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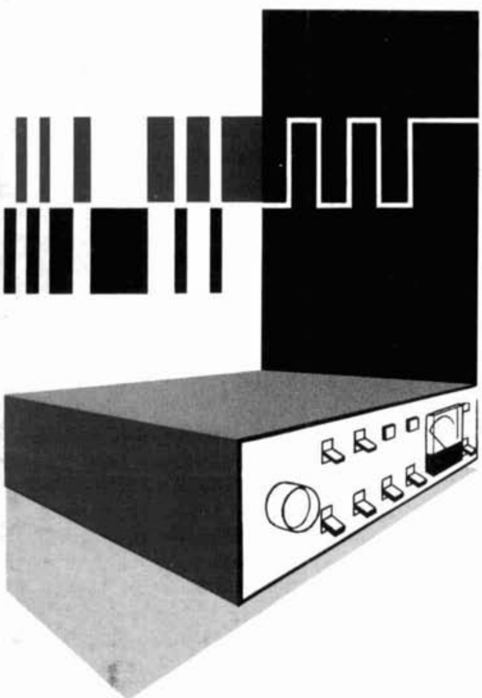
ham radio magazine

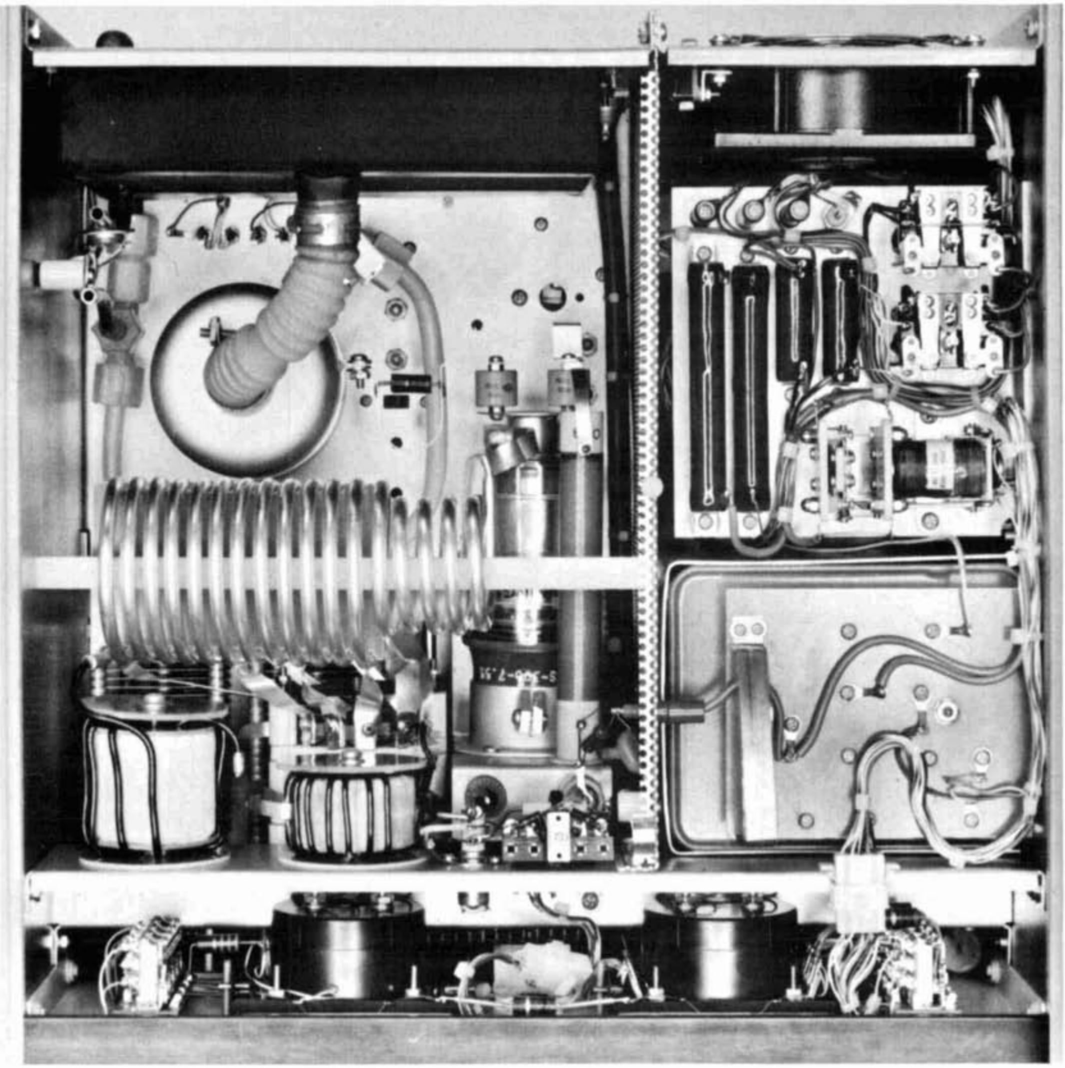
JANUARY 1971

THE MAINLINE ST-6 RTTY DEMODULATOR



this month

The *ALPHA SEVENTY*



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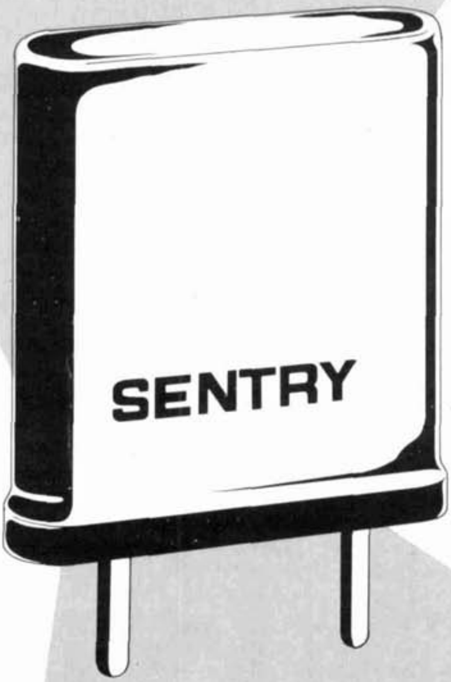

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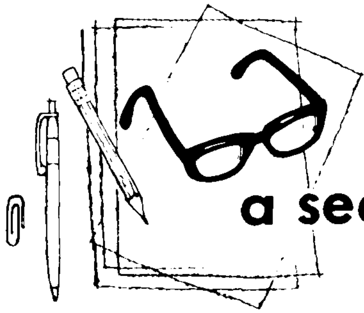
contents



a second look

by jim fisk

Although the number of manned Apollo missions to the moon has been drastically cut back by NASA, the amateur group working on Moonray still hopes to have their uhf lunar repeater carried to the moon on one of the remaining flights. The primary objective of Moonray, proposed in 1960 by W6OLO, is to provide a free-access uhf repeater for world-wide communication on the 432-MHz band.

The Moonray package will contain a sensitive low-noise receiver, tuned to 439.9 MHz, a signal processor, an identifier, six to eight channels of telemetry, and transmitter output on 430.1 MHz, as well as a laser receiver. Power will be provided by a nuclear thermoelectric generator with a half life of 87 years. The system is expected to be continuously operational for a year or longer on a 24-hour-per-day basis, with one-minute interruptions at the end of each 10-minute period.

The antenna, pointing system and thermal controls are all self contained in a louvered metal cylinder about 6 inches in diameter and 10 inches long. Three legs will be used for supporting the package on the lunar surface, as well as leveling; a special pointing mechanism is provided so the astronaut who sets up the unit will be able to accurately align the Moonray antenna to earth.

The 10-KHz passband on both the 430.1- and 439.9- MHz links will accept all modes of transmission, including cw, fsk, modulated cw, afsk, narrow-band fm, ssb and a-m (in that order of preference). Moonray's callsign will be the identifier SS, transmitted every ten minutes along with a telemetry sequence.

Amateurs who want to use the Moonray repeater should be equipped with a high-gain antenna (15-dB minimum gain) capable of tracking the moon, as well as a low-noise (3-dB maximum) crystal-controlled converter on 430.1 MHz, and a stable 439.9-MHz transmitter. For cw operation, transmitter power output should be approximately 50 watts. More power will be required for other modes, progressing from about 100 watts for fsk to 1000 watts for slow-scan television.

The design, development and test of an operational prototype is now in progress, and final construction of a flight model is planned for the near future. There are many ways you can help with this ambitious project including technical help to the group, providing publicity, promoting additional 432-MHz activity, or by making financial contributions to help obtain special items and defray postage and printing costs (contributions are fully tax deductible).

To obtain more technical information on Moonray, or to offer help, write to Nassau College Amateur Satellite Tracking, Astronomy and Radio, Post Office Box T, Syosset, New York 11791. Your help will be appreciated.

Jim Fisk, W1DTY
editor

Henry Radio's

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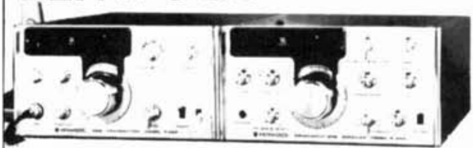

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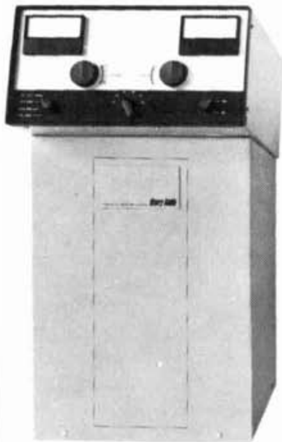

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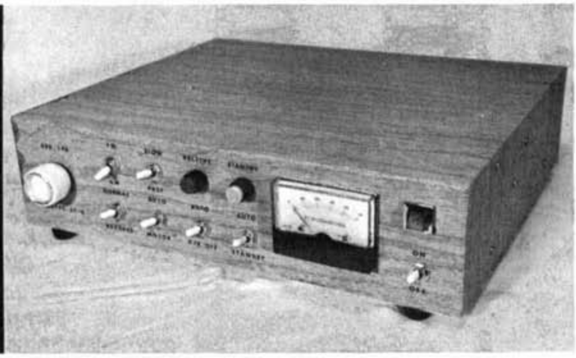


the Mainline ST-6 RTTY demodulator

Here's an ultra-modern RTTY tuning unit that features the latest in electronic circuitry and design

Irvin M. Hoff, W6FFC, Los Altos Hills, California 94022

An RTTY demodulator (often called a terminal unit, TU or converter) is used between the radio receiver and the Teletype machine to change the audio output of the receiver into on-off dc pulses to operate the printer.

Most RTTY demodulators work on the fm principle – they have a limiter followed by a discriminator that selects the mark or space tone, a detector to convert this audio into the dc keying rate, perhaps a low-pass filter to clean up the signal, a trigger stage that decides when mark has changed to space and vice versa, and finally, a keyer stage that drives the Teletype machine. Two power supplies are normally used, one to drive the demodulator and one to drive the Teletype machine, called the loop supply.

Some demodulators work on the a-m principle. This is often called two-tone, or limiterless operation. In this case, no limiter is used although some modest amplification might be incorporated. A threshold corrector is required to provide the proper symmetry to the slicer. This type of demodulator can copy mark-only or space-only type signals also. It works quite well in some circumstances, especially at full automatic machine speed, sometimes called "tape speed." To realize the advantages of a-m reception, high-performance channel filters should be used, but rarely are – a simple linear discriminator providing little advantage over fm in a majority of cases. If automatic printer control (auto-start) has been added, it must be disabled for a-m copy since the steady reference level used for the squelch system is no longer a stable voltage.

A good demodulator should have provisions for both fm and a-m operation, as the circuitry used for a-m is beneficial even when using normal fm reception.

the mainline rtty demodulators

The original Mainline RTTY converter was published in 1963.[1] The Mainline TT/L was introduced in late 1964[2] and had features that soon set the standard for serious RTTY enthusiasts. The Mainline TT/L-2[3] was an up-graded TT/L with a heftier power and loop supply, plus a few minor circuit improvements.

Rear-panel layout of the ST-6 RTTY demodulator.

Then I turned to solid-state – all units just mentioned used vacuum tubes. The first in the new series was the ST-1, using an RCA integrated circuit. It was never published, as the GE PA-238 operational amplifier became available about the same time. The ST-2 (autostart but no motor delay) and the ST-3 (autostart with motor delay) were published in 1968.[4] The ST-4 was the same as the ST-3, but designed exclusively for narrow-shift (170 Hz) reception for autostart. The ST-5[5] used two 709C operational amplifiers and was as simple a unit as a person could hope to get for normal reception of RTTY signals. The Mainline ST-6 presented here is an advanced solid-state demodulator offering all the practical advantages known to be beneficial for RTTY reception.

features of the ST-6

1. Optional bandpass input filters of 3-pole Butterworth design.

2. Use of seven 709C operational amplifiers; nine if both 170 and 850 shifts are added.

3. A limiter having over 90-dB gain.

4. Well-designed linear discriminators for various shifts.

5. Full-wave detection.

6. Active low-pass minimum bandwidth 3-pole Butterworth filter using two operational amplifiers.

7. Threshold corrector for a-m reception.

8. High-gain operational amplifier for a slicer that allows reception on shifts as low as 1 Hz.

9. 300-volt keying transistor stage for minimum distortion.

10. Floating-loop supply giving optimum plus-minus voltages for best FSK (transmitter) provisions.

11. Narrow-shift cw identification provisions.

12. Regulated plus-minus 12-volt supply.

13. *Anti-space* system that quickly puts the printer to mark-hold if the signal goes to steady space.

14. Automatic printer control (autostart) that ignores voice or cw signals but responds to RTTY, turning on the printer motor automatically.

15. Motor delay control to keep the motor from turning on and off excessively during weak signal reception or compulsory cw identification.

16. Optional a-m or fm reception.

17. Simplified switching for versatility.

18. Low-cost but effective tuning indicator.

19. Very simple alignment and adjustment procedures.

circuit description

The bandpass input filters These are 3-pole Butterworth design, based on modern filter synthesis networks. The one for 850 shift uses normal 88-mH toroids wired in series for 88 mH. It is about 1 kHz wide at the ±3 dB points. The filter for 170 shift uses 88-mH toroids wired in parallel for 22 mH. (The two outer wires together and the two pigtails together.) This keeps the impedance of the two units similar. The 170-shift input filter is about 275 Hz wide.

The limiter This is a 709C operational amplifier running "open loop" for maximum gain. It has been frequency compensated only lightly. For a-m reception the gain is reduced so that the unit becomes a linear amplifier at normal input levels, but reverts to a controlled limiter if the input exceeds the normal level.

The discriminator When using inductors of the same value for both mark and space, great attention must be given by the designer in order to achieve similar bandwidths, similar voltages, good zero-axis crossover, good noise balance, etc. It becomes even more difficult to design discriminators for both 170 and 850 which can be interchanged in the same overall circuit. Attention to these details has been given to all the Mainline demodulators and the ST-6 is based on the experience learned from the other units.

Front-panel layout of the ST-6 RTTY demodulator.

The detector Full-wave detection is used, a unique feature of the Mainline ST-series demodulators. This offers optimum detection for easiest filtering of the remaining ripple component. An additional "plus-plus" detector is incorporated for a tuning display and to drive the automatic printer control system.

The lowpass filter The optimum lowpass filter of minimum bandwidth will do more to improve the performance of a demodulator than any other single thing, assuming a high-voltage loop supply is already being used. Vic Poor[6] pointed out in his outstanding article on RTTY filters that this filter should cut off at

27.3 Hz for 60 speed (45.45) Baud operation, and set up the criteria for testing such filters. The active lowpass filter in the TT/L was built with these features in mind. **Fig. 1** shows the curve obtained with the ST-6. The observed "eye pattern" was ideal, indicating optimum cutoff for 60 wpm. The active filter is one that uses feedback circuits with amplification rather than passive components (inductors, etc.). This gives consistent uniformity from one unit to

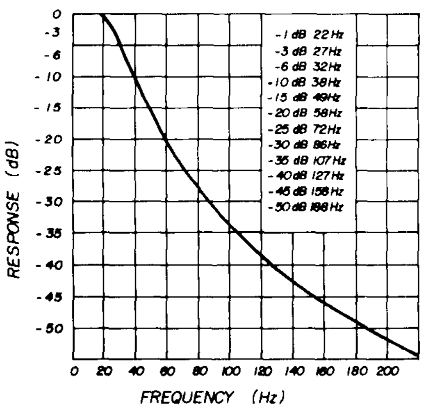


fig. 1. Bandpass curve for the low-pass active filter used in the ST-6.

another, small size, modern design, light weight, low-cost components and freedom from magnetic fields and hum.

The atc threshold corrector This section provides the automatic symmetry needed for the slicer to minimize distortion when using limiterless a-m reception. It also enables mark-only or space-only reception. It is beneficial even with the limiter in use as it offers a form of diversity reception, capitalizing on the redundancy of the mark and space signals. As a good minimum-bandwidth lowpass filter changes square-wave inputs to sine-wave outputs, such a threshold corrector is practically a requirement for proper zero-axis crossover at the slicer.

The slicer This is another 709C operational amplifier running in "open loop" for maximum gain. It is heavily frequency compensated since the signals handled are at nearly dc. The output of the lowpass filter is so clean and the gain of this stage so high that signals as low as 1 Hz shift will adequately swing the output from full mark to full space. No hysteresis was either necessary or desired.

The control section The output of the slicer is followed by a simple control section that allows a mark-hold voltage to be placed on the keyer stage when there is no authentic RTTY signal, putting it in mark-hold. This same control section allows simple use of the Sel-Cal[7] unit some enthusiasts have built for autostart purposes. It responds only to their own call letters. The control section is part of the manual standby system.

The loop supply This is a 180-volt supply that gives virtually distortion-free keying of the Teleprinter. A voltage-absorbing network is used on the collector of the keying transistor to protect it against excessive back-emf of the printer magnets which could otherwise occur if two or three printers were used on the same loop supply. The loop also puts out plus-minus voltages at the FSK output for best transmitter keying. It also adapts instantly (with no changes) to the Mainline AK-1 AFSK Keyer[8] for ssb units. It also offers narrow-shift cw identification.

Normal loop current is approximately 60 mA. This means the selector magnets of the printer and/or reperf should be in parallel. This keeps the inductance in the circuit at 25% the value it would be were the selector magnets in series. If a reperf and printer are to be in the same circuit at the same time, they would then go in series with each other, both having their own selector magnets in parallel. For solid-state keyers the lower the inductance the better due to "spikes" generated by the back-emf of the inductors in a collapsing field.

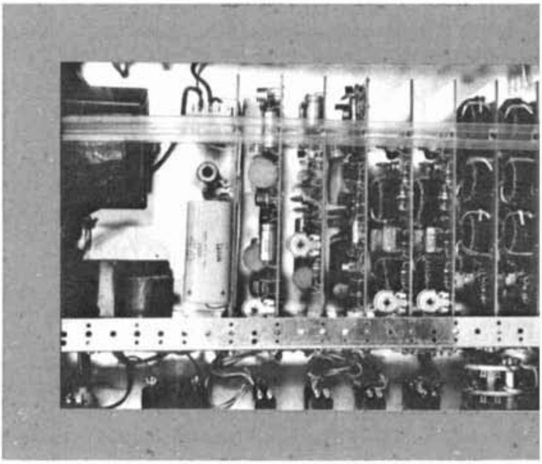
The power supply This plus-minus 12-volt supply is transistor and zener-regulated for good stability. It is heavily fused to prevent any damage during long periods of unattended operation and is bypassed for rf.

The anti-space circuit A "blank" key has the longest continuous amount of space time of any RTTY character, about 132 milli-seconds. Any space signal longer than this cannot be RTTY. The anti-space system samples the mark-space output of the slicer. If the signal goes to space more than 132 ms the system says "tilt" and locks the printer to mark-hold, at the same time turning the automatic printer control off and starting the countdown on motor delay cutoff. Thus, if a person is checking his shift at the other end, your printer does not sit there running "open." This also gives greatly improved protection from a non-RTTY signal in the space channel from activating the automatic printer control and turning the motor on. This system works just as effectively with the limiter on or off, with the autostart on or off and with straddle tuning of any shift. No provisions for disabling it were provided. If this were needed, a switch to short the base of Q7 to ground would be suitable.

Tuning meter Although labeled as optional this is a most worthwhile device. Many amateurs prefer a scope for tuning, but this type of meter gives satisfactory results. It is better than most scope displays for straddle tuning where the incoming signal is not very accurately adjusted for correct shift, i.e. the operator might be using 600 shift, thinking it was in reality 850. The tuning meter is also helpful in adjusting the ST-6, although any voltmeter can be used for alignment.

Automatic printer control This system is normally called autostart. It is a unique squelch system that responds only to authentic RTTY, or to a steady mark carrier. A steady space carrier will not affect it due to the anti-space system. It samples both the mark and space channels for a signal having a duty time in excess of about 75%. Since most cw has a duty time of less than 50%, and most voice signals a duty time of perhaps under 30%, this system responds almost exclusively to RTTY signals.

To get the 75% duty time requirement an analog charging circuit is used. Since this is based on fm squelch principles, the use of limiterless a-m is not compatible with this system and is disabled if the limiter is turned off. Since momentary static crashes, deep fades and other temporary interference could cause the system to decide there was no longer any RTTY present, a one-second delay is incorporated into the shut-off feature. This in turn requires about a 3 to 4 second turn-on delay to obtain 75% recognition. Other ratios are shown in **table 1** for those who may wish to experiment.



Internal construction of the ST-6 built by the author. A total of eight printed-circuit boards are used.

The higher ratios (like 8:1) will only respond to the very best RTTY signals and will not try to copy those signals that would normally produce garble, but would lock up if the signal deteriorated momentarily. Perhaps their biggest disadvantage is the long turn-on time: 6 to 7 seconds. This is the equivalent of about a half-line of RTTY.

The system used for automatic printer

table 1. Autostart ratios which may be used for protection from printing garble from marginal signals.

ratio	duty time	R61	R59	R60	time to on	time to off
2:1	67%	5.1k	390	4.7k	1.80	.88
3:1	75%	3.6k	2.4k	4.7k	2.48	.84
3.3:1	77%	3.6k	2.7k	5.1k	2.74	.86
4:1	80%	3.3k	3.9k	6.8k	3.53	.87
5:1	83%	3.0k	5.1k	6.8k	4.16	.84
6:1	86%	3.0k	6.8k	8.2k	5.25	.88
7:1	88%	3.0k	9.1k	9.1k	6.38	.90
8:1	89%	3.0k	10k	11k	7.35	.93

control in the Mainline series is unique in that it requires no special call-up or turn-off characters. As a result, it is extremely useful for normal RTTY QSOs where autostart itself would not be considered by the operator. In this case automatic printer control is a more vivid and realistic description of the system than autostart.

Motor delay This feature allows the automatic printer control to place the printer in mark-hold without turning the motor off. During poor conditions, it is a nuisance to have the motor turning on and off. During fast break operation the motor could turn off if it took more than approximately one second for the other station to respond. Also, the FCC requires cw indentification between transmissions, and this would normally cause the motor to turn off if no delay system were used. The motor delay in the ST-6 keeps the motor running for 20 to 30 seconds after the autostart system thinks there is no further RTTY present.

Loop supply cutoff A feature is incorporated in the ST-6 that opens the loop supply to space whenever the motor relay turns the motor off. Otherwise there is some 10 watts of heat in the cabinet from the 2750-ohm, 20-watt loop-current regulating resistor. This is not detrimental, but serves no useful purpose, and consumes an additional 10 watts of unnecessary power when the printer is not running.

Fuses The ST-6 probably has more fuses in it than any other item in your entire station. They aren't all *necessary,* but for unattended operation good fusing is worthwhile. Receivers, transmitters and other electronic items have been known to develop partial shorts in the high-voltage secondary systems, destroy components which may occasionally catch on fire, ruin transformers and *still not blow the fuse* in the primary! This is often because the secondary has several windings. By merely fusing the primary, it is hard to select a fuse that will quickly blow if the secondary pulls excessive current in *one* of the windings.

Thus the ST-6 fuses each secondary winding as well as the combined primaries. The jack for the motor is not fused (and should not go through the on-off switch) since the printers have their own protective fuses. The relay handles the motor current.

On the printed-circuit boards from Halle,* the indicator lamps also run through the fuses. In the event you add those lamps, you may find it necessary to increase the size of the fuses somewhat.

Rf protection The operational amplifiers have such fantastic gain that precautions should be taken to prevent amplification of nearby rf signals, because their usefulness is destroyed while that rf is present. The ST-6 bypasses the 120 Vac input line, the power supply output, and isolates the plus-minus voltages to each op amp to prevent any instability or oscillation. Thus, no adverse affects have been noted from nearby kilowatt transmitters.

Scope connections Provisions have been included for connecting an oscilloscope. the 1 megohm isolating resistors provide adequate protection against the low-impedance scope inputs from affecting discriminator balance. If you incorporate a scope it should be an external unit that plugs into the rear of the ST-6. This allows the scope to be used for other demodulators, to be larger than the 1" or 2" display the ST-6 cabinet might allow, and allows the operator to run the ST-6 twenty-four hours a day for autostart.

the switches

S1 is a dual-purpose switch to change the unit from fm to a-m reception. When in a-m limiterless, it also disables the autostart system, putting the motor automatically to *on.*

S2 is the normal-reverse switch. It is not necessary, but there are rare occasions when a newcomer is "upside-down" and you may want to see who it is. Many people will leave this switch completely off their unit.

S3 is the local standby switch. This places the printer in mark-hold and disables the autostart (turns the motor on and keeps it on). There is also a jack for an external remote standby switch. **Fig. 2** shows how this can be used. Switches S10 and S11 would be placed at or on the printer itself; S10 as a standby switch and S11 as the transmit control switch. This not only automatically turns the transmitter on, it mutes the ST-6 so incoming signals for the tuning meter or scope do not affect the transmitted signal – without this provision acoustical feedback could cause incorrect signals to be transmitted. By placing these two switches next to the printer single-switch station control may be used, and the ST-6 can be across the room out of arm's reach. This offers maximum versatility plus simple fast-break operation.

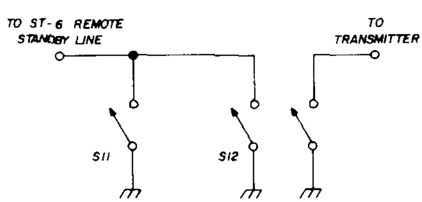


fig. 2. Station switching. S11 and S12 normally located near printer. Standby switch S11 keeps machine from printing; station control switch S12 puts the transmitter on the air and mutes the ST-6 for local copy.

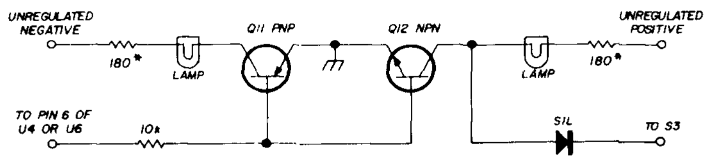
S4 is the fast-slow autostart; it also turns the motor on when in *fast* and keeps it on. The *fast* system uses the same ratio of turn-on to turn-off times, but speeds them both up. This makes it convenient to use automatic printer control for fast break, but gives inadequate protection against momentary signal loss during unattended operation.

S5 merely turns the automatic printer control off, allowing manual operation via the standby switch S3 or S10. (S10 is not shown on the schematic, it is shown on **fig. 2.**)

S6 is the manual motor *on* switch. It keeps the motor running regardless of any other switch position except the power off switch, S7.

