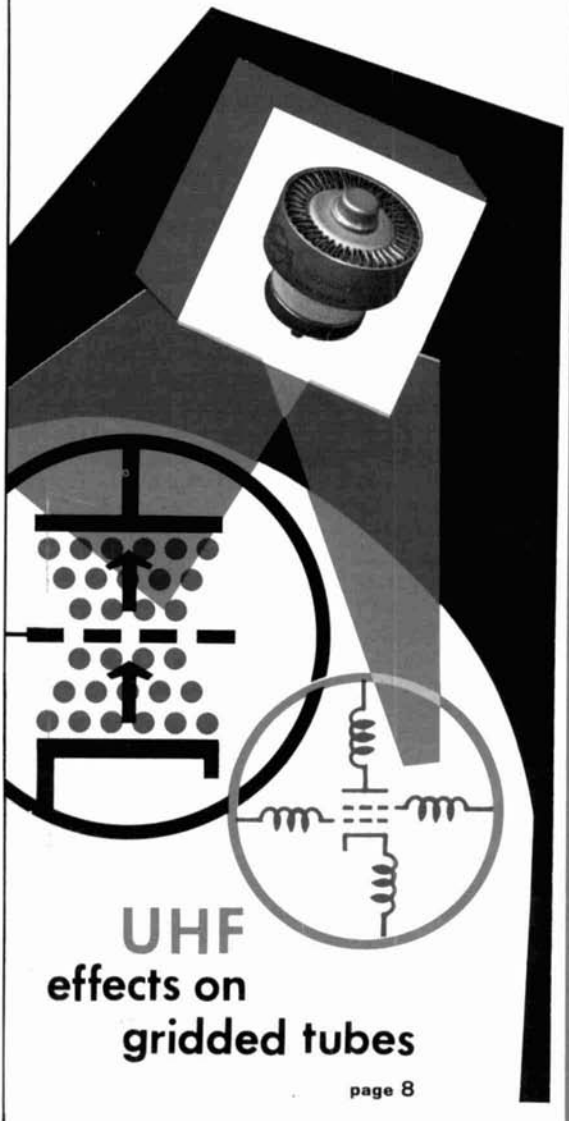
60 cents

hr focus on communications technology . . .

ham radio

JANUARY 1969



UHF effects on gridded tubes

page 8

this month

- solid-state ssb circuits 18
- 220-mhz mosfet converter 28
- stub-switched antennas 34
- cubical quads 42

HERE'S HOW TO GET TO US

These distributors carry Collins' KWM-2, the incomparable S-Line, and a complete line of Collins amateur accessories. Contact the one nearest you.

ALABAMA
Birmingham
Ack Radio Supply Co.
Huntsville
Electronic Wholesalers, Inc.
Mobile
Specialty Distributing Co.

ALASKA
Anchorage
Yukon Radio Supply

CALIFORNIA
Anaheim
Henry Radio & Electronics, Inc.
Burlingame
Ham Radio Outlet
Fresno
Dymond Electronics
Los Angeles
Henry Radio, Inc.
Oakland
Amrad Supply, Inc.
Riverside
Mission Ham Radio Supply
San Diego
Western Radio & TV Supply Company
San Francisco
Amrad Supply, Inc.
San Jose
Quement Electronics

COLORADO
Denver
Burstein-Applebee Company

CONNECTICUT
Hartford
Corky's Division, Hatry of Hartford, Inc.

DISTRICT OF COLUMBIA
Washington
Electronic Wholesalers, Inc.

FLORIDA
Coral Gables
International Electronic Systems, Inc.
Miami
Amateur Radio Center, Inc.
Pensacola
Grice Electronics, Inc.
Tampa
Kinkade Radio Supply, Inc.

GEORGIA
Atlanta
Ack Radio Supply Company
Atlanta
Southeastern Radio Parts, Inc.
Atlanta
Specialty Distributing Company, Inc.

HAWAII
Honolulu
Honolulu Electronics

ILLINOIS
Chicago
Newark Electronics Corp.
Peoria
Klaus Radio & Electric Company

INDIANA
Indianapolis
Graham Electronics Supply, Inc.
South Bend
Radio Distributing Co.

IOWA
Council Bluffs
World Radio Laboratories
Des Moines
Amateur Radio Center

LOUISIANA
New Orleans
Sterling Electronics

MARYLAND
Wheaton
Uncle George's Radio Ham Shack
Division of Electronic Dist., Inc.

MASSACHUSETTS
Boston
DeMambro Radio Supply Company, Inc.
Reading
Graham Radio, Inc.

MICHIGAN
Ann Arbor
Purchase Radio Supply
Detroit
Radio Supply & Engineering Co., Inc.
Kalamazoo
Warren Radio Company
Muskegon
Electronics Distributors, Inc.

MINNESOTA
Minneapolis
Electronic Center, Inc.

MISSOURI
Butler
Henry Radio Company
Kansas City
Burstein-Applebee Company
St. Louis
Ham Radio Center

NEW HAMPSHIRE
Concord
Evans Radio, Inc.

NEW JERSEY
Springfield
Federated Purchaser, Inc.

NEW YORK
Amsterdam
Adirondack Radio Supply, Inc.
Farmingdale
Harrison Radio Co.
Ithaca
Stellar Industries, Div. of Stellar, Inc.
Jamaica
Harrison Radio Corporation
New York
Harvey Radio Co.

NORTH CAROLINA
Asheville
Freck Radio & Supply Company, Inc.
Winston-Salem
Electronic Wholesalers, Inc.

OHIO
Cleveland
Pioneer Standard Electronics, Inc.
Columbus
Universal Service
Dayton
Srepco Electronics
Toledo
Selectronic Supplies, Inc.

OREGON
Portland
Portland Radio Supply Company

PENNSYLVANIA
Jenkintown
"Ham" Buerger
Philadelphia
Radio Electric Service Company
Pittsburgh
Cameradio Company

SOUTH DAKOTA
Watertown
Burghardt Radio Supply

TENNESSEE
Nashville
Electra Distributing Company

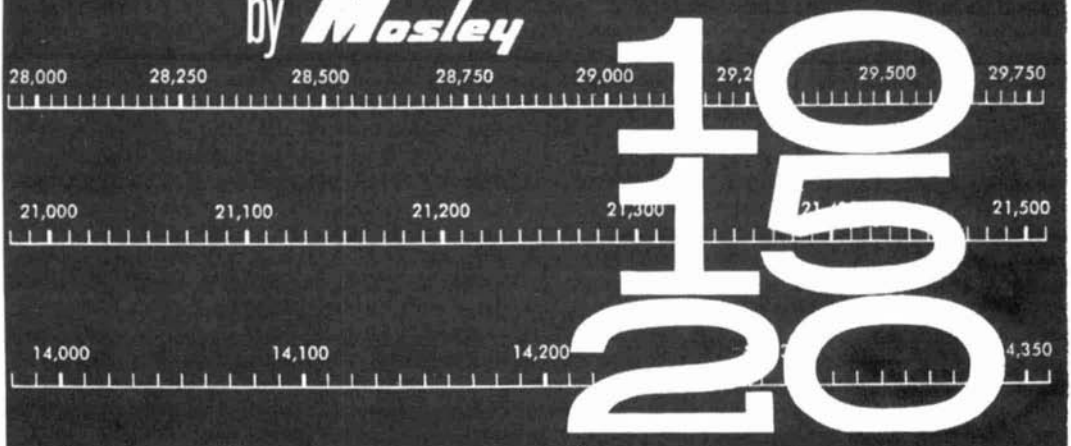
TEXAS
Abilene
Howard Radio
Corpus Christi
Douglas Electronics
Dallas
Electronic Center, Inc.
El Paso
McNicol, Inc.
Houston
Madison Electronics Supply

WASHINGTON
Lynnwood
Cascade Electronic Supply
Spokane
HCJ Electronics
Tacoma
C & G Electronics Company

WISCONSIN
Milwaukee
Amateur Electronic Supply

COLLINS

NEW | Cubical Quads by Mosley



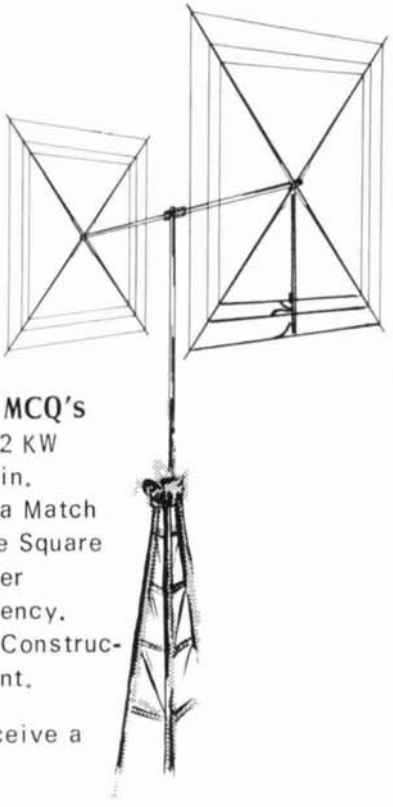
Four NEW Two-Element QUADS

SINGLE BAND QUADS

Model MCQ-10 for 10 meters
Model MCQ-15 for 15 meters
Model MCQ-20 for 20 meters

TRI-BAND QUAD

Model MCQ-3B for 10, 15 & 20 meters



Designed and Engineered for Superior DX, the new **MCQ's (Mosley Cubical Quads)** are rated to 1 KW AM and 2 KW P.E.P. SSB. Maximum Front-to-Back and Forward Gain. A Single 52 ohm Line feeds the Quads via a Gamma Match resulting in a low SWR over the full bandwidth. The Square Configuration of the **MCQ** Series guarantees better performance by providing optimum electrical efficiency. The Durable, Lightweight, Weatherproof Aluminum Construction yields a lifetime of maintenance-free enjoyment.

For detailed brochure, Write Dept. 169 . . . and receive a **FREE** 1968/69 Mosley Antenna Catalog.

Mosley Electronics, Inc. 4610 N. Lindbergh • Bridgeton, Missouri 63042 **Dept. 169**

Take a good first look at the new HQ-200 general coverage receiver.

At only $229.50, you won't need a second look.

Write for the HQ-200 catalog sheet and a CQ magazine review of the outstanding HQ-215 Solid State Communications Receiver.

The HAMMARLUND Manufacturing Company Incorporated

Established 1910

A subsidiary of Electronic Assistance Corporation

73-88 Hammarlund Drive, Mars Hill, North Carolina 28754

contents

ham radio

january 1969

volume 2, number 1

staff

editor
James R. Fisk, W1DTY

roving editor
Forest H. Belt

vhf editor
Robert M. Brown, W9HBF

associate editors
A. Norman Into, Jr., W1CCZ
Nicholas D. Skeer, K1PSR
Alfred Wilson, W6NIF

art director
Jean Frey

publisher
T. H. Tenney, Jr. W1NLB

offices

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

ham radio is published monthly by Communications Technology, Inc., Greenville, New Hampshire 03048. Subscription rates, world wide: one year, $5.00, three years, $10.00. Application to mail at second-class rates pending at Greenville, New Hampshire 03048.

Copyright 1968 © by Communications Technology, Inc. Title registered at U. S. Patent Office. Printed by Capital City Press, Inc. in Montpelier, Vermont 05602, U.S.A.

Microfilm copies of current and back issues are available from University Microfilms, 313 N. First Street, Ann Arbor, Michigan 48103.

Postmaster: Please send form 3579 to **ham radio**, Greenville, New Hampshire 03048.

8 UHF Effects of Power-Grid Tubes
Robert I. Sutherland, W6UOV

18 Solid-State Circuits for SSB
Forest H. Belt

28 220-MHz MOSFET Converter
Donald W. Nelson, WB2EGZ

34 Stub-Switched Stub-Matched Antennas
John J. Schultz, W2EEY

38 Current-Controlled Tuning Circuits
Robert M. Brown, K2ZSQ

42 Notes on Cubical Quad Measurements
L. W. VanSlyck, W4YM

47 Low-Power Linear Amplifier for Two
Ralph W. Campbell, W4KAE

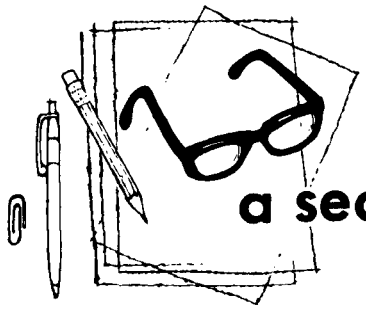
52 Troubleshooting with an Ohmmeter
Larry Allen

60 Sunspots and Solar Activity
Victor R. Frank, WB6KAP

66 Antenna and Rotator Preventive Maintenance
F. M. Woolner, WA1ABP

departments

4	A Second Look	32	Next Month
94	Advertisers Index	60	Propagation
85	Flea Market	52	Repair Bench
72	New Products	76	Short Circuits



a second look

by jim fisk

At one time or another I suppose most of us have wondered why our semiconductors are numbered as they are with 1N, 2N and 3N numbers. To the newcomer, it must look like a meaningless bunch of random numbers—and it isn't a great deal more to the oldtimer! Receiving-tube numbers follow certain guidelines, as do many transmitting tubes, so what happened to solid state? To say that it is a numbering system that grew on us isn't too far from wrong—but that's getting ahead of the story.

During the early days of radio, each vacuum tube manufacturer numbered his tubes as he saw fit. When there were only a few tube types available—with very little difference in their characteristics—this was no great problem. In fact, if you look in any of the old radio books, you'll see that none of the circuits specify what tube to use; it didn't make that much difference.

However, with the invention of the tetrode and pentode, and the introduction of tubes with vastly different characteristics, the problem became pretty sticky. The replacement problem was particularly bad, so in 1933 the industry voluntarily adopted a numbering system that called for a number, a letter and another number. The first number denoted the filament voltage range, the middle letter was a serial designation and the last number indicated the number of useful elements for which terminals were provided (including internal shield and shell connections). This is pretty much the system still in use today.

Transmitting tubes didn't run into the standardization bugbear until 1942. With the war, and the great number of tube types being manufactured, a standard number-letter-number system was adopted for transmitting and special-purpose tubes. Examples of devices assigned number from this system are the 1N21, 2C39, 2E26 and 3E29. The first number indicated the power rating of the heater: 1 for zero power, 2 for up to 10 watts, 3 for up to 20 watts and so on. The letter indicated the structure or function: B for diodes, C for triodes, D for tetrodes, E for pentodes, N for crystal diodes and rectifiers, etcetera. The final number was a serial designation, started at 21 to avoid conflict with the receiving-tube system.

Except for the use of 1N for semiconductor diodes, this system was scrapped in 1946 for a purely numerical system starting at 5500. Although several manufacturers wanted a numbering system for diodes (and later transistors) that told the user more about the device than a simple serial system, none was ever agreed upon. In the meantime, the system we use today kept growing. The first digit came to indicate the number of elements minus one—thus a 1N34A is a diode, a 2N706 is a triode and a 3N159 is a tetrode; the N indicates a solid-state device, and the last number is the order of registration.

This brings up another question—who decides precisely what number will be assigned to a particular transistor? The answer is an industry sponsored committee that registers all new transistors (and vacuum tubes), assigning the next open number in the system. If the system doesn't make much sense to you, don't feel too badly; a number of professional groups have tried to put some meaning into it, but without a great deal of success. The big argument against any new system at this point in time concerns the great number of solid-state devices already on the books—making any new numbering system impractical.

Jim Fisk, W1DTY
Editor

We're first... because we offer more.

HENRY RADIO

Let us prove it to you.

BOB HENRY
WØARA

FAST SERVICE: You can depend on faster service because Henry Radio has large stocks of Collins, Swan, Drake, Hallicrafters, Hammarlund, Hy-Gain, Tristao, Johnson, Mosley, National, Telrex, Waters, New-Tronics, Galaxy, Tri-Ex and many other receivers, transmitters, antennas, towers and parts at low prices. Plus, of course, the superb new 2K-3 Linear Amplifier.

BIG TRADES: Henry wants trade-ins. We trade big. Tell us what you want — what you have to trade. Get Henry's offer. We pay cash for receivers and transmitters too.

TED HENRY
W6UOU

TIME PAYMENTS: Get what you want and pay by the month. Henry gives you better terms because we finance all terms ourselves.

SATISFACTION: Henry Radio has satisfied thousands of customers since 1927. Ask any ham about us.

PERSONAL ATTENTION: You get personal attention. Bob Henry runs the Butler store . . . Ted Henry is in charge at the Los Angeles store . . . and Walter Henry runs the Anaheim store. Write, phone, wire or visit any of these stores for personal service. Send us your orders and inquiries. Export inquiries solicited. Also, military, commercial, industrial and scientific users . . . please write for information on our custom line of high power communication linear amplifiers and RF power generators.

SPECIAL OFFERS: Currently Henry is featuring a versatile antenna package program that is second to none. Write for literature.

WALTER HENRY
W6ZN

WRITE, PHONE OR VISIT A HENRY RADIO STORE TODAY:

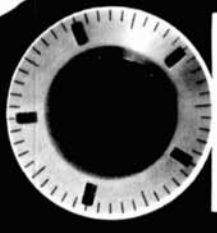
Henry Radio Stores

CALL DIRECT . . . USE AREA CODE

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

"World's Largest Distributor of Amateur Radio Equipment"

the Great ones



from NRCI

the Great Transceiver
NCX-500

Here's the potent 5-bander with a 500-Watt punch. Check the terrific features on this low-priced performer:
☐ 500-Watt PEP input on SSB, grid-block keying on CW and compatible AM operation. ☐ Sidetone monitor, plus built-in code practice oscillator. ☐ Receive vernier, with tuning range greater than ±3 kHz. ☐ Separate AM and product detection ☐ Fast-attack/slow release AGC in all modes. ☐ Crystal-controlled pre-mixing with single VFO for effective frequency stability, plus identical calibration rate on all bands. ☐ Crystal lattice filter for high sideband suppression on transmit, and rejection of adjacent-channel QRM on receive . . . plus solid-state balanced modulator for "Set-and-forget" carrier suppression.
AC-500 Power Supply . . . operates from 115/230 VAC and provides all operating voltages for the NCX-500.

the Rockcrushing Linear NCL-2000

Here's the full legal power, completely self-contained desktop 2000-Watt SSB PEP linear amplifier for the 80 through 10 meter bands. The NCL-2000 may also be operated on CW, AM, or RTTY at 1000 Watts DC input.
☐ Built-in power supply, built-in cooling fan. ☐ Equal power output on all bands 80 through 10 meters. ☐ Most complete safety and overload protection, including 1 minute time delay relay, overload relay, lid interlock, and automatic shorting bar.

the Classic Receiver HRO-500

No other amateur receiver can come close to the performance of the HRO-500, with the widest frequency range and greatest performance of any general coverage receiver ever built:
☐ 5 kHz through 30 MHz frequency range, in five main bands (60 500-kHz sub-bands) with 1 kHz calibration accuracy on ¼ inch per kHz dial. ☐ Passband tuning for SSB and CW operation. ☐ All solid-state for high reliability, portability, low power requirements, and absolutely cool operation. ☐ Phase-locked frequency synthesizer for superior stability and overall calibration. ☐ AGC threshold control to knock out background QRM.

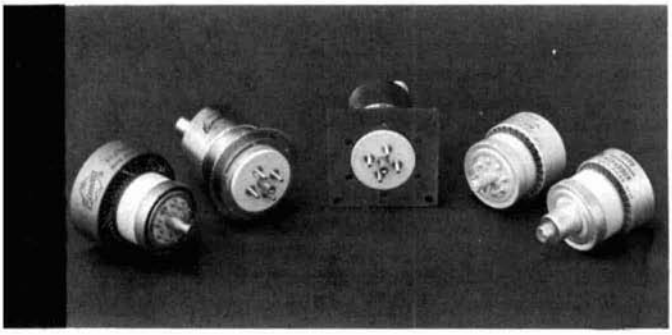
For complete details and specifications, write:

NATIONAL RADIO COMPANY, INC.

NRCI 37 Washington St., Melrose, Mass. 02176
Telephone: (617) 662-7700 TWX: 617-665-5032

©1968, National Radio Company, Inc.

