANSMITTER KIT

Drilled, plated, glass epoxy **HAL** PC boards. 2N5913 final transistor. RF detector with 0-1 ma. meter added. All parts, and the RF detector and meter only $50.00 + shipping. Cabinet and crystals excluded. Board only $7.50.

OTHER HAL PRODUCTS

ID-1 REPEATER IDENTIFIER. . . . . $75.00 wired
W3EFG SSTV CONVERTER. . . . . 55.00 kit
DOUBLE BALANCED MODULATOR. . . . 6.50 kit
DIP IC BREADBOARD CARD. 5.50
MAINLINE ST-5 TU KIT. $50.00
MAINLINE AK-1 AFSK KIT. 27.50
HAL RT-1 TU/AFSK KIT. 51.50

HOT CARRIER DIODES: HP2800 90¢ 12/$10.00 — Matched by HAL 4/$4.25
ZENERS: 1N4729(3.6v) 1N4733(5.1v) 1N4735(6.2v) 1N4738(8.2v) 1N4739(9.1v) 1N4742(12v) 1 watt 75¢
LINEAR ICS: 709N 75¢ — 709L 710N $1.25 — 741N $1.50 — MC1429G $3.75 — MC1496G $3.25 — MC1590G $5.80
DIGITAL ICS: FML923 90¢ — MC723P 95¢
MRTL: MC788P $1.30 — MC880P $3.50 — MC890P $2.00 — MC724P MC725P MC789P MC792P $1.05 — MC767P $3.30 — MC771P $1.75 — MC970P $3.30 — MC9760P $5.45
DIP TTL: 7400 7401 7402 7410 7420 7430 7440 48¢ — 7404 7405 60¢ — 7441 7495 7496 $3.00 — 7442 $2.25 — 7472 75¢ — 7473 7474 $1.05 — 7475 $2.40 — 7486 $1.15 — 7490 7492 7493 $2.10 — 74121 $1.40
FETS: 40673 MOSFET $1.60 — MPF102 60¢ — 2N3819 55¢
Indiana General CF102-06, CF102-01, CF101-02 50¢
TOROIDS: CF102-Q3 $1.25 — FERROXCUBE FERRITE BEADS 10 $1.25
CINCH IC SOCKETS: 8 ICS 14 DIP 60¢ — 10 ICS 16 DIP 70¢

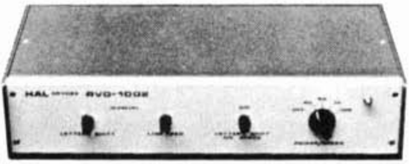
ORDERING INFORMATION

Catalog, including photos, of all items 24¢ postage. Please add 75¢ on parts orders, $2.00 on larger kits. Shipping via UPS when possible. Give a street address.

HAL DEVICES, Box 365H, Urbana, Il 61801
Phone 217-359-7373

HAL DEVICES

ANNOUNCING



The HAL DEVICES RVD-1002

A revolutionary approach to amateur radio teletype. The RVD-1002 provides:

- Display of 60, 66, 75, and 100 WPM 5 level TTY
- 1000 character display in 20 lines of 50 characters per line
- Selectable letters shift on space
- Manual control of line feed and letters shift.
- Standard CCIR video output for use with modified TV receiver
- Noiseless operation with solid state reliability

RVD-1002 (assembled). $495
RVD-1002 R (rack mount). $495
ST-6 (assembled). $280
ST-6/AK-1 (assembled). $320
TTY KEYBOARD. . . . . available soon

Modified solid state TV receivers will be available. Write for details.

HAL DEVICES, Box 365H, Urbana, Il 61801
Phone 217-359-7373

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See you at SAROC, Las Vegas, January 6-9, 1972.

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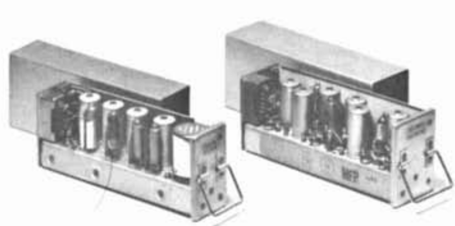

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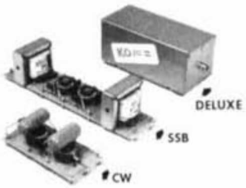

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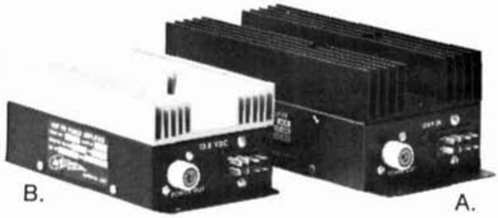
THE ALL NEW, TOTALLY UNIQUE, TEMPO CT 220 TR FM/AM TRANSCEIVER

Don't let its small size fool you (it's only 7" wide). This little giant outperforms its big brothers. Look at these specifications... then look at the low price. Completely solid state. 220 to 225 MHz operation. Transmitter: Positions for 5 internal crystals (not supplied). 1 external crystal position and VFO input. Power Output: 4 watts FM, 1½ watts AM. FM internally adjustable to 15 kc. Power Requirements: 13.8 VDC XMT 1.2 amps FM, .5 amp AM, 25 ma Stby. Receiver: Tuning Meter for AM and FM. .6 micro-volt for 20 db quieting. Tunable or pre-set to five internally adjustable frequencies. FM is detected by limiter discriminator, 6 db at 15 kcs. 1 watt audio output — 5% distortion. Double conversion, 10.7 MHz and 455 KHz. ACCESSORIES AVAILABLE: AC Power Supply & Speaker. Internal amplifier to increase output to 20 W FM and 8 W AM. External VFO. External high power amplifiers for FM operation. (CT 220-40 or CT 220-80 suggested.)
Introductory price: $179.00