S7 turns the 120 Vac power on and off, and opens the FSK line when in off, to prevent any hum loops from the FSK keyer in the transmitter. This could be annoying when using voice or normal cw if the ST-6 were in the off position. This is normally no problem, but the switch is

fig. 3. Simple lamp circuit to indicate standby and receive. Resistors marked with asterisk are selected for normal lamp current.



available for this purpose if you want to use it.

standby-receive lamps

Fig. 3. shows how lamps may be added to indicate standby and receive. When the manual or remote standby switch is activated the standby lamp turns on, whether the receive lamp is on or not. The receive lamp works only from the output of the automatic printer control system.

Thus it is possible to have both lamps on at the same time. This tells the operator he has selected manual standby. As a result he is informed that he is not in automatic reception mode at all, and before leaving the room he must turn off the standby switch (S3 or S10) if he expects to get automatic copy. It makes an excellent fail-safe reminder.

If you prefer an indicator for mark and space signals, attach the 10k resistor in **fig. 3** to pin 6 of U4. In this case the diode on the collector of Q12 is removed.

850-170 switch

If incorporating both 850 and 170 shifts, duplicate the front end up to but not including the first 16k resistor on U3. Then a multipole two-position switch would be used to switch the audio input, the output of the two U2 stages, the output of the U1 limiter for the limiterless a-m mode, and the two 47k resistors on the inputs to the U1 stages. The scope display for mark and space probably should be switched as well as the output to the meter and autostart at point 2. Other poles can be used to ground the audio input of the unused limiter off. I used a two-section (6 poles per section) two-position ceramic switch.

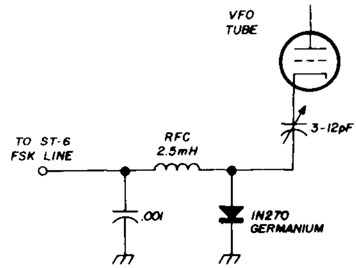


fig. 4. Circuit for adding frequency-shift keying to your transmitter. If your signal is "upside down," turn the diode around.

construction

The unit shown in the pictures uses printed-circuit boards. There are six different boards. For both 170 and 850 shift the first two are duplicated, making a total of eight.* The boards are laid out by function as follows:

1. Bandpass input and limiter U1.
2. Discriminator and U2.
3. Lowpass filter, slicer, keyer and anti-space.
4. Autostart, standby, meter, delay system.
5. ±12V volt regulated power supply, lamp drivers, meter driver Q10.
6. Loop supply (and room for motor relay).

Room for all parts is included on the boards except for the control switches, meter and the two transformers. The boards are approximately 2¾ inches high by about 6 inches long and plug into 12-pin connectors such as the Amphenol 143-012-01. This is not only neat appearing, it allows the boards to be removed easily for other shifts or to try various

*Printed-circuit boards and complete parts kits for the ST-6 are available from several sources, including Hal Devices, Post Office Box 365, Urbana, Illinois 61801. This firm offers various options and has a brochure available on request. The printed-circuit boards are designed for the 14-pin dual-inline op amps. Hal Devices also have a unique power transformer available that has windings for both the loop voltages *and* plus and minus dc supplies.
For Canadian builders, arrangements have been made with Space Circuits Ltd. to provide printed-circuit boards for Canadian amateurs. Write to Hugh Watt, VE3HY, President, Space Circuits Ltd., 156 Roger Street, Waterloo, Ontario, Canada.

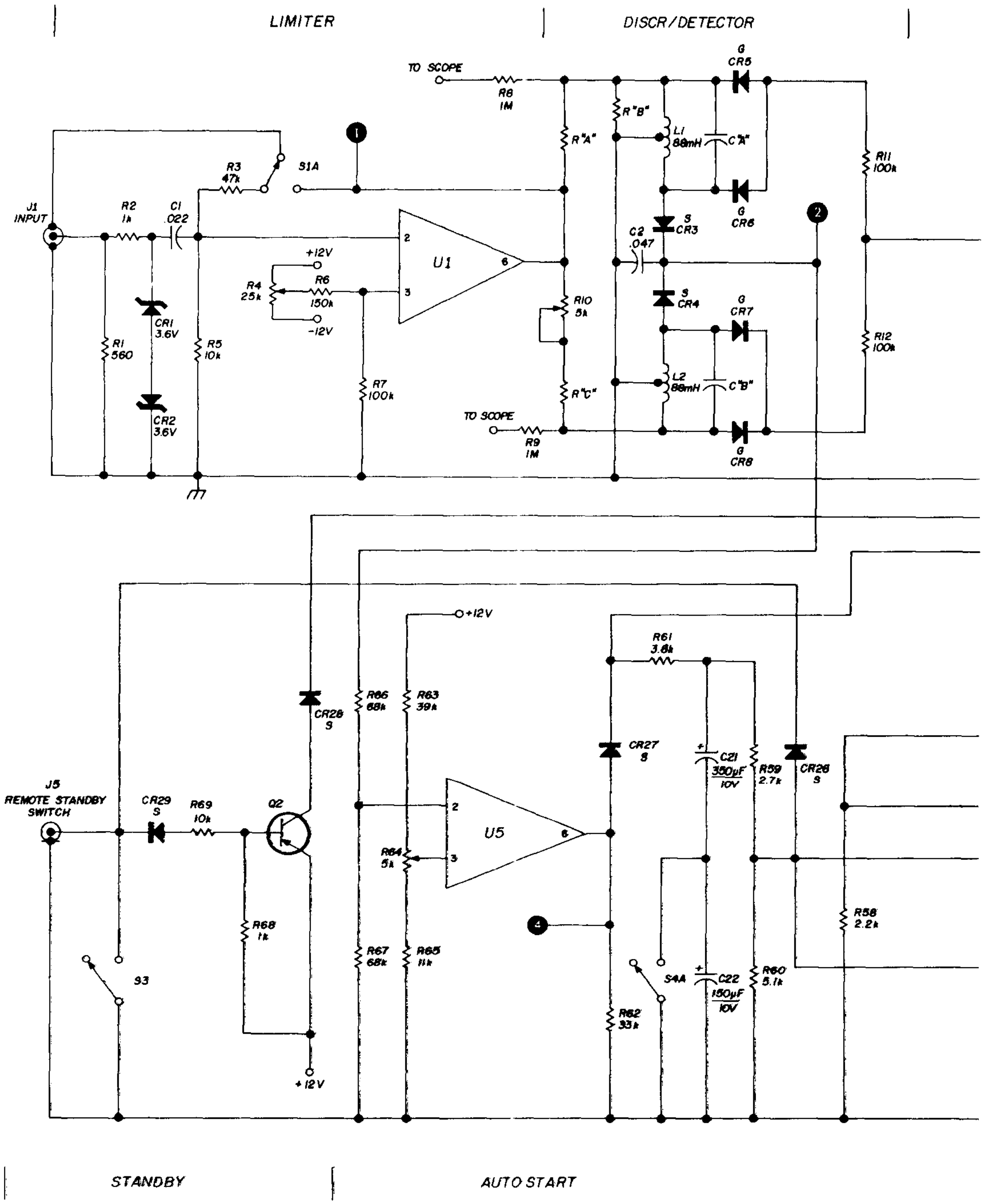
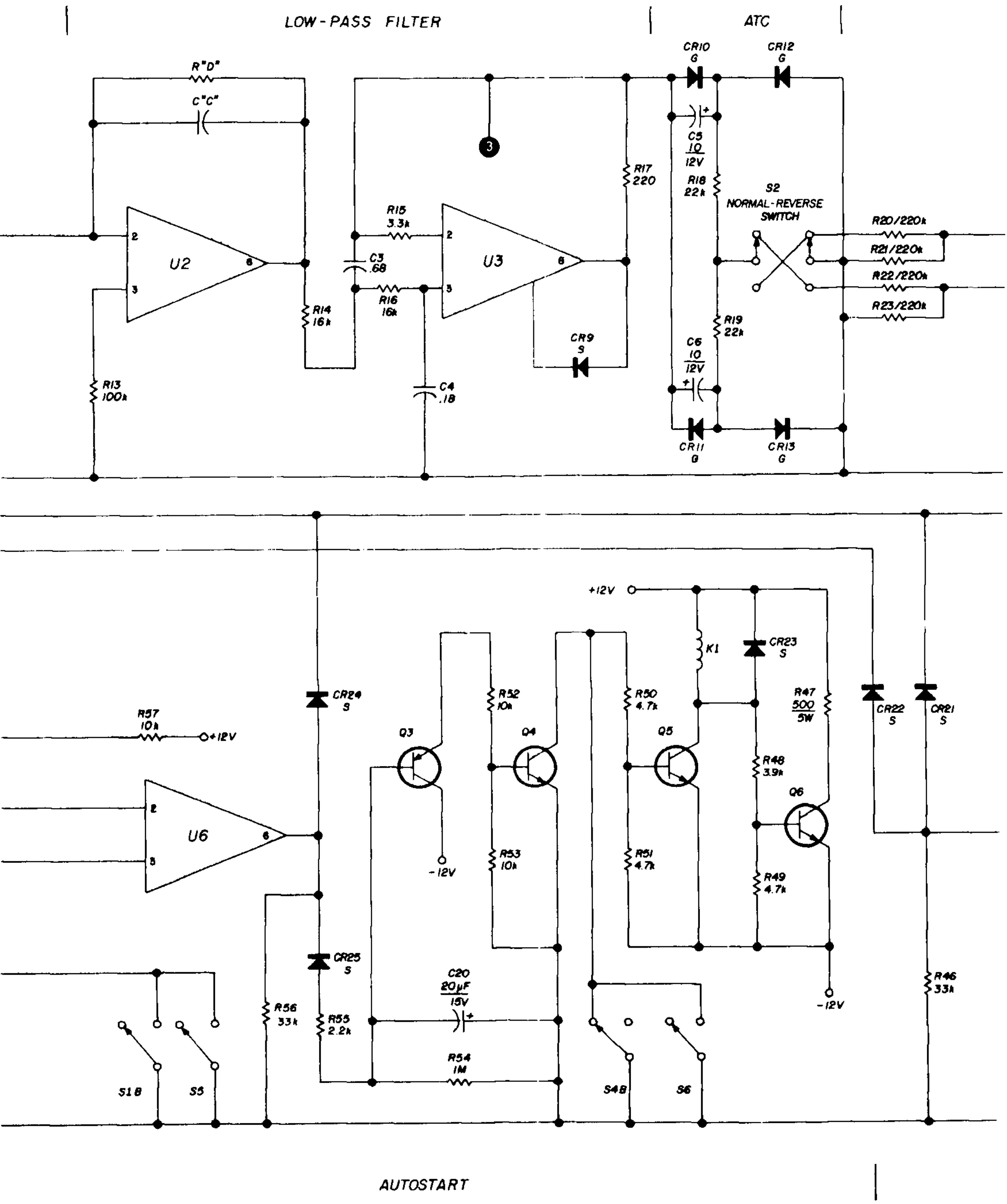
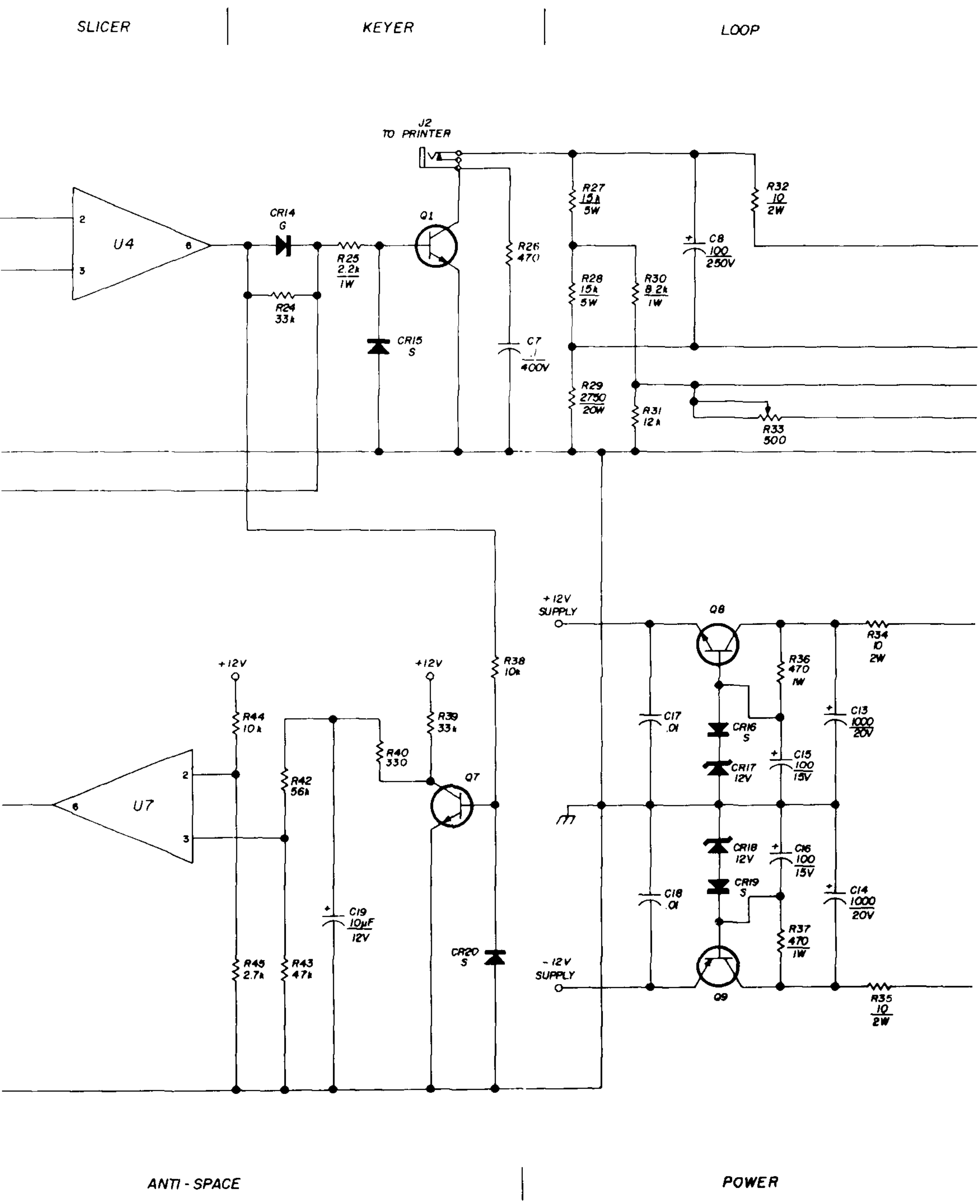
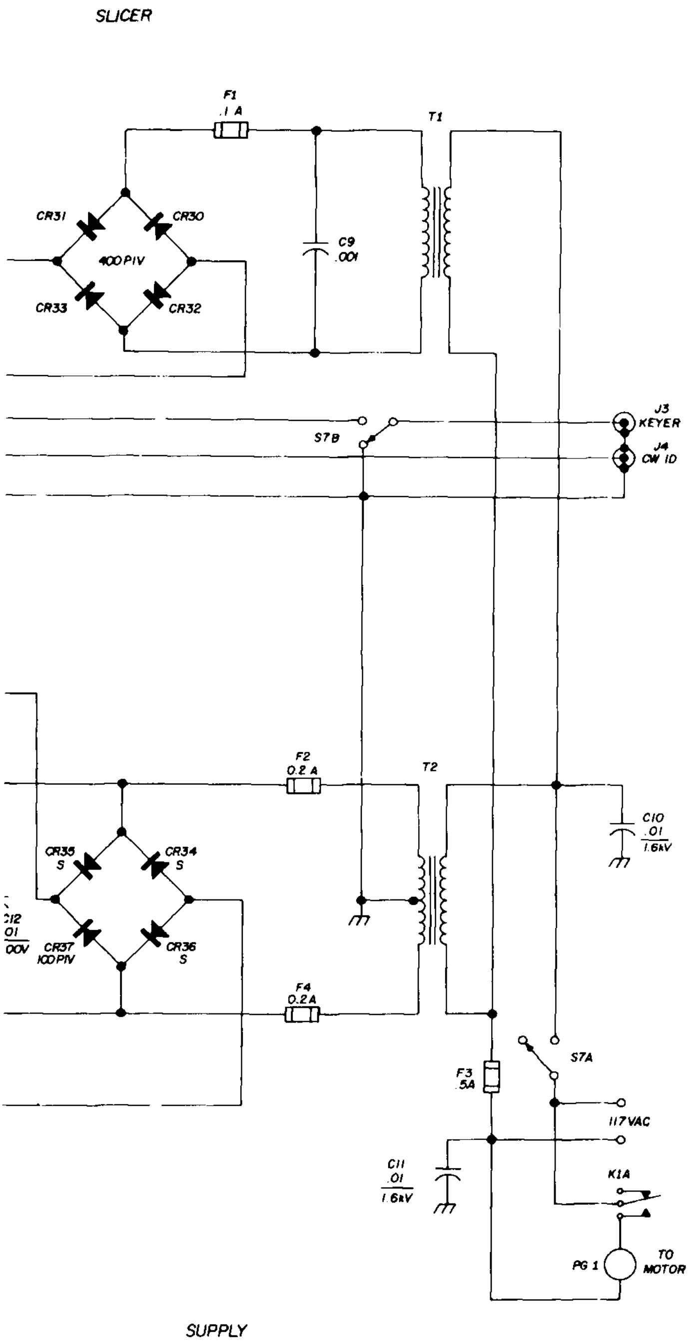


fig. 5. Schematic diagram for the Mainline ST-6 RTTY terminal unit. Contacts on relay K1B open the loop when the motor is off.


LOW-PASS FILTER
ATC
R"D"
C"C"
U2
U3
R14 16k
R13 100k
R15 3.3k
R16 16k
C3 .68
C4 .18
R17 220
CR9 S
CR10 G
CR12 G
CR11 G
CR13 G
C5 10 12V
C6 10 12V
R18 22k
R19 22k
S2 NORMAL-REVERSE SWITCH
R20/220k
R21/220k
R22/220k
R23/220k
+12V
K1
CR23 S
R47 500 5W
CR22 S
CR21 S
CR24 S
R57 10k
+12V
Q3
Q4
Q5
Q6
R52 10k
R53 10k
R50 4.7k
R51 4.7k
R48 3.9k
R49 4.7k
-12V
-12V
U6
CR25 S
R56 33k
R55 2.2k
C20 20µF 15V
R54 1M
R46 33k
S1B
S5
S4B
S6
AUTOSTART



SLICER
KEYER
LOOP
J2
TO PRINTER
CR14
G
U4
R25
2.2k
1W
R24
33k
Q1
CR15
S
R26
470
C7
.1
400V
R27
15k
5W
R28
15k
5W
R29
2750
20W
R30
8.2k
1W
R31
12k
C8
100
250V
R32
10
2W
R33
500
+12V
SUPPLY
-12V
SUPPLY
Q8
Q9
R34
10
2W
R35
10
2W
R36
470
1W
R37
470
1W
C13
1000
20V
C14
1000
20V
C15
100
15V
C16
100
15V
C17
.01
C18
.01
CR16
S
CR17
12V
CR18
12V
CR19
S
U7
R44
10k
R45
2.7k
R42
56k
R43
47k
C19
10µF
12V
R40
330
R39
33k
Q7
R38
10k
CR20
S
ANTI-SPACE
POWER



S1 limiter on-off, also disables autostart

S2 normal-reverse switch, keep wiring short

S3 standby, also turns motor on

S4 fast-slow autostart, fast keeps motor on

S5 autostart off, keeps motor on

S6 manual motor on

S7 power on-off, also ground fsk line when off

T1 isolation transformer, 115 Vac, 0.3 A (Triad N-51X)

T2 filament transformer, 28.6 Vac, 1 A (Triad F-40X)

Diodes marked "G" are 1N270 germanium.

Diodes marked "S" are silicon, 50 piv unless otherwise noted

discriminator values

	170 2125/2295	850 2125/2975
R'A'	6800	4700
R'B'	100k	33k
R'C'	6800	6800
R'D'	270k	180k
C'A'	.068	.068
C'B'	.056	.033
C'C'	.02	.03

Large schematics are available directly from the author for easy-to-follow construction. $1 in USA or Canada, $2 US for airmail elsewhere.

circuit changes the operator may wish to *experiment with.*

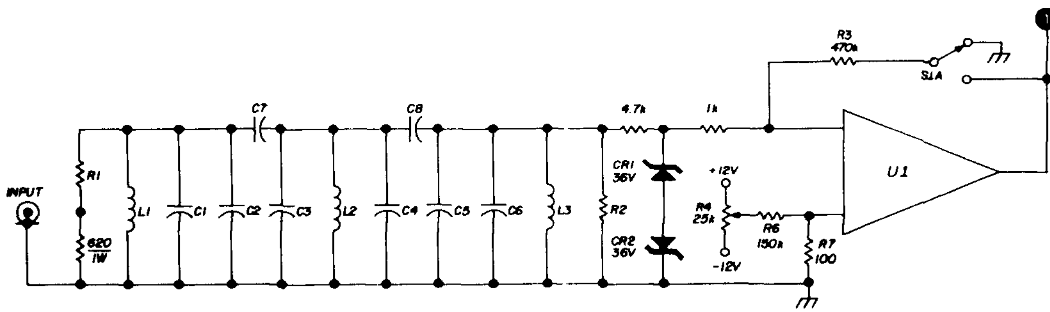
The unit shown in the photos was built into a 10 x 12 x 3 inch chassis, and covered with shelf paper from the local dime store. This makes an attractive way to cover the aluminum chassis and provides an excellent base for rub-on labels.

No shielded lines were used except to the external scope jack. The normal-reverse switch should be as close as possible to board 3 to keep the leads short. The *connectors and switches were all wired* before placing them in the chassis.

are S1, S4, the receive lamp, the standby *lamp, the tuning meter and the power-on* indicator. The latter is superfluous if you have either the meter or the indicator lamps. On the bottom row are S2, S6, S5 and S3, and in the bottom right-hand corner, S7.

On the rear from left-to-right are the remote standby jack, remote scope jack (2-way type), audio input (600 ohms), printer motor, FSK output, fuse, and 120 Vac input.

No cw identification jack was provided as I normally hook that into the fsk line



shift	C1	C2	C3	C4	C5	C6	C7	C8	L1,2,3	R1	R2	tuning frequencies sec1	sec2	sec3
170	.15	.056	.18	—	.15	.056	.022	.022	22 mH	1600	2200	2195	2195	2195
859	.015	.018	.015	.01	.015	.018	.015	.015	88 mH	2700	3300	2400	2300	2400

fig. 6. Optional bandpass input filter.

Adequate spacing is 1″ between boards, with board 6 (loop supply) facing the open air with its 2750 ohm, 20 W resistor. This board would be somewhat more than 1″ wide when all the parts are mounted.

The printed-circuit boards sold by Halle have transistor connections for Motorola transistors. The Q1, Q8 and Q9 transistors have connections that differ from the others. If you use RCA or GE transistors, be careful to install them properly. About 0.4 watt will be dissipated through Q8 and Q9.

panel layouts

In case you cannot read the printing on the photos, the 170-850 switch is at the far left. Next to it on the upper level

externally, but another jack could be provided as suggested in the schematic.

tuneup

The ST-6 is very simple to align, and once done, should not require any further attention. No pots are located on the front or rear panels. Complete alignment is as follows:

1. Unhook the audio input. Place a dc voltmeter at test point 1 on pin 6 of U1. Adjust the 25k pot on pin 3 of U1 so the meter reads zero. This is a very touchy adjustment due to the high gain of the 709C op amp, so get it as close to zero as is convenient and leave it – this adjusts the offset input balance which allows the op amp to run at its maximum gain level.

2. Either move the dc meter to test point 2 on the discriminator or observe the tuning meter on the front panel. Connect audio to the ST-6 and tune between mark and space signals, adjusting the 5k pot on pin 6 of U1 for equal readings on the meter. This balances the discriminator.

3. If using the tuning meter, with maximum mark indication, adjust the meter sensitivity pot on the emitter of Q10 so the meter reads 70% full scale. Hopefully it will have markings each 0.1 of full scale. Now detune the input frequency to the point where the meter reads 60% of full scale. Place the voltmeter on test point 4 on pin 6 of U5. Adjust the 5k pot on pin 3 of U5 so the voltmeter cannot decide to stay positive or go negative. This sets the autostart sensitivity to approximately ±3 dB bandwidth – about ±45 Hz for 170 shift and about ±100 Hz for 850 shift. If both discriminator boards have been included, set this adjustment in the 170 shift position and take what you get for 850 (850 is much less critical than 170 shift).

If a tuning meter was not incorporated on the front panel, use a voltmeter at test point 2. Tune for maximum mark and note the meter reading. Multiply this by 85%, and retune the input frequency for this new meter reading. Then proceed to adjust the pot on U5 so the voltage at test point 4 cannot decide if it should stay positive or go negative.

tuning the filters

Access to a digital counter makes this job very simple. The Mainline TT/O semi-counter[9] also makes the job very easy. That unit is low cost and hooks to an existing oscilloscope but is quite accurate when compared to anything but a true digital counter. The values of the capacitors in parallel with the toroids in the bandpass input filters and discriminators are only approximate. With toroids that can vary 2 to 3% and capacitors that are ±10%, you can miss the desired frequency by as much as 150 Hz.

When tuning the bandpass input filters, a review of my filter article might be of interest.[10] Basically the procedure is as follows:

1. Disconnect the input and output lines.
2. Disconnect the resistors at input and output of the filter.
3. Short out the center toroid with a piece of wire.
4. Tune the first section.
5. Tune the third section.
6. Remove the shorting wire from the center section and short the first and third toroids to ground.
7. Tune the center section.
8. Remove all shorts.
9. Connect the resistors.
10. Connect the input and output lines.

Room has been provided on the circuit boards for as many as three tuning capacitors for each toroid. This should allow easy, precise tuning without adding or removing turns of wire from the toroid.

The coupling capacitors on the bandpass input filters (C7 and C8) should not be changed from those indicated.

A good method for final checking of discriminator tuning is to put a meter at test point 2 and tune for maximum. Then tune off on the high side to a slightly lower meter reading, note that frequency; tune for the same reading on the other side of center and note that frequency. Average the two to get the best center frequency and change as needed to get the frequency you want.

low tones

This is a subject that is difficult to discuss as part of a demodulator article. Mark tone is customarily 2125; space tone is customarily 2295 for 170 shift or 2975 for 850 shift. Years ago, when these tones were selected good mathematical reasons were used. They are an excellent compromise between channel separation for harmonic suppression and adaptability to communications receivers.

table 2. Components for low-tone discriminators.

		170 1275/1445	850 1275/2125
R'A'	(R1)	2.7k	1.5k
R'B'	(R2)	27k	8.2k
R'C'	(R3)	2.7k	2.2k
R'D'	(R4)	240k	160k
C'A'	(C1)	.18 μF	.18 μF
C'B'	(C2)	.12 + .018 μF	.068 μF
C'C'	(C3)	.022 μF	.033 μF

Many ssb receivers use 2100 Hz audio filters in the i-f and are limited to the range of 300-2400 Hz. Thus, many operators complain that they cannot receive the 2975 tone and assume there must be more appropriate audio tones. Many operators feel that 1275 and 2125 would be suitable. These tones *can* be used and for several years I used them on my 75S-1 receiver and Electrocom demodulator.

However, they are not recommended, particularly if a linear discriminator is used in the demodulator to separate mark and space tones after the limiter.

It is very simple with most receivers to change the bfo frequency with a new crystal so that an audio range of 1400-3500 Hz is obtained instead of 300-2400 Hz. The Collins S-line, the Heathkit SB-line and many others require only a new bfo crystal about 1 kHz lower than that normally used for ssb reception.