International Marketing through: **Ad. Auriema, Inc. 85 Broad Street, New York, New York**



vhf/uhf effects in gridded tubes

Here is a rundown on the characteristics you should understand to get the most out of gridded tubes at uhf

Bob Sutherland, W6UOV, Power Grid Development Lab, Eimac Division of Varian, San Carlos, California 94070

The technically-minded amateur has known for some time that a vacuum tube becomes progressively less effective as the frequency of operation is increased. Amplifiers require greater driving power, output power drops off, and the manufacturer may be obliged to derate the tube at the high-frequency end of the operable range. If the frequency is raised high enough, the gain of the amplifier will drop to an unusable level. Upon further increase in frequency, the gain will drop to unity or less. At the same time this is happening, the input impedance of the amplifier drops as does the maximum impedance realizable in the plate circuit.

Numerous factors contributing to the reduction of amplifier output at vhf and uhf can be listed and divided roughly into three groups:

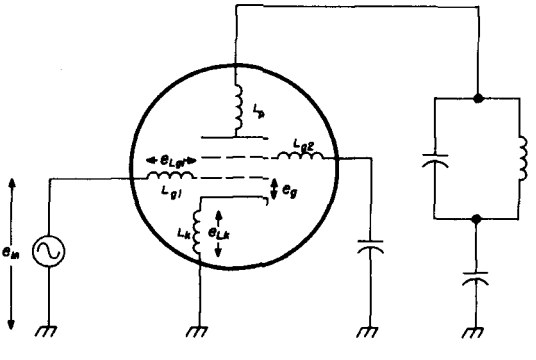
1. Circuit-reactance limitations
2. Circuit and tube loss limitations
3. Electron transit-time limitations.

circuit-reactance limitations

At the very-high and ultra-high frequencies there exists a situation which is quite different from that which exists at low frequencies. At low frequencies the electrical circuits and the tube are quite distinct. As frequency increases, this ceases to be true, and it is found that part of the resonant circuit exists within the tube (**fig. 1**). The electrode leads, while they are normally short and have large surface area in modern tubes, have a small but finite inductance. As the frequency of operation is raised, the reactance of the **lead inductance** will become quite appreciable, often reaching undesirable proportions in the vhf-uhf regions. The effect of lead inductance is to create a voltage drop such that the applied voltage across the external terminals of the tube will not entirely appear across the electrodes. Driving voltage is thus lost across the lead inductance.

In addition, while the interelectrode capacitances may be small, at ultra-high frequencies they approach a large fraction of the capacitance required to establish resonace in an external circuit. As such, the interelectrode capacitances represent a limitation in terms of actual operation as the external tank circuit may "disappear" within the tube. The combination of the electrode-lead-inductance and the interelectrode capacitance may cause an **internal resonance** in the uhf region.

fig. 1. The total input voltage does not act upon the grid-to-cathode electron stream because of grid and cathode lead inductance—the voltage across them subtracts from the input voltage.



A typical internal resonance experienced in a large power tube is the circuit consisting of the control-grid cage and mounting cone, and the screen-grid and cone. These two assemblies can form a quarter wavelength long tuned-line circuit shorted at the tube envelope by the capacitor consisting of the two contact rings and the dielectric material used in the envelope. The internal resonant frequency could be in the range of 1400 MHz for a five- to ten-kilowatt tube. This could lead to a 1400-MHz parasitic oscillation.

The smaller the tube, the higher the resonant frequency. All tubes will have internal resonances and the designer must move them out of the normal usable frequency range or load the circuit in such a way as not to degrade the performance within the rated frequency range. Even if resonances do not occur, the combination of reactances within the tube may constitute an undesired network that creates a mismatch between the driver and the tube electrodes.

magnitude of lead inductance

The most important reactance encountered in a vacuum tube is that associated with the lead inductance. An estimate of the magnitude of lead inductance may be made using the following equation:

$$L = 1.00508\ell \left(2.303 \log_{10} \frac{4\ell}{d} - 1 + \frac{d}{2\ell}\right)$$

where L = inductance (microhenries)
ℓ = wire length (inches)
d = wire diameter (inches)

This equation assumes no mutual inductance with some other nearby lead or wire.

As an example of how great lead inductance can be, consider the case of a lead that is 0.1-inch in diameter and one-inch long. This lead will have an inductance of 0.015 μH and an inductive reactance of 47 ohms at 500 MHz. An inductive reactance of this magnitude, for example, between the screen element and the screen by-pass capacitor outside the tube can cause stability problems. A voltage drop exists across the

screen reactance caused by the current flowing through it which is the vhf current charging the output capacitance of the tube. This voltage is impressed upon the screen, which thereby is removed from ground potential, disturbing the grid-plate isolation normally afforded by this element.

This source of positive input resistance can be better understood by realizing that it results from a signal appearing across the cathode lead inductance, driving the cathode a small amount, as in a cathode-driven amplifier. (In a cathode-driven amplifier, the alternating current component of the plate

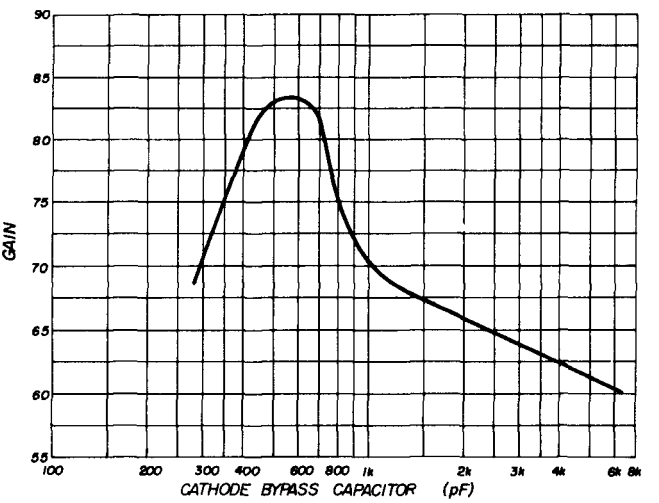


fig. 2. Gain of a 5CX1500A 100-MHz class-B amplifier with different values of cathode bypass capacitance. Gain peak occurs when bypass capacitor is series resonant with tube, socket and cathode lead inductance.

cathode lead inductance and input loading

Tube gain will also be adversely affected due to a reduction in input resistance because of the cathode-lead inductance. A small amount of cathode-lead inductance in conjunction with the grid-to-cathode capacitance of a vacuum tube will cause a resistive load to appear across the input of the tube. The magnitude of this added shunt input resistance is:

$$R \cong \frac{1}{\omega^2 L_k C_{gk} g_m}$$

R = input resistance due to cathode-lead inductance
$\omega = 2\pi f$ where f is frequency (hertz)
L_k = cathode lead inductance (henries)
C_{gk} = Grid-to-cathode capacitance (farads)
g_m = transconductance (mhos)

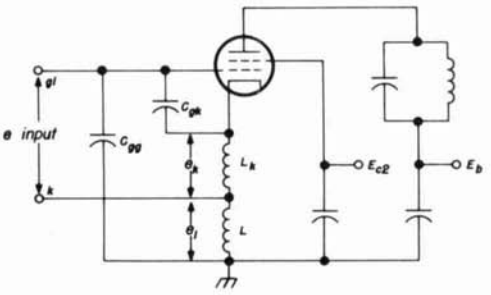
current has to flow through the cathode lead inductance to reach the cathode. Since the driving signal is in series with the output load through the cathode-to-plate resistance of the tube, some of the power in the load is supplied by the driver.) Unwanted feedthrough power is thus supplied by cathode lead inductance in a grid-driven stage.

The above equation shows that as the frequency is increased, the grid-loading due to cathode-lead inductance increases. For example, if the frequency of the amplifier is tripled from 144 to 432 MHz, the input resistance of a particular tube at 432 MHz would be one-ninth the resistance at 144 MHz. If it is desired to drive the 432 MHz tube to the same maximum grid voltage swing, then nine times the power is required just to cover the input loading due to cathode-lead inductance.

There will be other losses such as skin

effect, dielectric, radiation, transit time and the circuit reactance effects shown in **fig. 1.** The amount of grid loading due to cathode-lead inductance may be reduced somewhat by separating the input and output circuit paths back to the cathode. Some miniature tubes and low power transmitting tubes, such as the 4CX250B, 6146 and others, have multiple cathode leads to minimize the cathode-lead inductance effects. Transistors also have this problem, only it is called emitter-lead inductance instead of cathode-lead inductance.

fig. 3. Cathode lead neutralization.



vhf/uhf cathode-lead inductance neutralization techniques

It is possible to neutralize the effects of the cathode-lead inductance by choosing the value of cathode by-pass capacitor so it will be **approximately** series resonant with the total lead inductance (tube, socket and circuit inductance). This technique is particularly effective in low noise stages of vhf/uhf receivers.

Fig. 2 illustrates stage gain as a function of cathode by-pass capacitance value in a high power vhf amplifier. This particular graph was obtained from an experimental 100-MHz, 5CX1500A amplifier running in class B. The 5CX1500A cathode lead, socket and circuit lead inductance was measured to be just over four nanohenries. A capacitance of 637 picofarads was calculated to be necessary for cathode lead inductance neutralization. The graph agrees fairly well with the calculated data.

A neutralization technique described in the October 1939 issue of **Electronics** is of interest (**fig. 3**). I have had no personal experience with this technique, but it does appear to have merit. The voltage drop e_L across L, caused by the cathode current, is reversed in polarity with respect to e_k in the sense that C_{gg} and L are in series between grid 1 and the cathode. Thus, the current flowing back to the grid through C_{gg} is 180 degrees out of phase with the applied voltage, e_{input}. For a certain value of L the currents through C_{gk} and C_{gg} will be equal as well as opposite in phase; thus, the conductance between grid 1 and the cathode is zero. For neutralization of the cathode lead inductance the following ratio must be met:

$$\frac{L}{L_k} = \frac{C_{gk}}{C_{gg}}$$

For the 5CX1500A 100-MHz amplifier component values for neutralization of the cathode lead inductance could be:

$L_k = 4$ nanohenries
$C_{gk} = 35.8$ picofarads
$C_{gg} = 10$ picofarads
$L = 14$ nanohenries

The well known 4CX250B—rated to 500 MHz.

This tube has twice the cathode area of the 4CX250B and provides better than —40 dB intermodulation distortion.

L_k and C_{gk} are typical characteristics of the 5CX1500A and SK840 socket while C_{gg} and L are added components.

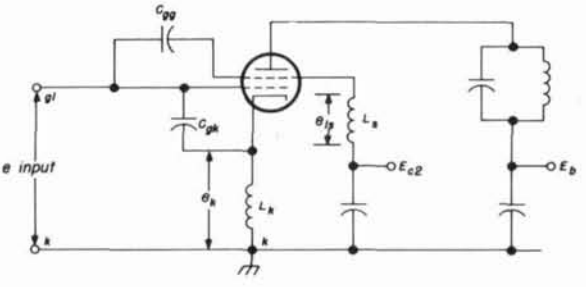
A very similar method of neutralizing that part of input resistance caused by the cathode lead inductance uses an inductance in the screen-grid lead and has been often used in 6146-type gear at 144 MHz (**fig. 4**). Basically, this circuit is the same as **fig. 3.** There are two differences: the point K (cathode pin) is now at ground potential and only screen current flows through the inductance L_g.

Other circuits may be used to minimize the effects of the cathode-lead inductance. The grounded-grid, cathode-driven (or probably more correctly called the "grid-separation" circuit), is often used (**fig. 5**). In this case the cathode is driven while the grid in a triode, or the grid and screen grid in a tetrode, are operated at some low rf potential. The grid structures then act like a shield between the input and output circuits. The main advantage, as far as cathode-lead inductance is concerned, is that this inductance is now just another inductor in series with, and therefore a part of, the input tuned circuit. There are other advantages that can be credited to the "grid separation" amplifier which will be discussed in the section on interelectrode capacitances.

intermodulation distortion and input loading

An appreciable amount of input loading can increase intermodulation distortion. Any tube plate-characteristic non-linearity will cause a variation in this input loading with signal level and thereby present a varying load to the driver, thus causing increased distortion in the drive voltage.

fig. 4. Neutralizing cathode lead inductance with an inductor in the screen lead on the tube side of the screen bypass capacitor.



screen lead inductance

The screen lead inductance between the screen element and the screen by-pass capacitor may help or hinder the operation of an amplifier. Below the **self-neutralizing frequency**[1,2] of the tube, the screen lead inductance is usually detrimental to the stability of the amplifier, as the rf current flowing through this inductance will cause an unwanted rf voltage to be developed. The point where the screen bypass is connected to the screen terminal may very well be at rf ground potential, but the potential of the screen itself may be varying above and below ground by the magnitude of voltage developed across the screen lead inductance, eL_g (**fig. 4**).

The magnitude of the developed voltage depends on the inductance of the screen lead and the frequency of operation. The higher the frequency, the greater the inductive reactance and the greater the rf current through this inductor. The current is greater

because the capacitive reactance of the output capacitance of the tube will be smaller, and the capacitor will be charging to the same rf plate voltage swing each cycle.

At operating frequencies below the self-neutralizing frequency of a tetrode, screen inductance may be added in order to neutralize the amplifier. That is, the self-neutralizing frequency is lowered to the operating frequency.[3] At operating frequencies above the self-neutralizing frequency of the tube, a series capacitor is sometimes added to move the self-neutralizing frequency up to the operating frequency (**fig. 6**). As was briefly touched upon previously, sometimes it is desirable to add a certain amount of screen lead inductance to neutralize the number of leads to use to provide the inductance he needs for his design.

In a cathode-driven (grounded-grid) amplifier, control-grid inductance is very important. Just as in the case of the screen-lead inductance in a grid-driven tetrode amplifier, the control-grid inductance in a cathode-driven amplifier may aid or hinder the designer. The control-grid inductance may cause instability, a loss in drive voltage due to the voltage divider effect (**fig. 1**) or it may be used to provide a method of neutralizing the amplifier.[2]

plate lead inductance

The plate in modern tubes used for vhf/uhf operation is usually designed with a

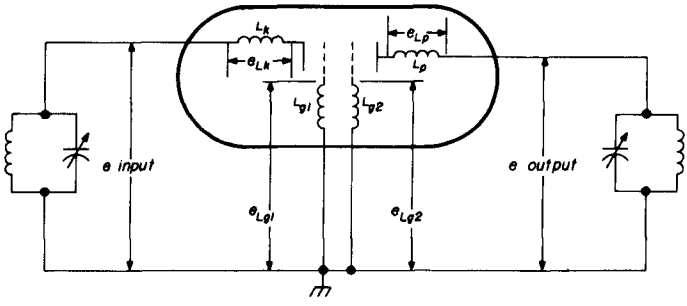


fig. 5. Cathode-driven or grid-separation amplifier.

cathode-lead inductance portion of the input resistance.

control-grid lead inductance

The **control-grid lead inductance** in a grid-driven amplifier is usually not of much concern as the relative magnitude of the tube lead inductance as compared to the external inductance added to it to attain resonance is very small. The control-grid lead inductance is wholly a part of the input resonant circuit with no current being induced from the output circuit, and it becomes part of the input tuned circuit. An exception to this is in the case of a vhf/uhf **distributed amplifier.** In this application an active filter is designed using all of the tube lead inductances and interelectrode capacitances. The control-grid inductance is important in this case, and modern distributed amplifier tubes are made with four grid leads available to the equipment designer. He then has the choice of the massive anode structure in order to dissipate the heat that is generated in this element of the tube. For this reason, plate lead inductance is usually low enough so it is not of any great concern. If normal good engineering practice is followed in designing vhf/uhf circuitry, the plate lead inductance becomes inconsequential.

interelectrode capacitance

In addition to lead inductance, interelectrode capacitance plays an important role in the operation of tubes in the vhf/uhf regions. Interelectrode capacitances due to active parts of the tube structure are incapable of reduction beyond a certain point. However, in many tubes the interelectrode capacitance results largely from capacitance between leads in areas of the tube where electrons do not flow. It is the job of the tube designer to reduce this unnecessary capacitance to a minimum.

input capacitance

The input capacitance of a grid-driven tube is the sum of the grid-to-cathode and grid-to-screen capacitances. The larger the input capacitance, the greater the drive power must be. This can be explained by the very large increase in input charging current necessary to charge the input capacitance. As the frequency increases the reactance of the input circuit becomes smaller, and for the same peak grid voltage, the charging current must increase. As power is proportional to the square of the current, the power lost in the input circuit necessarily increases as the charging current rises. The driver must supply this extra power.

To reduce this loss, the circuit designer must keep the input capacitance down and may limit the magnitude of the peak grid voltage. Peak grid voltage can also be minimized by operating with less bias. Quite often in certain amplifiers the class-B mode is more desirable than class-C operation. Reducing the peak grid voltage and the charging current will reduce the amount of power that must be dissipated by the control grid. Radio frequency power dissipated by the control grid unfortunately cannot be measured by the dc meters on the front panel of the amplifier, so the operator has no means of knowing if charging currents cause excessive grid temperature. High input capacitance also limits the bandwidth of the input circuit. For those applications requiring large instantaneous bandwidth, great care must be taken in the design of the equipment.

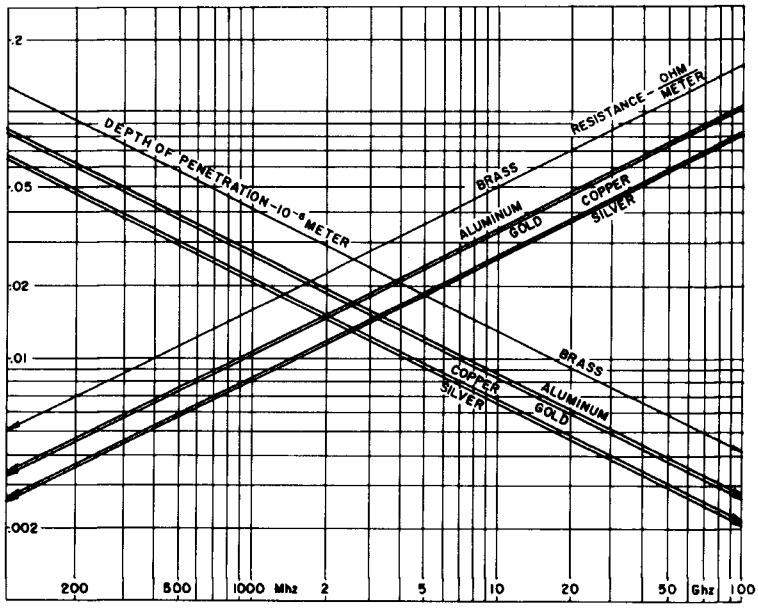
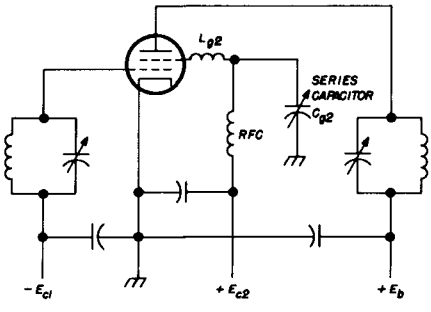


fig. 7. Chart for computing resistivity and depth of penetration for metallic conductors between 100 MHz and 100 GHz.

fig. 6. Screen neutralization at operating frequencies above self-neutralizing frequency of tube.



The grid-separation or cathode-driven amplifier offers quite an advantage as far as input capacitance is concerned. The input capacitance consists only of the cathode-to-grid capacitance. For the same tube in the cathode-driven configuration, the input capacitance will be roughly half that value in the grid-driven circuit. This is quite an advantage for applications requiring wide bandwidths.

output capacitance

The output capacitance of a power tube is an important factor in determining what plate-load resistance can be used. This in turn determines the stage gain and power output that is available. The equivalent shunt resistance (plate-load) of a parallel resonant circuit can be written as $R_L = Q/2\pi fC$ or $R_L = 2\pi fLQ$ where R_L is the plate-load resistance, Q is the loaded Q of the resonant circuit and f is the resonant frequency. For

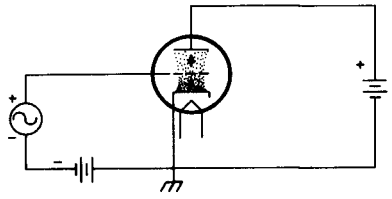


fig. 8. The effect of transit time on grid losses. At the instant shown, the grid potential is increasing in a positive direction and there is a consequent disproportionate number of electrons between grid and cathode so there is electron flow from the grid even though it may be negatively biased.

operation at a given frequency, to **increase** the shunt resistance it is necessary to **decrease** the shunt capacitance. This can be done to a point by reducing the circuit capacitance and increasing the tank coil inductance, maintaining the same frequency of resonance. Eventually, this process is limited by the fact that the capacitance external to the tube has been reduced to zero; the shunt resistance is finally determined by the tube interelectrode capacitance. The larger the interelectrode capacitance, the smaller the shunt resistance that can be realized. Accordingly, power output tends to drop off as the load resistance, or as the square of frequency, as frequency increases.