B. A.

TEMPO CT HIGH POWER VHF 2 METER AMPLIFIERS ... COMPACT AND HANDSOME

A. The CT 1002-2; Operates directly from a 12 VDC power source. Antenna switching is automatic when as little as 1.5 watts of RF drive is applied. The amplifier incorporates Balanced Emitter transistors and state of the art design practices, making it virtually immune to destruction due to high VSWR or misloading conditions. It may be used anywhere in the 2 meter band without the necessity of retuning. Only 9⅜" x 4" x 3", the CT 1002-2 can be installed almost anyplace. Since there are no switches or meters, it may be mounted under a seat, in the trunk or in a desk drawer. SPECIFICATION: Power output: 100W. Input voltage: 13.8VDC. Current required: 12-14 amps. Drive required: 10W. Price: $220.00

B. The CT 602-2: A superior quality 60 watt VHF FM 2 meter power amplifier measuring only 6½" x 3½" x 3". $145.00

TEMPO CT OFFERS THE MOST COMPLETE LINE OF AMPLIFIERS AVAILABLE TODAY

MODEL NUMBER	POWER INPUT	POWER OUTPUT min.	BAND	MODEL NUMBER	POWER INPUT	POWER OUTPUT min.	BAND
CT6-30	1 to 10 W	30 W	6 M	CT252-A2	1 W	25 W	2 M
CT6-60	1 to 10 W	60 W	6 M	CT352-2	8 W	30 W	2 M
CT6-100	1 to 10 W	100 W	6 M	CT220-40	4 W	40 W	220 MHz
CT1202-2	25 W	125 W	2 M	CT220-80	4 W	80 W	220 MHz
CT1002-2	5-10 W	95-100 W	2 M	CT445-1	100 mw to 300 mw	1 W	440 MHz
CT602-2	5-10 W	60 W	2 M	CT445-5	200 mw to 1 W	5 W	440 MHz
CT606-B2	1 W	60 W	2 M	CT445-15	1 to 5 W	15 W	440 MHz
CT452-2	5-10 W	45 W	2 M	CT445-30	1 to 10 W	30 W	440 MHz
CT452-B2	1 W	45 W	2 M	CT445-50	1 to 10 W	60 W	440 MHz

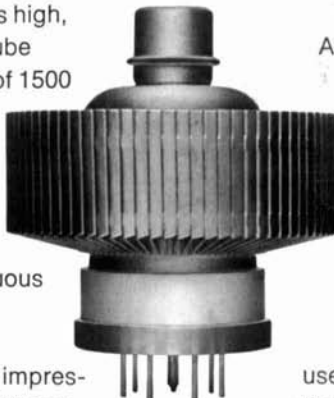
Available at select dealers throughout the U.S. See page two.

Henry Radio

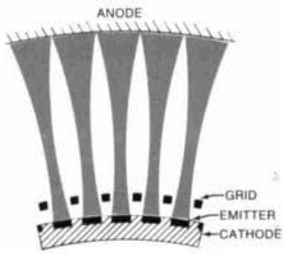
11240 W. Olympic Blvd., Los Angeles, Calif. 90064 213/477-6701
931 N. Euclid, Anaheim, Calif. 92801 714/772-9200
Butler, Missouri 64730 816/679-3127

EIMAC's new 8877 high-mu triode delivers over 1500 watts output at 220 MHz. (2000 watts output at 30 MHz is easy)

On your right is the new, rugged, ceramic/metal 8877 high-mu power triode by EIMAC. Another state-of-the-art tube. Only three and one-half inches high, this low-profile, heavy-duty tube has a plate dissipation rating of 1500 watts, a maximum plate voltage rating of 4000 and a maximum plate current rating of one ampere. In the HF region, typically, the 8877 coasts along at a continuous duty level of 3500 watts PEP input. A peak drive signal of only 65 watts is required. This impressive power gain is achieved with 3rd order intermodulation distortion products −38 decibels below one tone of a two equal-tone drive signal.



This magnificent power triode is rated at full input to 250 MHz. The low impedance grid structure is terminated in a contact ring about the base of the tube, permitting very effective intrastage isolation to be achieved up to the outer frequency limit of operation. The close tolerance grid, moreover, is composed of aligned, rectangular bars to achieve maximum grid dissipation and controlled transconductance. This aligned grid, plus the EIMAC segmented, self-focusing cathode provide low grid interception and the low grid drive requirement; both of paramount importance in the VHF region.



Parallel electron "guns" provide electron focusing, low intermodulation distortion, and low grid interception.

Although primarily designed for superlative linear amplifier service demanding low intermodulation distortion, the 8877's high efficiency permits effective operation as a class C power amplifier or oscillator, or as a plate modulated amplifier. The zero bias characteristic is useful for these services, as plate dissipation is held to a safe level if drive power fails, up to an anode potential of 3 kV.

The sophisticated circuit connoisseur will appreciate the many advantages of this newly developed power tube. Write for detailed information. And remember—the 8877 is another example of EIMAC's ability to provide tomorrow's power tube today. For additional information on this or other products, contact EIMAC, 301 Industrial Way, San Carlos, California 94070. Phone (415) 592-1221 (or call the nearest Varian/EIMAC Electron Tube and Device Group Sales Office.)

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division
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