The Collins 75A4 and most Drake receivers have passband tuning which automatically allows reception of tones in excess of 3 kHz.

Component values for discriminators for 1275-1445 shift and 1275-2125 shift are shown in **table 2** for those who wouldn't build the ST-6 otherwise. No bandpass input filters have been designed for these shifts nor are any contemplated.

relay circuit

Just a word about an unusual feature – Q6 has a 500-ohm resistor in its collector circuit. Q6's only purpose is to afford a similar current drain on the power supply when the relay is not being used, hence voltage regulation is materially aided. This can be omitted if you are not a purist.

The 47k resistor on U1 was picked for limiterless operation, *without* the bandpass input filter. If using the filter, you will want to change this resistor to a 470k (or whatever value gives adequate meter indication) when running limiterless and using normal audio level on the receiver.

controlled limiting

In limiterless operation if the audio input is more than is needed to reach

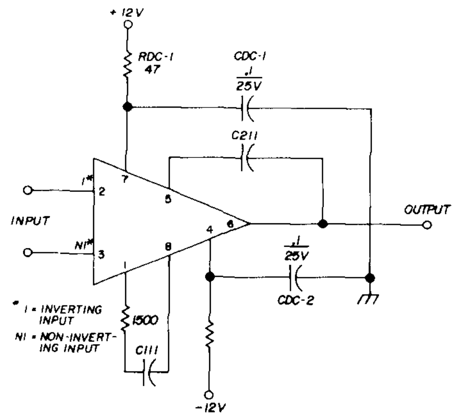


fig. 7. All operational amplifiers used in the ST-6 must be compensated and decoupled as shown here. For U1, C111 is 47 pF and C211 is 3 pF. For integrated circuits U2 through U7, C111 is .005 μF and C211 is 200 pF.

normal meter reading, then the unit goes into modest limiting, sometimes called controlled limiting. This is no longer linear a-m, nor is it hard limiting for fm, but somewhere in between. Some people feel this gives excellent results, but of course you need sharper filters than a linear discriminator offers to take full advantage of any limiterless mode.

cost

The approximate cost using all new parts is $100 for one shift, using vector boards and no PC boards. With both 170 and 850 shift, using the drilled PC boards with connectors, the new-item cost should be around $150.

parts suggestions

Meters may be obtained for as low as

$2.98 from Radio Shack. That is the meter shown on the ST-5. It did a nice job. The one shown on the ST-6 is an imported *Micronta* movement.

The op amps are the 709C types, and Motorola, Fairchild, Texas Instruments, National Semiconductor, and Signetics all make them. The PC boards were made for the round TO-5 type that has eight leads. Prices are dropping constantly. They were $12 each when I first started using them, but at the time this article is being written they are $1 each in small quantities.

The pots used for the PC boards are the 39¢ Mallory MTC-L1 type for vertical

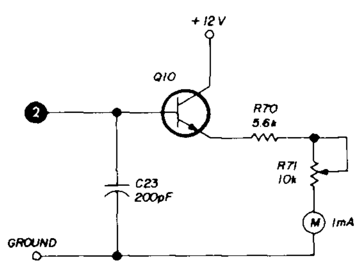


fig. 8. Optional tuning meter for the ST-6.

mounting. IRC type X-201 at 39¢ are similar.

Any 24 Vdc dpdt relay should be adequate. The resistor on the collector of Q6 would be chosen to have the same value as the dc resistance of the relay, such as the Potter and Brumfield KA11DG at $3.90.

The small 0.1 μF 25V capacitors used on each op amp can be the 21¢ Sprague HY-550. Both Centralab and Sprague make 1.6 kV ceramic capacitors used for bypassing the 120 Vac line. The other small value capacitors can be Sprague *Orange Drop* Mylar types, 75 V where obtainable, to keep the size small. Typical price 18¢. The 10-, 20-, 150-, and 350-μF capacitors can be Sprague type 30D. The large 100- and 1000-μF types can be Sprague TVA.

Diodes marked *G* are 1N270 germanium; those marked *S* are silicon with 50 volts PIV except in the loop supply where 400 PIV minimum are needed. The zener diodes can be 400 mW or more, preferably 1 W in the power supply.

Transistors are not critical except in a few places. Q1 should be rated for at least 300 volts; the Motorola MJE-340 is recommended ($1.06). The MJE-340 can also be used in the power supply for Q8. An MJE-370 can be used for Q9 as well as many other types handling 5 W or more – these two being 25 W types. The other transistors can be literally any that are rated for at least 15 volts or more. Those for Q5 and Q6 should be rated at 30 volts or more.

Recommended low-cost transistors for Q2, Q3, Q4, pnp, MPS-3703 (39¢); Q5, Q6, npn, MPS-6565 (52¢); Q1, Q8, npn, MJE-340 ($1.06); Q9, pnp, MJE-370 ($1.07); Q7, Q10, npn, MPS-3394 (27¢); Q11, pnp, MPS-6518 (67¢); and Q12, npn, MPS-3395 (45¢).

The Stancor PA-8421 makes an excellent loop transformer. Other 24 Vct, 0.5 A units should be suitable for the power supply.

The lamps should be low current types, hopefully under 50 mA. Those shown are the Sylvania 925 cartridge indicator lamps using 15 to 20 mA. If you use lamps that pull 80 mA each, change the 10k resistor to the bases of Q11 and Q12 to 4.7k.

The Muralite L-28/40 indicator is ideal for the ST-6. This lamp is rated at 10,000 hours life and may be used with voltages from 12 (25 mA) to 28 (40 mA). They are 39¢ each from: Western Radio, 1415 India Street, San Diego, California 92101; Attn: Gary Pierce Amateur Store Manager.

They are available in violet, red, white, green, blue and amber. Gary suggests you specify "violet leads" as this apparently identifies the L-28/40 bulb, not the color of the lens. These lamps are complete and are normally distributed through the Mura Corp. 355 Great Neck Road, Great Neck, New York 11021. The Sylvania lamps will run around $2.25 each by the time you get the cartridge lamp, lens and holder.

The 709C op amps are now only $1.00

each from Texas Instruments distributors in the 14-pin dual-inline style, and $1.25 for the round 8-pin TO-5 style. By the time this article appears in print it is possible prices could be even lower; as of now the other brands cost about $2.60 each. Texas Instruments uses their own designations for the 709C op amp: SN72709N for the 14-pin dual-inline package and SN72709L for the TO-5 can.

performance

The ST-6 outcopies any other demodulator I have tried. It does not run away from the TT/L-2, but the ST-6 seems to do better *most* of the time. Other operators who have built the ST-6 report similar experiences, and one enthusiast sold both his TT/L-2s and has replaced them with ST-6s. The unit only pulls 5 to 7 watts in standby when the motor is off, so it can run 24 hours a day without affecting the monthly electricity bill. The convenient switching system makes it very simple to use.

The ST-6 is designed for 600-ohm input. Most receivers have such an output available somewhere (on the Collins S-line it is the anti-vox jack). In some receivers, such as the Drake, there is no 600-ohm output. You will throw away about 30-dB potential limiting in the ST-6 if you use the 3.2-ohm speaker line, but small 3.2-ohm to 600-ohm transformers are available for under $1 from most distributors.

other op amps

Some people have asked why I did not use newer, more exotic op amps. Most of the newer devices are internally frequency compensated (such as the 741, for example), and not at all suited for audio use. They have other excellent qualities and could be used in the ST-6 at places other than U1 and U2. Their cost is such that even with external compensation, the 709C is still cheaper. The 709C already has so much inherent potential performance it would be similar to running the TT/L-2 with perhaps 7500 volts on the plate of each tube.

100 speed

For those needing 100 speed, change the two 16k resistors at the input of U2 to 10K, and change the capacitor between pins 2 and 6 of U2 to 60% of its usual value. That is, for normal 60 speed with the 850 shift discriminator for 2125-2975, the normal 0.03-μF capacitor would be changed to 0.018 μF.

The unit would then receive 60, 75 and 100 speed. Do not attempt to switch these items around, just leave it for 100 speed.

conclusion

The ST-6 offers the RTTY enthusiast a high-performance solid-state demodulator. It has features similar to those in the Mainline TT/L-2 but with greater inherent capabilities. It has automatic printer control which is useful for unattended autostart operation as well as for normal QSOs. Printed-circuit boards are available which simplify the construction and make it possible for the home enthusiast to make a commercial-looking unit with only simple tools.

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More Details? CHECK–OFF Page 94

intermittent voice operation of power tubes

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The power capability of a transmitting tube is often the subject of long and heated discussions among amateurs (and even among equipment design and tube engineers). In the past, amazing things have been done to power tubes by daring amateurs who seemingly had an inexhaustible supply of replacement tubes at hand.[1] The tube manufacturer looks upon such goings-on with mixed emotions; he's proud his products can take such a beating, but he shudders at the gross overload he knows is taking place, and he has nightmares when he imagines that such tactics are being done by users who may be ignorant of the basic limitations of vacuum tubes. Sometimes that manufacturer may be his own worst enemy. When he speaks of the ruggedness, long life and reliability of his product, he may unintentionally be inviting some eager-beaver to prove the utter conservatism of his remarks.

Up to now, tube ratings have been based upon an absolute system providing "maximum" ratings and "typical" operating conditions for various classes of service, for use below a certain specified frequency. These ratings are designated as *Continuous Commercial Service* (CCS) and *Intermittent Commercial and Amateur Service* (ICAS). The CCS rating may be defined as, "that type of service in which long tube life and reliability of performance under continuous operating conditions are the prime consideration.[2]" The ICAS rating is defined to include the many applications where the "transmitter design factors of minimum size, light weight, and maximum power output are more important than long tube life." The term "intermittent" is used to identify operating conditions in which no operating or "on" period exceeds five minutes and every "on" period is followed by an "off" or standby period of at least the same or greater duration.

These ratings are of cold comfort to today's radio amateur. The first rating applies to high-reliability service (broadcast, military, etc.) wherein off-the-air time is critical or costly; and the second rating, by its very definition, excludes amateur operation in meaningful terms. Neither classification, moreover, applies to ssb or cw operation. Ssb and cw are more properly expressed in terms of peak-to-average power ratio rather than in terms of "on" and "off" periods.

Before new and meaningful ratings are proposed for today's operational modes, it would be prudent to look for a moment at transmitting tube ratings now in use and examine their validity. Contrary to often expressed belief, maximum ratings and typical operating conditions are not arbitrary figures dreamed up by the manufacturer to avoid answering legitimate questions posed by users. On the contrary, they are the result of careful analysis of tube geometry and of prolonged life tests run on typical production tubes with some guaranteed or expected life in mind. Properly understood, the maximum ratings and typical operating conditions can be employed by the tube user to decided advantage.

transmitting tube ratings

Maximum ratings (or absolute maximum ratings) are those limits within which all tubes of a given type should give satisfactory service and long useful life. Why they are necessary at all and how they are determined are discussed in this article.

The *data sheet* (often suspected of being written by the wise to impress the humble) informs the user of the capabilities and limitations of the tube, both of which are based upon the maximum temperature the elements of the tube can safely withstand for an expected life. Heat, then, is the enemy of unlimited tube life, but heat is the unfortunate consequence of making the tube work. Once the maximum tube capability is determined *a compromise of some kind must be made to establish useful life without exceeding the heat limitations, yet allowing some safety factor for "cockpit troubles."*

maximum plate dissipation

Plate dissipation is limited by the maximum safe temperature of the plate and plate-to-glass (or ceramic) seals of the tube. Generally speaking, the plate will withstand several times its maximum rated dissipation level for a short period of time. Other parts of the tube (glass envelopes, mainly) are greatly affected by the excessive heat radiated by the plate. High level of plate temperature may cause the grid, filament or envelope to become overheated. The grid structure may warp, the filament temperature may rise to an excessively high degree, or the tube envelope may be destroyed. These effects, however, are not instantaneous, and short periods of plate overload do not usually overheat the adjoining tube structure to a damaging extent. However, the user has no way of telling to what degree he can safely exceed the plate dissipation limit, or over what period of time this abuse can take place. The obvious conclusion is that the maximum plate dissipation rating should not be exceeded in continuous operation if long tube life is desired.

maximum plate voltage

The maximum plate voltage point is set at a value above which the internal or external insulators of the tube may arc over, or above which the envelope of a glass tube may be damaged from dielectric losses. Finally, a plate voltage ceiling tends to set a limit to the maximum rf charging current flowing in the plate and screen leads, or plate and grid leads in grounded-grid service. The charging current is a function of the rf plate voltage which, in turn, is a function of the dc plate voltage. Setting a limit on the dc voltage sets a limit on charging current without the difficult task of determining the current directly. This effect depends on frequency and is the reason for the upper frequency limit for maximum ratings.

average dc plate current

The fundamental limit on plate current is the available supply of electrons emitted by the filament or cathode of the tube. The maximum plate-current figure is intended to set a value which may be easily realized throughout the expected life of the tube. If operating conditions are chosen which require that the maximum plate-current limitation to be exceeded at the start of tube life, it may become increasingly difficult to maintain the desired value of plate current as the tube ages. There is a definite relationship between the *maximum instantaneous value* of plate and grid current and the *average dc* (meter reading) *plate current* which differs for each class of tube operation. In linear-amplifier service, for example, most transmitting tubes are run class AB_1, AB_2 (loosely termed class B).* In these cases, the peak plate current is about three times the indicated (average)

*Most class-B linear amplifiers are operated in class AB_2. Class-B operation is defined as cutoff operation with an 180° operating angle of plate current flow. Class AB_2 operation signifies less-than-cutoff condition with more than 180° operating angle.

dc plate current. For long life, the cathode emission should be great enough to provide two or three times the required peak value of plate, plus grid, plus screen current.

The user can quickly determine the allowable average dc plate current in linear service for thoriated tungsten filament-type tubes by merely multiplying the filament watts by a factor of about 5.5. This is a rule-of-thumb number that – over the years – has proven to give a conservative balance between allowable plate current and good tube life. For the 3-500Z, therefore, the filament power is 5 (volts) x 14.5 (amperes) = 72.5 watts. Therefore, allowable maximum average dc plate current for linear amplifier service is 72.5 x 5.5 = 400 milliamperes.

In the case of an indirectly heated cathode the rule-of-thumb is different. Emission from an indirectly heated cathode depends upon the emissive material and the active cathode area, assuming cathode temperature is the proper value. The rule-of-thumb in this case for oxide cathodes is that maximum average dc plate current is approximately 125 milliamperes for each square centimeter of cathode area. For example, the 4X150A tetrode has an active cathode area a little over 2.0 square centimeters and the average dc plate current rating is 250 milliamperes.

long pulse service

In pulse service where the "on" time is small compared to the "off" time, many transmitting tubes can be run to much higher peak power limits than are permissible in continuous service. In continuous service, the maximum voltage and current limitations are set with a safety factor in mind to consider average power dissipated on the tube electrodes. In pulse service, when the tube "rests" for an appreciable time, it is possible to set new guidelines on peak electrode dissipation and maximum ratings, provided the *average* electrode dissipation and maximum temperature ratings are not exceeded.

In pulse service (less than 0.1 second) a thoriated tungsten power tube may have an anode instantaneous peak dissipation capability as high as 100 times the average power capability, and the available filament emission may be as high as 80 milliamperes per watt of filament power. In some cases, the filament voltage has been boosted above normal to obtain emission levels as high as 150 milliamperes per watt with the penalty of greatly reduced tube life.

In the case of the oxide-coated cathode, the peak pulse current is not as clearly defined or as easily generalized as in the case of the thoriated filament tube. A figure of 500 milliamperes peak plate current per watt of heater power is often used for very short pulse service (less than 3 microseconds), and other numbers are available giving pulse plate current in terms of active cathode area.

In *long* pulse service (more than 0.1 second), the rise in temperature of the electrodes rather than the average power during the pulse often becomes the basic tube limitation, and twe maximum capability of the power tube is progressively derated as the pulse length increases. For a radiation cooled tube, a pulse length of 2.5 seconds is often considered equivalent to a continuous duty operation. In the case of an oxide-coated cathode, life tests indicate that a peak-to-average dc plate current ratio of 2.0 for long pulse (0.5 second) is not unrealistic. This corresponds to a duty factor of 0.5.

voice and cw operation

A shadow world exists between continuous duty (CCS) operation, and ICAS operation on the one hand and pulse operation. Amateur voice and cw operations seem to fall into this shadow area. Cw operation may be compared to a form of pulse operation as it defines an "on" and "off" duty cycle wherein the two times are approximately equal. This would represent a duty cycle of fifty percent (0.5) and the pulse (cw) waveform would be nearly square.*

*Note quite true; waveshaping is necessary to some extent to reduce key clicks.

Voice operation, on the other hand, is a different and more complex problem. The voice waveform is not a square pulse; it has a large peak-to-average power ratio with irregular waveform. Normal speech, unclipped, uncompressed or otherwise altered, seems to have a peak-to-average ratio of about 14 dB.[3] Various compression and clipping techniques can reduce this ratio to 3 to 5 dB before severe distortion becomes apparent.[4] Thus, heavily clipped or compressed speech waveforms tend to resemble the cw duty cycle as far as the peak-to-average power ratio is concerned.

It is prudent to expect, therefore, that the power capability of a tube can be safely increased for *Intermittent Voice and CW Service* (IVS service) over the CCS rating provided the maximum element temperature of the electrodes is not exceeded and the cathode (or filament) emission is sufficient to satisfy plate and grid current peaks. In addition, the tube in question should not have an intolerable level of intermodulation distortion when operated in linear service under these enhanced conditions.

This type of intermittent operation is done everyday with the popular sweep tubes used in ssb equipment designed for amateur service. Small soft-glass envelope tubes (i. e., the 6LQ6) are run up to 250 or 300 watts PEP input with no apparent harm *provided* the maximum level of plate dissipation is held within reason, even though the average, long-term dissipation rating in tv service is only 30 watts or so. The user is taking advantage of the intermittent nature of amateur voice operation and the high peak-to-average ratio of the human voice to get more watts per dollar of tube investment. Many amateurs have found, to their regret, an overworked sweep tube tends to overheat and shows extremely short life when a voice clipper/compressor unit is used to bring up the average power of the equipment, or if extended cw operation is used. A moment's reflection upon the heating process in the tube will show the reason for this problem. The tube is being pushed so far that any margin of safety has vanished. Unfortunately, no one has yet been able to miniaturize the watt!

Thus, there's a limit beyond which pushing the transmitting tube becomes uneconomical. It may be well to push an inexpensive sweep tube to 300 watts PEP input, since a tuning error, or other maladjustment won't bankrupt the unlucky user. The owner of a more expensive transmitting tube, however, may well have second thoughts before he blasts his pet power tube. Obviously, some middle ground is called for where the peak-to-average power ratio of ssb and cw operation can afford new and conservative tube ratings more in line with today's usage.

intermittent voice service

In single sideband service, the two plate current values of significance are the single-tone plate current and the two-tone plate current. The ratio of single-tone to two-tone plate current may vary from 1.1/1 to 1.57/1, depending upon the class of operation. Two-tone plate current is useful as the magnitude of intermodulation distortion products may be specified as the reduction in decibels of one product from one tone of a two-equal-tone signal. Precedence exists, therefore, for providing typical operating data for linear amplifier service specifying the dc plate current under two-tone conditions of average plate current and plate current at the peak of the modulation envelope. Such data for the 8122 is shown in **table 1**.[2]

Based upon such data, extensive life tests have been run at the Eimac Division of Varian to determine if more meaningful operating conditions could be specified for either ssb or cw operating modes. As far as amateur operation is concerned, the limiting mode is cw, where the duty factor is about 0.5. The duty factor for single sideband transmissions with unprocessed speech runs about 0.05 for a 13-dB peak-to-average signal and could rise as high as 0.5 for high levels of speech compression or clipping. A duty factor of 0.5 (peak-to-average ratio of 2.0) for Intermittent Voice Service rating would therefore cover both table 2. Preliminary operating data for 8873 family of ceramic/metal, zero-bias power triodes.

Cathode: Oxide coated, unipotential	
Warm-up time	60 sec
Heater voltage	6.3 V
Heater current	3.2 A
Direct interelectrode capacitances, grounded-grid connection	
Input	19.5 pF
Output	7.00 pF
Feedback	0.04 pF
Maximum frequency ratings	450 MHz
Operating temperature, maximum, ceramic seals and anode core	250° C
Base	11-pin Special (JEDEC E11-81)
Radio-frequency linear amplifier, cathode driven, class AB_2	
Absolute maximum ratings, to 450 MHz	
Plate voltage	2200 Vdc
Plate current, continuous	250 mA
Plate dissipation	see note 1
Grid dissipation	5 W
Typical operation, Intermittent Voice Service[2] frequencies to 30 MHz	
Peak envelope or modulation crest conditions	
Peak voltage	2000 Vdc
Cathode voltage[3]	8.2 Vdc
Zero-signal plate current	22 mA
Single-tone IVS plate current	500 mA
Two-tone plate current (approximate)	312 mA
Average plate current	250 mA
Single-tone grid current	30 mA
Two-tone grid current	12 mA
Peak rf grid-cathode voltage	67 V
Peak driving power	26 W
Peak power input	1000 W
Single-tone IVS useful output power	587 W
Resonant load impedance	2140 ohms
Intermodulation distortion products:	
3rd Order	-35 dB
5th Order	-36 dB

notes. 1. 8873 is conduction cooled, and plate dissipation depends upon heat-sink cooling. 8874 plate dissipation is 400 watts, and tube has an axial-flow, forced-air cooled anode. 8875 plate dissipation is 300 watts, and tube has a transverse-flow, forced-air cooled anode.
2. Intermittent voice and cw ratings are based upon the maximum voltage and current ratings given for a signal having a peak-to-average power ratio of 2.0 or more. During short periods of adjustment (less than 30 seconds), the average plate current may be as high as the IVS value.
3. Cathode bias is obtained from a zener diode.

the cw and ssb speech-with-processing situations.

The derivation of a different rating from an existing rating may only take place after extensive life tests have been completed to make sure that tube life is not being shortened and that maximum temperature and dissipation limits are not

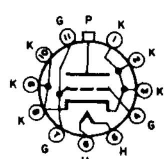

fig. 2. Tube base diagram for the 8873, 8874, 8875 family of zero-bias triodes. Multiple cathode leads keep cathode inductance to a minimum.

being exceeded. Any tube may be limited by grid or screen dissipation level and some may be limited by a plate voltage ceiling, or by available cathode emission. *Each tube type is an individual case, and to jump to conclusions or to interpret data from one type to another is risky and unfounded to say the least.* In all cases the total average current load on the oxide cathode will remain about the same for the new rating as for the average situation.

The *Intermittent Voice and CW (IVS)* rating may be defined as:

> That maximum voltage and current rating given for a signal having a maximum peak to average power ratio of 2.0 or more. During short periods of adjustment (less than 30 seconds), the average plate current may be as high as the IVS value.

In all cases, the IVS rating and "short period of adjustment" are limited by the maximum allowable temperature of the tube anode and seals.

using the ivs rating

The IVS rating is especially attractive to amateur operators as it outlines typical operating parameters for cw and ssb. How are the new ratings used? The following is an example of how an amateur operator can safely and properly tune up for an IVS operating condition with the aid of an inexpensive oscilloscope.

The oscilloscope is necessary for ssb adjustment at first since meter response to a voice waveform may vary from meter to meter and is, in any case, highly irregular and difficult to interpret.

1. The first step to achieve an IVS condition for either ssb or cw is to tune and load the linear amplifier with carrier (single tone) to an IVS rated value of dc plate current (as read on the plate meter), observing maximum "on" time. The amplifier is now ready for IVS CW operation. This could be called the "long-dash" tuning method. An electronic key is handy for this operation.

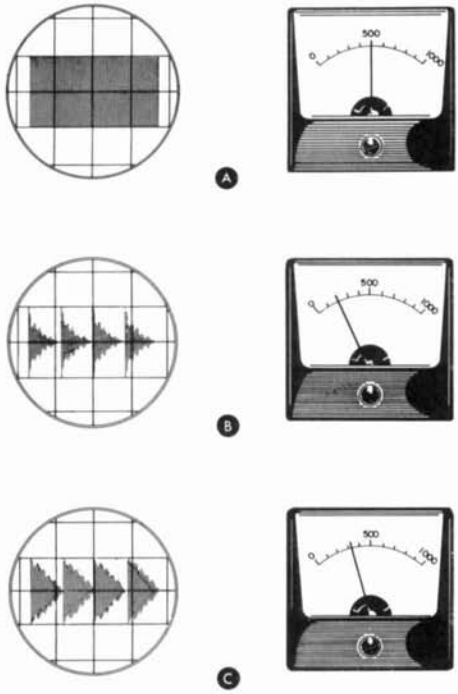

fig. 1. Typical meter readings for IVS operation.

A. With single tone (carrier), the linear amplifier is loaded to maximum IVS plate current (500 mA in this example). Oscilloscope shows carrier pattern. Pattern height is noted as 2 units. Observe short tuneup time.

B. Carrier is removed and voice modulation applied and gradually increased until voice peaks reach carrier height of 2 units as noted in pattern A. Plate meter kicks up to about 200 mA on voice peaks. No speech processing used.

C. Adding speech processing (clipping or compression). Note that plate meter now kicks up under voice peaks to about 325 mA, but that voice peaks on oscilloscope rise no higher than the single-tone limit of 2 units. However, area under the peaks is greatly enhanced, indicating greater average-to-peak ratio of voice signal. If oscilloscope peaks are greater than 2 units height, with or without voice processing, amplifier is being overdriven, with accompanying splatter and distortion.

2. For ssb observe the rf output pattern on the oscilloscope and note the amplitude for reference.

3. Remove the carrier. Insert audio and slowly increase audio gain so that the instantaneous rf peaks observed on the oscilloscope reach the same maxi-

table 1. Type 8122, linear rf power amplifier service (AB_1). Typical CCS operation at 30 MHz with two-tone modulation.

Plate voltage	2000 Vdc
Grid no. 2 voltage	400 Vdc
Grid no. 1 voltage	-35 Vdc
Zero-signal plate current	100 mA
Plate current	
Peak of envelope	335 mA
Average	250 mA
Grid no. 2 current	
Peak of envelope	10 mA
Average	7 mA
Average grid no. 1 current	0.05 mA
Effective rf load resistance	3050 ohms

mum level as obtained in *step 2* under carrier insertion. The amplifier is now working at the correct IVS level of peak input.

4. Observe the average current peaks on the plate meter for future reference.

In summary, the amplifier is tuned up to IVS condition with single-tone excitation to set the peak signal level. The single tone is removed, and audio is applied so the instantaneous signal peaks reach the same peak level as before, but the peak-to-average level of the intelligence may vary widely, depending upon voice characteristics, degree of speech processing, etc. This is summed up in **fig. 1**.

ivs ratings for the 8873 family of triodes

The new 8873 family of zero-bias triodes is the first to carry the new IVS rating. These ratings are based upon the original design concept of the tube, plus extended life tests where electrode temperatures, cathode emission and power output were carefully monitored. For example, the continuous plate current rating is 250 milliamperes. The cathode area of the 8873 is over 2 square centimeters; this corresponds quite closely to the 125 milliamperes per square centimeter rule-of-thumb stated earlier for an oxide-coated cathode. The life tests showed that a peak dc plate current rating of 500 milliamperes is reasonable at a duty cycle of 0.5 (peak-to-average power ratio of 2.0), corresponding to the IVS philosophy (**table 2**). The various input levels at a given plate voltage may now be established. At 2000 volts, for example, the average plate input is 2000 (volts) x 250 (milliamperes) = 500 watts. This corresponds to key-down service, such as RTTY. The two-tone rating (as in a short two-tone test) is 2000 (volts) x 312 (milliamperes) = 624 watts, average power. The IVS rating for ssb voice or cw is 2000 (volts) x 500 (milliamperes) = 1000 watts peak envelope power. In the case of voice and cw, the average current "load" on the cathode is the same.