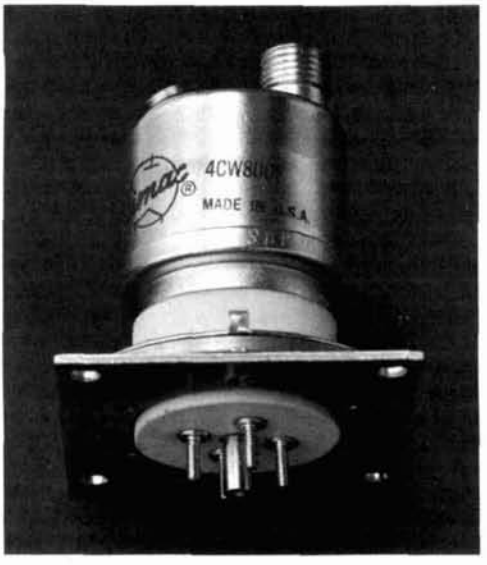
There are other problems brought about by the effect of output capacitance. The output capacitance must be charged and discharged during each cycle of the radio frequency. Again, as the frequency increases, the reactance of the output capacitance decreases. Therefore, with the same value of peak rf plate voltage, the current flowing through the output capacitance must increase as the frequency increases. The output capacitance of a tetrode is made up of the screen grid structure, the plate structure and the tube envelope.

The charging currents must flow over the surface of these components of the tube, all of which have varying degrees of rf resistance. It is possible for the charging currents to exceed the dissipation rating on the screen grid even though the dc meters indicate all is within ratings. It is advisable in vhf/uhf circuits, therefore, to try to achieve the lowest usable value of peak rf plate voltage by using the lowest plate load resistance and drawing the highest plate current consistent with desired output power and efficiency. Running the tube in this manner will lighten the rf stress on the tube seals and reduce the rf current in the screen grid structure thus providing for a potentially longer tube life.

feedback capacitance

The feedback capacitance in a grid-driven amplifier is the capacitance from anode to the control grid. The higher the frequency of operation, the greater the chance for instability due to rf feedback from the output circuit through feedback capacitance to the input circuit. In the vhf/uhf region this capacitance and other tube capacitances and inductance must be adjusted to provide for neutralization by added circuit components.[4]

The grid-separation amplifier helps minimize the effects of the feedback capacitance. The feedback capacitance in this configuration is very much less than the grid-driven case since it is the capacitance from anode to cathode with the grid, or grids, shielding the output from the input. In some applications no neutralization will be required. Other applications may require quite extensive neutralization.[3,5]



Distributed-amplifier tube discussed in text. By choosing the number of control-grid leads, the designer can control lead inductance. The tube in the right-hand photo has a screen by-pass capacitor installed. Center pin is one of the heater pins; the square tab on the capacitor is the other heater connection and the cathode. The *threaded pins are control-grid leads.*

Tube designed for large phased-array radar system. Two of these tubes were used in the 1000-watt 432-MHz amplifier used by WA6LET with a 150-foot dish for moonbounce contacts in 1965.

circuit and tube-loss limitations

The power losses associated with a tube and circuit all tend to increase with frequency. In the vhf/uhf region, almost all radio-frequency current flows in the surface layers of a conductor because of skin effect (**fig. 7**). The resistance and rf losses in a conductor increase with the square root of frequency because the layer in which the current flows decreases in thickness as the frequency increases. Insulating supports in the tube and external circuit have losses associated with the molecular movements produced by the electric fields. These dielectric losses will usually vary directly with frequency. Also, there will be additional losses due to the *radiation of energy from the wires and leads* carrying rf current. The power radiated from a short length of wire carrying current increases as the square of the frequency.

All these factors contribute to a general reduction in tube and circuit efficiency as operating frequency is increased. In the manufacture of power tubes the resistance losses are reduced by increasing conductor surface area and by proper choice of lead materials. Dielectric losses are reduced by

selection of envelope and insulating materials. Support insulators are positioned, when possible, out of high voltage fields. Radiation losses are reduced by constructing vhf and uhf tubes and circuits so as to be totally shielded. At times it is prudent to use concentric line construction techniques so that tube and circuit fields are entirely confined.

transit-time limitations

Electron transit-time effects can contribute to reduced tube output in many ways. Transit time is the finite time an electron takes in going from the cathode to the grid. If the transit time (a function of grid-to-cathode distance and grid-to-cathode voltage) is an appreciable fraction of one ultra-high-frequency cycle, then an electron in transit in the grid-to-cathode region might be still heading for what was once a more positive location than the cathode surface it just left, but now finds the grid may be less positive or perhaps even negative (**fig. 8**). As a result of transit-time effect in the cathode-grid region, there will be a dispersal of "out of step" electrons. Because of this dispersion of the electron stream, the plate-current pulses are not as sharp as the current pulses liberated from the cathode.

In addition, energy is required to accelerate the electron towards the anode, and this energy is supplied by the driver. As the operating frequency is raised, more energy is required because the grid-input resistance due to transit time varies inversely as the square of the frequency. That is, if the frequency is doubled, the input resistance due to transit time effects will be one-fourth that at the lower frequency. The extra power required to overcome transit-time loss due to grid-input resistance is supplied by the driver and appears as lost drive-power—required but put to no practical use other than to heat the tube seals and waste precious exciter output.

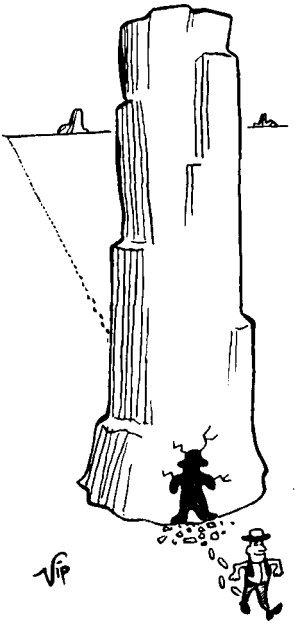
Paradoxically, transit-time loss and cathode-lead inductance loss (both of which cause input loading) are not all evil because they often tend to stabilize a "wild" stage. Cure of the trouble may lead to higher stage gain with the possibility of oscillation and instability!

Circuit loading can be used to achieve stability and this is often done at the lower frequencies by adding resistors across i-f transformers, for example. The circuit designer, therefore, finds that a tradeoff exists between loading and stage gain that will work to his advantage or disadvantage, depending upon his ability to analyze the circuit. There is often more than one successful path to a proper design and the good circuit engineer has several alternative paths (in his head, if not on paper) to choose from. A candid realization of uhf/vhf effects will help the circuit designer obtain maximum power, efficiency and reliability from his equipment.

references

1. K. R. Spangenberg, "Vacuum Tubes," McGraw-Hill, New York.
2. W. I. Orr, W6SAI, W. H. Sayer, WA6BAN, "Cathode Driven Linear Amplifiers," *QST*, June, 1967, p. 36.
3. R. I. Sutherland, W6UOV, "Care and Feeding of Power Grid Tubes," Eimac Division of Varian, San Carlos, California.
4. R. B. Dome, "Television Principles," McGraw-Hill, New York.
5. F. E. Terman, "Radio Engineering," McGraw-Hill, New York.

ham radio



High-power linearity with Eimac power-grid tubes.

solid-state circuits for single sideband

More and more transistor circuits are creeping into commercial ssb gear—here are some of the circuits that are currently being used

Forest H. Belt, 2610 Whittier Avenue, Louisville, Kentucky 40205

Transistors haven't taken over ham equipment as quickly or as thoroughly as they have some electronic gear, but semiconductors of all kinds are steadily working their way in. You see more solid-state construction in homebrew rigs than in commercial ones. Nevertheless, when you look over the range of ssb equipment now available, you find there's hardly a circuit that hasn't gone solid-state in some brand or some model. No serious ham can help being interested.

At first, only small size and portability (battery operation) were the reasons for using transistors. But semiconductors have been around for 20 years now, and they are more reliable and stable than ever before. With few exceptions (high power, extremely high frequency) transistors can now perform most tube functions—and in many cases do a better job. Furthermore, the field-effect transistor (FET) has made high-impedance solid-state circuits possible.

Here are some places you'll see transistors in single-sideband transmitters and receivers.

speech or af amplifier

The two-stage amplifier of **fig. 1** is typical of audio transistors used in sideband rigs. This circuit is from the Galaxy V Mark 2 transceiver. Q9 and Q10 are speech amplifi-

ers between the microphone and the balanced modulator. Power and frequency demands are modest, and hundreds of inexpensive transistor types can do this job.

The dc supply hookup is simple—positive voltage to the collectors, and emitters returned to ground through stabilizing resistors R105 and R109. R106 and R112 drop the supply voltage to the right collector potential, and C157 and C124 decouple the two stages from each other and from the rest of the transceiver.

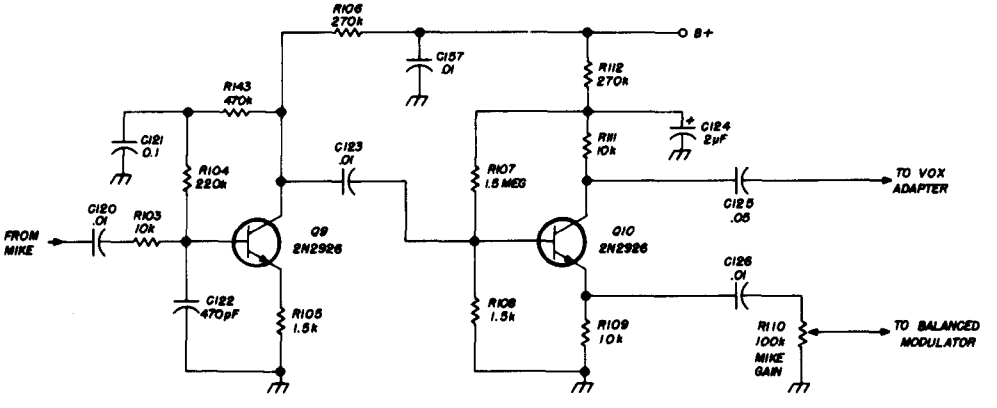
Q9 gets base bias through R143 and R104, with C121 for decoupling. Q10 uses R107 to carry base bias; R107 is a voltage divider with R108.

audio output stage

Audio power requirements aren't stringent in ssb receivers; a watt or two is usually sufficient to drive the speaker. Many sets use a pair of transistors in class-B push-pull service—like the one in **fig. 2,** from the Gonset 910A transceiver.

Since these transistors are pnp types, they require negative collector voltage (with respect to emitter). In this hybrid rig, however, supply voltage is positive with respect to chassis. The collectors of Q10 and Q11 are connected to ground through the low dc resistance of T5's split primary. The emitters go to the 12-volt line through R32, a stabilizing resistor. The collectors are thus negative

fig. 1. Microphone amplifier.



The audio signal is brought from the microphone through blocking capacitor C120 and is applied to the base through a filter consisting of R103 and C122. This filter removes any stray rf, but has little effect on speech signal. Emitter resistor R105 is unbypassed; that adds a little degeneration to improve linearity in the stage. The audio output from Q9 develops across collector load R106.

This output signal is fed to the base of Q10 through C123. Q10 is a phase splitter, with collector and emitter resistors (R111 and R109) equal. The collector signal goes to a VOX adapter. The emitter signal is fed through C126 and microphone gain control R110 to the balanced modulator.

with respect to the emitters. Base bias comes from a voltage divider (R30-R31).

The signal from the audio driver stage is coupled to Q10 and Q11 by the split secondary windings of input transformer T4. The collectors feed their output signals to the split primary windings of T5. The secondary matches a 3.2-ohm speaker.

crystal bipolar oscillator

Raytheon's Sideband Engineers SB-34 transceiver uses a germanium bipolar pnp transistor as a 456.38-kHz oscillator. On transmit, it generates the carrier frequency, and on receive it supplies the carrier-reinsertion signal. Output from this stage is fed to the balanced modulator, which is also the bal-

anced detector for receiving.

The circuit—shown in **fig. 3**—is a Pierce crystal oscillator. Feedback is from collector to base via the crystal.

As in the preceding circuit, the supply voltage is connected to the stage in what some people call an upside-down arrangement, which is used a lot with pnp transistors. The emitter and base are positive with respect to chassis, and the collector is grounded (through L11). The collector is thus negative with respect to the emitter.

Base bias is taken from divider R18-R19. The emitter stabilizing resistor (R20) is bypassed by C19, to prevent degeneration. Output voltage is developed by the collector across L11. Since the output is untuned, Q12 is operated class A, with a fairly clean sine-wave output.

fet crystal oscillator

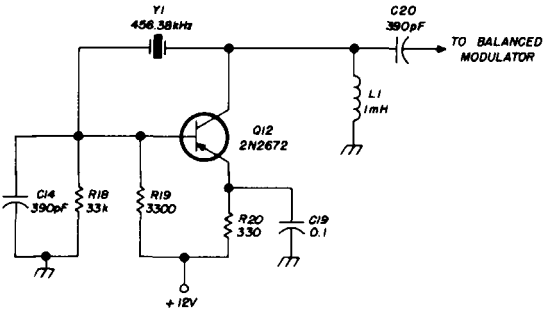
One advantage of the field-effect transistor (over the bipolar) is that the FET's high impedance loads a crystal very lightly, making a more stable oscillator. FETs also have better temperature stability than bipolars.

These advantages are put to good use in the Drake R-4B receiver, which uses an n-channel junction FET as a calibration oscillator. The circuit is shown in **fig. 4.** It's another Pierce type, with feedback through the crystal from drain to gate. C119 is a trimmer to allow zero-beating the 100-kHz oscillator with WWV.

R73 returns the gate to ground for dc. Source bias is used, and source resistor R72 is bypassed for rf by C120. Output voltage is developed across drain load R155, decoupled by C189. C188 feeds this rf to a buffer amplifier. C138 lowers the drain-circuit impedance, thereby stabilizing the oscillator. The output is very high, so the shunting effect of C138 does no harm.

Q8 is operated class A and produces a clean sine wave at 100 kHz. Other stages divide this down to 50 and 25 kHz. The last stage produces lots of harmonics, putting harmonics every 25 kHz across the bands of interest. By rearranging jumpers in the divider stages, the user can get 25-, 50-, or 100-kHz markers to calibrate from.

fig. 3. Pierce type crystal oscillator.

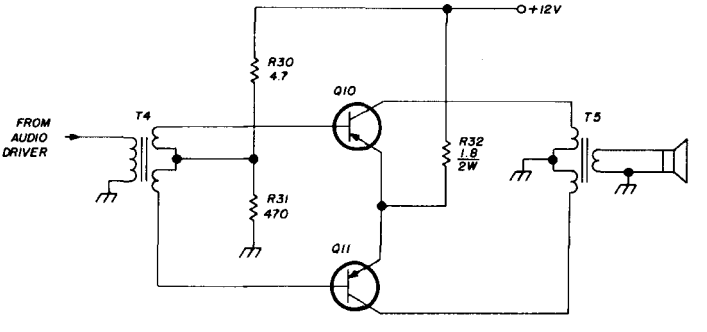


voltage-tuned vfo

In the past, vfo's have been LC-tuned, usually with an air-dielectric capacitor as the variable element. Some new transistor vfo circuits, however, use a voltage-variable capacitor (also called a varactor or varicap). The Gonset 910A transceiver uses a varactor to tune a vfo over the range of 5.5-6.5 MHz.

The circuit is shown in **fig. 5A,** and it's somewhat complex. Look at how it's redrawn in **fig. 5B,** though, and you'll recognize a

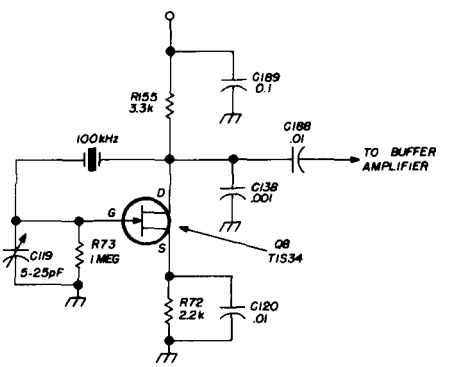
fig. 2. Class-B audio output stage.



Colpitts oscillator; C32 and C34 form the feedback divider. L1 and all those capacitors are in series across the divider.

Q17's collector is negative with respect to its emitter, as befits a pnp bipolar. R33 is the load resistor, connected from collector to ground. R46 is the emitter stabilizing resistor, and connects the emitter to the positive 10-volt line. Base bias comes from a divider

fig. 4. Pierce oscillator using a field-effect transistor.



(R45-R34) between the 10-volt line and ground.

Still referring to **fig. 5B,** note that in the tank circuit there is only one variable element. This symbol represents six capacitors and a variable-capacitance diode. In **fig. 5A** you can see those parallel capacitors on the left side of the diagram. C26, C27, and C28 furnish the bulk of capacitance that resonates with L1. C29 and C30 are trimmers for aligning the vfo. C31 is a blocking capacitor, so the control voltage can be connected to D8 without affecting the base of Q17.

A voltage divider (R68, R47, and the vfo tuning control), connected from the 10-volt line to ground, supplies the control (tuning) voltage. As the slider of the tuning control is moved, it varies the bias applied to the diode. As the capacitance of D8 varies, it changes the frequency of the oscillator over a 1-MHz range. L2 and C98 decouple the tank circuit from the control-voltage line.

i-f amplifier

For an example of a simple i-f amplifier, look at **fig. 6**—the circuit used in Gonset's 910A transceiver; frequency is 9 MHz.

You should recognize the upside-down dc supply circuit used for Q5. Its collector is grounded for dc through T2's primary, and the emitter is returned to the 12-volt positive line through emitter stabilizer R16 (bypassed for rf by C12) and the rf gain control. Base bias is applied through R58, but is overridden during certain signal conditions by voltage from the agc line. Stage gain is varied two ways: by the manual rf gain control and by the agc line.

Transistor i-f transformers—such as T10 and T2—often use a lot of turns on the tuned winding (the primary in this case) to improve the Q of the tuned circuit. With many turns on the coil, the parallel capacitor can be small. Also, the slug-type tuning is more effective. But, because bipolar transistors are low-impedance devices, the primary of T2 is tapped at a low-impedance point for the collector connection. The low-impedance base of the next stage is fed from a low-impedance, few-turn secondary.

two-way i-f amplifier

The Raytheon SB-34 transceiver uses a novel i-f amplifier stage at 456 kHz. During transmission, the stage amplifies the dual-sideband signal from the balanced modulator and applies it to the mechanical sideband filter. During reception, the direction is reversed. Incoming rf is heterodyned down to the 456-kHz i-f and passed through the mechanical filter. The i-f stage amplifies these signals and passes them to the balanced modulator, which then functions in reverse as a product detector.

The circuit of this bilateral i-f amplifier is shown in **fig. 7.** The emitters of the two transistors share a common stabilizing resistor (R33) and by-pass capacitor (C29), and both emitters are tied to the 12-volt positive line. Q5's collector is returned to dc ground through the mechanical filter (not shown). Q6's collector is returned to dc ground through the secondary of T2.

As you may have guessed, one transistor is on during transmit, and the other is off. They switch during receive. The swapping is done by changing base bias. In the transmit

mode, line A is grounded. R31 and R32 become a voltage divider from 12 volts to ground, forward-biasing Q5 and turning it on. The sidebands of 456 kHz are fed from the balanced modulator through T2, and then through C28 and R30 to Q5, which amplifies them and sends them on to the mechanical filter.

Line B meanwhile is 12 volts positive. Divider R37-R38 has 12 volts at both ends. Q6 is therefore not forward-biased, and does not conduct.

In the receive mode, line A gets 12 volts, which turns off Q5. Line B is grounded, so now divider R37-R38 develops bias at the base of Q6. Rf coming from the mechanical filter goes through C30 to the base of Q6, where it is amplified and fed through T2 to the balanced-modulator/product-detector.

rf amplifier

In one commercial transceiver, a simple rf amplifier is used. Its circuit is shown in **fig. 8.**

The dc circuit is pretty much what you've seen before. No emitter resistor is used; the emitter is tied directly to 12 volts—although it is bypassed for rf by C106.

Base bias is developed by divider resistors R97 and R98; but notice: they're connected between the 12-volt line and the agc line. This keeps the rf stage from overload by applying agc action.