Thus, today's power tube may be rated in two different and useful ways. Commonly, it bears the continuous duty (CCS) rating, and occasionally it bears the semi-obsolete ICAS rating. It is hoped that the new IVS rating will find favor in the future as it permits greater operating economy to be achieved in the use of all power-grid tubes.

what about . . .

The immediate question arises, "If this is so, what about the IVS ratings for the 3-500Z or the 8122 or the 4X150A, or whatever?" The present answer to this query is that *each tube type must be examined on its merits* and the outer limits established for any new rating, whether it be pulse, ICAS, or IVS. This is a continual process with most tube manufacturers, and more relevant date of this type will probably be forthcoming over the months.

Thanks to William McAulay, W6KM; Jack Quinn, W6MJG; and Robert Sutherland, W6UOV, for their help in the preparation of this article.

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modifying the Heath SB-200 amplifier for the new 8873 zero-bias triode

Simple modification of the SB-200 linear to provide increased power dissipation, better frequency stability, and lower drive. Two designs are featured — air cooled and conduction cooled

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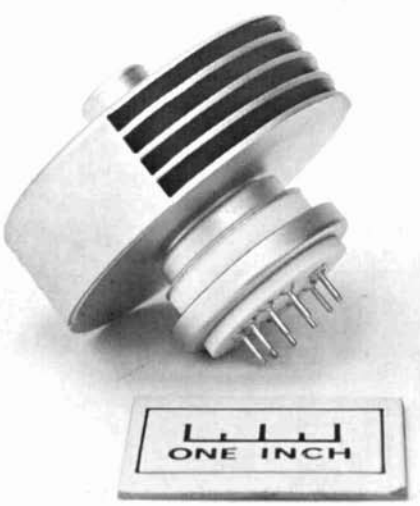
The high power capability, moderate cost and compact size of the new 8873 family of zero-bias, ceramic/metal power triodes make them well suited for new design, as well as for retrofit into popular amateur equipment that uses older tubes having restricted power capability and limited frequency range. The well-known Heath SB-200, a one-kilowatt PEP linear amplifier, is a likely candidate. This article covers the modification of this unit to use the new power tubes. The modification provides increased power dissipation,



The Eimac 8875 is a ceramic/metal zero-bias triode with a transverse cooler that provides 300 watts anode dissipation.

better high-frequency stability and lower drive requirements, and (in the case of the 8875) at a lower overall tube replacement cost then the original pair of tubes.

Based upon a study of the SB-200 circuit design, it was decided to try different modifications on two separate amplifiers. The first version uses the 8875, a high-mu power triode having 300 watts anode dissipation and capable of about 1200 watts peak input in Intermittent Voice Service (IVS).[1] The 8875 has five large, round, horizontal anode fins that may be adequately cooled with a small phono-motor fan, the type already in the Heath amplifier. This modification requires a minimum amount of disruption of the existing Heath circuitry.

The second amplifier has a more sophisticated and interesting modification: a conduction-cooled 8873 power triode (electrically equivalent to the 8875) is used with a finned heat sink for proper anode dissipation. The heat sink forms the vertical back wall of the rf enclosure.

This section discusses the first conversion, which provides full input level for the amplifier, with low intermodulation distortion and good tube life. The conduction-cooled version is described in the last part of the article.

the 8875 modification

The 8875 zero-bias power tube is shown in the photo and is capable of 1200 watts PEP input for ssb and 1000 watts when run in IVS service. The tube is about the size of a 4CX250B, has an 11-pin base and uses an inexpensive socket. Cathode and grid connections are brought out to multiple base pins, and, in addition, the grid is terminated in a low-inductance contact ring at the base of the tube which may be used for vhf operation. The anode is intended to be cooled by a horizontal air blast from a small fan. Dissipation is a function of cooling air, and a small phono-motor fan provides about 300 watts dissipation. For RTTY service, the power input level of the amplifier is dropped to about 600 watts. These levels are entirely compatible with the rating of the intermittent-duty power supply of the SB-200 amplifier.

The 8875 is mounted in a horizontal position in the approximate space previously occupied by the two glass tubes as shown in the chassis photo. The 11-pin tube socket is near the center of a small aluminum sub-chassis mounted to the rear wall of the amplifier enclosure. The existing cooling fan, mounted at the

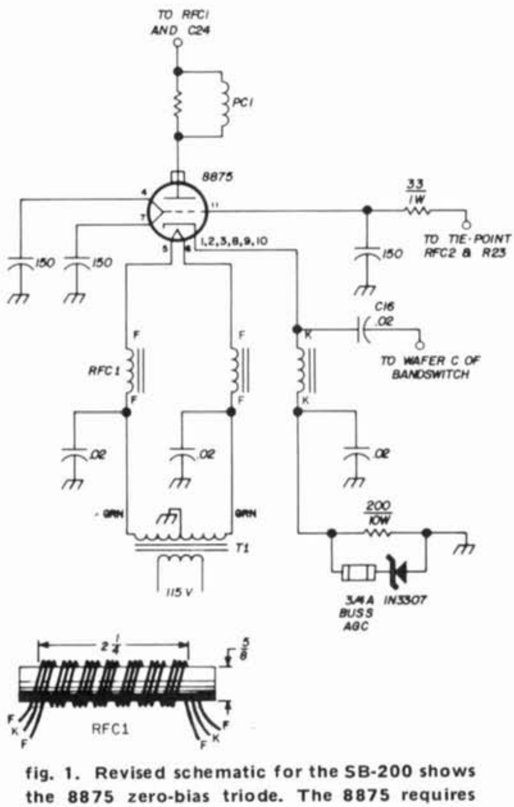


fig. 1. Revised schematic for the SB-200 shows the 8875 zero-bias triode. The 8875 requires 6.3 volts and the filament voltage in the SB-200 is on the high side because of reduced current drain. The original filament-choke windings are removed and three new windings put in their place. The filament windings are two 44" lengths of no. 20 enameled wire; the cathode winding is a 44" length of no. 26 insulated wire. Each winding has a 3" pigtail. Twenty trifilar turns are wound on the ferrite form. The ends are tied with twine and given a drop of epoxy to hold the windings in place. The socket for the 8875 is an E. F. Johnson 124-311-100. The 150-pF grid bypass capacitors are dipped mica units.

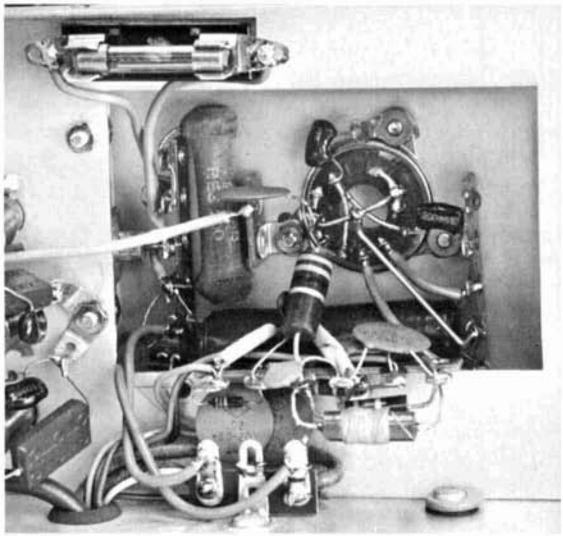
bottom of the enclosure, is moved to a new positon in respect to the anode of the 8875.

The revised circuit is shown in **fig. 1.** It uses most of the original components. A new filament choke or dropping resistor is required, as well as zener-diode bias for the 8875. All new components, with the exception of the zener fuse, are mounted within the sub-chassis, as shown in the rear-view photograph.

mechanical modifications

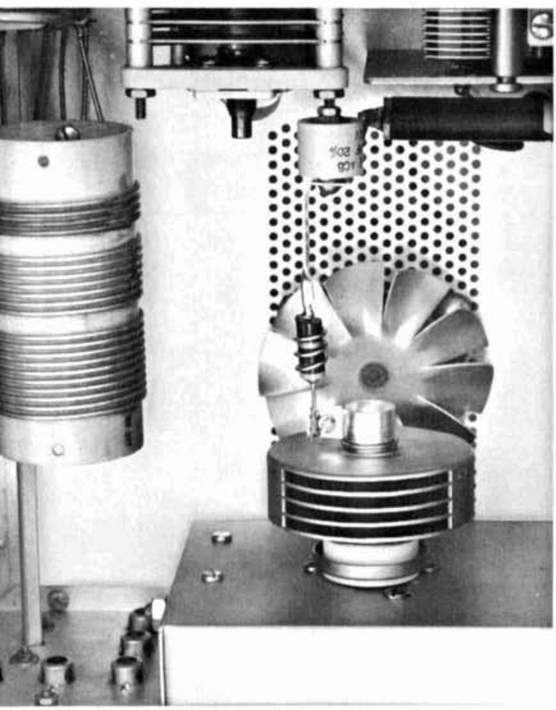
The first step is to remove the components around the existing 4-prong sockets, and then remove the sockets themselves.

Remove the filament choke from tie-point M. Unbolt tie-point AB, leaving the wiring connected. (See pictorial 11, page 39 of the Heath Instruction Manual. Original components are identified by their Heath nomenclature.) The next step is to cut out a rectangular hole on the rear wall of the enclosure as shown in the rear-view photo, with the dimensions



The rear panel of the SB-200 is cut out to allow access to the underside of the new sub-chassis. Untouched cathode coils are to left of the cutout. The zener fuse is at top of cutout with 200-ohm cathode resistor and zener diode mounted in sub-chassis. In this installation an extra cathode choke was used with the original SB-200 filament choke. The cathode choke has 15 μH inductance and 1000 mA current rating (J. W. Miller 4624).

In the modified Heath SB-200 the 8875 is mounted horizontally in the space formerly occupied by the two glass tubes. Major plate circuit components remain unchanged.



shown in **fig. 2.** The new sub-chassis for the 8875 is placed over this hole. The sub-chassis is a 4 x 5 x 2-inch Bud AC-1404 chassis cut down to 1-¼" height and held in place with spade lugs and bolts. The tube socket is placed on the sub-chassis as shown in **fig. 2.**

The new sub-chassis interferes with various bolts holding the rf enclosure to the main chassis deck along the bottom rear edge, and it is necessary to provide clearance for these bolts. Proper clearance is provided by noting position of the bolts and drilling ¼-inch clearance holes in the sub-chassis at the points of interference.

Once the sub-chassis is in position, the tube is placed in the socket and the phono fan moved until the blades are positioned beneath the anode of the tube as shown in **fig. 3.**

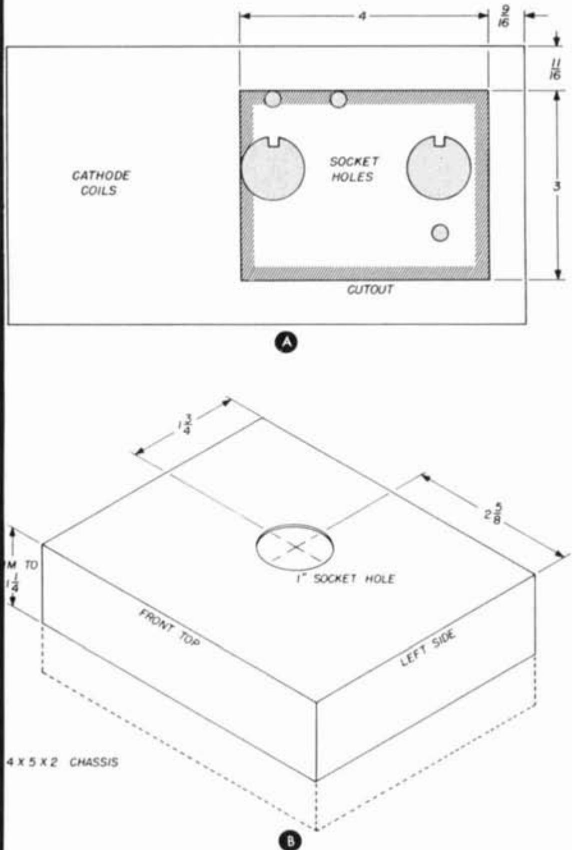


fig. 2. SB-200 chassis modifications to accomodate the 8875. The enclosure cutout for the sub-chassis is shown in A. The modified sub-chassis for the 8875 socket is shown in B.

electrical modifications

The portion of the original schematic of the SB-200 that is revised is shown in **fig. 1.** The 1N3307 8.2-volt zener diode is bolted firmly to the wall of the sub-chassis, using a thin coating of *Wakefield Thermal Compound* smeared on the zener stud to allow a good thermal bond. The new component layout in the sub-chassis is shown in the rear-view photograph.

Using the new tube, the existing filament voltage of the SB-200 is too high, and it is necessary to drop it slightly to avoid over-volting the tube filament; a 0.3-volt drop is necessary. This may be readily achieved by placing a 0.1-ohm wirewound resistor in series with one filament lead, or the filament choke may be rewound with the proper wire length and size to develop the required voltage drop. Since a cathode rf choke is required, the builder has the option of rewinding the present filament choke and adding a cathode winding as shown in **fig. 1** or using the existing choke and adding a cathode rf choke and filament dropping resistor. The latter was done for the first tests, and a new trifilar rf choke was substituted at a later date.

amplifier testing

When the modification is complete, all wiring should be checked and the resistance to ground from the anode clip should be checked. As in the original amplifier, before modification, the resistance should be about 180,000 ohms (the resistance of the filter bleeder resistor, $R_5 - R_{11}$). The amplifier should be connected to the exciter and to a dummy load. Before the amplifier is turned on, the exciter is tuned up, feeding through the unenergized antenna relay of the amplifier. The amplifier is now turned on, and the panel meter should read about +2400 volts in the HV position. Amplifier plate current is zero because of the cut-off bias voltage.

The amplifier controls are set as des-

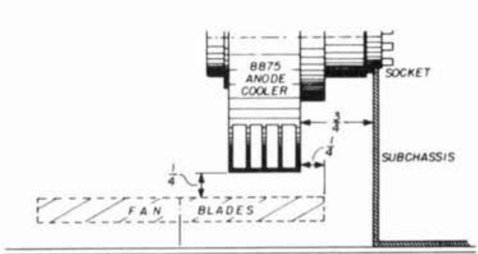
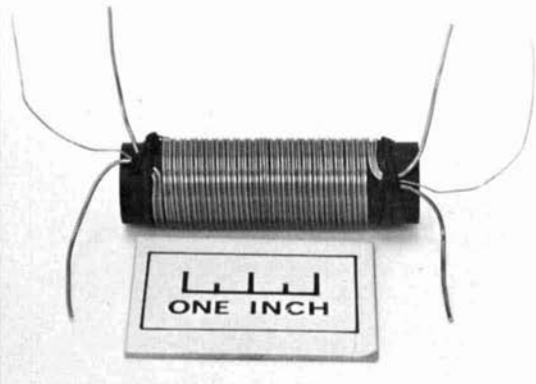


fig. 3. Phono-motor fan installation for the 8875. The motor must be moved so the shaft is in line with the center of the anode, and the tip of the fan blade clears the bottom of the tube by ¼ inch. The blade should also clear the edge of the anode by ¼ inch.

cribed in the *Operating Procedure* section of the Heath Manual (page 47), and the amplifier is again turned on. With no driver output, the meter of the amplifier should indicate an idling plate current of about 20 milliamperes. A ninety-second cathode warm up time should be observed before excitation is applied to the



New trifilar filament and cathode choke for the modified SB-200 uses ferrite rod from original unit. Winding details are shown in fig. 1.

8875. The drive level of the exciter is advanced until the plate current rises to about 200 milliamperes. Tuning and load controls are adjusted for maximum power output (minimum plate current) on the amplifier meter. Grid current should be about one division on the meter (25 milliamperes, or less). **Caution:** *The 8875 is easy to drive; watch out for excessive grid current.*

The amplifier may now be loaded for a maximum plate current of 500 milliamperes, using carrier injection from the exciter. Maximum grid current is 45 milliamperes. This corresponds to a drive level of 55 watts or less. Loading should be done quickly so as to not run excessive IVS plate current for more than 30 seconds or so.

When proper loading with carrier injection is achieved you will find that maximum power output occurs at this point along with the recommended values of plate and grid current. At maximum input the power output (measured with an accurate wattmeter) is between 520 watts (10 meters) and 630 watts (at the lower frequencies). Power gain is about 10 decibels. Under voice conditions, with no speech processing, voice peaks will run about 200 milliamperes on the meter.

Thanks to Merle Parten, K6DC, and Dick Rasor, WA6NXB, for their help and assistance in modifying the amplifier and making measurements on the completed version.

conduction-cooled linear

Modern power tubes such as the 8873-family have the capability of developing anode power dissipation densities (watts per square centimeter) comparable to the power densities in many jet and rocket engines. For this reason, effective cooling techniques are essential for long life and high tube reliability.

Conduction cooling is an efficient system of heat elimination, making use of the *heat source* (power tube or transistor), a heat transmission path (*thermal link*) and a *heat sink,* wherein the heat is removed. Many amateurs have seen transistors with tiny heat sinks on them; far fewer amateurs have observed heat-sink systems capable of dissipating several kilowatts of power. Such large systems exist, and the general design (suitably scaled down) may be adapted for use at amateur power levels. Although common in commercial and military gear, the heat-sink conduction-cooled system is just beginning to appear in amateur equipment (i. e., the Signal-One transceiver).

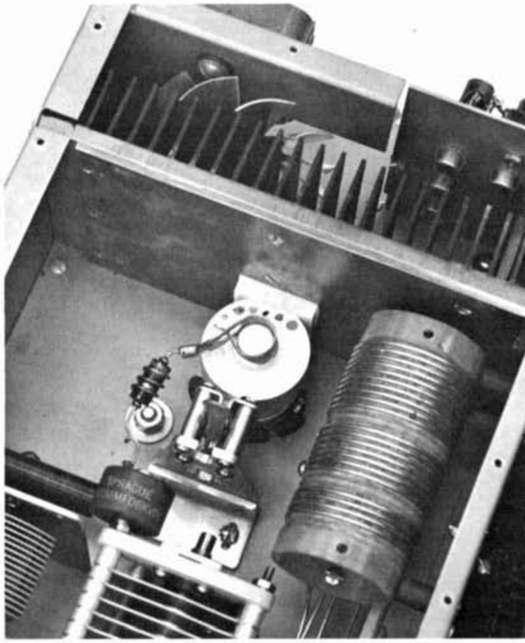
In the case of a power tube whose anode operates at a high voltage potential, the thermal link must have the dual properties of a thermal conductor and an electric insulator. One of the most practical materials for this task is *Beryllium Oxide* (BeO), an insulative ceramic (refractory) material which has the thermal conductive properties of aluminum.

The 8873 zero-bias power triode makes use of a BeO thermal link and external heat sink. The link is detachable, providing mounting flexibility and reduced tube replacement cost. However, since two thermal interfaces occur with the detachable link (tube anode to link and link to heat sink), attention must be paid to ensure low thermal resistance at these two interfaces if optimum cooling performance is to be achieved.

The heat sink, receiving heat through the thermal link from the tube anode, emits energy in the form of radiant heat. The quantity of heat radiated depends upon the absolute temperature of the sink relative to the surrounding environment and the nature of its surface. A heat sink operating at an elevated temperature compared to its environment will transfer heat to the environment by radiation, convection and conduction, as is done in this case.

The added output capacitance of the tube supplied by the thermal link and heat sink is typically 6 to 10 pF, and this must be taken into account when vhf tank circuits are concerned.

The heat sink used with power tubes may be liquid or air cooled. In this case two or three hundred watts of anode dissipation are required so air cooling is feasible.



Conduction-cooled 8873 zero-bias triode mounted in the Heath SB-200 linear. The 8873 is held in place with a toggle clamp that presses the anode of the tube against a beryllium-oxide thermal link and finned heat sink. The flat surface of the heat sink is covered with 1/8-inch copper sheet to distribute anode heat evenly. Under normal voice operation heat-sink dissipation provides sufficient cooling. For cw or long-winded voice operation a thermal switch turns on a small phono-motor fan to hold the temperature of the heat sink at a conservative level. When heat-sink temperature drops to normal value, the fan is automatically switched off.

The 8873 conduction-cooled zero-bias triode.

the 8873

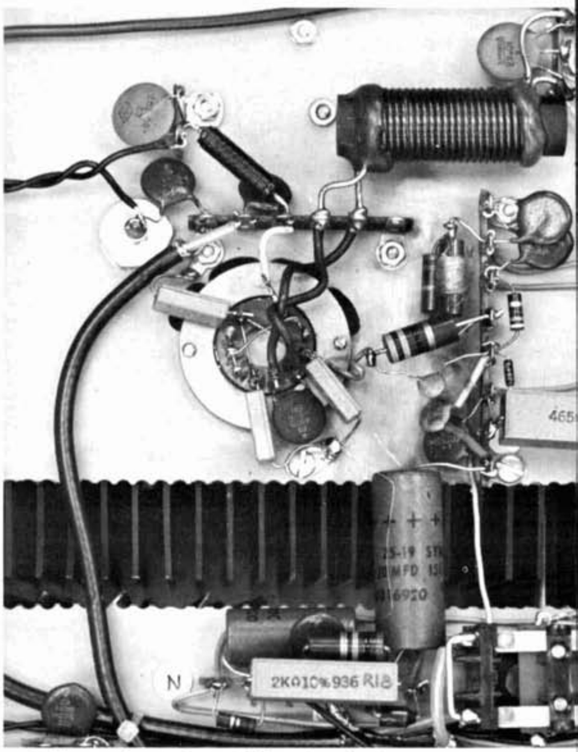
The 8873, like the 8875, is a ceramic/metal, zero-bias triode intended for hf and vhf service up to 450 MHz or so. No air cooling of the base is required if the socket is mounted on a chassis which has sufficiently low thermal resistance to drain the filament heat away from the stem of the tube.

The 8873 seemed a natural for retrofit in an existing Heath SB-200 amplifier. It was planned that the cabinet and power supply of the SB-200 could be used as a test bed for future experiments (such as a 50 MHz or 144 MHz amplifier) so a new, two-piece aluminum chassis was made. The power supply was rebuilt on one chassis and the amplifier section on another. Both units were then bolted together to resemble the original Heath chassis and shields. An amateur intending to modify his own SB-200 to this design probably would use the Heath metal work as-is.

heatsinking the SB-200 chassis

The 8873 anode is heat sunk to a finned radiator mounted at the rear of the amplifier enclosure. Generally speaking, the modification consists of removing the present tubes, sockets and auxiliary components and reworking the circuit electrically as described in the 8875 modification. Views of the heat sink installation are shown in the photographs. The heat sink measures 7-3/4 x 4-1/4 inches and is mounted to the chassis and side walls about 8-3/4 inches behind the front wall of the enclosure. The 8873 socket mounts in the center of the enclosure, with the center of the socket about 15/16-inch from the smooth surface of the heat sink.

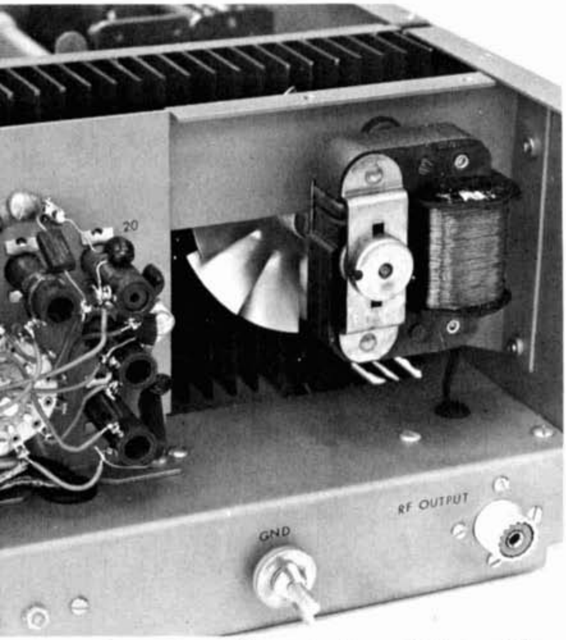
Anode heat flows from the 8873, through a BeO insulating block into the heat sink. Good bonding is essential between these three components in order to hold anode core and seal temperatures below the maximum permitted rating of 250°C. To hold the components firmly together, a DE-STA-CO toggle clamp is mounted in front of the tube. A small ½-inch ceramic insulator is substituted for the rubber nose of the clamp, which presses against the tube and heat sink. While the clamping action takes place, the tube and socket should be free to move. Accordingly, the socket is mounted in a clamp ring so that a slight amount of rotational and lateral movement can be accomplished. The rotational movement is required in order to align the flat surfaces of the tube, thermal link and



Bottom view of amplifier chassis shows submounted tube socket. Chassis bolt holes are slotted so tube and socket may be moved slightly so the anode is properly seated against the heat sink. The rear of the amplifier chassis has been cut away below the heat sink so cooling air may pass through the fins. Filament choke is at upper right with zener diode mounted on chassis at upper left.

heat sink. The socket is then tightened in position after alignment and clamping takes place.

The heat sink provides about 160 watts of continuous anode dissipation when cooled by normal currents of 20°C air (room temperature). It is possible to raise the dissipation of the sink to about 200 continuous watts by passing cooling air across it from the small phono-motor fan which was a part of the original SB-200 assembly. The fan was included in this design, along with a thermal switch.



Rear view of conduction-cooled amplifier shows cooling fan and cathode tuned circuits. Chassis beneath the heat sink has been cut away for proper flow of cooling air.

When the temperature of the heat sink approaches a value that indicates high anode temperature, the fan is automatically switched on, increasing the capacity of the sink and protecting it from long-winded rag chewers and marathon talkers.

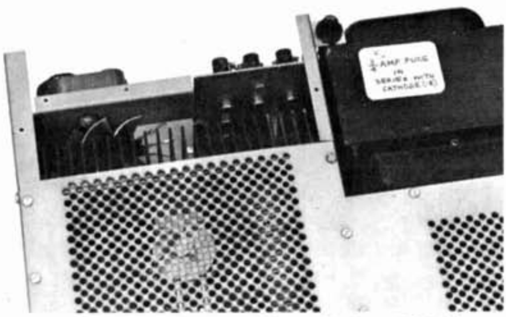
To determine the capacity of the heat sink system, temperature runs were made on the sink and tube anode, with various values of anode dissipation. Heat-sink and anode temperature were measured with temperature sensitive paint, and the thermal switch was moved about on the sink until it switched on when anode temperature reached about 180° C, well below the upper design limit of the tube.

To hold tube base temperature to a safe level, slots were cut in the chassis around the tube socket to allow cooling air from beneath the chassis to flow up and around the tube base (see under-chassis photo).

amplifier operation

Tuning and loading of the amplifier is normal, and follows the procedure outlined in the 8875 description. Under most operating conditions, the heat-sink temperature does not rise to the point at which the cooling fan is actuated, and amplifier operation is completely noiseless, a welcome "sound" these days!

While this unit is considered to be experimental, it points the way to the amplifier design of tomorrow: heat-sunk, noiseless, compact and highly efficient — quite a far cry from the old days of rack mounted gear, heavy, buzzing power supplies and black-crackle panels. How time flies!