Rf from the antenna is fed through the T/R relay to tuned circuit L17-C129, which is broadly resonant across the transceiver's operating range of 49.975 to 54.025 MHz. The rf input is tapped down on L17 to match the 50-ohm antenna.

Another tap on L17, a little higher, matches the base impedance of Q21. From there, dc blocking capacitor C107 feeds the rf to Q21.

A tap on L16 matches the collector impedance of Q21. The resonance of tank circuit L16-C105 is broadened by R95. The rf output signal developed across the tank is fed through C104 to the first mixer.

two-way mixer

Earlier, you saw the two-way i-f amplifier used in the Raytheon SB-34 transceiver. The same principle is used in that unit's vfo mixer. The circuit is shown in **fig. 9.**

The dc hookup is about the same as in the i-f amplifier in **fig. 7.** The collectors are returned to ground through T3 and T6, and the transistors share a common emitter resistor (R45) and bypass (C43). Base bias is developed by dividers from the 12-volt line to control lines A and B.

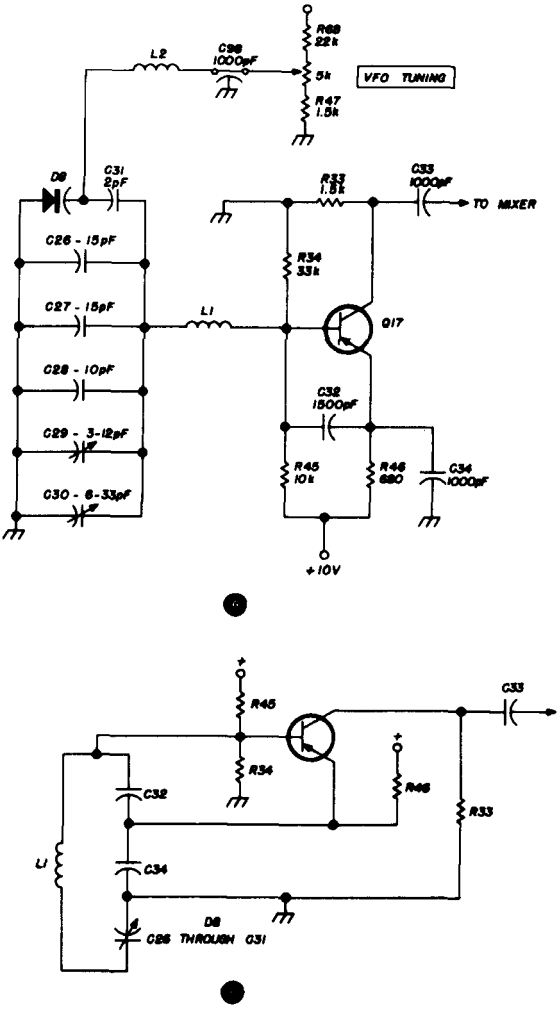
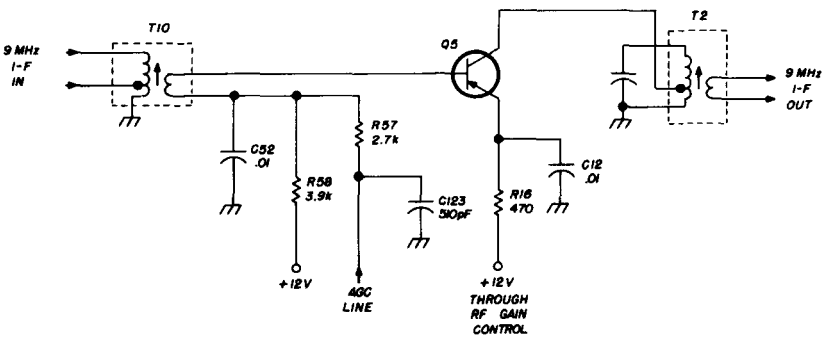


fig. 5. Voltage-tuned vfo; simpler version is shown in B.

In the transmit mode, Q7 is on; it amplifies the sideband signal, sending it on to the hf mixer and ultimately to the power amplifier and antenna. During the receive mode, Q8 is on; it amplifies incoming rf and sends it to the mechanical filter.

But the purpose of this stage is to add the vfo output to the i-f signal. The vfo operates between 5457 and 5707 kHz. Transformer L4 the vfo signal, producing a difference frequency of 2289 kHz, which is fed to the next mixer stage.

fig. 6. Simple intermediate-frequency amplifier.



couples its output to the emitter-base circuits of both Q7 and Q8.

For transmitting, the sideband signal passes from the mechanical filter through T3 to Q7. There, it is heterodyned with the vfo (5457-5707 kHz). The new difference frequency is between 3175 and 3425 kHz, and this signal is applied to T6. Of course, T6 accepts only the specific difference frequency produced by the vfo. It's tuned by the A and B sections of C48, which are on the same shaft as the vfo's tuning capacitor.

For receiving, the system works in reverse. The incoming rf is in the range of 3175 to 3425 kHz. It's tuned by C48 and T6 and passed to Q8. There, it is heterodyned with

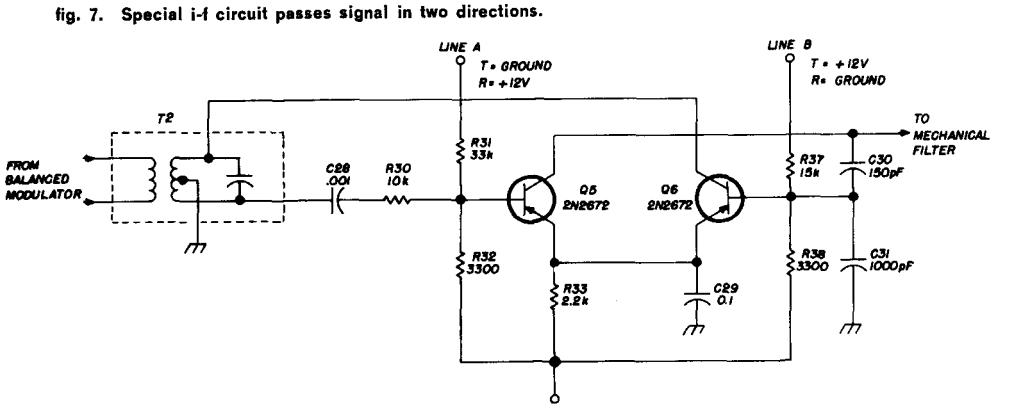
product detector

In the Gonset 910A, a transistor is the product detector for ssb (a diode is the a-m detector). The emitter-follower circuit is shown in **fig. 10.**

The rf sidebands around 9 MHz are brought through T3, whose secondary is a low-impedance link that matches the low base impedence of Q7. C16 keeps dc out of T3 while coupling the rf to Q7's base. A steady signal from the 9-MHz crystal oscillator is also fed to the base of Q7, where it heterodynes with the sideband signal from transformer T3.

The collector of Q7 returns to ground

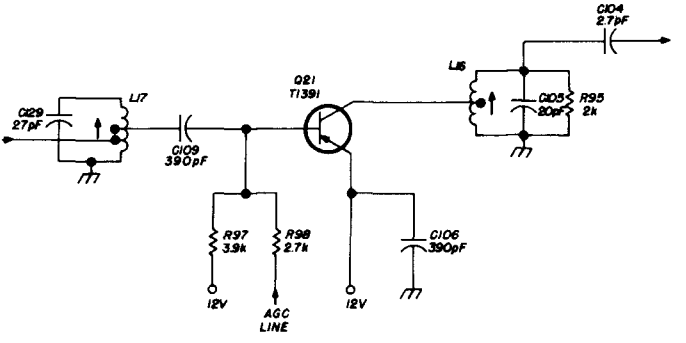
fig. 7. Special i-f circuit passes signal in two directions.



through resistor R23, and is grounded directly for rf by C19. The emitter is fed dc from the 12-volt line through load resistor R24. C131 eliminates any rf that is "hanging on," and C20 couples the audio to the volume control. Base bias is developed by divider R20-R21.

through R124 to the base (through R121) and the emitter (through R123). The rf gain control (R122) forms the bottom part of the divider from the 100-volt negative line. All this makes the collector positive with respect to emitter.

fig. 8. Rf stage uses tapped coils to match transistor impedances.



agc amplifier

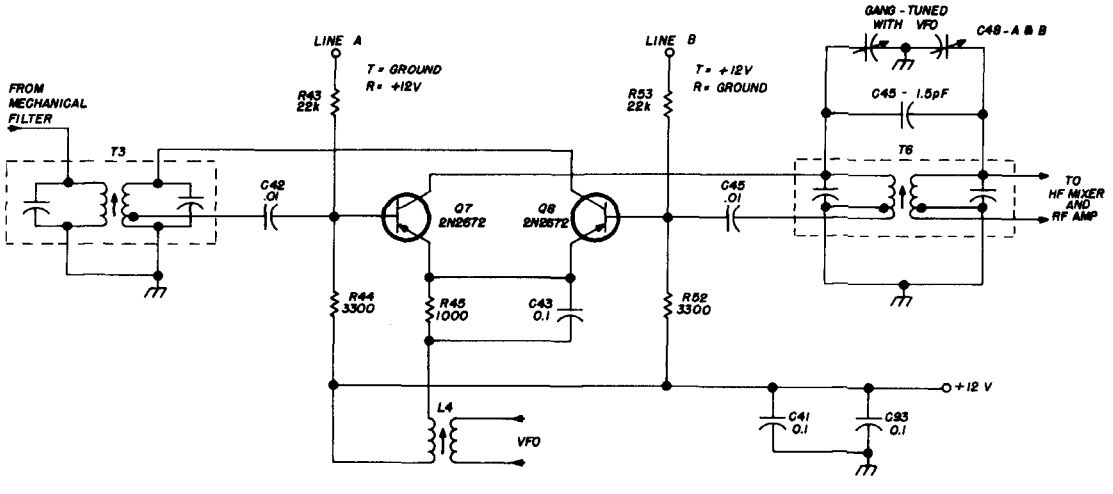
One transistor agc circuit, from the Galaxy V Mark 2, is shown in **fig. 11.** Audio signals are fed through C137 from the product detector to the base of Q8. This is an npn stage which requires positive collector voltage. But the collector must develop a negative voltage to apply to vacuum-tube grids (the set is a hybrid).

If the collector must be somewhat negative with respect to ground, the emitter and base must be even more negative. As you can see, a 100-volt negative line is tied

Q8 rectifies the audio signal and develops a negative dc output across the R125, R126, and part of R122. C138 and C139 bypass what audio is left, and the negative dc voltage is used to bias the grids of the rf and i-f amplifiers.

Manual gain control for both rf and i-f stages is provided by R122. The arm taps off a portion of the voltage from the negative 110-volt line, and applies it to the grids of the rf and i-f amplifiers through R126. Only if the dc output of Q8 exceeds the amount set by R122 does the agc take effect.

fig. 9. Two-directional mixer stage with common oscillator for both receive and transmit.



bias regulator

National's NCL 2000 is a linear power amplifier in which a pair of power tubes in parallel furnish 2000 watts PEP when driven by an ssb exciter. For proper sideband operation, the PA grid bias must be held constant despite varying line voltage or load changes. **Fig. 12** shows the circuit that accomplishes this task.

A dc supply furnishes 90 volts negative directly to the collector of the regulator transistor. This —90 volts is also tied, through R39, to the emitter of Q2, the error amplifier. Q2's emitter is held at —18 volts by zener diode D9, as a steady reference. C17 and C12 bypass any transient voltages that might be too quick for the zener diode.

The collector of Q2 is also tied to the 90-volt negative line, through R38. C6 and C8 bypass any transients that get into this branch. Q2's collector is more negative than its emitter or its base (which goes to ground through R42). Q2 is biased on and conducts.

But Q2's collector is tied directly to the base of regulator transistor Q1. Also, remember, Q1's collector is tied directly to the 90-volt negative line. Q1's emitter, which is the output element of the regulator, is returned to ground through resistors R40, R41, and R42—a voltage-sensing divider across the regulator output line. C11, C15, C16, C10, and C49 bypass any transient voltages in the grid-bias sensing network.

When Q2 is on, Q1 is also on, but its base bias depends on the conduction of Q2. Current flows from the 90-volt negative line through Q1, and through the sensing divider R40-R41-R42 to ground. This places Q1's emitter—and the PA grid-bias line—normally somewhere between —25 and —45 volts with respect to ground.

If the voltage on the grid-bias line changes, it affects voltage at Q2's base. Q2 amplifies this change and inverts it at the collector.

fig. 10. Emitter-follower product detector.

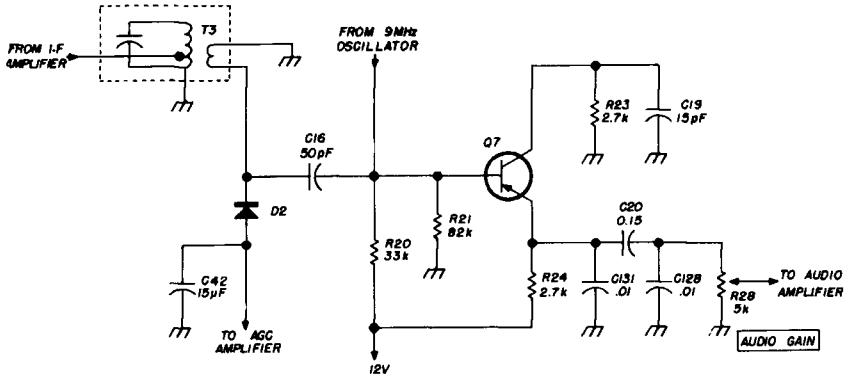
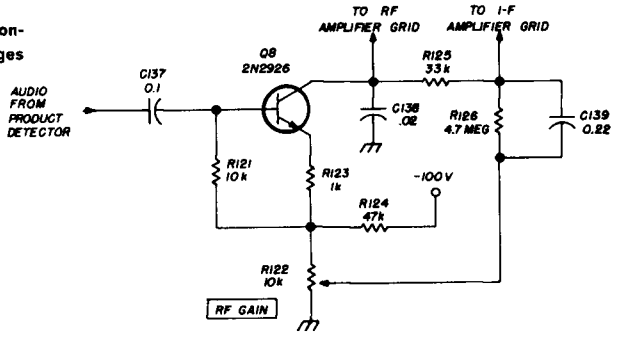
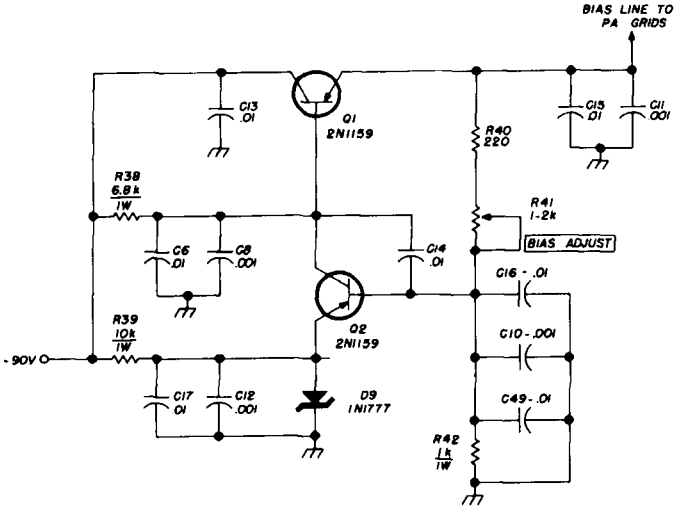


fig. 11. Solid-state automatic gain control circuit that furnishes control voltages for vacuum tubes.



Thus, any error signal is applied to the base of Q1. The emitter-collector conductance of Q1 changes and restores the original voltage at Q1's emitter. The normal bias value is adjusted manually by R41, which sets the operating point for the base of Q2.

fig. 12. Two-transistor circuit regulates power-tube grid bias.



drive indicator

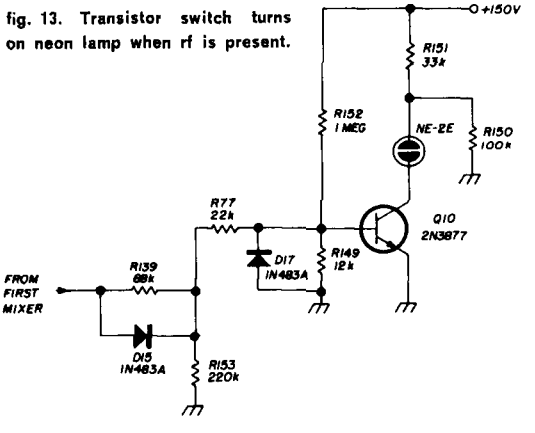
The Drake R-4B receiver is often used with a companion transmitter. When it is, the receiver vfo is used to excite the transmitter. The frequency is then identical for receiving and transmitting.

But if the transmitter were fired up without rf drive, the final tubes could be damaged. A neon lamp might be used to monitor rf drive directly, but the rf level is too low to fire a neon. So, a transistor switcher is used instead, as shown in **fig. 13.**

R150 and R151 form a divider from the 150-volt line to ground. Q10 is an npn grounded-emitter transistor, and is not normally conducting, so it has a high emitter-collector resistance. The lamp stays off.

When the vfo operates, rf from the first mixer stage is rectified by D15; a positive voltage develops across R153. This dc is applied through R77 to the base of Q10. (D17 is a protective diode which shunts any negative peaks to ground.) The transistor is biased into conduction and becomes a low resistance from its collector to ground. The neon fires.

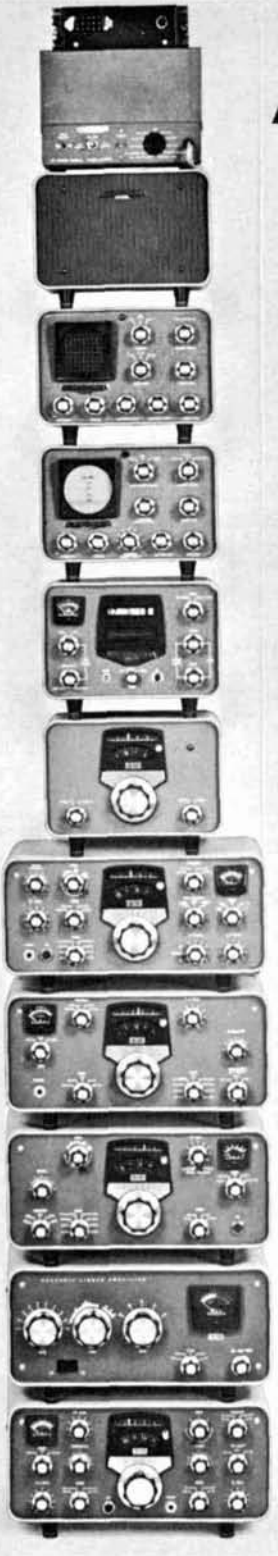
fig. 13. Transistor switch turns on neon lamp when rf is present.



future of transistors in ssb

That's a real handful of transistor circuits. Most sideband functions, you have seen, can be performed by today's transistors or diodes. You may have noticed that no rf power stages were mentioned here. This lack will soon be filled. New silicon "overlay" transistors promise up to several hundred watts and can work beyond 50 MHz. Some are available now, but at high cost. In time, though, all but the very highest-powered ssb transmitters will be completely solid-state.

ham radio



STACK THESE UP AGAINST THE OTHERS...

This Complete Heathkit SB-Series 80 thru 6M Mobile And Fixed Rig Costs Only $1936.70

A bit impractical to install in one place perhaps, but so is spending nearly $2000 on new equipment and not getting the maximum amount of operating versatility and performance. For the price of a few pieces of gear from most others, you can buy every piece of SB-Series gear Heath makes, plus both mobile and fixed power supplies. Many hams don't have $2000 handy though, and that's why Heathkit sells each of these pieces separately. We believe that you should still be able to get a stack of gear without spending a pile of money. For performance, versatility and top dollar value, the others just don't stack up.