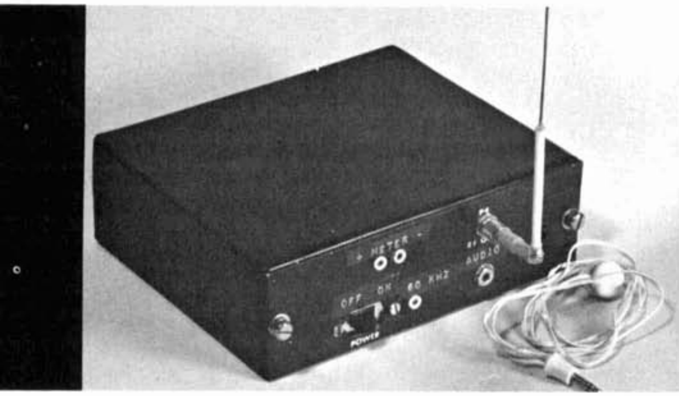
Conduction-cooled amplifier with top shield in place. Shield has been trimmed at rear to allow air to flow over heat sink.

Again, thanks to K6DC and WA6NXB for their assistance in this experimental project.

reference

1. William I. Orr, W6SAI, "Intermittent Voice Operation of Power Tubes," *ham radio,* this issue.

ham radio



photographs by F. C. Lamm, WB4FUJ

two-meter fm frequency meter

A highly accurate heterodyne-type frequency meter that provides crystal-controlled frequency markers on two meters

C. A. Baldwin, W4JAZ 3406 Old Dominion Boulevard, Alexandria, Virginia 22305

On two-meter fm a .005% tolerance crystal can put your transmitter outside the passband of a narrow-band receiver, even if it is working into the same capacitance at which it was calibrated. If the capacitive load is very much different it can even put you closer to the next channel. This is why frequency-shifting capacitors must be adjusted to the crystal in use.

In the local area there are half a dozen hams who have access to laboratory standards and measurement equipment who will help you get your gear on *the* frequency – six *different* ones. These amateurs are performing a very useful service but one wonders where *the* frequency actually is. A fairly accurate answer can be provided by a relatively simple and inexpensive piece of gear.

The unit shown in the photographs measures 2x5x6 inches and weighs 26 ounces complete with batteries. It can be used to adjust a transmitter or receiver to any channel at 60-kHz intervals from 146.94 MHz to below 145 MHz. *Immediately* after calibration it will be within 15 Hz, which is roughly 1/100,000% or one part in 10^7. From day to day, at comfortable shirtsleeve temperatures, the instrument stays within 100 Hz.

how it works

A crystal-controlled oscillator at 49 MHz feeds a buffer-tripler with an output at 147 MHz. This stage is coupled to the emitter of a mixer or modulated amplifier stage. Another crystal-controlled oscillator at 60 kHz with high harmonic output feeds an emitter-follower buffer which drives the base of the mixer, modulating the vhf signal at 60 kHz and its harmonics. The first lower sideband is on 146.94 MHz, and strong signals are available at 60-kHz intervals to below 144 MHz. The output of the mixer feeds a 19-inch whip antenna to radiate signals for receiver calibration.

The antenna and mixer also feed a full-wave diode detector to obtain a beat note between the internally generated signal and a signal at the antenna. A capacitively coupled transistor audio stage provides enough output to a broadcast receiver earpiece to permit adjustment of a transmitter to within about 30 Hz of the internal frequency. Tip jacks on the front of the unit allow connection of a low-range (5-volt) dc voltmeter across the dc detector output. Unless the meter is highly damped, the needle will quiver before the beat note becomes inaudible, and when the meter swings from minimum to maximum and back less than once a second, you have matched the frequencies within 1 Hz.

construction

The frequency meter shown in the photographs was built in a surplus module of uncertain source and purpose which contained most of the parts and circuitry of the calibrator. Where possible the original circuits were used without any attempt to optimize the component values. In the 60 kHz oscillator, it was found necessary to provide a tip jack to read this frequency for calibration checks after the unit was in its case. Since the crystal in this circuit was within 0.1 Hz of the intended frequency, a variable capacitor in series or parallel with the crystal seemed unnecessary. The frequency of the 49 MHz oscillator is adjusted at L1. Substitution of parts or complete circuits of sections of the unit should work equally well.

The circuit is shown in block form in **fig. 1**; a schematic is shown in **fig. 2.** Parts layout is not critical and can follow the dictates of the available housing and the preference of the builder. Some of the features of this unit, however, might deserve consideration.

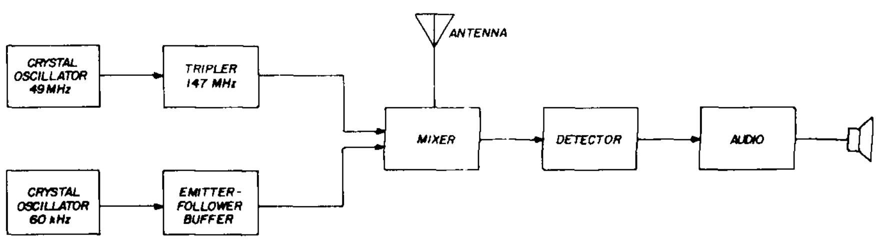


fig. 1. Block diagram of the two-meter fm frequency meter.

First, a sturdy chassis is required for high-stability portable gear. All parts must be securely mounted; in this unit the crystals and their sockets are attached to the chassis with epoxy cement. Power to each oscillator is supplied through a dropping resistor with a 6.3-volt zener to ground; a 20% drop in battery voltage can be tolerated without affecting the frequencies. The enclosure was made from flashing copper sheet and permits rf coupling into and out of the unit only at the antenna jack. Audio and meter connections are bypassed at the jacks. Two paralled 9-volt batteries provide long life at the 33 mA load.

calibration

This instrument was calibrated by using an available crystal standard con-

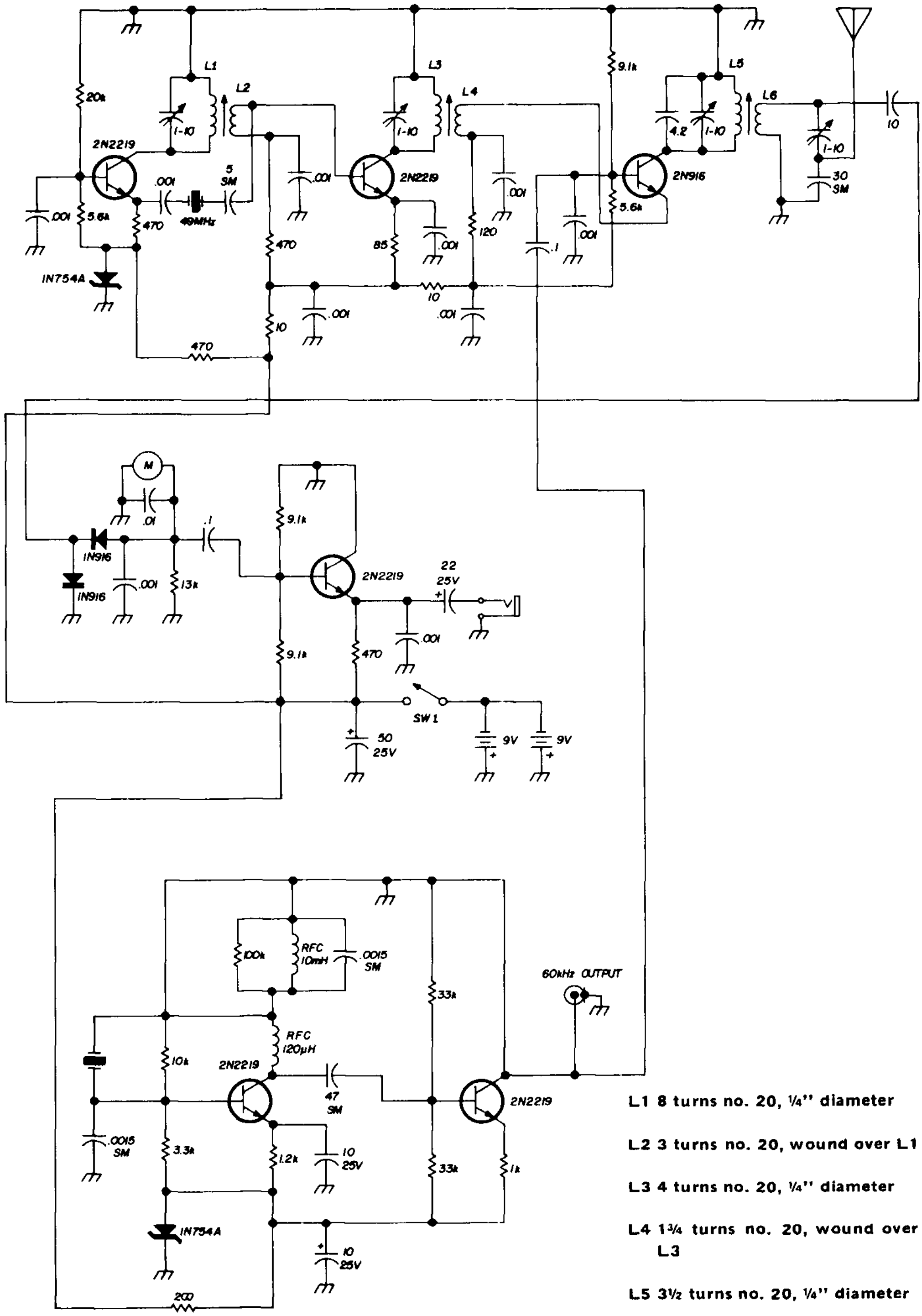


fig. 2. Schematic diagram of the two-meter fm frequency meter. The extensive decoupling circuits and most of the component values were part of the original equipment.

L1 8 turns no. 20, 1/4" diameter

L2 3 turns no. 20, wound over L1

L3 4 turns no. 20, 1/4" diameter

L4 1 3/4 turns no. 20, wound over L3

L5 3 1/2 turns no. 20, 1/4" diameter

L6 2 1/2 turns no. 20, wound over L5

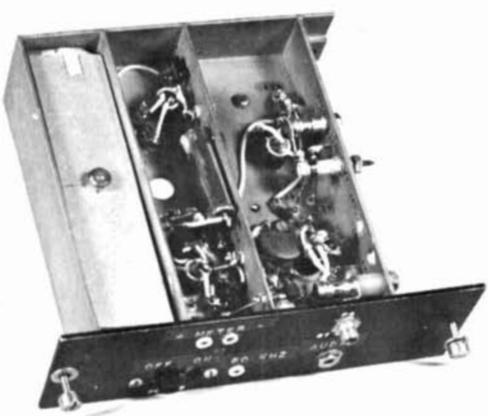
3 turns no. 20, wound over L1

stantly monitored against a WWV broadcast. 10 MHz was used, but where other frequencies are more reliable, the same principles can be applied. This 10 MHz oscillator will hold within 0.5 Hz for the duration of the calibration process. It is followed by a divider to 1 MHz and a multiplier to 50 MHz, both of which feed a mixer. This results in a signal at 49 MHz plus or minus 2.5 Hz. The unit can be adjusted so that its signal, when fed to a receiver along with the 49 MHz standard frequency, will swing the S-meter less than once per second. The cumulative errors at 49 MHz, when tripled, net a maximum error of 10.5 Hz at 147 MHz.

By a similar process, the 60-kHz oscillator can be compared with the WWV signal and adjusted easily to within 0.1 Hz. Since this frequency is multiplied by 1 at 146.94 MHz and by only 20 down to 145.80 MHz, this error does not exceed 2 Hz. It was found necessary to bring this frequency out to a tip jack on the panel for calibration purposes.

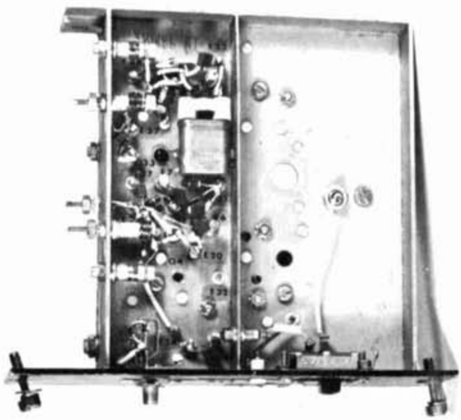
This system results in an error of less than 15 Hz within the intended range of the device. This is not as good as the best laboratory counters, but is cheaper, more rugged, portable, battery powered, and always available.

Top view of chassis. The 60-kHz oscillator is located next to the batteries; buffer is at rear. On the right, front to back, are the antenna coupling capacitor, detector and audio stages, and tripler.



use

The simple frequency meter is used just like the LM, BC 221, or other heterodyne frequency meters with an audio detector, except that a low-range, high-resistance dc voltmeter can be used to monitor the beat note at less than audio frequency. The signal from the unit can be picked up on the receiver under

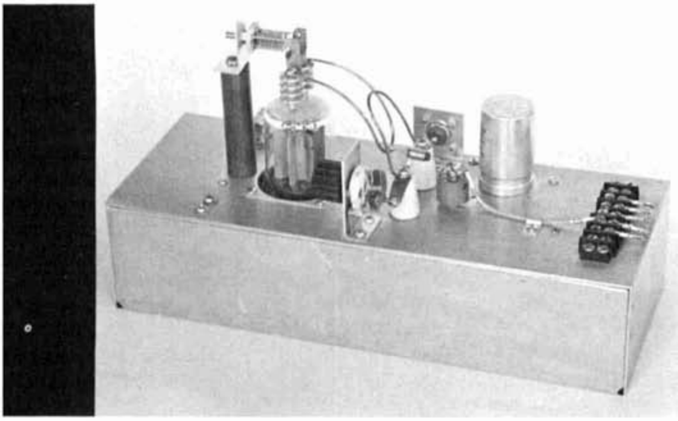


Bottom view. The 49-MHz oscillator is at rear, mixer in front.

test, and the receiver's oscillator adjusted until its discriminator voltage is zero, or as otherwise directed for that receiver.

To adjust a transmitter frequency, the unit must be within about 20 feet of the transmitting antenna for powers of ten watts or above. The transmitter frequency is adjusted for zero beat as heard in the earpiece or shown on the meter. In practice, little equipment has been encountered which can be adjusted below the beat note range without meticulous care. But this is much better than most of the ham transmitters you are likely to hear. Also, it is comforting to know that the error is mostly in the transmitter or receiver adjustment, and not in the test equipment.

ham radio



an rf power amplifier for 220 MHz

Have you been avoiding vhf operation because of construction difficulties? Then meet the "220 Lady"

M. O. Beck, WB6DJV, 1637 Hood, Wichita, Kansas 67203

The apparatus shown in the photographs accompanying this article is a class-C rf power amplifier for the 220-MHz amateur band. It was designed and built to disprove the remarks made by hams who claim that operation on 220 MHz presents too many technical difficulties. The classic remark is, "220 MHz is just too hard to get on." Well, all that is changed now.

The amplifier described here has features that should appeal even to the most skeptical vhf critic. Standard parts are used, and if my layout and construction suggestions are followed, the amplifier will give a good account of itself with a minimum of debugging.

After a considerable amount of thought on the subject of why many hams shy away from building vhf amplifiers, I arrived at the real reason: neutralization. Since this is the main objection, I decided to put it out of the picture once and for all by designing an amplifier that requires absolutely no neutralization whatsoever. I further decided that the amplifier should require such minimal drive that the driver could be a multiplier (again, no neutralization).

I dubbed this amplifier the "220 Lady," simply because it behaves like a lady – in the classic sense, that is! From the moment it was first fired up, it was a perfect example of what a good amplifier should be: tame, cool running, and efficient. In fact, the night it was completed this amplifier was the subject of a lecture given at the Wichita Amateur Radio Club.

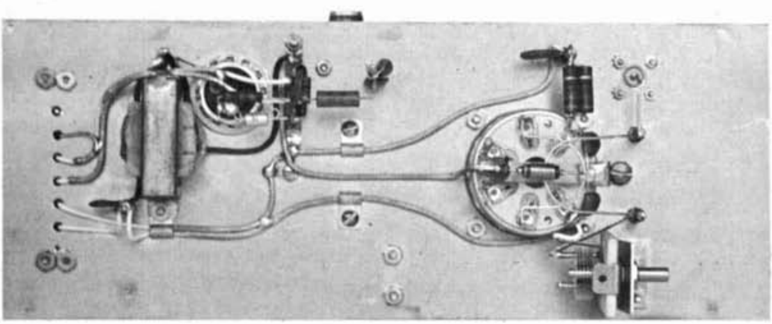
Other than praise, there's little else to be said about the amplifier, as the schematic **(fig. 1)** and the excellent photographs (taken by a friend, Mike McConnel) just about tell the whole story.

publication for beginner and experienced vhfer alike.[1]

I'd like to emphasize one important point. It's strongly recommended that my design and layout be followed exactly. Parts layout, lead dress, and mechanical details have been very carefully worked out. The shielded wire (see photos) is an absolute necessity. Although some variation could be made in parts layout, I don't recommend it. The grid and plate tank circuits are rather old fashioned, but that's probably why the amplifier works so well. This construction method **(fig. 2)** is tried and true. If the amplifier "takes off" then you have made some mistake in wiring or have side-stepped my layout.

bias requirements

I hope you'll put the little bias supply where I did – under the chassis where it belongs! As to setting the bias voltage,

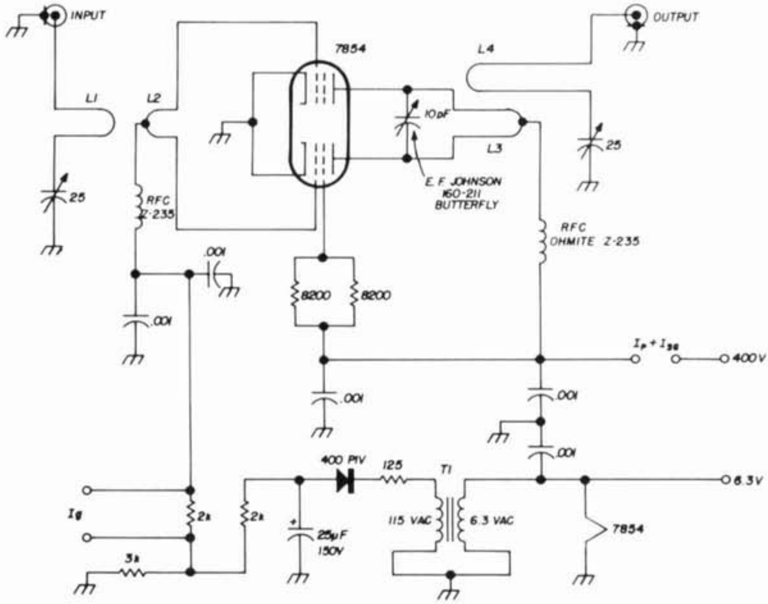


Under-chassis view. Shielded wiring is necessary for circuit isolation at this frequency. Note simple bias supply, which doubles as tube-heater source.

construction

The fact that you've read this far indicates you're interested in getting on 220 MHz. I'll assume you've had some experience in construction and wiring techniques at the vhf-uhf level. If not, all you have to do is read one of the many articles published on the subject. The vhf-uhf manual by G6JP is an excellent

I've included photos and the schematic of the supply I use. It may differ a bit from your idea of what class C should be, but before you knock it – try it. I strongly advise against keying the amplifier in the cathode, as instability could result. We're talking about class-C operation, so key the transmitter where it should be keyed – in the exciter.



Top-chassis view of the amplifier. Parts layout should be close to that shown for trouble-free results.

phone operation

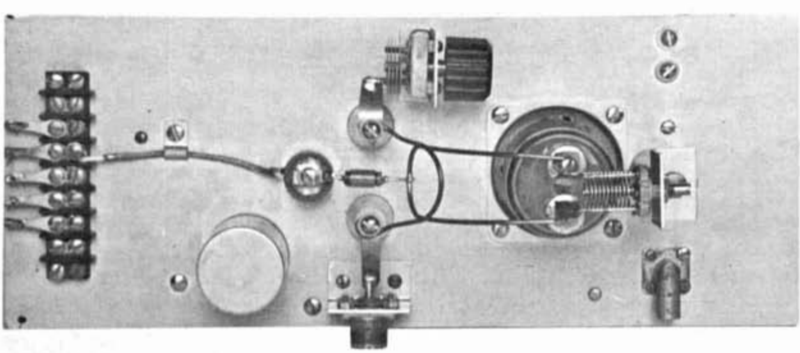
You want to modulate the rig? By all means, go ahead and plate modulate; remember, the amplifier is operating at class C. Interested in ssb? Just decrease the bias and increase the screen voltage, which should be obtained from a separate source, of course, Your scope will tell you when you have the correct bias adjustments.

tube considerations

If you have a 5894 it may be substituted for the 7854 but this may present neutralization problems which we're trying to avoid. Using the 7854, I obtained rated output with a type 6360 tube as a driver-tripler. Drive power is no problem; only a watt or two is required.

The amplifier should not be operated at dc inputs exceeding 50-60 watts. Initial

fig. 1. Schematic of the "220 Lady." Neutralization has been eliminated in this amplifier. Full dc input of 50 watts requires only one or two watts of drive.



circuit adjustments should be made with the aid of a grid-dip oscillator. These dual tetrodes (7854, etc.) don't take kindly to excessive out-of-resonance maltreatment.*

conclusions

This amplifier is just about the ultimate from the standpoint of cost and construction simplicity, but don't be deceived – it's a real performer. The amplifier is designed for cw and really does a good job in this mode.

This article is a cart-before-the-horse thing. I told Jim Fisk I had an article on *the exciter for this amplifier, but second* thoughts led me to rebuild it for appearance as well as efficiency. So maybe this *amplifier will at least sooth the editor as* well as convince a few more fellows that it really isn't "hard to get on 220 MHz."

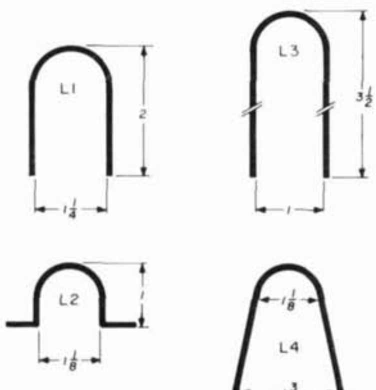


fig. 2. Dimensions for plate and grid inductances. Material can be small-diameter copper tubing or large-diameter copper wire.

reference

1. G. R. Jessop, C. Eng., MIERE, G6JP, "Vhf-uhf Manual," Comtec Book Division, Box 592, Amherst, New Hampshire 03031 ($3.75 ppd).

ham radio

*Although not shown in the schematic, good insurance against tube failure is a screen-grid *protective circuit. Several schemes are shown in* the ARRL handbook. **editor.**

EIMAC's new 8873 family of grounded grid, zero bias triodes offers you top-man-on-the-frequency performance to 432 MHz.

(Imagine how these tubes will work at 14 MHz).

EIMAC's many contributions to grounded grid triode design and production have now been combined with the advantage of rugged, low-profile ceramic/metal assembly to bring you this new family of impressive high-mu triodes. They're inexpensive, and work up to 1000 watts PEP input at frequencies up through 432 MHz. Quickly, here are the outstanding features of these state-of-the-art tubes:

8873
CONDUCTION COOLED ANODE

8874
AXIAL COOLED ANODE

8875
TRANSVERSE COOLED ANODE

88 and 73

The numerals 88 and 73 have been a tradition in communications language for almost 120 years. The older of the two, 73, appeared in 1853, meaning "My love to you." In 1857, the first official definition made it a "fraternal greeting between operators." Two years later, 1859, Western Union made "73" a part of their "92 Code" to indicate "Accept my compliments." The final change came in 1895, when "73" meant "Best Regards" for the telegraph, and later for radio operators.

"88" never received the formality of an official listing until it was adopted as one of the "Ham Abbreviations." It had been one of the telegraph operators' traditional terms since well before the turn of the Century. During the First World War, "88" was used by the U. S. Army Signal Corps, again strictly as an operator's abbreviation in unofficial communications. At the close of WWI, "88" achieved official status as a part of amateur radio terminology: "love and kisses."

Louise Ramsey Moreau,
WB6BBO/W3WRE

More Details? CHECK–OFF Page 94

1. Up to 1000 watts PEP input per tube to 432 MHz. Typically, 2000 volts at peak dc plate current of 500 milliamperes.
2. Indirectly heated cathode. No expensive filament choke needed for grounded grid HF operation as filament is electrically isolated from cathode.
3. Easy to drive. Extremely low grid interception plus EIMAC's exclusive self-focusing cathode combine to provide high power gain, high overall efficiency and low, low intermodulation distortion.
4. May be driven to full rated input with solid state driver in many cases.
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8. And, of course, no bulky screen or bias supply needed!

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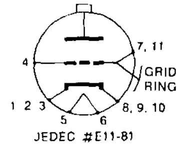

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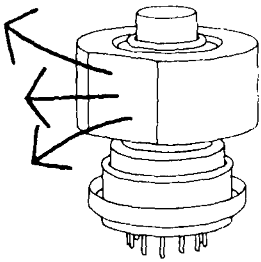

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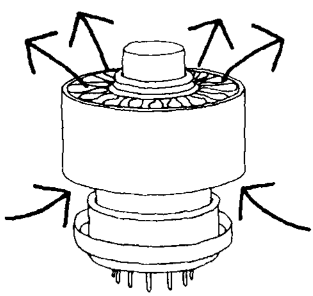

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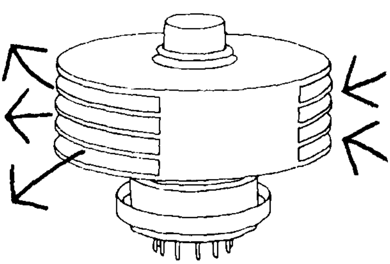

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division
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inexpensive swr indicator

A simple, easily constructed device that indicates behavior of your feedline at any point

J. A. Houser, WB2GQY, 23 Washington Street, Rensselaer, New York 12144

The fact that this standing-wave indicator is inexpensive in no way detracts from its usefulness as a measuring instrument in the ham shack. It's not an in-line device and is not connected to the transmitter. Therefore it contributes no insertion loss and doesn't disturb the circuit with which it's used. It is simply an rf-current loop connected to a half-wave rectifier that actuates a sensitive dc microammeter.

antenna feedlines

I believe it's self-evident that there's no such thing as a perfect antenna. This leaves the ham with a choice of alternative compromises. He can erect a dipole antenna, which seems to be the most popular on the four lower-frequency amateur bands. Then comes the decision as to the best method of feeding the dipole. More and more hams are using RG-8/U 50-ohm coaxial cable. The reasons are low cost, trouble-free service, and high efficiency.

The low impedance of RG-8/U dictates a current-fed system. It's well known that the feedpoint impedance of a half-wave dipole is closer to 70 than 50 ohms. This means that a mismatch will exist between the feedline and the antenna, which is a starting point for a whole series of loss parameters.

cut-and-try matching

One of the usual ways of compensating for the mismatch between 50-ohm line and the antenna feed point impedance is to start cutting the line, which may partly reduce mismatch loss to a minimum. Another method is to use some type of matching device between transmitter and antenna so that the transmitter is looking into the terminating impedance for which it was designed. This involves added expense, so the average ham uses the cut-and-try approach until the transmission line electrical length is close to a half-wavelength or multiple thereof at the operating frequency. When this condition is met, the transmitter will load properly.

All the cut-and-try matching method does is improve the transmitter-to-line match; it does not improve the impedance match between transmission line and antenna. Transmission lines with a characteristic impedance of 70 to 75 ohms present a better match to a dipole, but this line is more expensive for the maximum legal power. Therefore, most hams use the more inexpensive 50-ohm cable and live with the consequent impedance mismatch.