The HP-13 — mobile power supply for the SB-101 & SB-110A. All solid-state construction. 7 lbs.	**$64.95**
The HP-23A — fixed power supply for the SB-101 & SB-110A. Overload and short circuit protection. 19 lbs.	**$49.95**
The SB-600 — 8 ohm fixed station speaker to match all SB and HW-Series gear. 6 lbs.	**$18.95**
The SB-610 — Signal Monitor for transmitted & received AM, CW, SSB & RTTY signals, 160-6M. 14 lbs.	**$74.95**
The SB-620 — "Scanalyzer" for monitoring band activity up to 500 kHz each side and bench testing transmitters. 15 lbs.	**$119.95**
The SB-630 — Station Console with 24 hr. digital clock, SWR meter, resettable timer, etc. 10 lbs.	**$74.95**
The SB-640 — External LMO for the SB-101. The 640/101 combination will operate in five different modes. 9 lbs.	**$99.00**
The SB-101 — world's finest 80-10 M transceiver. 180 watts PEP SSB input, 170 watts CW. 23 lbs.	**$370.00**
The SB-301 — world's finest AM, CW,SSB & RTTY receiver. 80-10 M +15 MHz WWV coverage. 0.3 uV sensitivity. 25 lbs.	**$260.00**
The SB-401 — world's finest 80-10 M transmitter. 180 watts PEP SSB input, 170 watts CW. 36 lbs.	**$285.00**
The SB-200 — world's greatest 80-10 M linear value. 1200 watts PEP SSB input, 1 kw on CW. 41 lbs.	**$220.00**
The SB-110A — the best 6 M rig anywhere. 180 watts PEP SSB input, 150 watts CW. 23 lbs.	**$299.00**

TOTAL $1936.70

NEW Free 1969 Heathkit Catalog

Now with over 300 kits described for stereo /hi-fi, color TV, electronic organs, amateur radio, marine, educational, CB, home & hobby. Mail coupon or write Heath Co., Benton Harbor, Michigan 49022.

HEATHKIT

HEATH COMPANY, Dept. 122-1
Benton Harbor, Michigan 49022
In Canada, Daystrom Ltd.

☐ Enclosed is $_____ plus shipping.

Please send model (s)_____

☐ Please send FREE Heathkit Catalog.

☐ Please send Credit Application.

Name_____

Address_____

City_____ State_____ Zip_____

Prices & specifications subject to change without notice. AM-206R

mosfet converter for 220 mhz

You must still select these semiconductors for the higher frequencies—but it's worth it

Don Nelson, WB2EGZ, 9 Green Ridge Road, Asland, New Jersey 08034

Superior gain characteristics of the metal-oxide semiconductor field-effect transistor (MOSFET) have been exploited in ham-band converters for six and two meters in **ham radio's** June and August 1968 issues.[1,2] Although its gain diminishes slightly between 200 MHz and 300 MHz, the MOSFET—particularly the dual-gate type—is still a fine performer at 220 MHz. The deluxe combination of low noise, high gain and low cross-modulation are packaged in the following solid-state converter, which is reasonably easy to construct and tune.

circuit considerations

The 1¼-meter band is more demanding of semiconductors than are the lower frequencies. Only by selecting high-quality components was it possible to achieve the desired level of performance. Much to my surprise, the oscillator and multiplier transistors are equally as critical as those used in rf stages.

The first rf amplifier uses an RCA 3N159 dual gate MOSFET, which is a low-noise version of the RCA 3N140. In using the 3N159, you achieve the lowest possible noise figure, about 2.5 dB. Very low feedback capacitance

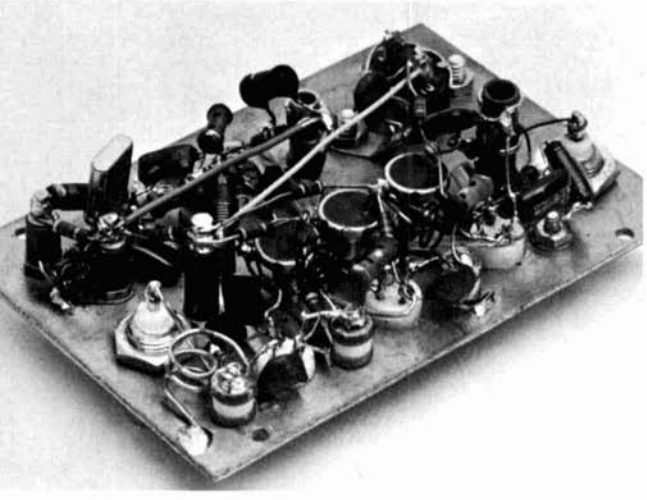
—less than 0.02 pF—allows operation with no neutralization. The second stage, being less critical, uses the 3N140 operating at lower gain to prevent overload.

Two rf stages may be stagger tuned if wideband operation is desired. Unlike the two-meter converter, which had to be stagger tuned, this converter can have both stages peaked on the same frequency. This added utility is made possible by using dual-gate MOSFET's in both rf stages, with Teflon sockets, to minimize feedback capacitance.

Only one change is made in the 3N141 mixer circuit from that in the 6- and 2-meter converters. It is the addition of a neutralizing circuit from gate 2 to ground.[3] The L and C resonate at 14 MHz, effectively bypassing gate 2 at the intermediate frequency. (Values must be changed if output other than 14 MHz is employed.) Incoming signals will be improved one S-unit or more with this circuit. The technique may also be used on the two-meter converters.

Birdies and "garbage" on 220 have not helped to make it a popular band. One way to improve the situation is to use a high-frequency local oscillator as was done here. A 2N3478 drives a 103-MHz fifth overtone crystal whose frequency is doubled in a second 2N3478. Cheaper transistors did not deliver enough injection voltage for good gain in the mixer.

I find that the use of back-to-back diodes in the antenna circuit is quite controversial. Some feel they are essential to prevent burnout of the front-end transistors, while others say this is not so.* My friend Ed, W2DMR, uses a 3N140 preamplifier with no diodes on ten meters with a kilowatt. His only isolation is a DK60G relay. He operates within 1/4 mile of another kilowatt on the same band without problems. I have removed the diodes in all my converters without mishap, but 10 watts of rf is the greatest power I've generated on any band. Diodes are shown in the schematic for those who care to use them.



Sometimes rf burnout has been traced to slow decay of the transmitter's output, rather than the lack of isolation of the relay. In this case, large amounts of rf may load the converter during coaxial relay switching. A very good solution to this problem is found in delaying the relay, or by using two sequentially operated relays—one for the transmitter; one for the receiver.

construction

As with the 6- and 2-meter converters, all components were mounted on copper-clad printed-circuit board according to the layout shown. The board is fastened to a Bud CB1626 chassis. Satisfactory operation is once again possible without shields. For those who may have forgotten the rules for handling MOSFET's, the following should be observed:

1. Keep MOSFET leads shorted until ready to use. (These devices are shipped this way.)

2. When cutting leads, grasp lead and case with fingers to reduce possibility of electrical and mechanical shock.

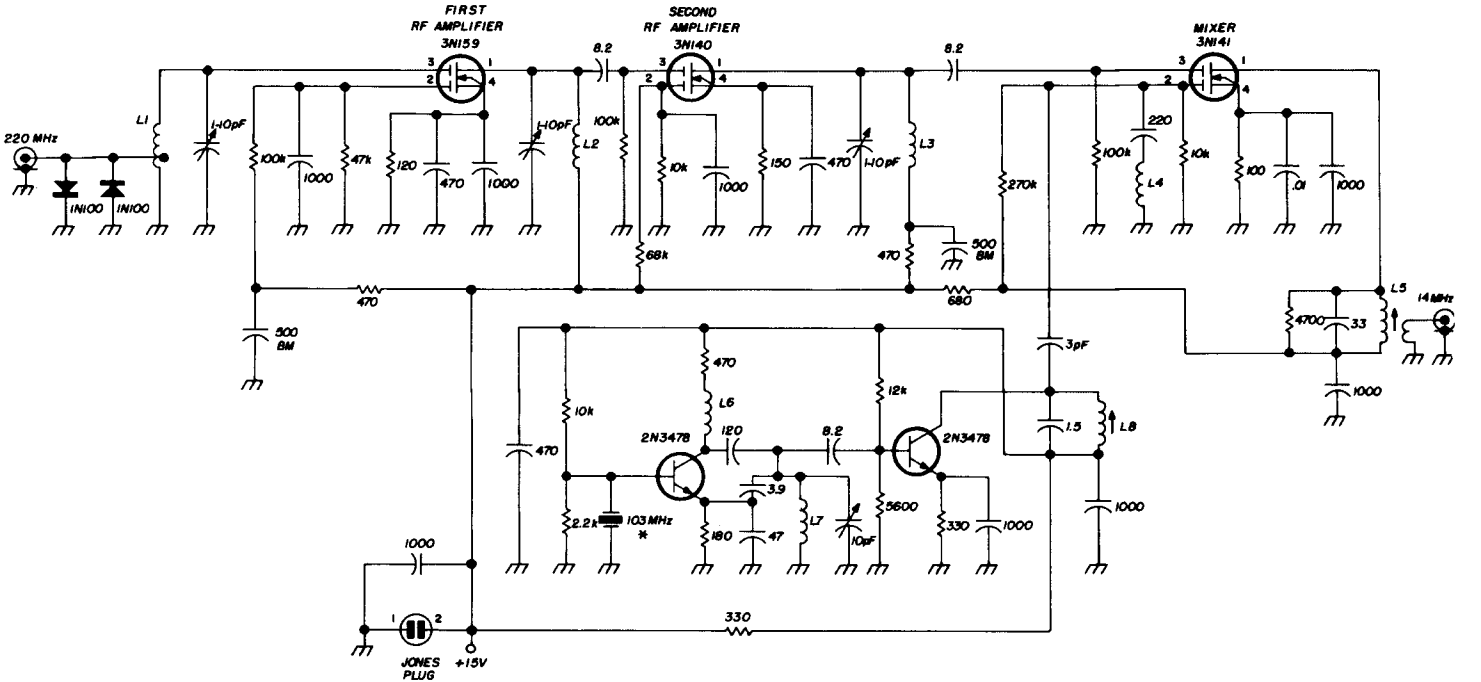
3. Do not solder or change components with MOSFET's in their sockets. (Such a practice may be acceptable if you use a soldering iron with a grounding system.)

4. Never insert or remove transistors when power has been applied.

performance plus

A comparison of this converter was made with my Nuvistor converter whose noise

* Depends on the transistors. Quality control and inspection mean different things to different manufacturers. Better use the diodes and be safe. **Editor.**



L1 2½ turns number 20, spacewound, ¼" diameter; tapped 1 turn from ground

L2, L3 2½ turns number 22, ¼" diameter

L4 0.68 μH. (J. W. Miller 9310-08)

L5 3 μH. 17 turns number 22 on 3/8" diameter slug-tuned form (J. W. Miller 20A336); secondary is 3 turns number 26 on cold end of L5

L6 1.5 μH (J. W. Miller 9310-16)

L7 0.22 μH (J. W. Miller 9310-02)

L8 3½ turns number 22 on .205" diameter slug-tuned form, red core (J. W. Miller 4300-3)

103-MHz crystal is 5th overtone (International Crystal FM-1-GP)

All 10-pF trimmers are JFD type VAM-010 (Allied Radio 43F345)*

fig. 1. Schematic diagram of the 220-MHz converter. Capacitors marked BM are button micas; bypass capacitors are discs or laminated ceramics.

*Available from Allied Radio Corporation, 100 N. Western Avenue, Chicago, Illinois 60680. Order catalog number 43F3475. $3.95 each plus postage: shipping weight, 2 ounces.

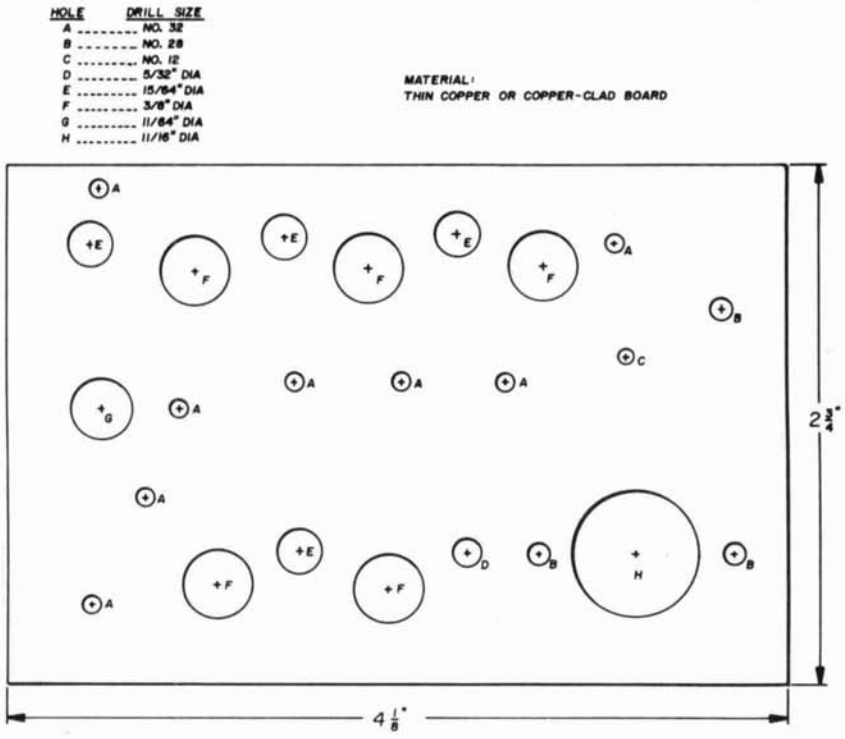


fig. 2. Chassis layout for the 220-MHz mosfet converter; this chassis designed for Bud CB-1626 chassis.*

figure is about 5 dB. The noticeably quieter MOSFET's are music to my ears. I find that the gain is comparable, which is not an easy achievement with the best of the current JFET's.

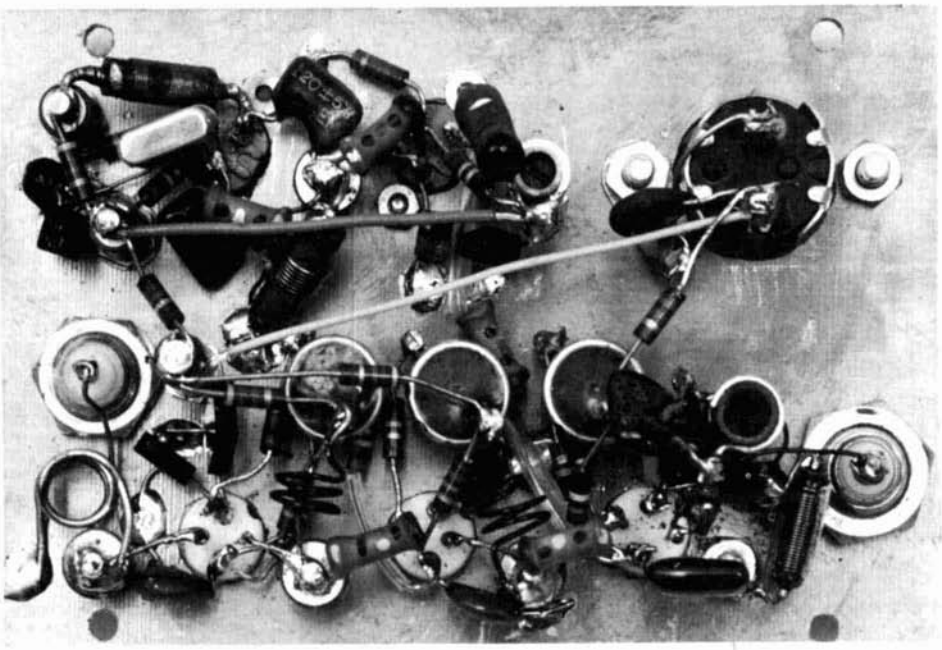
While 220 is an orphan band in many parts of the U.S., the Mt. Airy VHF Society has kept it alive in the Philadelphia area. Only one station has managed to overload my MOSFET converter. (He is hard on the tubes too!) Admittedly, this is no test for comparison, but I feel the MOSFET is at least as good as the proven two-rf-stage 2-meter converter[2] with respect to cross modulation and dynamic range.

mosfet's and the future

Only a few of the semiconductor manufacturers are manufacturing MOSFET's, and not all are interested in the depletion-mode types for vhf such as the RCA transistors used in this series of three articles. Stability problems of the oxide layer which once plagued the MOSFET have been largely solved, giving time for curing the ills of static burnout and frequency limitations.

MOSFET amplifiers at 500 MHz are practical now, but high-volume production is not in effect on these units. Some feel the

*Bud CB-1626 chassis available from Allied Radio Corporation, 100 N. Western Avenue, Chicago, Illinois 60680. Order catalog number 42E7812, $.55 plus postage; shipping weight, 12 ounces.



Under-chassis construction of the 220-MHz mosfet converter.

upper frequency limit of the MOSFET is 1000 MHz, but science may soon disprove that notion. Even now, Motorola has incorporated a layer of silicon nitride to eliminate static burnout of the oxide layer.

Fairchild has integrated additional circuitry in the MOSFET package to reduce the burnout hazard, while other manufacturers are experimenting with still different techniques. Presently, there is no simple solution compatible with all MOSFET's, but the fact also may be changed in the near future.

The metal-oxide semiconductor field-effect transistor answers the challenges of high input impedance, extremely low feedback capacitance, high gain, low noise, inexpensive construction, wide dynamic range and low cross modulation. It is so distinctive that it invites comparison in all rf and many dc applications.

references

1. D. W. Nelson, "The WB2EGZ Six-Meter MOSFET Converter," *ham radio*, June, 1968, p. 22.
2. D. W. Nelson, "The Two-Meter Winner," *ham radio*, August, 1968, p. 22.
3. H. M. Kleinman, "Application of Dual-Gate MOS Field Effect Transistors in Practical Radio Receivers," *IEEE Transactions on Broadcast and TV Receivers*, July, 1967.

ham radio

next month in ham radio magazine:

signal detection in the presence of noise

programmable repeater identifier

stable transistor vfo

universal solid-state preamp

power supplies for ssb

analyzing incorrect dc voltages

sloping dipole antenna

plus many more . . .

NOT FOR THE NOVICE

THE FT DX 400 "FULL HOUSE"

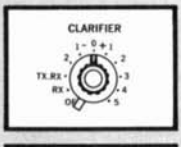
Conservatively rated at 500 watts PEP on all bands 80 through 10 the FT dx 400 combines high power with the hottest receiving section of any transceiver available today. In a few short months the Yaesu FT dx 400 has become the pace setter in the amateur field.

FEATURES: Built-in power supply • Built-in VOX • Built-in dual calibrators (25 and 100 KHz) • Built-in Clarifier (off-set tuning) • All crystals furnished 80 through the complete 10 meter band • Provision for 4 crystal-controlled channels within the amateur bands • Provision for 3 additional receive bands • Break-in CW with sidetone • Automatic dual acting noise limited • and a sharp 2.3 KHz Crystal lattice filter with an optimum SSB shape factor of 1.66 to 1.

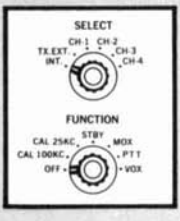
Design features include double conversion system for both transmit and receive functions resulting in, drift free operation, high sensitivity and image rejection • Switch selected metering • The FT dx 400 utilizes 18 tubes and 42 silicon semi-conductors in hybrid circuits designed to optimize the natural advantages of both tubes and transistors • Planetary gear tuning dial cover 500 KHz in 1 KHz increments • Glass-epoxy circuit boards • Final amplifier uses the popular 6KD6 tubes.

This imported desk top transceiver is beautifully styled with non-specular chrome front panel, back lighted dials, and heavy steel cabinet finished in functional blue-gray. The low cost, matching SP-400 Speaker is all that is needed to complete that professional station look.

SPECIFICATIONS: **Maximum input:** 500 W PEP SSB, 440 W CW, 125 W AM. **Sensitivity:** 0.5 uv, S/N 20 db. **Selectivity:** 2.3 KHz (6 db down), 3.7 KHz (55 db down). **Carrier suppression:** more than 40 db down. **Sideband suppression:** more than 50 db down at 1 KHz. **Frequency range:** 3.5 to 4, 7 to 7.5, 14 to 14.5, 21 to 21.5, 28 to 30 (megahertz). **Frequency stability:** Less than 100 Hz drift in any 30 minute period after warm up.

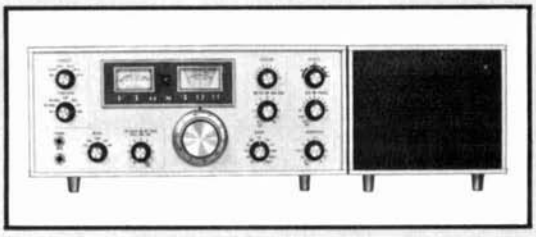


CLARIFIER CONTROL — Does the work of an external VFO — allows operator to vary receive frequency 10KHZ from transmit frequency, or may be used as an extra VFO combining transmit and receive functions.



SELECT CONTROL — Offers option of internal or outboard VFO and crystal positions for convenient preset channel operation.

FUNCTION CONTROL—Selects crystal calibration marker frequency and desired transmit mode of operation.



FT DX 400 $599.95 — SP-400 $14.95

SPECTRONICS BOX 356, LOS ALAMITOS, CALIFORNIA 90720

— PROFESSIONAL EQUIPMENT FOR THE AMATEUR —

stub-switched stub-matched antennas

A simple multiband antenna system that features automatic stub matching as you change bands

John J. Schultz, W2EEY, 40 Rossie Street, Mystic, Connecticut 06355

Transmission lines can be used for various purposes besides transferring power to an antenna. Depending on the electrical length of the line, it can function as a frequency-dependent switch, an impedance-matching transformer or a reactive circuit element. You can devise a number of interesting antenna designs with the first two functions. Normally these characteristics are used separately, but there is no reason why they can't be combined.

Before you digest any designs, it's important to have a clear idea of how transmission-line sections work as impedance-matching transformers and frequency-dependent switches.

transmission line characteristics

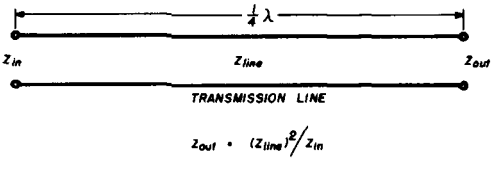
A lossless transmission line one-quarter wavelength long will transform the impedance at its input terminals to an impedance at its output terminals equal to

$$\frac{(Zo)^2}{Zin}$$

where Zo is equal to the impedance of the line.

However, this is only true when the input

fig. 1. Basic quarter-wave transmission-line transformer; limiting cases occur where input impedance is either zero or infinite.

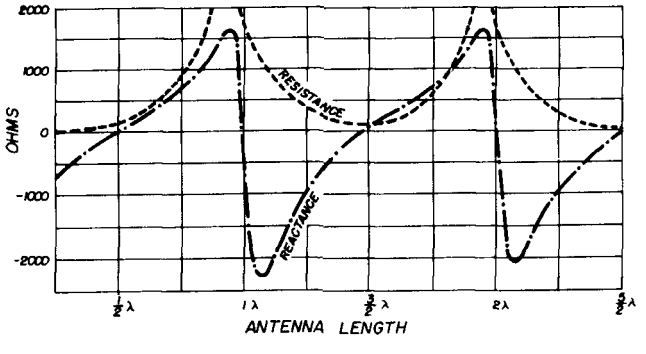


or output impedance is a pure resistance. Although the whys of this impedance transformation can be shown mathematically, the proof is somewhat tedious. Perhaps the simplest way to visualize the action is to remember that the input voltage and current vectors undergo a 90° phase shift on the quarter-wave line. Therefore, their relative amplitude values are reversed. If the input impedance is lower than the line impedance, the output impedance is always higher. If the input impedance is greater than the line impedance, the output impedance is always lower.

Any number of quarter-wave sections can theoretically be used in series if one particular line does not provide the desired transformation. If the transmission line is one-half wavelength long, the output impedance is the same as the input impedance since this is the same as putting two quarter-wave sections back-to-back.

The limiting case occurs as shown in **fig. 1** when the input impedance is either zero (short circuit) or infinite (open circuit). It can be seen from the impedance-transformation formula that the output impedance must be opposite from the input impedance. With this in mind, we can use the quarter-wave transmission line as an rf switch.

fig. 2. A dipole antenna has reactive and resistive components at harmonic frequencies as shown here.



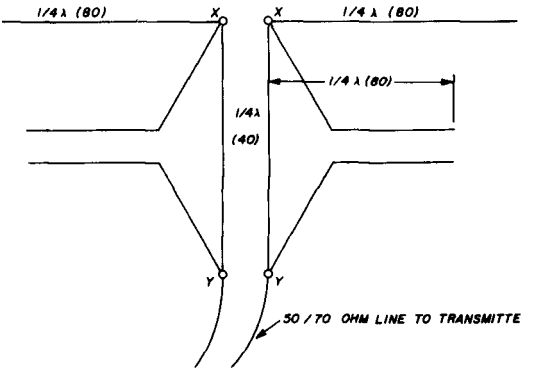
However, the switch is frequency dependent. If the input impedance is zero at a frequency where the transmission line is a quarter-wavelength long, the output impedance is infinite and looks like an open circuit. If line length is fixed and the frequency is doubled, the transmission line represents one-half wavelength and the output impedance is the same as the input impedance.

Therefore, by controlling the termination and length of the transmission line, it can be used as an impedance transformer, a 1:1 impedance transfer element or a frequency-dependent switch.

dipole harmonic operation

A simple resonant half-wave dipole presents a pure resistive impedance which matches 50- or 70-ohm cable fairly well. If the dipole is used at harmonic frequencies, its terminal resistance and reactance will vary as shown in **fig. 2.** At even multiples of a half-wavelength, the terminal impedance is highly resistive with practically no reactive component; at odd multiples, the terminal impedance is resistive at almost the same value as at the fundamental frequency with no appreciable reactive component. This is the reason you can use a 7-MHz dipole successfully on 15 meters with the same feedline.

fig. 3. A stub-switched and -matched antenna for 80 and 40; construction is shown in fig. 6.



To feed maximum power into a dipole at any multiple frequency of its fundamental, you have to match the antenna's terminal impedance. The usual way to do this is to use a resonant transmission line and an antenna coupler at the transmitter. By using combinations of quarter-wavelength transmission line sections at the antenna, however, it's

possible to obtain multiband operation without an antenna coupler or any tuning or bandswitching circuits. The transmission line going to the transmitter will still operate at a low swr on each band.

some basic antennas

Once you understand how the transmission line sections can be used, you'll undoubtedly be able to come up with designs of your own. As a starter, here are some basic designs I have investigated.

A dipole which automatically bandswitches from 80 to 40 meters is shown in **fig. 3.** On 80 meters, the open-circuited quarter-wavelength sections (shown horizontally) between points X and Y effectively short out the vertical quarter-wavelength section. This effectively connects points X and Y together as in a normally fed dipole.

On 40 meters, the flat-top portion of the antenna is a full wavelength long with a rise in input impedance as shown in **fig. 2.** The horizontal transmission line section which was one-quarter wavelength long on 80 meters is one-half wavelength long on 40 and presents an open circuit between terminals X and Y.

The vertical quarter-wavelength section is effectively connected between terminals X and Y; this section acts as a transformer, and its characteristic impedance is chosen to match the transmission line to the transmitter.

Normally, if 50- or 70-ohm coaxial cable is used, the matching section can be made from 300-ohm twinlead. The characteristic impedance of the horizontal transmission line sections aren't particularly important since they only perform a switching function.

The antenna operates as a normal dipole on 40 meters; the main radiation remains broadside to the line of the flattop with about 1.8-dB gain.

Variations of the same antenna for different bands are shown in **fig. 4.** The antenna of **fig. 4A** is designed for 20 and 10 meters

fig. 5. Using transmission-line sections for switching vertical antennas.

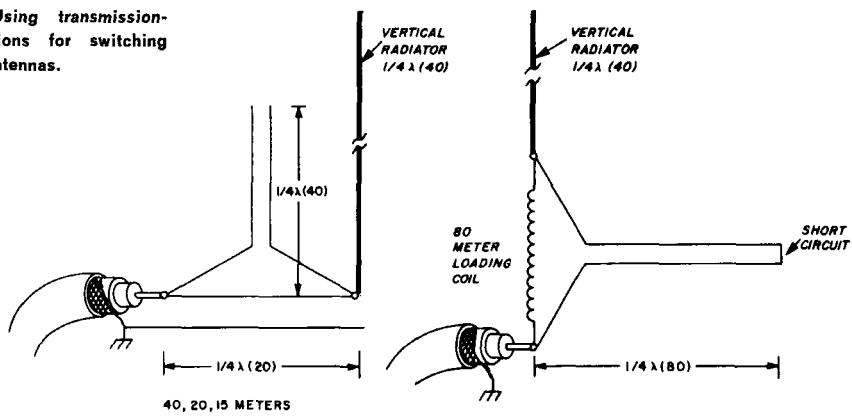
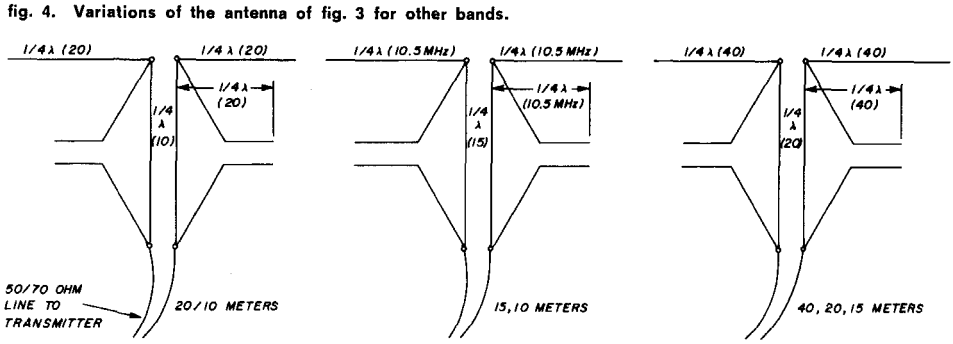


fig. 4. Variations of the antenna of fig. 3 for other bands.



and is simply a scaled version of the antenna shown in **fig. 3.** The antenna of **fig. 4B** is for 15 and 10 meters but is a bit different. Since you can't cut a half-wave dipole for 15 meters and use it as a full-wave dipole on 10, a different approach is used. The dipole is cut one-half wavelength long on 10.5 MHz; this makes it a full-wave dipole on 15 and approximately three half waves long on 10.

If you analyze the switching section, you'll find it produces a short circuit on 10.5 MHz, an open circuit on 15 meters and a short circuit again on 10 meters. The antenna is matched on 10.5 MHz and while this feature has no amateur value, it may be useful for WWV reception. Because of the length of the flattop, the antenna has about 1.8-dB on 15 and 10 meters. However, on 10 meters the radiation pattern takes the form of a cloverleaf characteristic of a 3/2-wave dipole.

The antenna shown in **fig. 4C** is a little more conventional although it is basically the same as **fig. 3.** Operation is possible on three bands —40, 20 and 15 meters—because the flattop is 3/2-wave long on 15 and the transmission-line switch shorts out the matching section.

The use of transmission line sections doesn't have to be limited to dipoles; they can be used just as easily with unbalanced vertical antennas. The antenna in **fig. 5A** is basically one half the antenna shown in **fig. 4C.** Although it resonates on 40, 20 and 15 meters, it is mainly useful on 40 and 20 since the radiation angle is quite high on 15 meters. This is because the vertical radiator exceeds 0.64 wavelength. A simple two-band antenna can also be built as shown in **fig. 5B;** in this design the transmission line section acts as a switch.

construction

You should observe a few precautions when building any antenna. For one thing, the physical length of the transmission line must take the velocity factor of the line into consideration (typically 70% for 300 ohm twinlead). The line sections shouldn't be formed into coils and placed at the center of the flattop since this will introduce spurious resonances. It's better to bring both ends of the sections to the center of the antenna in the form of a drooping "U" as shown in **fig. 6** and then make all the interconnections.

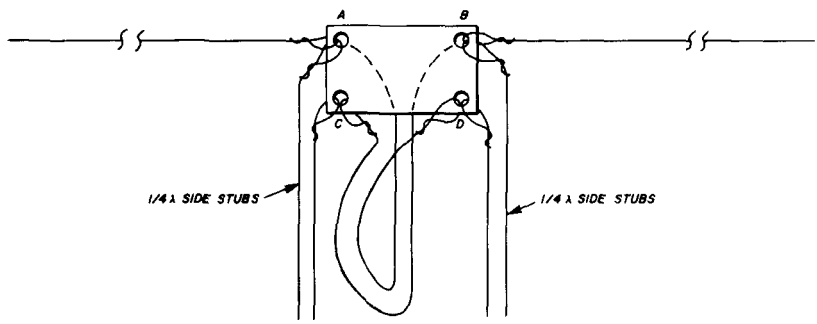


fig. 6. Construction of the stub-switched antenna. The center stub section is looped between terminals AB and CE. The coaxial feedline is connected to terminals C and D.

The values shown in **fig. 2** are typical for wire antennas made from number 12 or 14 wire. If the antenna is made from very thin wire and used on 80 meters, the impedance values at harmonic frequencies may be higher than those shown. In this case it's a good idea to put the antenna together temporarily without the switching sections and operate it on the harmonic frequency; then measure the swr to determine if you've picked the right impedance for the matching section.

You should have no difficulty with the switching sections if they are cut to formula length. The power handling capability of the antenna is determined by the rating of the transmission line used for the line sections.

ham radio

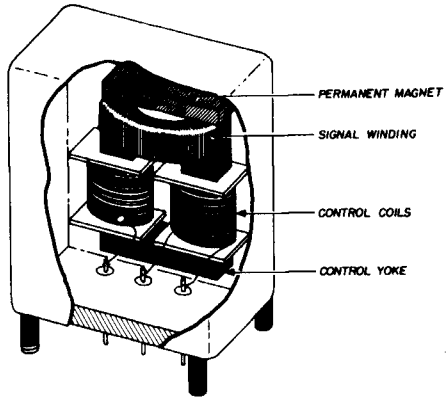
solid-state current-controlled tuning

How to use a new electronic component that adds versatility to a number of circuits

Robert M. Brown, K2ZSQ, 5611 Middaugh Avenue, Downers Grove, Illinois 60515

Coming for the most part as fallout from military research and development—where they have been used for almost ten years—are a fascinating line of variable inductors. These inductors are electrically variable, but unlike varicaps, they alter the inductance of a circuit as a control current is varied from 0 to 60 mA.

Cutaway of a typical Vari-L current-controllable inductor.

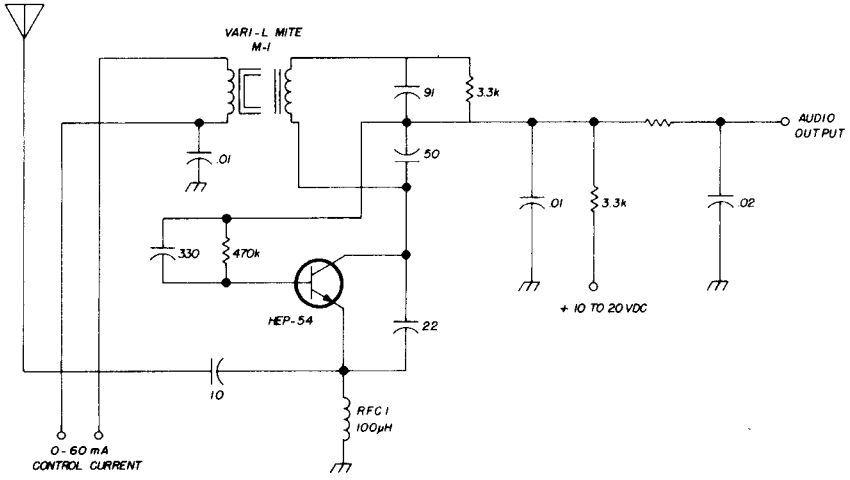


One of the circuits developed by the Vari-L Company* to demonstrate typical applications of the Mite series variable inductors is shown in **fig. 1.** As the control current is varied from 0-60 mA, this superregenerative receiver's detector tunes from 20 to 50 MHz. The audio output can be fed to a simple transistor amplifier. While the inductor shown presently sells for $15.80, the manufacturer expects production costs to fall appreciably as time goes on.

(at zero control current). With the 100-mH units, frequency bands of 3 through 30 kHz can be covered; with the .05 μh inductor, a 250-300 MHz range can be realized.

When you use these inductors, it's recommended that the signal winding be connected to the tuned circuit the same way as any conventional high-Q coil. Next, it is resonated with a suitable tuning capacitor, and the control winding is connected to a source of continuously-variable current (such as a battery and a rheostat).

fig. 1. Superregenerative receiver using a Vari-L coil. Receiver tunes from 20 to 50 MHz as the control current is varied from zero to 60 mA.



how the inductor works

These tiny variable inductors are two-part assemblies. The control winding is wound on the support legs of a U-shaped ferrite or laminated core. The signal winding is wound on a ferrite core positioned over the open end of the U; this winding is used as a tunable coil in a Colpitts oscillator or other two-terminal networks. When ac or dc current is passed through the control winding, it causes the magnetic flux to vary—decreasing the over-all permeability of the signal-winding core.

These Mite-series units are available with inductances from 100-mH to .05 μH

* Vari-L Company, Inc., 207 Greenwich Avenue, Stamford, Connecticut 06904.

By varying the current, the operating frequency is smoothly controlled. A tracked chain of several units can be controlled equally well—tuned to the same or harmonically related frequencies. The characteristic curve of a typical Mite inductor is shown in **fig. 2.**

applications

Since the inductance can be varied slowly or at high speed rates—up to several million times per second—command can come from just about anywhere. It can be a manually-operated source, an electronic circuit or a transducer. They are useful for remote control or closed-loop systems, for sweeping oscillators or passive filters and

for frequency switching.

These variable inductors have been used in receivers, both in local oscillators and gang-tuned rf amplifiers, sweep generators of all types from audio to vhf, frequency modulators for transmitters, ultrasonic test generators and spectrum analyzers. Since the unit is sealed, ruggedly built and without any moving parts, field failures are unknown. Early versions are still going strong after 12 years according to the manufacturer.

Additionally, Vari-L is now concentrating on the development of new uhf variable-inductor designs and resonant-cavity units which will extend the useful region of the devices into the gigahertz range. This should be of particular interest to uhf enthusiasts looking for better ways to remotely control their plumbing installations, such as preamps/converters that are employed at the feedpoints of parabolic dishes and corner reflectors.

One vhf application is shown in **fig. 3.**

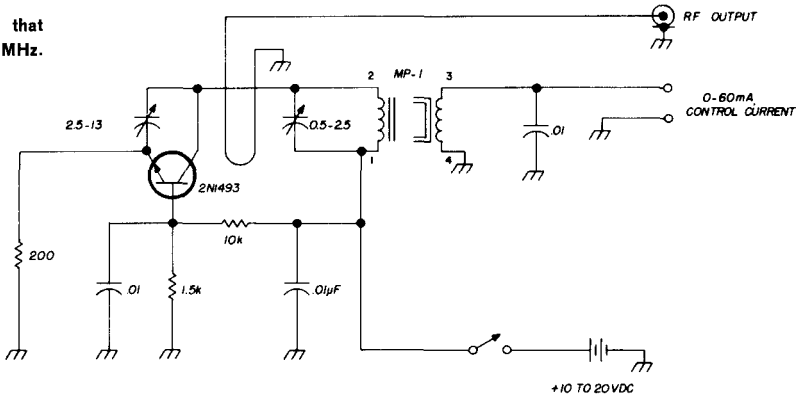
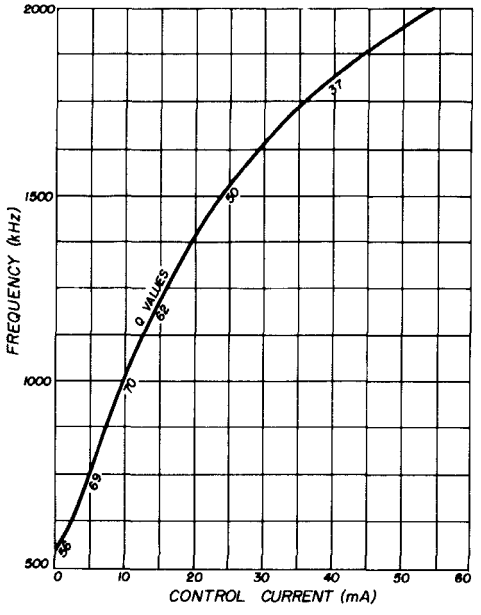


fig. 3. Oscillator that tunes from 170 to 240 MHz.

fig. 2. Characteristics of a typical Vari-L inductor.



This oscillator tunes from 170 to 240 MHz. The frequency is varied by the 60-mA control current fed to the MP-1 inductor at terminal three. The output link is a conventional hairpin located close to the tank and adjusted for maximum output at the frequency desired. The 2.5-pF variable capacitor may be a fixed value if only 220-MHz operation is desired. Do not substitute other transistors for the 2N1493.