Any mismatch – at the antenna or transmitter or both – can be indicated to a varied degree by an swr meter, which is generally inserted between transmitter and the load. When the swr meter indicates a 1:1 ratio, this means that the transmitter is presented with a load whose impedance is equal to that of the transmitter output circuit. It *does not* necessarily indicate that the transmission line is matched to the antenna.

matching at both ends

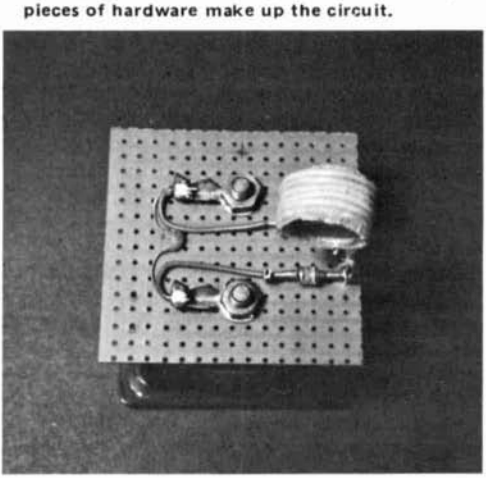
How then, you might well ask, can one tell how closely the feed line is matched at the transmitter *and* the antenna? Merely by building and using the swr indicator described here. Because this instrument will indicate the standing wave ratio at any point, and therefore at *all* points along the feedline, it is much more useful than the ordinary swr bridge/indicator usually employed.

If you doubt what I'm saying, just take that swr bridge you've purchased and insert it into your transmission line at various distances from your transmitter by adding lengths of line, and you'll see immediately what I'm trying to put across. You'll find that the swr meter reads differently for each length of cable added. If it doesn't, pat yourself on the back, because you have a near-perfect impedance match between your rig and the antenna.

construction

The swr indicator is simple to build, as the photo shows. Total cash outlay for parts will be somewhere between $5.00 and about $14.00, depending on how much you want to spend for the most expensive component – the microammeter. A complete parts list is provided in **table 1.**

Business end of the simple swr indicator. An inductor, diode rectifier, and a few simple pieces of hardware make up the circuit.



The coil is constructed with no. 14 dcc wire. Six turns are wound on a ¾-inch-diameter dowel, with one layer of Saran wrap between wire and form to make coil removal easy. A coat of polystyrene dope is then applied to the coil to make it rigid.

A 20-microamp meter makes a sufficiently sensitive indicator, which will indicate currents as low as 1 microamp – sufficient for very low-powered transmitters.

I used a 1N34A diode rectifier, as it

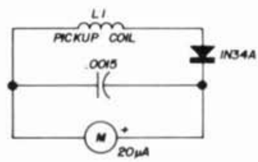


fig. 1. Circuit for the simple swr indicator. L1 consists of 20-inch piece of no. 14 double-cotton-covered wire closewound on 3/4-inch form.

exhibits little frequency sensitivity from the lowest ham band to 250 MHz. Sufficient indication was obtained on all bands, so no tuned circuit was used. However, the sensitivity can be increased for one particular frequency by connecting a variable capacitor across the coil.

The coil and diode were mounted on a piece of perf board, which was mounted directly onto the two machine screws at the rear of the meter. Watch the rectifier polarity – the positive end is connected to the positive side of the meter, and vice versa.

The only other component is a 1500-pF ceramic capacitor mounted across the meter terminals to bypass rf around the meter movement. The current is small, so solder well.

operating principles

Quite heavy current flows in the center conductor of a coaxial cable. The same current also appears in the outside braid. The only difference is that the current is concentrated in the inner con-

table 1. Parts list for the inexpensive swr indicator.

quantity	Component
1	20-microampere meter
1	1N34A diode
1	.0015 μF ceramic capacitor
1	perf board, 2-3/4 in. square
2	meter connecting lugs, washers
3	.065-in. connectors
1 length	no. 14 dcc wire, 20 in. long polystyrene coil dope 1 x 2 in. plastic sheet solder and hook-up wire

ductor but is diffused to a great extent in the outer braid, which is capable of conducting about ten times the current in the inner conductor. However, the same amount of current is carried by the braid. It is this diffused, very minute current, that is indicated by the swr meter.

using the instrument

The outgoing current and any reflected current in the feedline will add and subtract in the feedline to form nodes (high current) or near-nulls (low current) at various points, which are generally unpredicatble. Sometimes a device called a transmatch is connected between transmitter and feedline to reduce the difference between these two currents; *i.e.*, to tune the line. Such devices introduce some loss into the system.

The swr indicator described here is not an in-line device. It is slipped over the transmitter-end of the feedline, and the feedline reconnected to the transmitter. The transmitter is then turned on, but not keyed. Then, while the indicator coil is held in one spot on the line, the transmitter is keyed for length of time to make one dot. The meter should show an indication. The procedure continues as follows:

> Slip the device along the cable a few feet, and again key a dot on the transmitter. This reading will probably be higher than the first. Either way, it will indicate a standing wave on your feedline.
>
> Mark the feedline at one-foot intervals as far as possible with a light-colored crayon. Generally, there will be from 6 to 15 feet of line inside the shack that you can so mark. Move the coil along the line, key the rig and record the data. At one point you'll get a maximum reading, either side of which the indication will decrease. At another point on the line you'll get a minimum reading, either side of which the reading will increase. In my case, a node and null were obtained in just 6 feet of line, so I knew I had a high swr. If your swr is low, you may have to move the device along the line a greater distance to determine where node and null occur.

determining swr

Once you have recorded the readings on the meter, merely divide the lowest into the highest reading. The quotient is a sufficiently accurate indication of swr for most ham purposes.

My feedline runs outdoors parallel to the ground for about 20 feet before heading up to hang at a right angle to the dipole. I used a coat hanger bracket to hold the meter onto a wood pole; this arrangement was slid along the cable to take additional readings. I obtained the same node/null readings as on the indoor section of line, so this procedure may not always be necessary or convenient. These indications, of course, occurred at distances further apart at 40 meters than on the higher bands.

conclusion

If, by chance, your swr is *really* low; i.e., very close to unity, this fact would be immediately obvious due to the very slight difference in meter readings over a quarter-wavelength of line at the operating frequency.

The main advantage of this little device over an in-line instrument, such as the swr meter, is that no insertion loss or mismatch occurs between transmitter and load. Such loss may be significant at certain frequencies and power levels.

ham radio

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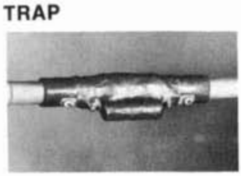

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More Details? CHECK—OFF Page 94

fire protection

in the ham shack

With a few simple precautions the electrical and fire hazards in your shack can be minimized

Jack Darr and Alan James

Hot rocks and hot receivers are fine to have around the ham shack, but not when they are caused by a "hot house" – in other words, *fire.* Wherever there's electrical gear, there's always the chance of fire. Furthermore, there is always other fire-prone stuff either in use or lying around the busy shack.

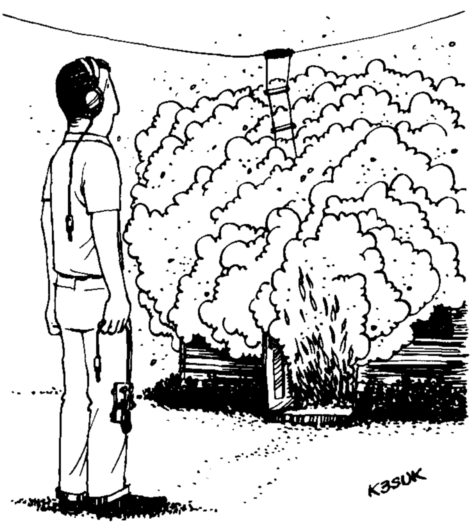
It shouldn't take much talk to convince any serious ham he should make a fire-safety check at regular intervals. The only trouble with this plan is that many fire-prevention precautions are so darn simple that they get overlooked. Let's look over some of the commonest hazards, and work up a check list to keep from missing any.

electrical fires

Hams have a special problem. A fire in the ham shack is always likely to be or become an electrical fire, because there is always electric power around. This situation demands special precautions. You can't just pick up a bucket of water and heave it on. (Assuming normal equipment in your shack includes a bucket of water – mildly unusual for a radio station, you must admit!)

First, what is an "electrical fire?" Well, it always begins with an arc. When insulation breaks down, or the applied voltage is too high for the insulation, an arc "happens." Temperatures in even a tiny arc get pretty high – up into the thousands of degrees.

The heat can melt ordinary insulating



Fuse it . . .

material, crack ceramic insulators, and raise the dickens in general. It can even make insulators into conductors, by carbonizing them! Phenolic and similar insulators turn into carbon when they're burned, and away we go with more arcing. Carbon encourages the arc, which gets hotter, which carbonizes more of the insulator, and so on and on. The heat generated melts other insulation on nearby wiring – which can start still more arcs. You can wind up with a real mess.

You could build a chassis that is absolutely fire-safe, if you want to. Glass-insulated wire, ceramic insulators, chassis coated with Teflon, and liquid asbestos sprayed over the whole thing . . . all would help, but would skyrocket the cost and be a lot of trouble. There's an easier answer – just give the thing better protection. If you can stop an arc as soon as it starts, you're in; the unit will easily keep its own cool. One way is simply by removing the power.

fuses as friends

The easiest way to stop an electrical fire is to keep it from getting started. What that boils down to is fuse protection on *all* electrical equipment in the shack! You might have the dangerous idea that "Aw, what the heck! It's only 110 volts!" That little ol' 110 volts has all the current available it needs to burn your shack to the ground. Current is what makes an arc so hot and destructive. (An arc-welder puts very low voltage on its electrodes, but the dozens of amperes that flow in them can melt steel.)

Fuses are affected mainly by current. The voltage rating you see on a fuse is put there so you won't use it in some circuit where the voltage is so high that an arc could form *across the fuse* after the fusible wire inside has melted. The principle of correct fusing is: use a fuse that can carry the normal current load, but will open up instantly whenever there is a serious current overload (such as caused by an arc).

There are also small circuit breakers, which do the same job of protection. Chassis-mount circuit breakers come in ratings from 0.325-amp up to 7.0 amps. The kind that go in the ac line range from 5.0 amps to any size you need. However, the small ones will protect ham gear.

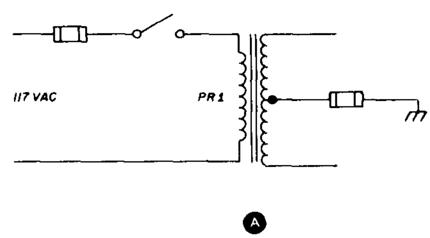
So, there's the first point for your fire-prevention check check list. Make sure every piece of gear in the place, down to the soldering iron, is protected by fuses of the right size! When you build anything, even kits, if the designer didn't use fuses where he should have, you add them! There is a simply amazing number of units that have no protection at all, or not enough.

The diagram in **fig. 1A** shows two *places where they'll do the most good.* If your rig uses the popular bridge rectifier circuit as in **fig. 1B,** the secondary fuse is best put in the dc output circuit. A short in one of the rectifiers or filter capacitors would have to blow the primary fuse.

You need to know only one thing to add a fuse: how much current the equipment draws normally. Add a little safety

is flowing (automatic Ohm's-law computer). On factory-built gear, there is a rating-plate, usually near the line cord. Divide the wattage by 115 to calculate the primary current.

If you have some piece of gear that needs a fuse, but the chassis is so crowded it would be hard to mount, try a "fusible plug" on the line cord. A pair of glass cartridge fuses, which can be any size from ¼-amp up to 20-amp or more, fit into push-in clips. To replace a blown fuse, you just push it out of one end with a stick or kitchen match, and push the new fuse in.



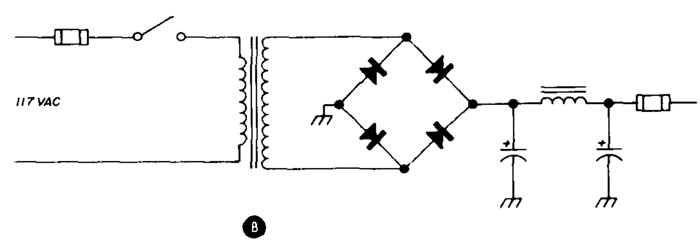


fig. 1. Methods of fusing power supplies.

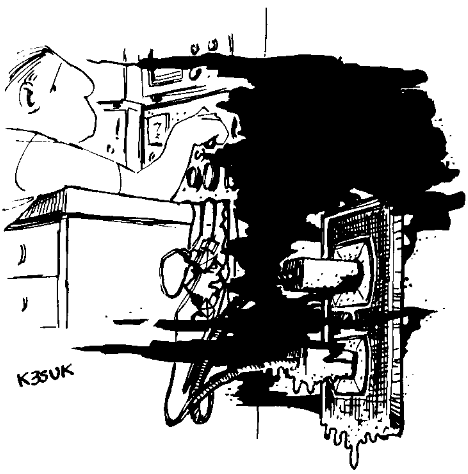
factor of about 50%. Up to about 10 amps, the fuse rating can be about double the normal current; in the higher values, up to 15 or 20 amps, use a smaller margin.

To find out normal current for a B+ fuse, insert a dc milliammeter at the point where the fuse is to be connected. Primary fuses aren't that easy to figure, since ac ammeters aren't common. Easy way: hook a 1-ohm wirewound resistor (big watts) in series with the primary, and read the ac voltage across it with the equipment operating at full load. A 1-volt drop means 1 amp of alternating current

So, the fuse is your answer. You can't usually clear a short once the arc has started, so you had better get power off that circuit as quickly as you can. The best way is with a fuse. Without current, the arc must stop. Result: *no more fire hazard.*

behind the wall outlets

An important factor in fire safety is the ac wiring. If you live in a house more than 20 years old, look it over. The fixtures (outlets, switches, etc.) used then weren't as good as those now. Besides, they're 20 years old. Wall outlets and receptacles *were* rated at about 600 watts, which isn't much today. Plug in a big transmitter, a receiver, and a soldering iron, and you've had it.



Plug in a big transmitter, a receiver, and a soldering iron, and you've has it.

So what happens? The contacts (even if they're bright and clean, which they're not) get hot. This makes them tarnish, which makes them get hotter, which makes them get dirtier, which makes them . . . (sound of fire sirens approaching).

Modern outlets have a minimum rating of 15 amps, or 1800 watts, and you can buy 20-amp types for practically the same price. Contacts run cool.

The ac wiring in old houses is often only number 14 solid, which is not very heavy. Maximum current it can safely carry is a measly 4.6 amps. More than that makes the wire get hot. And there you have another fire hazard.

The shack can have surface-type fittings, with Romex cable along the surface of walls or floor, on the underside of the operating bench, etc. However, be sure the wire can carry your maximum load – and then some.

Don't start heavy shack-wiring at an existing outlet-box. This is worse than useless; it's dangerous. If you tap a wall outlet that happens to be at the end of about 50 feet of number 14 wire, you can heat up the old wire with the overload. If special ham-shack wiring is installed, go all the way to the main breaker-box or load-center, and run new heavy wire from there.

If you have a big rig, say a full-gallon transmitter plus a good-sized receiver, those babies are going to draw a pretty good hunk of current. With a kilowatt of rf coming out, the transmitter alone can use up 2000 watts. The receiver takes another 150 - 200. That's crowding even the best modern outlets.

It would be better to run a special line right into the transmitter cabinet. A pair of standard home-type circuit breakers (one in each side of the line) can mount on the back of the cabinet in a neat metal box. You can also use them as a master switch when you want to work on the transmitter.

the lightning hazard

Lightning is a fire danger you can't always do a whole lot about. With that nice, big four-element "lightning-rod" sticking up outside, you're apt to get a shot once in a while. The basis of all lightning protection is keeping the hot stuff outside the building and shuttling it off to ground as quickly as possible.

Thing number 1 is a good lightning arrester. You can't actually "arrest" lightning, but you can "steer it" some place where it will do the least damage, and where it won't set the place afire. An arrester carries the energy off to ground by providing an easy path for it. The connection from arrester to ground had better be short, heavy, and direct. A too-small ground wire will simply vaporize if it gets a solid hit.

The coaxial transmission lines so popular now are safer than older open-wire lines. You can make a good lightning arrester from the cable itself. Carefully slit the outer jacket, near where the line enters the building. Turn the insulation back, and wrap 8-10 turns of clean, heavy, bare copper wire snugly around it. Don't solder it; you'll melt the plastic insulation. Cover this with at least two layers of tightly wrapped plastic tape, and spray the outside with a couple of coats of an acrylic plastic like "Krylon Clear." Run the other end of the copper wire *straight down* (don't make sharp bends in it) to an 8-foot ground rod, driven all the way in.

For open-wire transmission lines, a wide-spaced spdt knife switch can be used to disconnect the transmitter and ground the antenna when you're not around.

Even with these precautions, a direct hit can wander all over your incoming leads and wires. To minimize the chance of a fire starting, run all transmission lines well away from wooden walls, drapes, and any flammable materials. Even a coaxial transmission line can get very, very hot if it's carrying a lightning surge.

. . . an 8-foot ground rod driven all the way down.

(We've seen coax line welded to a 100-foot tower, all the way up!)

A system of good grounds is one of your best lightning-damage preventives inside the shack. Run a good, heavy wire from your transmitter cabinet (receiver, cabinet, too) over to a good ground – cold-water pipe if you must, but the deep rod outside is better. Upstairs shacks must use a very heavy ground cable; you can often get pieces of stranded pole-guy cable from the power company.

A surprising amount of energy is floating around on the ac power lines when you get smacked by lightning. So, proper-sized fuses can do a lot to protect your stuff. With a direct hit, the fuses will vaporize instantly (and the fuse-holder may, too – wait till you see a 2-pound ceramic fuse-holder blown to powder!). However, when they go, they'll leave the circuit open, and there won't be so much likelihood of arcing from the hot powerline to start fires.

diverse dangers

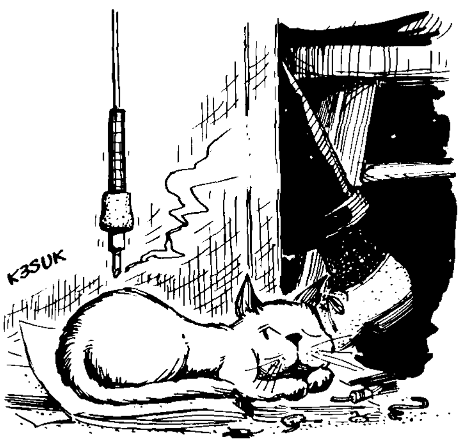
Watch the common things you're apt to forget. Take the soldering iron. It's handy and all that, but it does get plenty hot. Put yours on a heavy stand that can't tip over. A stand with a screen or mesh cover over the barrel is best. Keep rags or scratch-paper away from the barrel of the iron. Be a good housekeeper, and you'll be much more fire-safe.

Now and then you have to use chemical compounds to clean things around the shack. Switches and such things get dirty, and you have to police-up so they'll work again. Be darn sure the cleaner is fireproof. Nobody in his right mind would use gasoline for this, but lighter fluid can be just as dangerous. A little vapor . . . a spark . . . and BOOM.

Carbon-tet is fireproof, but the vapor can make you pretty sick. The safe stuff is the spray-can cleaners. They're nonflammable, and there are no noxious vapors. Also, they do a better job of cleaning.

If your shack is in its own separate little building, a gas stove for heating can be dangerous, especially the open-flame type without a vent to the outside. Check the connecting hose at the gas outlet often, to make sure there's no leak. Natural gas is bad enough, but bottle-gas is worse in one respect: It's heavier than air. If there's a leak, a layer of gas forms from the floor up. When the layer gets high enough, any spark (like turning on the shack lights) can set it off. Then, if you don't have a fire, you may have an air-conditioned shack – no windows, and maybe no door (and probably no roof).

Heating gas is odorized so you can smell a leak. So, if you think you smell a skunk when you walk in, keep your



take the soldering iron . . .
it does get plenty hot.

fingers off the switches until you find out what's causing the smell.

if prevention fails

We've mentioned the most likely conflagration-commencers, and how to keep them from starting a fire. What do you do if a fire suddenly blazes up anyway? Easy – grab your fire extinguisher and pour it on. That's fine, but . . . be darn sure you grab the right kind of fire extinguisher! The wrong kind can get you killed.

If there is any electrical hot stuff in or near the fire, and there probably will be somewhere, *DON'T* use a soda-acid, a foam, or a carbon-tetrachloride extinguisher.

The soda-acid types are those old ones you see hanging on the walls with a hose on top. You turn them upside down to spray the fire. The solution in them is mostly plain water. You can figure out what can happen when a half-inch stream of conductive water hits a live 2,000 volts, with you hanging onto the metal case. You'd better hope you're standing on dry rubber.

The foam types contain mostly water mixed with special chemicals. The popular carbon-tetrachloride types are okay if you're out-of-doors. Carbon-tet is a very good fire-extinguishing fluid, but when it strikes a hot fire, the fumes are deadly poison! They are phosgene, the toxic gas used during World War I. In a small room, and most ham shacks are small, it can put you off the air permanently in just a little while. So, don't use carbon-tet in the shack, unless you have time to stop and put on a gas mask!

There are three types of extinguishers recommended for use on electrical fires. The best known of these is the CO_2-type . . . or "fogbottle," as some people call them. (Don't confuse it with what a fireman calls a "fog nozzle" which is a special hose-nozzle that sprays plain water in a very fine mist.) The carbon-dioxide gas smothers a fire by keeping it from getting enough oxygen to burn. It is harmless to humans.

The second type is a dry-powder extinguisher, which uses plain bicarbonate of soda as the fire-snuffer. The powder is often packaged in long paper tubes; you tear off the cap and toss the powder at the fire. Better ones are pressurized, and spray the powder on the fire.

Freon gas, the propellent in most pressurized spray-cans, is used in another electric-safe extingusher. Freon provides its own pressure so is easy to spray at the base of the flame. It works just like carbon-tet, but does not liberate toxic fumes.

You can buy any of these three extinguishers in supermarkets and drug stores, in 1- and 2-pound capacities. These sizes are not recommended for big fires. The fire chief will tell you the best sizes are 5- and 10-pounders. These will put out most fires completely, even though they have a good start.

fire alarms

If you're in the shack when a fire starts, you can combat it instantly. If something heats up while you're out of the shack, that's different. Some kind of automatic fire-alarm system can give you a warning that action is needed and needed right now!

The alarm itself can be a loud bell or anything else with an unmistakable sound. It can be ac-powered, or have a battery if you want a fail-safe system. You can rig up a little charger across the battery.

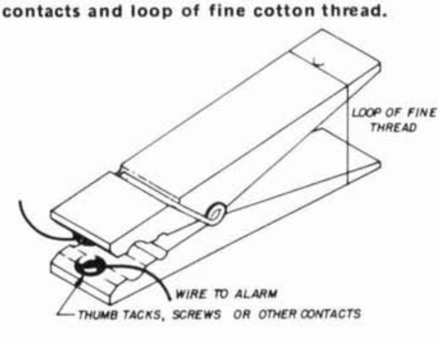
You'll need some kind of sensors that will detect heat, flame, or smoke. This can be done in dozens of different ways. You can have a lot of fun thinking up gadgets that will detect fire.

Heathkit GD-77 receiver alarm sounds high-pitched electronic tone when actuated by GD-97 transmitter.

One of the simplest is shown in **fig. 2.** It's a clip-type clothespin swiped from the clothes-washing department. Put a couple of thumbtacks in the jaws for contacts. Then rig up something to hold it open until it senses fire. Years ago, a small loop of celluloid movie film was used, which burned instantly. Modern plastics aren't too good; most are fireproof. However, a loop of fine thread is okay. Use just enough to hold the jaws open against the spring tension. This thread will burn open almost instantly; test it to make sure.

Transistors are heat-sensitive, some amazingly so. When a transistor's temperature goes above a certain point, it will conduct heavily, often going into ava-

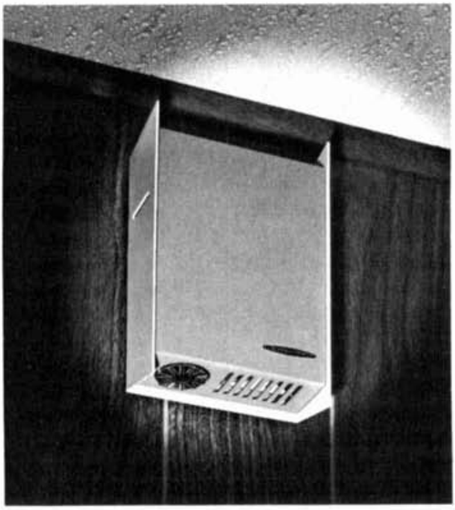
fig. 2. Simple heat sensor consists of household clothespin, thumb-tack contacts and loop of fine cotton thread.



FIRE-PROTECTION CHECK LIST

1. Electrical
   (a) Does all equipment have fuses?
   (b) Are they small enough to give real protection?
   (c) Is all wiring heavy enough to carry its normal load without heating?
   (d) Are all outlets and switches in good shape — not dirty or loose?
   (e) Is the radio gear fully protected by suitable lightning arrester?
   (f) Are your fire extinguishers the correct type for use on electrical fires?

2. Housekeeping
   (a) Is the shack neat?
   (b) Are papers, old magazines, or other flammable materials stacked around in corners?
   (c) Worse still, are they stacked right on top of hot electrical equipment?
   (d) Is the workbench soldering iron protected against rags or paper falling on the hot barrel?
   (e) Is the wastebasket made of fireproof metal or of meltable plastic?
   (f) Is the wastebasket full, running over, or kept nearly empty?
   (g) How are the ashtrays? Full? Clean? Big enough for a long rag-chew?

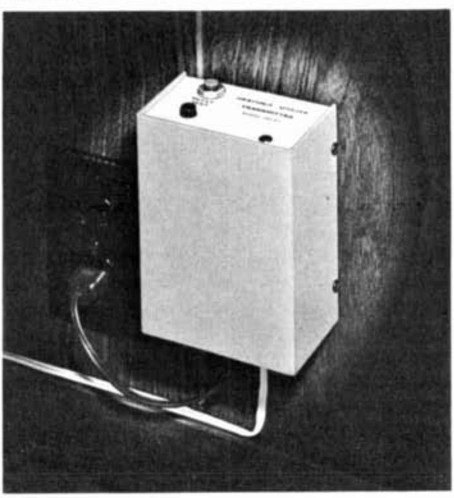


Heathkit GD-87 smoke detector actuates if smoke or 133° F heat is present.

lanche. You could connect the transistor across the input of a small dc-coupled amplifier. A change of resistance in the sensor transistor will trigger a stage that closes a relay.

Thermistors could be used, fastened to parts that might overheat. A bridge circuit will respond whenever the thermistor's resistance goes down as its temperature rises.

Heathkit GD-97 utility transmitter accepts any type switch or sensor to detect hazard you wish to guard against.



Smoke detectors can be simple: an amplifier circuit with a phototransistor at its input. Mount a pilot light to shine on it through a small light-tight tube. This setup is put just above any equipment where fire might start. If smoke comes up the tube, it will cut down the amount of light falling on the cell; this changes the cell resistance and . . . ding-a-ling-a-ling!

For maximum protection, make your system fail-safe. Design it to react, tripping the alarm, if its power supply or any of its parts fails. The principle is simple. Use a normally closed relay, and design the system so the relay is pulled in – energized – in the cool condition (no fire). If fire is detected, current is cut off and the relay drops out (closing the contacts). If the power-supply fails, or one of the amplifier parts should blow – same thing. No matter what happens, the relay armature is released, and the contacts close, sounding the alarm. The alarm bell must have its own separate battery supply, applied by the relay.