Another interesting application is shown in **fig. 4.** This circuit provides one milliwatt into a 50-ohm load in the 260- to 380-MHz range. A Fairchild 2N3563 is recommended by the manufacturer, although a 2N918 can be substituted with good results using the same circuit constants. Usual construction techniques are recommended to insure oscillation over the entire frequency range. Further, a shielding can is recommended for the Mite MP-1.

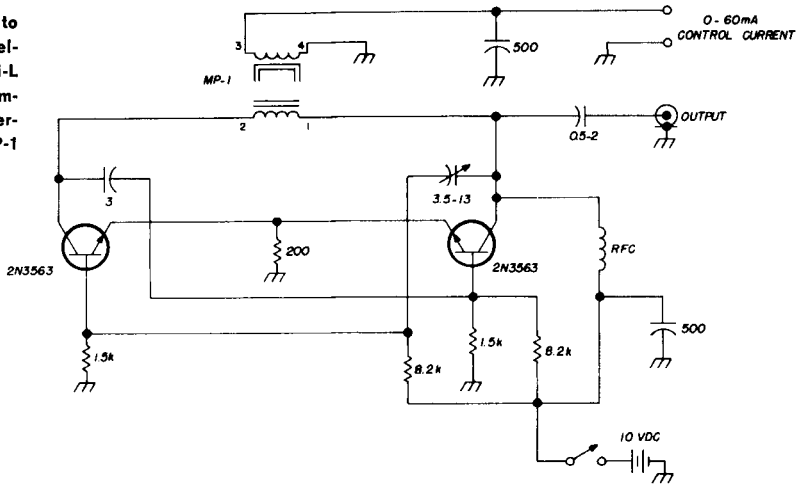


fig. 4. A 260- to 380-MHz vfo developed by Vari-L engineers to demonstrate the versatility of the MP-1 inductor.

Lastly, **fig. 5** shows how a Vari-L MK-100 inductor can be used in a 5 to 75-kHz continuously variable oscillator. With the 2N2712 transistors shown, output will be on the order of 0.1-volt rms with three-percent distortion. Unlike previous examples, this circuit requires a somewhat lower control-current range—zero to 15 mA. Other transistor types can be used with good results, including the 2N4124, 2N4265, HEP-54 and GE-10.

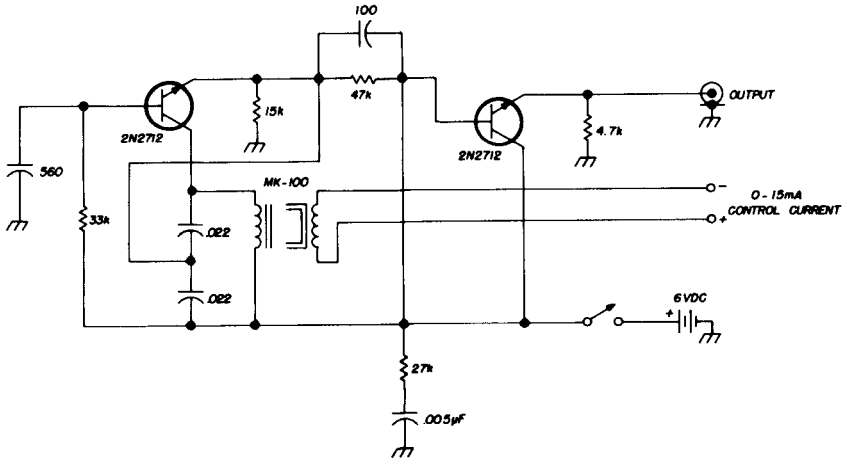
In conclusion, it should be noted that Vari-L products are presently not widely available at electronic distributors. If you're interested, it's suggested that you contact the manufacturer directly for literature. Vari-L will respond to interested amateurs and will ship single-unit quantities by first-class mail.

references

1. "Remote-Tuned Superregenerator," *Radio-Electronics*, May, 1967, p. 53.
2. "Manufacturers Circuit," *Popular Electronics*, June, 1967, p. 77. Description of a "Z-Match" unit also manufactured by Vari-L, showing application in a broad-band amplifier circuit. Readers interested in the wide-band transformer should request Bulletin 567.
3. "Vari-L Condensed Catalogue: Electrically-Variable Inductors, Sweep Oscillators, Develoboards," available on request from Vari-L Co., Inc.

ham radio

fig. 5. Variable oscillator that tunes from 5 to 75 kHz.



some notes on cubical quad measurements

L. W. VanSlyck, W4YM, 406 Bon Air Avenue, Temple Terrace, Florida 33617

Much has been written, and probably much remains to be written, about cubical quad antennas. A review of measurement methods for these popular antennas seems in order for those desiring to improve the performance of their quads and for those who wish to build one from scratch.

The basic beam consists of a driven element and reflector. Measurement data are given here for arrays with n-elements, however, for those interested in a larger antenna.

Test equipment includes:

1. Accurately calibrated receiver
2. Grid-dip oscillator
3. Antennascope (rf bridge)
4. Swr bridge
5. Signal source capable of providing a few watts at the frequencies of interest.

The accurately calibrated receiver is used to check the grid-dip oscillator to obtain a frequency reading within one-half percent. The signal source may be your transmitter or transceiver if power can be reduced to a few watts.

driven element resonant frequency

First, disable all elements except the driven element. Open these elements and fold the wire back over itself. If you don't do this, you'll get several readings on the GDO when it's coupled to the driven element. Now loosely couple the GDO by using a small "gimmick" made from a male coax connector and a short loop of wire. Solder one end of the wire to the connector shell, and connect the other end to the center pin, making a loop about a half-inch in diameter.

The gimmick replaces the coax on the driven element for the measurement. Next, raise the antenna as high as you can conveniently reach to make the measurement. The plane of the antenna should be perpendicular to the ground. Find the resonant point, using the GDO with very loose coupling, then check the GDO with your calibrated receiver. This should give an accurate measurement of the driven element resonant frequency. If there are other elements to be measured, proceed in the same manner. Keep a record of the data.

Cubical quad driven elements are cut according to the relationship

$$L = 1000/f$$

where

L is the length of wire (feet)
f is the resonant frequency (MHz)

Some manufacturers use a constant of 1005, but the difference, in terms of total percent length, is insignificant for amateur work.

On 20 meters, the wire length should be changed 5.7 inches for each frequency change

of 100 kHz. In other words, if your driven element resonates at 14.2 MHz, and you want it to resonate at 14.3 MHz, subtract 5.7 inches from the total length, or about 1.5 inches from each side ($4 \times 1.5 = 6$, which is close enough).

reflector resonant frequency

If coils are used in the reflector to lower its frequency, simply couple the GDO loosely to the coil, and measure f; it should be 3 to 5 percent lower than the driven element at the point chosen for it's operating frequency. If a stub is used to lower the frequency, couple the GDO to the stub. If you can't get a satisfactory reading by this method, then coil up the wire in the stub to make a small loop, and couple the GDO to the loop. The loop should be a single turn, or even a half turn, to get the correct resonant frequency. If f is obtained by increasing the wire length 3 to 5 percent, follow the procedure given above.

director resonant frequency

An identical procedure is used for checking director resonant frequency. These elements should resonate from 3 to 5 percent higher in frequency than that of the driven element. (I use 5 percent.) It's possible, if more than one director is used, to resonate the first director at 5 percent, the second at 4 percent, etc. No data have been obtained concerning shortening each director from the previous one by a fixed amount, but yagis are often constructed in this manner, so the same reasoning might apply to a quad.

input impedance

Couple the antennascope or rf bridge to the GDO, and couple the output of the rf bridge to the driven element. Set the GDO at the desired frequency, and tune for a minimum dip on the rf bridge. Next, read the input impedance on the rf bridge. A curve may be plotted, if desired, of frequency versus input impedance. It will give you a good idea on how flat the line really is. Remember, loose coupling is used in all measurements in order not to affect accuracy due to oscillator pull.

The coupling line between the rf bridge and the driven element should be as short as possible, not more than six inches to a foot, and should be coax cable of the same impedance used to feed the quad. Also the reflector and director must be in place, and connected, for these readings. The quad should be in exactly the same condition as it will be when used, except for height above the ground.

front-to-back ratio

Raise the quad in a vertical position above ground and as high as possible. You must still be able to reach the reflector coils, or the stub, whichever is used. Next, energize the quad at the resonant frequency. Point the quad **away** from where the measurements will be taken. This may be either a cooperating amateur a few blocks away, or your own receiver a few blocks away, or a field strength meter a few wavelengths away.

Now, adjust the stub or the coils (number of turns) until a minimum reading is obtained on the receiver or field strength meter. Measure the reflector frequency again, and if it isn't within 3 to 5 percent range there is something wrong with your measurements or your method of measuring.

standing wave ratio

In all cases, when using an swr bridge, first set the bridge "wide open," or at its most sensitive point. Then feed in just enough rf to get a full scale reading in the forward direction. Next, reverse the bridge, and read the swr. It's not necessary to hoist the quad in place to make these measurements. Quads have no open ends and thus are quite insensitive to nearby objects.

If the swr bridges were perfect, it wouldn't matter whether the bridge operated at the full-power output of the transmitter or at very much reduced power. Measuring instruments are not perfect of course, hence their limitations must be taken into account. Remember, too, that when the swr bridge is set to read reflected power, it also reads a small fraction of the incident power, and any stray coupling will affect the accuracy of the reading. Also note that the true swr will always be lower, but never higher, than the instrument indicates.

A theoretically perfect swr bridge would read the same regardless of the amount of

power fed to it. In a way, therefore, the difference between the full-power reading and the reduced-power reading is somewhat of a test for the quality of the bridge assuming that no power is leaking to the reverse diode.

Now, let's assume that the actual mismatch is 2:1 between the feed line and the antenna. This is the **maximum** you can read on the bridge regardless of where you insert the bridge into the line. If there is in fact a mismatch, you'll obtain a different reading everywhere along the line. If the true input impedance is 50 ohms, then if you measure one-half wavelength from the input point, taking the coax propagation factor into consideration, the measured impedance will be 50 ohms.

At one-quarter wavelength from the input point the measurement would be either 25 or 100 ohms, depending upon whether or not the quad input impedance was higher or lower than that of the cable. However, at exactly one-half wavelength from the feed point, it would be immaterial what cable impedance were used as long as the propagation factor is accounted for in measuring the one-half wavelength.

The reason for this is that the reflected voltage, traveling back along the line from load to source, meets the incident voltage. If these voltages meet at multiples of one-half electrical wavelength on the line, the voltages will add, because at that instant they will be exactly in phase. It is possible, with certain line lengths, to get a reading of 1:1 when the actual swr is considerably greater than this. The only way to be sure is to use several different line lengths of the same cable, and if the swr comes out approximately the same, then you're reasonably sure that the swr is being read correctly. With a perfect match the swr will be 1:1 regardless of where the meter is placed.

optimum element spacing

According to reference 1, the optimum gain occurs in a quad with 0.125-wavelength spacing between driven element and reflector. If the spacing is increased to 0.25 wavelength the gain falls off about one dB. There is an infinite number of spacings that may be used on any beam, but I found that 0.125 wavelength between reflector and driven element is indeed optimum. (The input impedance is about 50 ohms as well.) I also found that a 0.1-wavelength spacing between driven element and director, or directors, leaves little to be desired.

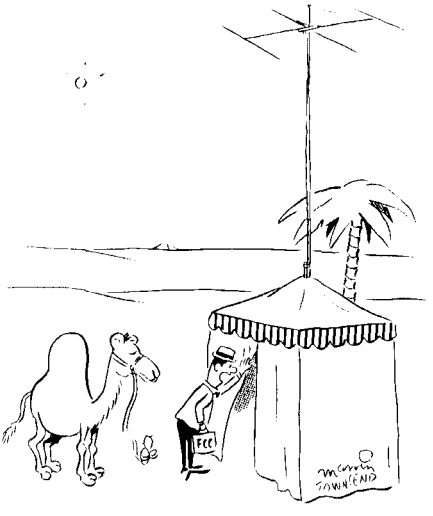
It's true that many successful quad users space the elements at considerably greater distances with possibly some advantages. But from a practical standpoint, spacings as indicated above have many advantages also, such as a reasonable size structure that can be rotated with a rotator of moderate strength, and one that can be put on a tower of the ordinary ham variety.

To obtain the excellent performance of a multielement quad (unless you want to use a boom of 25 to 50 feet), spacings of the order of 0.125 wavelength between driven element and reflector, and 0.1 wavelength between driven element and directors, are quite in order.[2,3]

references

1. William I. Orr, W6SAI, "Quad Antennas," Radio Publications, Inc., Wilton, Connecticut, 1959.
2. J. E. Lindsay, Jr., WØHTH, "Quads and Yagis," *QST*, May, 1968, p. 11.
3. L. W. VanSlyck, W4YM, "How Come?" *73*, February, 1968, p. 14.

ham radio



Sir! Do you realize that you are interfering with TV reception in this area?

WHEN YOU REACH THAT STATION IN LIFE WHERE *QUALITY & RELIABILITY* COME FIRST.....

The ESSCO Model TU-7 Teleprinter Demodulator is a completely assembled, ready to run system, fully wired with loop supply, connectors, tuning indicator, reversing switch, modular tracks, scope outputs, 50 ua zero center meter, function switch and famous ESSCO solid state modular plug-in units.

ESSCO's Complete RTTY DEMODULATOR ..... MODEL TU-7C $132.25*

TU-7B DUAL CHANNEL KIT	**$138.25**
TU-7 (As above) Factory wired, tested & guaranteed	**$163.00**
***TU-7C SINGLE CHANNEL KIT**	**$132.25**
TU-7D (As above) Factory wired, tested & guaranteed	**$156.25**

BASIC CABINET & INDIVIDUAL PLUG-IN UNITS AVAILABLE SEPARATELY

BASIC CABINET, fully wired, with loop supply, connectors, tracks, tuning indicator, reversing switch, jacks and function switch **$39.95**

PRICES OF INDIVIDUAL PLUG-IN UNITS

	KIT	ASSEMBLED
TU-1M, Demodulator	**$21.95**	**$31.95**
FS-1, AFSK		**$26.95**
PS-3, Power Supply	**$16.95**	**$26.95**
BP-1, Band Pass Filter		**$ 7.50**
SM-1, Sel. Mag. Driver	**$24.95**	**$29.95**

W2JAV DESIGNS ARE INCORPORATED IN SOME ESSCO CIRCUITS.

AVAILABLE THROUGH:

E. BUCHANAN & ASSOCIATES
Oakland, California

STELLAR INDUSTRIES
Ithaca, New York

ESSCO *"Teletype Specialists"*
324 ARCH STREET · CAMDEN, N. J. 08102
Phone: (609) 365-6171

A guide to better communications...

1. A direct reading WATTMETER that measures forward and reflected power.
2. Increased power and clarity for voice transmission; CSP-11 technique.
3. Four or eight way POWER DIVIDERS; use in reverse to sum signals.
4. Improved receiver sensitivity with these RF AMPLIFIERS (three packages).
5. Ultra-linear, low noise voltage controlled ATTENUATORS.
6. Frequency conversion with hi-rel BALANCED MIXERS.
7. Lower priced miniature BROAD-BAND TRANS-FORMERS.

If you're interested in more facts on these exciting new devices send for our packet of detailed data sheets . . . or contact a COMDEL representative near you!

CALIFORNIA
Henry Radio Co.
Los Angeles
Ham Radio Outlet
Burlingame

CANADA
Payette Radio Limited
Montreal

CONNECTICUT
Hatry of Hartford
Hartford

ILLINOIS
Allied Radio
Chicago

KANSAS
Interstate Electronic Supply
Wichita

COMDEL
inc.
beverly airport
beverly, mass.

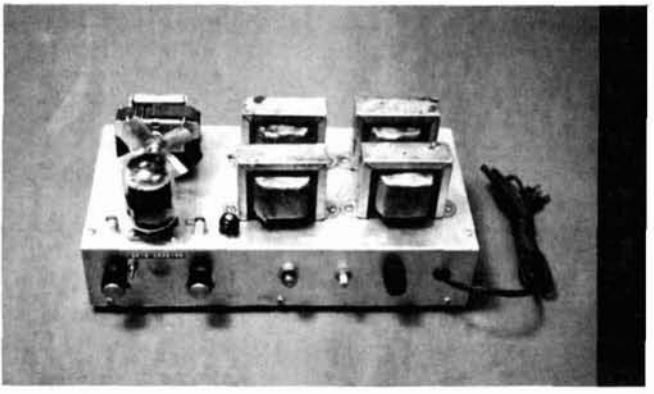
MASSACHUSETTS
Herbert Gordon Co.
Harvard

NEW HAMPSHIRE
Evans Radio Inc.
Concord

NEW YORK
Adirondack Radio Supply
Amsterdam
Hirsch Sales Co
Williamsville

OKLAHOMA
Radio Inc
Tulsa

WISCONSIN
Amateur Electronics Supply
Milwaukee



novel linear for two meters

inductive-divider input and toroid output circuits for high efficiency

Ralph W. Campbell, W4KAE, 316 Mariemont Drive, Lexington, Kentucky

Probably the easiest way to operate on two meters is to buy a "Two'er," select a crystal for the emergency frequency, then hope someone in the nearest large city will hear you. Well, with a good beam you might be heard; then again, if band conditions are poor —forget it.

I tried to buy a linear for my Two'er that would up the output at least ten times, i.e., to 30 watts nominal. None was available that would preserve the audio quality Heath is known for and still provide a respectable signal in the nearest town (which is some 83 miles way) with anybody on two.

Obviously, to get the most from the audio in the Two'er, AB_1 operation is a must. So I built such a linear using a 7984 pentode with series-tuned input, ferrite choke loading instead of resistor swamping and a toroidal-tank output. It gave the needed punch, and now I'm heard every day even with 20-dB tropo fadeouts, if the guys on the other end are using at least one Nuvistor ahead of their receivers. The circuit described is a refinement of an earlier amplifier using a novel input system that puts the power where it's needed.

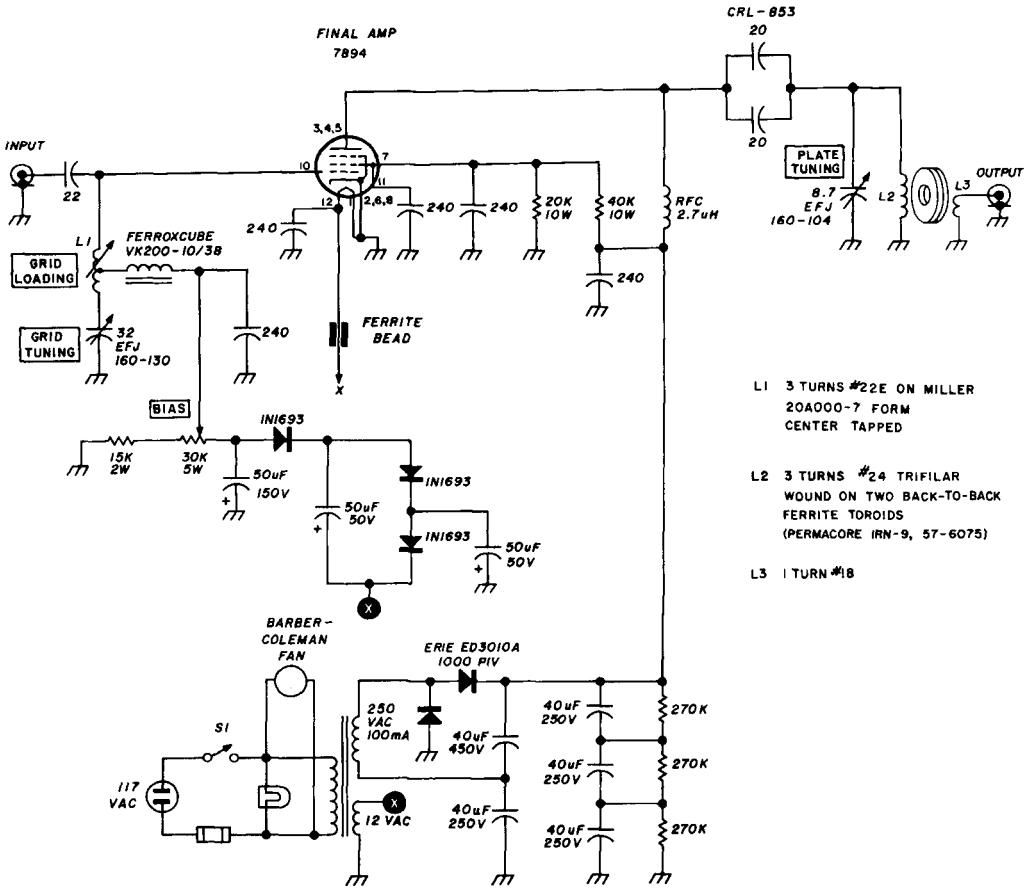


fig. 1. Schematic of novel two-meter linear amplifier. Although only one power transformer is shown here, the author used several small transformers to obtain the required voltages and currents.

development

Some of the problems I encountered involved the old TVI hangup. Living in a deep vhf TV fringe area, it's impossible to operate even class B on two meters. An exception might be a rig with a class-B single-balanced modulator with very little carrier—but even then some TVI would be a problem. In my case, however, uhf TV reception in Lexington is so popular that a dsb rig with a kW PEP final is feasible, but only because people hereabouts switch from vhf fringe channels to local uhf TV. Of course, anything like class C is "verboten."