Ham ingenuity will bring out many other ways of doing this important job. Just look for some kind of device that responds to heat, or to smoke, and there you are. If you don't like to design things, there's a kit available from Heath Company; you can see it in the photo. It is wireless and has several kinds of sensors.

do it now

There are wise sayings we could finish with, like: "Don't throw lighted matches into the wastepaper baskets full of old message blanks." But this is kid stuff. If you're not smarter than that, you haven't read this far.

There is a surprising amount of unprotected gear around the average ham shack, if you get right down and look for it. When you find something like that, add the needed protection. It won't take long, it won't cost much, and the peace of mind will more than make up for it.

ham radio

mosfet converter for receiver instrumentation

The Heathkit SB-610 monitor scope can be used in the receive mode with this circuit

Robert A. Schiers, Jr., WA9ZMT, 5522 Laurel Hall Drive, Indianapolis, Indiana 46226

An old saying is that necessity is the mother of invention. In this case the adage is quite precise. I own a Drake TR-4 transceiver and wanted to use a Heathkit SB-610 monitor scope to observe signals in the i-f passband of the TR-4 receiver section. However, the TR-4 i-f is 9 MHz, while the vertical amplifier in the SB-610 is only capable of responding to signals up to 6 MHz. This article describes a simple local-oscillator/mixer I built to put the TR-4 receiver i-f passband where the SB-610 could handle the frequencies involved.

The SB-610 verticle amplifier has a peak sensitivity of 70 mV/inch (rms) of the vertical deflection if the vertical amplifier is tuned to 455 kHz. This is in contrast to 600 mV/inch at 6000 kHz. A mixer is obviously needed, and, as can be seen by comparing sensitivities, 455 kHz offers the best response.

A tube-type mixer involves cumbersome components for heater and plate power. I, therefore, decided on a transistor mixer, which requires only a small battery.

conversion gain

A conventional bipolar transistor mixer, operating in the driven-emitter configuration, requires substantial drive from the local oscillator. Furthermore, this circuit gives conversion gain. Conversion gain is defined as

$$\text{gain in dB} = 20 \log_{10} E_{out}/E_{in}$$

where

E_{out} = converted-frequency output voltage

E_{in} = amplitude of the voltage to be converted as presented to the mixer transistor base

After reading some articles on the dual insulated-gate mosfet mixers, I decided that this device fulfilled the goals of this project; i. e., simplicity, light loading of the local oscillator by the mixer, and a conversion gain of up to 18 dB.

the circuit

The converter schematic is shown in **fig. 1.** The LO signal is applied to gate 2 of the 3N159, which must be biased to 4 volts by the divider across this part of the circuit. Both gates of an igfet present a very high impedance to the driving signal, usually of the order of 100k ohms. The rf signal to be converted is applied to gate 1, where no special biasing is needed. However, this gate is tied to ground through a high resistance to protect the device from static charges or transient voltages.

The 3N159 drain contains two 455-kHz i-f cans. The first i-f can is in the drain to present a high impedance to the converted signal. The other i-f can is used to match the low-impedance output of the first i-f can to the high-impedance input of the tuned vertical amplifier of the SB-610.

* The LO may be obtained from International Crystal Manufacturing Co., 10 North Lee, Oklahoma City, Oklahoma 73102. The type OX in kit form is about $3.00. Crystals for any frequency can be ordered for about $4.00. The 3N159 is available from Allied Electronics, 100 North Western Ave., Chicago, Ill. 60680. Cost is about $2.00 in small quantities.

local oscillator

The diagram shows a typical circuit available from International Crystal.* The oscillator is specified for 0.2 volt across a 50-ohm load. The obvious impedance mismatch is unimportant in this application, because distortion and power transfer are not an issue when trying to obtain a voltage swing across such a high impedance as that presented by the igfet gate.

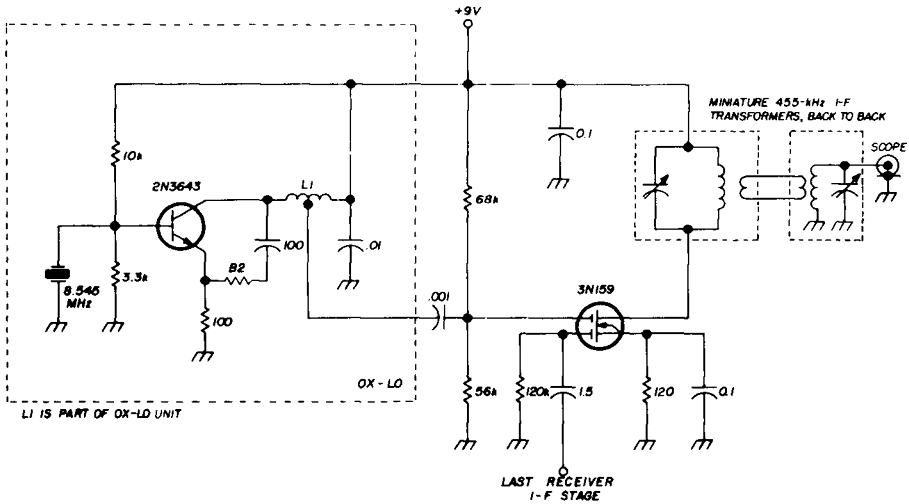


fig. 1. Schematic of the 9-MHz to 455-kHz i-f converter for driving a Heathkit SB-610 monitor scope in the receive mode. The igfet mixer provides 18 dB conversion gain with very low injection voltage.

construction and operation

Construction is not at all critical, nor is the supply voltage. The conversion frequency can be changed easily by tracking the LO frequency 455 kHz below the incoming rf signal. I varied the voltage applied to both the igfet and the oscillator from 4 to 9 volts without any degradation of signal quality or amplitude. Current drain varied from 12 mA at 4 volts to 40 mA at 9 volts. The voltage for the 3N159 can be varied anywhere between 5 and 9 volts with no noticeable deterioration in output amplitude or quality.

The current drain for the entire circuit is approximately 40 mA, depending on supply voltage. Despite the impedance mismatch, no problems were encountered in driving the very high impedance of the 3N159 gate.

The coupling capacitor from the plate of the last i-f stage in the receiver was selected for the smallest value necessary to ensure adequate display height on the SB-610.

The reason for the dual 455-kHz i-f transformers was based on impedance-transformation considerations. The minature transformers available to me had a high-impedance input with a low-impedance output, whereas the input of the SB-610 is about 100k ohms.

precautions

The igfet comes with a shorting clip that connects all leads together. This clip should be left on the device until it is placed in the circuit. Don't allow your fingers to come in contact with any part of the device except the case during installation. A small piece of solder can be wrapped around all leads, then the solder can be removed after installation.

final observations

The RCA 40673 dual-insulated-gate mosfet is zener-protected and may be directly substituted for the 3N159 *in this circuit.* Such substitution is highly recommended, as the special-handling problem of the device is eliminated.

If at any time you think you may have damaged the 3N159, the device can be easily checked. With a drain voltage of 10 volts and 120 ohms in the source; and with both gates tied to ground through a high resistance (100k), a drop of a few tenths of a volt should be observed across the source resistor. In addition, if gate 2 is biased up 1 or 2 volts, the current will rise sharply to 4 mA or greater, depending on source resistance and drain voltage. Note that the characteristics described pertain to *n-channel depletion-mode fets* only!

I'd like to express my thanks to Leo Bovard, W9SCK, for his help in the development of this project.

ham radio

a simple cw monitor

James Wiesmueller, WA9OHR, 315 East Freistadt Road, Thiensville, Wisconsin

Did you ever try to send code without using a cw monitor? To have consistently good sending characteristics without a monitor is like trying to drive an automobile blindfolded. Hundreds of articles on cw monitors have been published, but many of them are elaborate in design and expensive to build. The "minimonitor" is quite the opposite – it's the ultimate in simplicity. It costs pennies to build, is extremely reliable, and has a clean, pleasant-sounding tone.

The complete circuit is shown in **fig. 1**; components are mounted on a 1¼" x 2¼" circuit board. Although I use the mini-monitor with an automatic keyer, it can easily be used with straight or semiautomatic keys. It can also be used as a code practice oscillator; volume is sufficient for group listening.

Perhaps the most desirable features of the minimonitor are its small size and easily obtained components. It is small enough that it can be built into practically any keyer already completed by fitting it into a convenient space.

Choice of parts is not at all critical. Virtually any npn and pnp transistors can be used. The capacitor value can range anywhere from .01 to .05 μF. The resistor depends upon the desired tone. The diode is not critical; I used a 200 PIV unit. If you want, a 50k potentiometer can be used in place of the resistor to provide variable tone adjustment. Power to the unit may range from 3 to 6 volts,

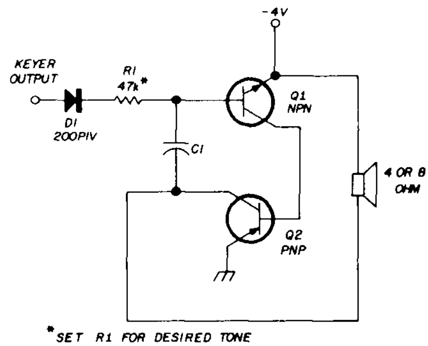


fig. 1. Schematic diagram of the simple cw monitor. Capacitor C1 is 0.01 to 0.05 uF.

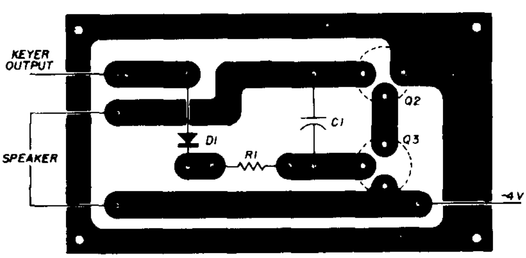
and any small 4- or 8-ohm speaker may be used.

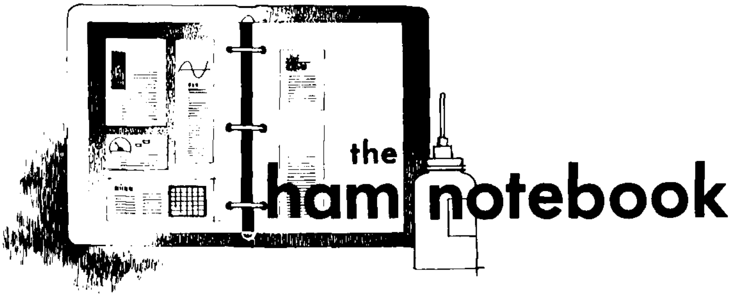
If you're skeptical about using the minimonitor, dig the parts out of your junkbox and connect them on top of the kitchen table. With a small 4.5-volt battery for power you'll get an idea of how the oscillator sounds. You'll also be able to select parts for the circuit board since tone quality depends on component choice.

Few amateurs realize just how simple a keying monitor can be until they get down to the basic principles of the more elaborate types. The simple minimonitor described here will provide trouble-free service for the life of the keyer, and help you develop and maintain a good "fist."

ham radio

Printed-circuit board for the simple cw monitor.





testing unknown meters

A typical 10-megohm or higher vtvm is an excellent tool for testing unknown meters to determine their approximate current ranges without the danger of pinning the needles or burning out the windings.

Set the vtvm to OHMS and the range dial to R x 1 MEG. Connect the test leads to the unknown meter. Move the range dial, one step at a time, through R x 100k, R x 10k, etc., until the meter under test reads upscale.

The maximum current through the meter from a typical 10-megohm vtvm (Lafayette KT-174, for example) is as follows:

range	I max	vtvm 1% series res.
R x 1 meg	0.156 μA	10 meg
100k	1.56 μA	1 meg
10k	15.6 μA	100k
1k	156.0 μA	10k
100	1.56 mA	1k
10	15.6 mA	99.1*
1	170.0 mA	9.1*

*0.9 ohm is allowed for the internal resistance of the D cell and test lead.

The effect of the meter resistance on the first four ranges of the vtvm is usually negligible. Don't try this idea with a vom. The currents will almost surely be much greater than those shown above, and the meter being tested may be destroyed.

Harold E. Brown, W1ONC

adjustment screwdriver

Many transceivers have internal adjustments for the S-meter, final-amplifier bias, carrier null, etc. Trying to get a screwdriver into these adjustments through the perforations in the cover is next to impossible. Here's what I use.

I fashioned an ordinary wire coat hanger into an adjustment tool by clipping the hanger about 1½ inches each side of where the Y is formed. Then I straightened this section until it was perpendicular to the hook. Next, I straightened the hook and filed the end until it was flat enough to fit into the transceiver adjustment slots. The finished tool should have the appearance of a T.

The tool is small enough and long enough to go through the holes in the transceiver cover, and it is strong enough to withstand the torque of some of the more stubborn adjustments. It's also handy for tapping those sticky change-over relays that hang up once in awhile.

Dan F. Davis, WAØKGS

75A-4 modifications

To anyone who has owned and cherished a 75A-4 receiver for many years, as I have, the discovery that it has developed sensitivity and frequency-stability problems is like discovering a trusted friend to be unfaithful. Here are some solutions to these problems, plus a hint to improve the receiver's audio response.

insensitivity

Loss in sensitivity first appeared as a loss of one or two S-units after about an hour of operation. (I use the "calibrate" signal as a sensitivity reference for a specific S-meter reading at 14.2 MHz, with a 50-ohm dummy antenna.) Sensitivity loss gradually increased until it was 6 or 7 S-units after 15 minutes of operation.

After several frustrating weeks of signal tracing and a new set of tubes, I was about to give up when I stumbled onto the answer. The "rejection tuning," which is a bridged-T filter, has a sharp, deep null when properly adjusted. I noticed that when the set was first turned on, the "rejection tuning" behaved normally, but after warmup the null deteriorated and finally became useless. It seemed as though a comparitively low resistance was across the bridged-T inductor, L26.

The schematic shows one-half of V7, the Q-multiplier tube; some resistors; a choke; and C71, a 1000-pF capacitor in series across this inductor. Checking with a vtvm between ground and either side of L26 showed a *positive* voltage, which varied between 2 and 5 volts. I disconnected C71 from the inductor, but left the other end connected to the plate of V7 (and hence, B+). When I touched the vtvm probe to the free end of C71, I found the positive voltage to be even higher and still varying.

I checked other grids in the receiver with the vtvm and found four other leaky capacitors. When these were replaced, the sensitivity problem cleared up completely. A vtvm must be used, however. A 20k-ohms-per-volt vtvm simply shorts the leaky voltage to ground and gives no indication.

probable cause

When checking for leaky capacitors the set must, of course, be on and the rf gain control positioned fully clockwise. If the rf gain control is backed off, the higher bias voltage will swamp the leakage voltage on some of the grids. I can only conjecture as to the cause of the capacitor leakage; but my friend Ray Wood, W9SDY, suggests migration of the silver coating on the mica. Until a better explanation comes along, I'll accept Ray's theory. Migration is supposed to accelerate in the presence of a dc voltage. However, some unused mica capacitors of the same type and vintage showed leakage to some degree; new units showed no leakage at all.

frequency instability

The frequency instability problem became evident in exactly the opposite manner. The pto frequency jumped around for about ten or fifteen minutes after the set was turned on, then settled to its usual rock-steadiness.

According to an article in *QST,*[1] instability in the pto can be attributed to several factors, including capacitor C205, a 51-pF mica of the same type as those giving sensitivity problems. When I originally read the *QST* article, I assumed C205 might be changing value. However, after the previous experience with leakage, I found that a vtvm check between pin 1 of V15 and ground showed the telltale positive voltage.

After the set had been on for 10-15 minutes, the positive voltage disappeared, and the pto became stable. I suspect that, since a current flows through the capacitor when the pto is operating, the leakage path burns off after several minutes, then regenerates when the set is turned off. At any rate, the pto remained stable after installing a new capacitor for C205.

audio response

I became increasingly annoyed by an emphasis on the bass of the audio response as both the 75A-4 and I grew older. I realize that as we grow older our ears become less sensitive to the higher frequencies, but retain their response to the lower frequencies, thus accenting the bass.

A newly acquired audio generator provided the opportunity to check the 75A-4 audio response. A surprisingly high peak (10 dB) appeared at 100 Hz, which decreased sharply on either side, to a level output between 300-3000 Hz.

Reference 1 suggested that feedback resistor R71 be removed. I tried this when I first read the article, but I didn't like the increase in audio, which required riding the af gain control; nor did I like the unpleasant audio quality.

The audio-signal generator showed that, with resistor R71 disconnected, the 100-Hz peak disappeared and the entire audio response became a broad peak centered around 3200 Hz. Substituting a 100-k resistor for the 33k originally used for R71 eliminated the objectionable 100-Hz peak and smoothed the entire audio response. A 1-meg resistor in series with the af gain control improved its action.

less bass response

Another source of bass emphasis is the cathode network associated with the noise-limiter diode, V 12. Since the limiter is useless for cw and ssb, I removed V 12 and inserted the leads of a 0.005-μF capacitor into the tube socket (holes for pins 2 and 7). This connects the detector output directly to the af gain control and eliminates the cathode network. If you would like even less bass, use a 0.001 μF capacitor.

reference

1. P. Rockwell, W3AFM, "Station Design for DX," *QST,* November, 1966, p. 53.

Albert G. Shafer, W4SD

new products

heathkit wattmeter/ swr bridge

The new Heathkit HM-102 wattmeter/swr bridge covers the frequency range from 1.8 to 30 MHz with wattmeter accuracy ±10% of full-scale reading*. The power capability of this new instrument is 2000 watts with full-scale readings of either 200 or 2000 watts. The built-in swr capability allows proper antenna tuning and transmission line impedance matching. The unit has a nominal 50-ohm impedance and provides negligible loss when inserted in a 50-ohm line. The remote torodial-type detector permits placement of the meter in a convenient location. The HM-102 kit is priced at $29.95 from the Heath Company, Benton Harbor, Michigan 49022, or use *check-off* on page 94.

*When calibrated on the 40-meter band through 300 feet of RG-58/U into a 50-ohm load.

collins receiver

The new Collins 651S-1 is one of the most versatile general purpose receivers ever developed, providing highly reliable reception from 0.4 to 30 MHz, with tuning phase-locked in 100-Hz steps. Because of the unique tuning system of the 651S-1, the convenience and "feel" of traditional receiver tuning is not sacrificed as a result of using discrete 100-Hz frequency steps. Large changes in frequency are aided by the 0.1-MHz and 1-MHz selector knobs.

Capabilities of the radio include computer programming, independent sideband, narrow band fm, operation from a remote control head, compatability with secure voice modems, phase-locked or manually adjusted vbfo, and syllabic squelch providing better reception of a weak voice signal in the presence of background noise.

Frequency readout on the front panel is provided by six light-bar devices, each of which consists of a seven-bar fluorescent segment tube.

The receiver construction techniques include Collins multilayer circuit boards mounted in plug-in card installations with blue-line connections. Micro-electonics logic and linear circuits are utilized. The plug-in card technique, along with convenient arrangement of other parts of the radio, provides easy accessibility. The receiver has no mechanical linkages – all tuning and band switching is performed electronically.

For information on the new 651S-1, write to Collins Radio Company, Cedar Rapids, Iowa 52406, or use *check-off* on page 94.

slow-scan television equipment

Robot Research, Inc., has announced a system of slow-scan television equipment that enables you to transmit and receive live television pictures with your existing station equipment. The model 80 slow-scan camera uses an efficient sampling technique that permits operation with everyday room lighting and transmits clear sharp pictures without involved adjustment. Features include digital timing chain, vidicon camera tube, built-in modulation calibration and solid-state construction.

The model 70 slow-scan television monitor demodulates and displays pictures transmitted by another amateur radio station. Simple connections between the monitor and your receiver are all that is required to receive an sstv picture. Included with the monitor are all of the switches and interconnections required to integrate sstv into your station. The monitor features balanced discriminator, automatic sync threshold, phase-locked horizontal sweep and solid-state construction.

The model 80 slow-scan camera and model 70 slow-scan monitor are available from Robot Research, Inc., 1250 Prospect Street, La Jolla, California 92037, or use *check-off* on page 94.

cubical-quad book

Bill Orr's new book, "Cubical Quads," features a wealth of new information not available in the previous edition. The new 2nd edition includes revised quad gain figures, analysis of the quad vs yagi, 4- and 5-element monster quads, miniature quad construction and performance, improved tri-gamma match for three-band quads, charts with dimensions for single- and multiband quads for 6 through 80 meters, as well as construction details for the delta quad, Swiss quad and birdcage quad.

This new book also includes information on feeding your quad for maximum swr; clear details on matching procedure; use of baluns; hints for sturdy, inexpensive quad construction; and how to adjust your quad for strongest signals. Quad installation, adjustment, evaluation and maintenance is covered along with quad facts; angle of radiation, directivity, power gain and front-to-back ratio.

"Cubical Quads" is $3.95 from Comtec, Book Division, Box 592, Amherst, New Hampshire 03031.

heathkit frequency counter

The new Heathkit IB-101 digital frequency counter provides accurate counting from 1 Hz to over 15 MHz with five-digit readout. The Hz/kHz selector switch and overrange indicator give eight-digit capability. The new counter features high input impedance, automatic trigger level for with range input without adjustment, storage circuitry for non-blinking, no-count-up adjustment, and temperature compensated crystal-controlled time-base oscillator. The *automatic decimal locator* puts the decimal point in the right place for any measurement with no need for interpolation or figuring.

The IB-101 uses 26 integrated circuits, 7 transistors, 6 diodes and one mosfet. The dual-gate diode-protected mosfet in the input circuit provides proper triggering over a wide range of input levels. It will operate properly with input levels from less than 100 mV to greater than 200 volts (depending on frequency). There is no input adjustment, and the instrument cannot be damaged by inputs within the specified range. Input impedance is 1 megohm shunted by less than 20 pF.

The new counter goes from kit to finished counter in about five hours, and complete adjustment can be made in a few minutes using only an a-m radio. No exotic test equipment is necessary. The IB-101 kit is complete with input cable. Priced at $199.95 from the Heath Company, Benton Harbor, Michigan 49022, or use *check-off* on page 94.

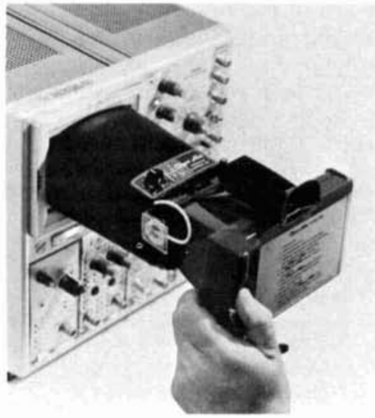
wideband rf power amplifier

The RF Communications has announced a new RF-806 linear amplifier module that features flat response within ±1 dB from 50 kHz to 80 MHz, and 3-dB bandwidth of 100 MHz. Gain is 47 dB with class-A amplification providing 10 watts with low harmonic and intermodulation distortion.

Input and output are overload protected against overdrive or operation into a short or open circuit. Unit is all solid state and operates from +28 Vdc. Standard options include 75-ohm input impedance and extended frequency response to above 100 MHz or down to 14 kHz. Accessories include impedance-matching transformers and power combiners.

Applications include use as a subassembly in test systems or amplifier chains to raise the power level of signal sources and generators without tuning or bandswitching. A-m, fm, pulse, ssb and other modulated signals can be amplified to 10 watts PEP with minimum distortion. Price is $795. For more information, write to RF Communications, Inc., 1680 University Avenue, Rochester, New York 14610, or use *Check-off* on page 94.

scope camera



Integrated Controls, Inc., has announced a low cost, hand-held oscilloscope camera set, Scope-Mate, which fits virtually all oscilloscopes. Fitting either three, four or five-inch round or rectangular scope faces, Scope-Mate can capture and record – either one shot or recurring trace – oscilloscope data. A standard Polaroid Colorpack II or III camera, in conjunction with the Scope-Mate hood, provides high-quality, high-contrast, black-and-white oscilloscope pictures in 15 seconds. The object-to-image ratio is one to one.

The Scope-Mate electronic control provides automatic adjustment of camera shutter speed, allowing you to vary photo contrast for perfect pictures.

The camera set, including a Colorpack II camera and Scope-Mate hood sells for $119.50. The Scope-Mate hood is available separately for $89.50. Order from Integrated Controls, Inc., Post Office Box 17296, San Diego, California 92117, or use *check-off* on page 94.

darlington power transistors

Five new series of complementary, power Darlington transistors – the first available in the industry – have been introduced by Motorola. The new silicon power transistors provide gain up to 2500 (typical) and are available in current ratings from 4 to 16 amperes. With their high gain, the power Darlington transistors can be driven with integrated-circuit milliampere output current levels. The new devices are supplied in 60 and 80 V collector-emitter breakdown voltage ratings (a 100 V rating is available in the 16 A series).

The Darlingtons incorporate both driver and output transistors plus necessary resistors in one monolithic structure. Thus, the usual separate driver and associated emitter-base resistors employed in a Darlington amplifier are eliminated.

Darlington transistors are useful in relay and solenoid drivers, servo amplifier, audio amplifier and power supply regulator circuits. Because they're available in both polarities, they can be used in either positive or negative ground systems. And, used in pairs, they are especially useful in complementary applications such as direct-coupled pairs in audio amplifiers.

4 ampere MJ4000/MJ4010 series, 1000 minimum gain at 1.5 amp, 60 or 80 BV_{CEO}, 75 watts, TO-3 package.

5 ampere MJ900/MJ1000 series, 1000 minimum gain at 3 amps, 60 or 80 BV_{CEO}, 90 watts, TO-3 package.

5 ampere MJE1090/MJE1100 series, 750 minimum gain at 3 or 4 amps, 60 or 80 BV_{CEO}, 70 watts, plastic thermopad-type package.

10 ampere MJ2500/MJ3000 series, 1000 minimum gain at 5 amps, 60 or 80 BV_{CEO}, 150 watts, TO-3 package.

16 ampere MJ4030/MJ4033 series, 1000 minimum gain at 10 amps, 60, 80 or 100 BV_{CEO}, 150 watts, TO-3 package.

For more information, use *check-off* on page 94, or write to Technical Information Center, Motorola Semiconductor Products, Inc., Box 20924, Phoenix, Arizona 85036.

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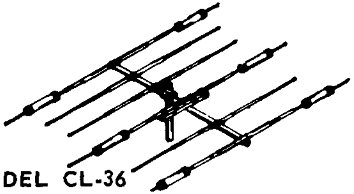

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The Classic 36, incorporating the Mosley superior feed system 'Balanced Capacitive Matching'. This wide-spaced, six-element beam employs 4 operating elements on 10 meters, 3 operating elements on 15 meters and 3 operating elements on 20 meters. Automatic bandswitching is accomplished through Mosley designed high impedance paralleled resonant "Trap-Circuits".

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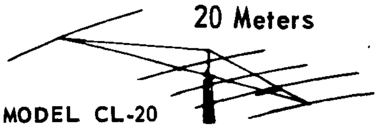

MODEL CL-20

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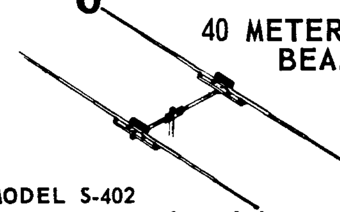
Matching Network	MD-48

Signal·Master 40 METERS BEAM



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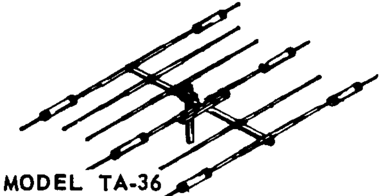

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SWAPFEST National Guard Armory, St. George, S.C., Sunday, February 7, 10:00 a.m. - 4:00 p.m. Talk-in 3950 SSB - 146.94 FM. "Hoss trading", Displays, Prizes. Bring all your gear for sale. Please let us know in advance how many to seat, number of tables, etc. Write Chamber of Commerce, Box 348, St. George, S.C. 29477 or call W4DTW, 803-563-4377.

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WORLD WIDE SSTV CONTEST. 1st Period 07.00-14.00 GMT Feb. 7, 1971. 2nd Period 16.00-23.00 GMT Feb. 13, 1971. All authorized frequencies. Suggest: 3.740 - 7.050 - 14.230 - 21.100 - 28.100 kHz. Messages: Exchange of picture. The message number may be given by voice. Scoring: A two-way contact with a station receives one point. (Total points will be the number of individual stations contacted.) No extra points for contacting the same station on different bands. A multiplier of 5 points is given for each continent worked. Logs must contain: date, time (GMT), band, call sign, message number sent and received, points. SWL: To encourage those who have no SSTV transmitting gear, a special prize will be awarded for the best collection of photographs of received SSTV pictures. All logs must be received by 28th February 1971. They should be sent to: Prof. Franco Fanti, I1LCF, Via Dallolio, 19, 40139 Bologna, Italy.

SELL: Hallicrafter SR150 AC PS, $275.00; HT32 Transmitter, $200.00; National NC 109 Receiver, $65.00. John Fearon, 3384 Peachtree Rd., N. E. Suite 705, Atlanta GA. W4WKP.

"DON AND BOB" new guaranteed buys. Monarch KW relative power SWR dualmeter bridge (reg. 24.00) 14.95; RCA 6LQ6 3.50; Amperex 8802/3500Z 32.00; 6146B 4.45; Ham-M 99.00; TR-44 59.00; Hygain TH6DXX 139.00; TriEx W51 329.00 prepaid; Regency HR2 6 channel 20 watt 2M. FM 195.00; Jennings vacuum variable capacitor 300PF/7.5KV 20.00; (no drive) Motorola HEP170 2.5A/1000PIV diode 39¢; write quote SPR4, R4B. Prices FOB Houston. GECC Finance. Madison Electronics, 1508 McKinney, Houston, Texas 77002. (713) 224-2668.

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

THE 20th ANNIVERSARY DAYTON HAMVENTION will be held on April 24, 1971 at Wampler's Dayton Harra Arena. Technical sessions, exhibits, hidden transmitter hunt and an interesting program for the XYL. For information write Dayton Hamvention, Dept. H, Box 44, Dayton, Ohio 45401.

DIGITONE TONE CONTROL DEVICES — decoders, encoders, logic. Compact, solid-state modules. Application Notes/Catalog. Write Digitone, Box 73-HR, Bellbrook, Ohio 45305.

JANUARY CLEARANCE SALE: "HOSS TRADER" ED MOORY is REDUCING INVENTORY: On a first come first serve basis at ridiculous prices: USED RECONDITIONED EQUIPMENT. 75A-4, $275.00: 75S-3, $349.00: KWM-2, $549.00: Drake 2A, $129.00: 2-B, $149.00: TR-3, $329.00: SX-111, $99.00: HQ-110C, $95.00: Marauder HX-10, $125.00: HX-20, $75.00: National NC-183D, $99.00: NC-303, $149.00: NCX-3, $149.00: Swan 350, $259.00: Ham-M, $79.00: Slightly Used Drake SPR-4, $325.00: TR-4, $395.00: Swan 500CX, $425.00: 702B Cygnet, $375.00: NEW WATERS 335 Coaxial Switch, $8.75: New W2AU Quad, $80.00: New Mosley Classic 33 and Demo Ham-M Rotor, $199.00: Write for quotes on other new and used equipment: Moory Electronics Co., Box 506, Dewitt, Ark. 72042. Phone (501) 946-2820.

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WORLD QSL BUREAU — see ad page 86.

7289 (3CX100A5) Ceramic replacement for 2C39 tube, $3 ea; 6/$15. Also 432MHz and 1296 MHz cavities. Trade for 2 mtr. FM gear. W4SOD, Box 73, Folly Beach, S. C. 29439.

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NOVICE CRYSTALS: 40-15M $1.38, 80M $1.83. Free flyer. Nat Stinnette Electronics, Umatilla, Florida 32784.

CIRCUIT BOARDS, Bishop Prekuts, Photo Resist, Litho negatives made. Send for free list: WA8OOB, Box 563, Waynesville, Ohio 45068.

NOISE GENERATOR: Kay Electric Model 3000 $175. Esterline Angus chart recorders; 0 - 5 ma $55., 0 - 1 ma $65. WB6LLT, 162 S. La Luna, Ojai, CA 93023. 805-646-6387.

ROCHESTER, N. Y. will again be headquarters for the huge W.N.Y. Hamfest, V.H.F. Conference and Flea Market May 15, 1971.

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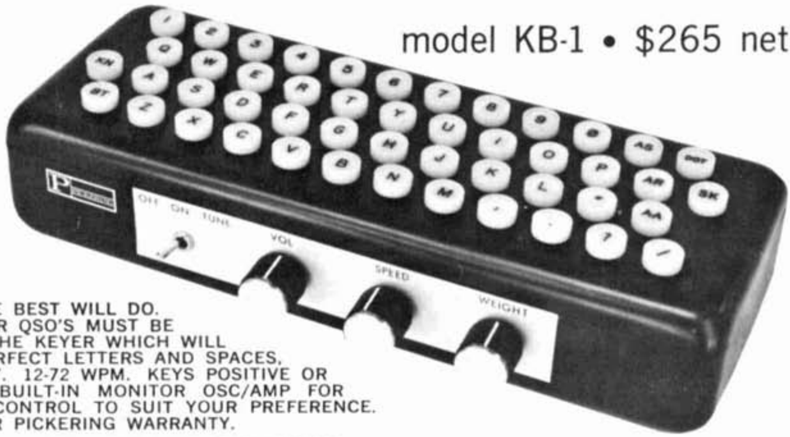

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TOLEDO MOBILE RADIO Association's 16th Annual Hamfest and Auction will be held February 21, 1971, Lucas County Recreation Center, Maumee, Ohio. $1.00 Registration, open table sales. Map and info write: TMRA W8HHF, Box 273, Toledo, Ohio 43601.

SELL: 75A4 EXCELLENT CONDITION, vernier knob, 800 HZ, 3kHz filters, noise blanker, speaker, $325.00. K0EXD, Carl Thorsell, 1195 E. 77th, Kansas City, Mo. 64131.

FOR SALE: KG 636 10 MC 'scope with triggered sweep. Dual trace plug-in pre amp, extra CR tube, excellent condition, $145.00. BC 221-T original calibration book, AC supply $30.00. B & W grid dipper, all coils $17.00. Many other bargains. SASE for list. Bill Blake W5SCM, St-Rt., Box 1350, Columbus, Miss. 39701.

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.

READ RADIO CONSTRUCTOR for many interesting home-brew projects. Radio Constructor, Greenville, N. H. 03048.

FOR SALE: Squire-Sanders SS1R, SS1RS, SS1S, (all new), $550. 75S3B #85399, $550. KWM2-A #18922, Noise Blanker, 516F2, $950. 75S1, 32S1, 516F2, $600. MP1, or 516E1, $125. 351D2, $100. 312B4: new, $175; used, $135. 75S3, 32S3, 516F2, $950. 30L1, #25752, $400. SR160, P150DC, $200. P500AC, $65. SR150, P150AC, $295. 312B5, $275. SW500C, 117XC, 14C, mobile mount, $475. Galaxy 300, PSA300 p. s. /console, $165. Waters Nuverter, $100. Viking Thunderbolt, $225. C. E. 100V, $235. Waters Hybrid Coupler, #3002, $40. Motorola 80D, complete, $75. Capacitors, 4 mfd/10KV, $15. Powerstat Model 136, 0-140V/20 amps, $25. Simpson Model 260 VOM (factory-reconditioned), $45. Telex headset, (new), $5. Lafayette HA750, HB502, mike, squalo, $100. TA33 (new), $120. Filter F455Y60 (for 75S1/S2/S3), $20. TR44 (new), $60. Lambda VR supplies, write for details, $25. Messenger III, AC supply, $100. Transformers: 115/2880VCT@500 ma, $15; 115/5VCT@30 amp, $8. RTTY Converter Electro-Com FSC-250 with TK-100 and filters, cables for use with KWM2/S-Line, all for $250. Polarad UHF rcvr to 10GHz (plug-in supplied for 1-2 GHz), $50. Model "B" Powerstats, 2½ amp, $6. 813's, $5. Bell & Howell Model 200EE 16 MM movie camera, with case, $50. Measurements Corp Model 80 RF Signal Generator, $100. Ferris Model 20-A Microvolter, $50. Transformers: UTC S44, $12: S49, $20; S57, $4; S63, $7; Stancor P8026, $20; 1300/3 amp, $35. H-P 212-A Pulse Generator, $35. Clegg 66'er, $135. Drake DC-4, new, $95. James W. Craig, W1FBG, 29 Sherburne Avenue, Portsmouth, N. H. 03801. (603) 436-9062

HRO-60 RECEIVER with ABCD coils, $100.00. Johnson Challenger Transmitter $37.50. Hammarlund HB-1K Electronic Keyer $12.50. FOB certified check or M.O. Don Baker, W8CVA, 4606 Wickford Dr. E., Sylvania, Ohio 43560.

ASK FOR FREE LIST of used Ham gear or for prompt personal attention on any new gear. Mail your order direct to VanSickle Radio, W9KJF, Indianapolis, Indiana 46205. 40 years experience.

CODE PRACTICE TAPES - Novice - General - Extra Class - Specify - $8.00 each. W9CJJ, 1105 Schaumburg Road, Schaumburg, Illinois.

MECHANICAL FILTERS: 455 Khz. 2.1 Khz $18.95. 300 Hz $22.95. J. A. Fredericks, 314 South 13th Avenue, Yakima, Washington 98902.

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HEATH SSB SB401-E, SB300, SSB/CW, VOX/PTT, $440. KW linear, H.B.-similar to SB200, 4CX250B's, solid-state supply $150. $550 for all. Ray Grimes, WB9CTT, 2146 Maple, Evanston, Illinois 60201.

NCX3, NCXA AC SUPPLY, $150, W9OEQ, R. R. 2, Mokena, Illinois 60448.

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WANTED — BACK ISSUES HAM RADIO March 1970. Can swap with any other issue or how much. Missed any issues? Maybe can help. Eskil Persson, SM5CJP, Frotunagrand 1, 19400 Upplands Vasby, Sweden.

DERRICK ELECTRONICS will not be undersold on new Swan, Drake, Galaxy, Hy-Gain or Mosley equipment. Check around, then write, 108 East El Paso, Broken Arrow, Oklahoma 74012.

THE WHEATON COMMUNITY RADIO AMATEURS will hold their ninth annual Mid-Winter Swap and Shop on Sunday, February 21, 1971 at the DuPage County Fair Grounds, Wheaton, Illinois. Hours - 8:00 A.M. to 5:00 P.M. $1.00 Advance/$1.50 donation at the door. Send SASE for advanced tickets P. O. Box QSL, Wheaton, Illinois. Refreshments and unlimited parking. Bring your own tables. Free coffee and doughnuts 9:00 to 9:30 A.M. Hams, CBers, electronic hobbyists, friends and commercial exhibitors are cordially invited. Contact John Stockberger, W9THI, P. O. Box QSL, Wheaton, Illinois 60187 for information.

DON'T BUY QSL CARDS from anyone until you see my free samples. Fast service. Economical prices. Little Print Shop, Box 9848, Austin, Texas 78757.

WANTED: Following back issues of Ham Radio: April, November, December 1968. July 1969. March, April, May 1970. Jerry Ellinger, 1829 Edenside, Apt. 9, Louisville, Ky. 40204.

MANUALS for R-390/URR, R-390A/URR, USM-24C, URM-25D, BC-348J, BC-639A, $6.50 each. S. Consalvo, 4905 Roanne Drive, Washington, DC 20021.

DRAKE TR3, AC3, set spare tubes $350. MM2 scope plus RM50 and RM455 receiver adapters $100. Heath HA-10 1 KW linear $150. Norman Webster, 19545 Ingomar, Reseda, Calif. 91335.

SELL: COLLINS 51J3/R388 excellent $400.00: Hammarlund SP600JX/R274 excellent $250.00: Galaxy 5 Mark 5 Transceiver, remote VFO, accessory console W/clock AC power supply, complete $350.00: CV89 audio teletype convertor $125.00: CV57 IF convertor $100.00. WA0KLC, 315 East 20th, Grand Island, Nebraska 68801.

B.A.R.T.G. SPRING RTTY CONTEST. 0200 GMT Saturday, March 13th until 0200 GMT Monday March 15th 1971. Not more than 36 hours of operation is permitted. Times spent in listening periods count as operating time. Off-periods may not be less than two hours. Times on and off the air must be summarized on the Log and Score sheets. The Contest is also open to SWL RTTYers. 3.5, 7, 14, 21 and 28 Mhz. Amateur Bands. Stations may not be contacted more than once on any one Band, but additional contacts may be made with the same Station if a different Band is used. ARRL Countries List, except VO to be considered as separate Country. Messages exchanged will consist of: Time GMT, Message Number and RST. Two-way RTTY contacts with one's own Country will earn TWO points. Contacts outside one's own Country will earn TEN points. A bonus of 200 points per Country worked including their own. Any one Country may be counted again if worked on another Band but Continents are counted once only. Two way exchange points time total Countries worked plus Total Country points times number of Continents worked. Use one log for each Band and indicate any rest periods. Logs to contain: Band, Time GMT, Message and RST Numbers sent and received and exchange points claimed. All Logs must be received by May 22nd 1971. Send Logs to: Ted Double G8CDW, 89, Linden Gardens, Enfield, Middlesex, England.

SELL: LATE MODEL SX101A RECEIVER excellent $200.00. K0GZD, 4228 W. Capitol Ave., Grand Island, Nebraska 68801.

IC'S — MRTL, MC 790 P, $1.90 each, 10 for $18.00; μL 914, .55 each, 10 for $5.00; 100 KHz freq. std. crystal HC 13/U, $4.00. Please add postage. Logic Components, Box 224, New Canaan, Conn. 06840.

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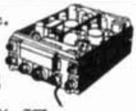

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TRANSMITTER has 4 tubes: WE-316A, 2-6F6, 7F7
RECEIVER has 11 tubes: 2-955, 4-7H7, 2-7E6, 3-7F7
RECEIVER I.F.: 40 Megacycles
SIZE: 10-1/2" x 13-1/2" x 4-1/2". Shpg wt 25 lbs.

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**

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.

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.

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**

HEADSET
Low impedance. With large chamois ear cushions. 4-ft. cord and plug. Reg. $12.50. OUR SPECIAL PRICE.......... **$2.95**
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
3-6 Mc.	BC-454	$16.50	$19.50	$22.50
6-9.1 Mc.	BC-455	$14.95	$17.95	$21.50
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
7-9.1 Mc.	BC-459	—	—	$23.50

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

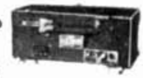
SCR-625 ARMY MINE DETECTOR Complete $32.50
EE-8 SIGNAL CORPS FIELD PHONES...................... $16.95
T-30 THROAT MIKE, NEW........ 59¢ USED............. 39¢
T-17 MICROPHONE, NEW......$8.50 USED, checked out $4.95
BC-605 INTERPHONE AMPLIFIER, NEW $3.45 EXC. USED.... $1.95
TELEPHONE HANDSET, W.E. type............LIKE 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............... **$4.95**

FREQUENCY METER MODEL LM
Fine general purpose Navy unit, range 125 to 20,000 Kc. Operates on 12/24 VDC & 200V 10 Ma DC. Complete with tubes, crystal, calib. book.
Checked out, EXCELLENT USED......... **$59.50**
As above, less book $24.50 AC Power Supply.$19.50

McELROY AUTOMATIC KEYER for keying transmitter or for code practice. Photoelectric cell & sensitive relay. Variable speed motor 110V 60 cy Complete with tubes, EXC. USED **$11.25**

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 UNIT 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.... **$7.45**

RADIO SET AN/ APR-21 TRANSMITTER & RECEIVER. Freq. modulated 152 to 174 Mc. Operated on any preset frequency within VHF range 152-174 Mc FM. Reliable voice communication over moderate distances. Includes antenna, handset H-33 and two carrying straps.
Size 12x8-1/4x5-3/4. Wt 15 lbs.
LIKE NEW, complete **$69.50**

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 **$6.95**

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**

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...... **$24.50**

BC-929 US GOVT SCOPE INDICATOR
Compact radar display unit uses 3BP1. A favorite with TTY fans as foundation for converter with cross-line scope presentation. Also for Hams: Modulation-monitor foundation.
Complete with all tubes. LIKE NEW.... **$16.95**

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**

TS-100AP TEST OSCILLOSCOPE Small portable instrument used to test and calibrate range measuring circuits of radar systems. Used for viewing short video pulses on 3" screen. Power supply: 115 or 230 V 50-1200 cps.
Complete with plugs, cables........... **$59.50**

TS-126/AP RANGE CALIBRATOR TEST SCOPE Top quality 2" scope with all positioning, focus, gain and intensity controls.
Complete with tubes and cables, NEW. **$24.50**
Demilitarized, like new................ $13.75

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

T-28 / APT TRANSMITTER radar jamming covering freq. 140 to 210 Mc. Osc. Amp. Plate, Grid Plate & Mixer Plate controls on front panel. Complete with tubes. 7-1/2x10x20"
Wt 40 lbs. NEW..................... **$32.50**

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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—Dames
—DyComm
—ES
—Ehrhorn
—Eimac
—Flinn
—G & G
—Goodheart
—Gordon
—Gray
—H & H
—H & L
—HAL
—Ham Radio
—Heath
—Henry
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—James
—Jan
—Justin
—L A
—Madison
—Meshna
—Micro-Z
—Mosley
—Motorola
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—R & R
—RF Communications
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—Callbook
—Radio Constructor
—Radio Shop
—Robot Research
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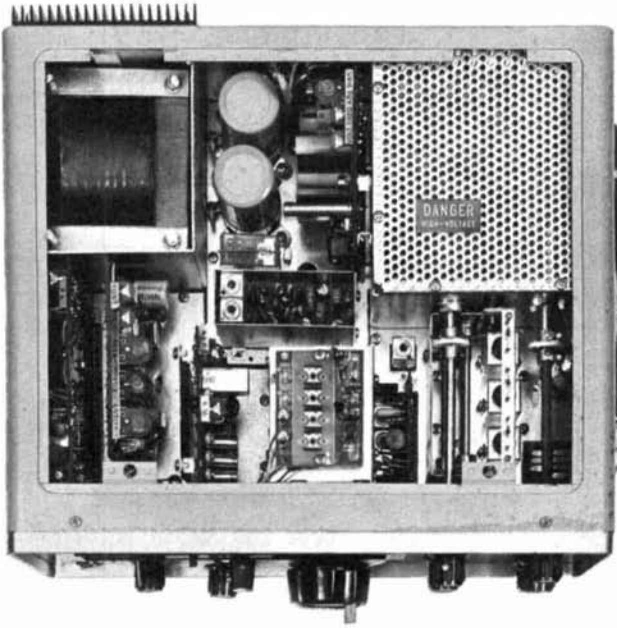
The reason the Yaesu FT-101 is the world's best portable rig is really an inside story.



Mill-spec gear? That's the way it looks. And that's the way it works. It's the solid-state FT-101 portable Yaesu.

Except for the final tubes, the FT-101 uses 10 FET's, 3 IC's, 31 silicon transistors and 38 silicon diodes. And most of them are found on plug-in computer-type modules. Modules that you mail to us for factory-new replacements, should they ever give you trouble. And the whole rig is guaranteed for one year.

But ruggedness is only a footnote to the FT-

101 story. The real story is found in features. Features like a built-in VOX, 25 KHz and 100 KHz calibrators, the WWV 10 MHz band, a high Q permeability tuned RF stage and a ± 5 KHz clarifier. That means home-base type operation, whether you're cruising near Pawtucket or working portable somewhere on the outskirts of Pago-Pago.

It's all in a thirty-pound package that even includes built-in 12 VDC and 117 VAC power supplies. You supply the 12 or 117 volts plus an antenna and you're ready to work the world — on the 80 meter band right through 10 meters. And you'll work it with 260 W PEP, 180 W CW or 80 W AM maximum input power. Receiving sensitivity is 0.3 microvolts for a 10 db signal-to-noise ratio.

For in-car operation, there's a built-in noise blanker. It picks out noise spikes and leaves clean signal copy behind.

Another important part of the FT-101 story is the price: only $499.95.

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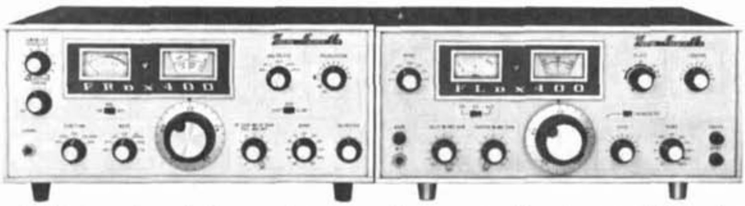
Now you don't have to pay twice the price to get twice the rig.



Picture this pair in your shack. The Yaesu FLdx 400 transmitter and the FRdx 400 receiver. Loaded with power. Loaded with sensitivity. Loaded with features. Loaded with value. Read on, and discover how you can have the most up-to-date receiver-transmitter rig in the world . . . and at an unbelievably low price.

The FRdx 400 Receiver

Get a big ear on the world with complete amateur band coverage from 160 meters through 2 meters, including WWV and CB reception. Four mechanical filters do it — they provide CW, SSB, AM and FM selectivity. Separate AM-SSB-FM detectors are included, along with squelch and transmit monitor controls. Plus a noise limiter and a variable delay AGC. And a built-in notch filter with front panel adjust for notch depth.

The FRdx includes calibration markers at 100 KHz and 25 KHz, with accurate calibrator checks verified by WWV. A solid-state FET VFO for unshakable stability. And a direct-reading 1 KHz dial affords frequency read-out to less than 200 Hertz.

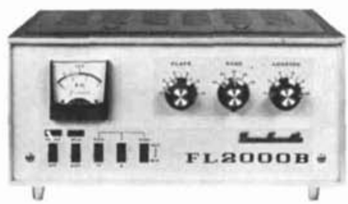
The FRdx 400 sells for $359.95.

The FLdx 400 Transmitter

Here's how to set yourself up with dual receive, transceive or split VFO operation. The FLdx 400 with its companion receiver brings you the ultimate in operational flexibility. Flexibility like frequency spotting, VOX, break-in CW, SSB, AM and even an optional FSK circuit.

The completely self-contained FLdx 400 features a built-in power supply, fully adjustable VOX, a mechanical SSB filter, metered ALC, IC and PO. A completely solid-state FET VFO provides rock-solid frequency stability.

We rate the FLdx 400 very conservatively. That rating guarantees you 240 W PEP input SSB, 120 W CW and 75 W AM. The FSK option will go all day at a continuous 75 W. And you get full frequency coverage on all amateur bands — 80 meters through 10 meters — with an optional provision for certain other bands that you can personally specify. For all that, you pay just $299.95.



FL2000 B Linear Amplifier.

Ideal companion to the Series 400, this hand-crafted linear is another example of Yaesu's unbeatable combination of high quality and low cost. Designed to operate at 1500 watts PEP SSB and 1000 watts CW, this unit provides superb regulation — achieved by a filter system with 28 UF effective capacity.

Other features include dual cooling fans (one for each tube), individual tuned input coils on each band for maximum efficiency and low distortion, and a final amplifier of the grounded grid type using two rugged carbon-plate 572 B tubes. Ready to operate at only $299.95.

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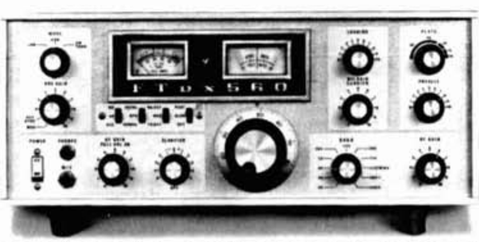

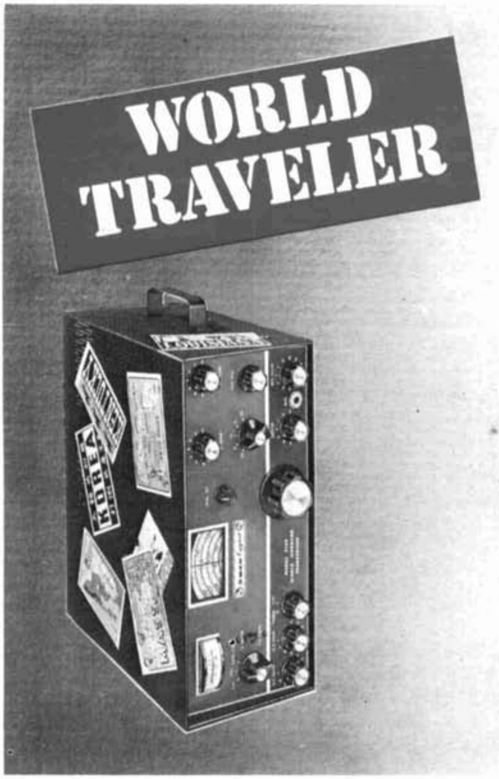

SWAN *Cygnet* 270B

SSB TRANSCEIVER

The 5 band deluxe 270-B, with a power rating of 260 Watts P.E.P., is a complete self contained radio station with built-in AC power supply and speaker in one compact, portable package. You can take it with you on vacation or business trips, operate from your motel room, your boat, car, or hide-away cabin. All you do is connect to an AC power source and antenna, plug in your mike and you're on the air, with enough power to work the world.

The Swan Cygnet 270B is a world traveler. And the price is a world beater! $499

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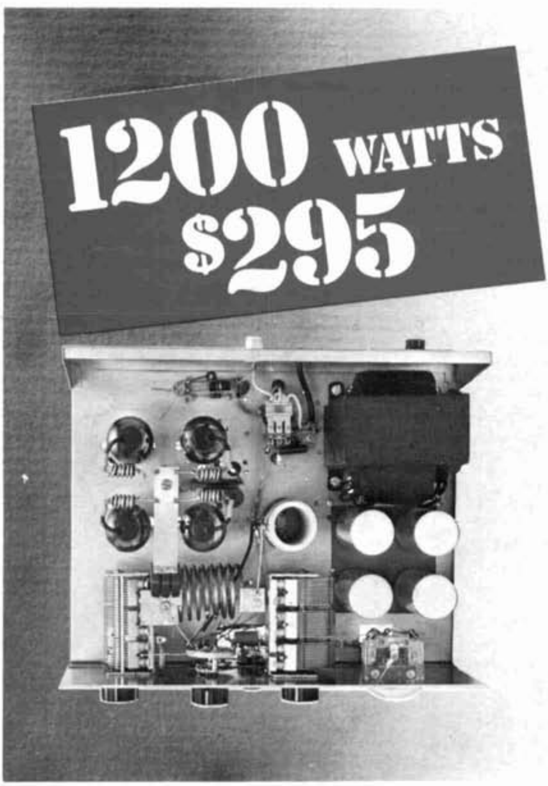

SWAN 1200W
1200 WATT LINEAR AMPLIFIER WITH SELF CONTAINED AC POWER SUPPLY

We built this little gem to go with our Cygnet 270B. But when word got around that Swan had a 1200 Watt amp with a built-in AC power supply, for just two hundred and ninety-five bucks, all h--- broke loose. Production has finally caught up with sales again, so see your dealer soon.

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