I had a surplus of 125-V, 50-mA power transformers and several E. F. Johnson variable "M" capacitors. Most of the hardware was scrounged from other projects that never got off the runway. This included two UG-1094/U BNC connectors, 1000 PIV rectifiers rated at 750 mA and a Bud CU-622 Convertabox for the chassis.

Having built the linear "à la haywire" six months before, I tossed out the phenolic Compactron socket for a new mica-filled one, doubled the number of transformers, and used a newer Convertabox. Everything at last fit well, and most of the hole centers were eyeballed-in using a steel scriber and fierce concentration on a 10c plastic pocket ruler. Everyone around Lexington said my old 7984 bomb was loud, but the newer version was even better, and no one at either time could hear **and** see me!

Except for the parallel-tuned toroid output, over-all design of the two-meter linear is

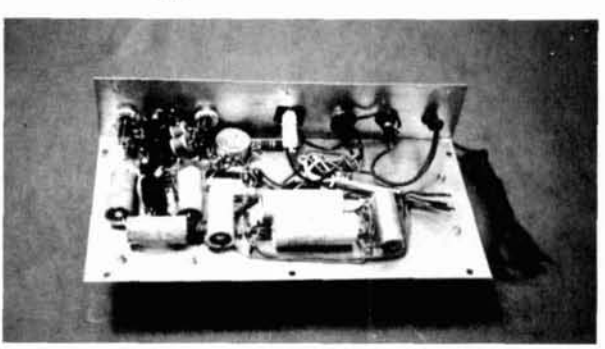
straightforward, and the series input circuit is conventional except as noted below. If desired, ceramic coil forms could be used and a physically "linear" quarter-wave line inserted in place of the IRN-9 toroids; but toroids keep the circuits small, and more power is coupled into the coaxial output and not into the wiring.

I tried a high-Q quarter-wave line and got less out. There is a limit, though, to the use of toroids on two meters. After trying unsuccessfully to get more than 25 watts measured output from a high-power PL-177WA amplifier, I have bowed a bit to the conservative by observing that a practical limit (tube dissipation basis) is 35 watts for ICAS operating conditions. This is all that seems worthwhile for AB_1 with the 7894. I did heat up some larger cores quite a bit, using the PL-177WA, but this tube is 40 watts "larger."

A new circuit feature is claimed here. As you read on you will notice that a grid-loading control is provided, saving lost watts in the output by peaking the control grid without a swamping resistor. This is really the most important part of what I have to say under "development," because by removing that swamping resistor and loading the grid only lightly you get very high efficiency in AB_1 and drive high enough to push the 7984 to its limit without an insertion amplifier.

In fact, before I accidently found that series tuning would give an rf voltage peak of the correct impedance at the control grid, I thought an amplifier would be necessary. Not so! But don't forget the trick is to center-tap the series inductance and load with a Ferroxcube VK-200-10/3B semiconductor low-z ferrite choke.*

Under chassis construction; chassis is a Bud Converta-box.

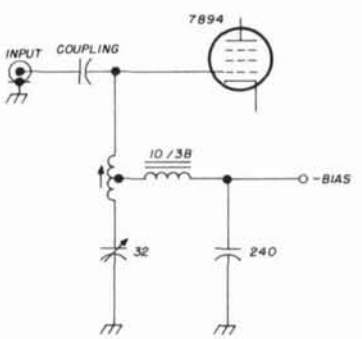


layout

Looking at the photo, from left to right we see the input connector, 30M11 input capacitor and the slug-tuned grid-loading inductance coil form. Next is the blower and 7984. Just to the right is the output BNC connector, output tuning and bias pot. The rest of the controls are as labeled.

The underchassis view shows the input tuning control; rear, Ferroxcube choke and series inductance, shield partition and heavy-duty ceramic coupling capacitors (the only kind that would handle the circulating current) and trifilar output tank circuit wound on two Permacor 3/8-inch IRN-9 sample toroids.** The rf components occupy only a small fraction of the chassis space. The rest of the chassis is used for the voltage-doubling power supply and bias-multiplier filters.

fig. 2. Input circuit used in the linear.



A series-limited neon lamp is used as the pilot and is held with a large Tinnerman speednut. The on/off switch is special in that it mounts in a 3/8-inch hole and not in the usual 7/16-inch or larger hole, which saves buying a punch for just this size.

* Order from Mr. R. Worban, Ferroxcube Corporation of America, 360 E. North Avenue, Northlake, Illinois 60164. 11c each plus shipping.

**Permacor Division of Radio Cores, 9540 South Tulley Avenue, Oak Lawn, Illinois 60453; Number 57-6075 IRN-Q material.

Button bypassing is used on both screen leads and also for plate circuit decoupling. These 240-pF buttons were salvaged from a surplus ARC-3. The plate choke is 2.7 μH, chosen for a cutoff of 149 MHz, with preference for the higher reactance obtained using the Miller chokes as opposed to the Ferroxcube. Remember that the VK-200 series are lossy when used with vacuum tube circuits for other than this application in swamping the grid. Their use in transistor circuits is a notable exception, where impedances are very low. Twenty pF was the value chosen for plate coupling, since two of these will have a series-resonant mode near the two-meter band.

Incidentally, I tried to use "dog-bone" capacitors and disc ceramics with no luck. They all burned up. When I switched from these to the more expensive ceramics I used pins 3 and 4 of the 7984 because they carry the bulk of the rf load. Pin 5 is fine for dc coupling.

the circuit

Fig. 1 shows the voltage-doubler power supply. Screen regulation is considered a myth for AB_1 operation using a pentode of such excellent structure for rf. If the plate voltage should get out of hand, so will the screen voltage, tending to reduce the plate current; also there's a bleeder and voltage divider using a 20k/10W resistor from screen to ground.

The input circuit is capacity coupled using a value equal to the input capacity of the 7984 plus strays. The ferrite choke takes the place of, say, a 220-ohm resistor and is more efficient when placed at the center of the series coil than at the grid proper. By using this approach a pole, or impedance maximum, is present with the tuning peak, and coupling is optimized by varying the inductor slug. Reactance is tuned out by the variable capacitor.

Fig. 2 is a drawing of the input circuit referred to above. Series tuning by the M capacitor is like moving up and down the VK 200-10/3B choke (made of the popular "bead" material) from center position as resonance is achieved. That is, inductive division, like capacitive division, (to quote RCA[1]) feeds the right voltage and current at two-meter rf frequencies to match the input admittance and susceptance of the high-C 7984. **Fig. 3** shows both tubes. Capacitive effects are represented by C_{in} (**fig. 3a**), with bead choke resistance swamping.

If you'll also look further into the RCA Transmitting Tube Manual, you'll notice they use only center-tapped series-tuned circuits for vhf since strays have already limited that fraction of the input which can be capacitively divided, and varying the slug of the coil form is the best way to optimize an input circuit like this.

Other arrangements are shown for high-C input vhf tubes (**fig. 3B**). In general, use at least one and one-half times the input capacity of the tube for the series variable, and

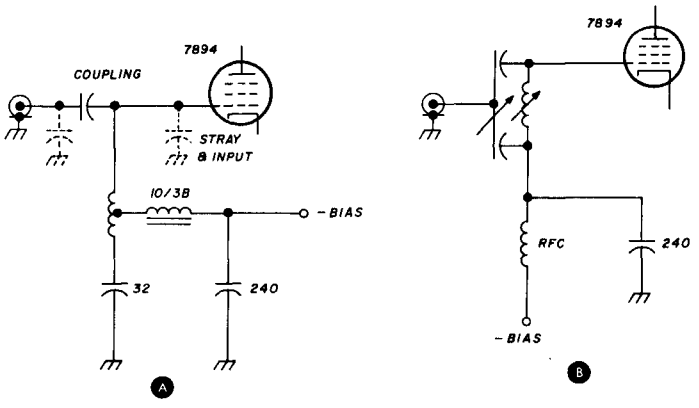


fig. 3. Different input circuits discussed in the text: inductive division in A, capacitive division in B.

always center tap the inductance. Also, use permeable cores in the form instead of the brass slug type, unless extreme bandwidth, lowered Q and extra power are available. Use of solenoid-wound rf chokes for class-C and -B operation is recommended, but use ferrite for linears that don't draw grid current.

operation

I used this linear for over a year without a blower, and have never had difficulty with it. It has a measured output of 12 watts (with a new 7984) in AB_1, and will go to AB_2 if the bias is set too low. (You can tell by listening for distortion in the monitor.) For AB_1 as opposed to class C, where the input power is specified, I chose plate dissipation as a more accurate gauge for rating, times the book value for theoretical efficiency, i.e., 33% of a maximum rating of 35 watts dissipation, which would be about 12 watts output.

On the air I say "50 watts," and this can be measured as input in the usual manner. My goal is 2000 watts dc input to two 4CX1000's in AB_1. Though of questionable legality, this would give no more than 660 watts output, like the class-C boys, with virtually no TVI.

references

1. *"RCA Receiving Tube Manual,"* 1966 edition, page 54.

ham radio

"My transceiver is over here. That's just my testing equipment."

NOISE BLANKER
FOR THE SWAN 250

Westcom Engineering is now offering the TNB Noise Blanker in a version specifically designed for use with the Swan 250 transceiver.

The TNB-250 Noise Blanker effectively suppresses noise generated by auto ignitions, appliances, power lines, etc., permitting the recovery of weak DX and scatter signals normally lost in noise.

Features include modern solid state design techniques utilizing dual-gate MOS FET transistors and two stages of IF noise clipping for the efficient removal of impulse noise at the transceiver IF frequency. The use of MOS FETs and a special gain controlled amplifier circuit provide *excellent cross-modulation characteristics* in strong signal locations.

TNB-250 shown installed on Swan 250 by means of the pre-punched accessory holes.

TNB-250 **$29.95 ppd.**
(Priced well below that of a VOX accessory. Can you afford not have one?)

Model TNB Noise Blanker, designed to operate with VHF converters by connecting in the coax between converter and receiver.

Choice of 12-18, 100-140, or 125-160 VDC, RCA phono or BNC connectors. Specify for 40, 20, or 10 meter converter output.
Model TNB **$29.95 ppd.**

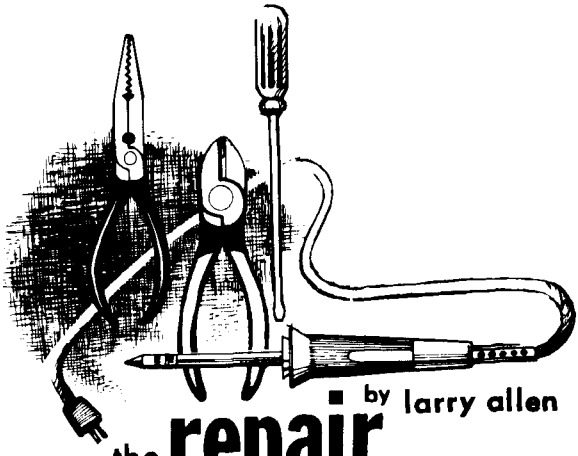
Refer to the New Products column of the August '68 issue of Ham Radio Magazine for additional information on the TNB Noise Blanker or write for technical brochure.

Prepaid orders shipped postpaid. (For fast Air Mail add $.80) C.O.D. orders accepted with $5.00 deposit. California residents add sales tax.

All products are warranted for one year and offered on a satisfaction guaranteed or return basis.

WESTCOM
ENGINEERING COMPANY

P. O. Box 1504 San Diego, Cal. 92112



by larry allen

the repair bench

more ohmmeter troubleshooting

Last month, I explained how to use your ohmmeter for safe troubleshooting. Before I ran out of space, I reviewed series and parallel paths and also told you how to get accurate readings on your ohmmeter.

I hope you learned to recognize the "odd" series-parallel paths I described. When you're tracking down a fault in some receiver or transmitter, how easy it is for you depends on how well you spot the resistance paths that aren't always obvious. This month, I'll start off by telling where you might find some of those paths.

hidden resistance paths

There are two small parts most likely to cause false ohmmeter readings: electrolytic capacitors and transistors. Electrolytics are part of all power supplies and are used for decoupling along dc supply lines. In either use, they often get in the way of ohmmeter tests. Transistors foul up ohmmeter readings because of their "diode" nature. To make matters worse in transistor equipment, many coupling capacitors are electrolytic. They mix their leakage currents with the transistor leakage currents, and you can drive yourself nuts sorting out the true paths.

Fortunately, these two paths follow known behavior patterns. If you know the patterns, you can figure out if you're being misled. Here are some of them.

1. In **power-supply paths.** The leakage resistance of most electrolytic capacitors is nearly 50k. Learn to allow for it when you're checking resistances along B-plus lines. The diagram in **fig. 1** shows power-supply paths in one receiver schematic (simplified, of course).

Suppose you clipped the common lead of your ohmmeter to ground and the test lead to the plate of V4. Since there is no apparent path to ground, you might expect to read an open circuit, or infinity. Instead, you read around 600k. As you can guess, the ohmmeter is reading the resistance of R13 **plus** the leakage resistance of the power-supply capacitors.

2. Allow for **diode action.** Suppose the reading from the plate of V4 to ground is almost exactly 470k. What does that mean? Maybe a short in one of the electrolytics? To check, you move the test lead to the junction of R3-C4. A very low resistance there seems to mean there's a shorted electrolytic.

But before you jump to a false conclusion, reverse the test leads: put the common lead on the R3-C4 junction and the other (red) lead to ground. The low reading disappears!

It's confusing, isn't it?

What happens is that the voltage of the ohmmeter battery causes the rectifier diodes to conduct and give the low reading. Whenever the negative side of the ohmmeter battery (sometimes, but not always, the red test lead) is touched to the cathode end of the rectifier, the ohmmeter reads the diode's forward resistance (which is low). An ohmmeter thus connected from R3-C4 to ground might read through R1-R2-R3 and the diode. Connected to the plate of V4, the same ohmmeter might read 470k almost exactly, since the 1k (approximate) resistance of the R1-R2-R3-diode path is tiny by comparison. In either case, reversing the test leads eliminates the false path.

The pnp transistor is wired up as a mixer. Suppose you connect your ohmmeter across R1 to measure it. Instead of the expected 4.7k, you read about 1k and figure R1 is bad. However, if you reverse the ohmmeter leads, you measure 4.7k. How come?

The base-emitter junction of a pnp transistor is forward-biased when the base is negative and the emitter is positive. If you connect the test leads the wrong way, the ohmmeter reading includes the base-emitter

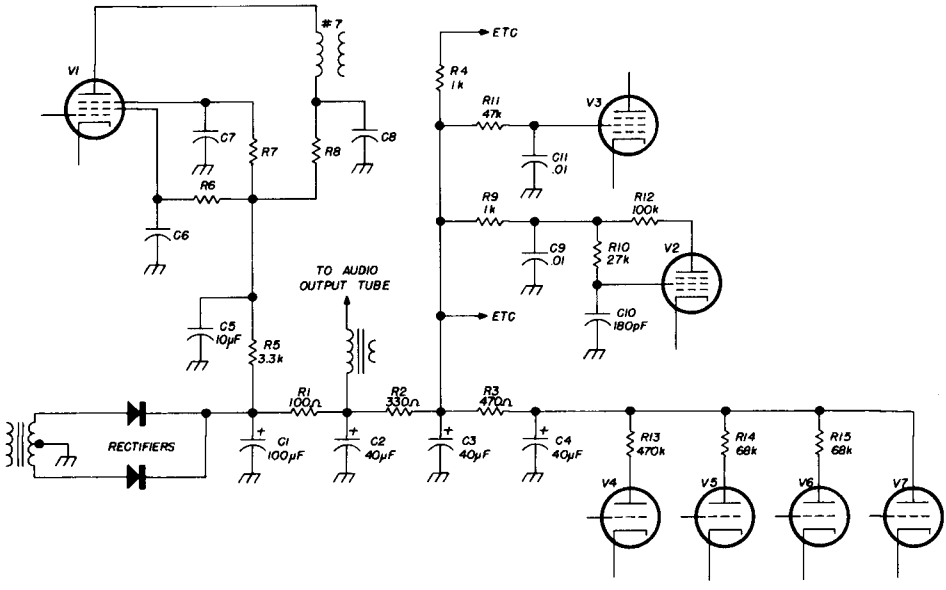


fig. 1. Power-supply from a popular receiver. It's simplified, to make tracing easy. If you must troubleshoot such a set, you can draw a simplified diagram like this to help you "see" the circuit branches.

3. Consider **transistor leakage.** A form of diode action takes place in transistors. That is, the ohmmeter battery can forward-bias a transistor junction and make it draw current. The ohmmeter then reads the junction resistance as well as whatever circuit-path resistance you're measuring. There's an example in **fig. 2.**

resistance (100 ohms or so). It is in series with R3, and both are in parallel with R1. The result: a wrong measurement.

How about when you measure R2? There should be no diode action between base and collector. What would you think, then, if you tried measuring R2 and got a 40k reading? Another hidden path is probably the cause. **Fig. 2B** shows the possible cause: leakage through the power-supply electrolytic capacitor (which may not even be drawn at that location on the schematic). The path through R4, the capacitor's leakage, and R1 lowers the resistance read by an ohmmeter connected across R2. You can thus get an

erroneous reading, even if the transistor is normal.

A significant clue, though it might fool you, is the fact that reversing the ohmmeter leads in this case doesn't change the reading. The trouble is therefore **not** diode action.

4. Watch out for **paths drawn elsewhere.** The path just described is a common example. There are others harder to spot. One is shown in **fig. 3.**

The situation in **fig. 3A** is apt to be overlooked in tube circuits. The trouble is that schematics show only the common power-supply connections. If there happens to be a ground path somewhere else on the schematic, you can get a low ohmmeter reading you can't account for.

In **fig. 3A,** for example, if you measure from the plate of V1 to ground, the voltage-divider network in the screen circuit of V9—which may be drawn at the other end of the diagram—causes an incorrect reading. (It should be infinity.) Even if you disconnect the power-supply capacitor, the too-low reading persists. The equivalent circuit is redrawn in **fig. 3B** to show how the circuit looks to the ohmmeter. (R9 has no effect, since it does not go to ground.)

You'll run into this voltage-divider situation more often in transistor sets than in tube equipment. Base-bias and emitter-bias dividers are standard practice. They cause trouble only when they are in parallel with each other but are widely separated on the schematic.

5. Something else to watch for in transistor circuits is shown in **fig. 4.** This one can fool you for several reasons. First, there is the diode action of the base-emitter junction. Second, there are parallel paths created by the power-supply electrolytic (not shown, as usual). Third, the parallel path depends on where you connect the ohmmeter.

The four rearrangements of the circuit show what the ohmmeter "sees" as it is connected between ground and each of the four points: A, B, C, and D. Anytime you have trouble figuring out paths, redraw them the way I have these.

From A, the ohmmeter should measure either about 850 ohms or about 4.6k. The diode is the reason for the alternative. One way, the ohmmeter makes the diode conduct and measures its forward resistance plus R4; the other way, it reads only the resistance of R1, since the diode can't conduct. The resistances of R1, R2, and R3 are comparatively so high, they have little effect even though they are in parallel.

From B, the ohmmeter should measure about 35k. The diode shows little effect, because R1 and R4 are relatively small compared to R2. The ohmmeter therefore reads about the same either way. The 68k–72k is in parallel with the (approximate) 77k.

From C, there are several considerations. First of all, you don't have to worry about the effects of R2, R3, and the power-supply electrolytic. They are so much larger than R1 that the 4.7k is the only resistance that can affect that leg of the circuit. The diode action of the base-emitter junction is important, though. Connected one way, the ohmmeter

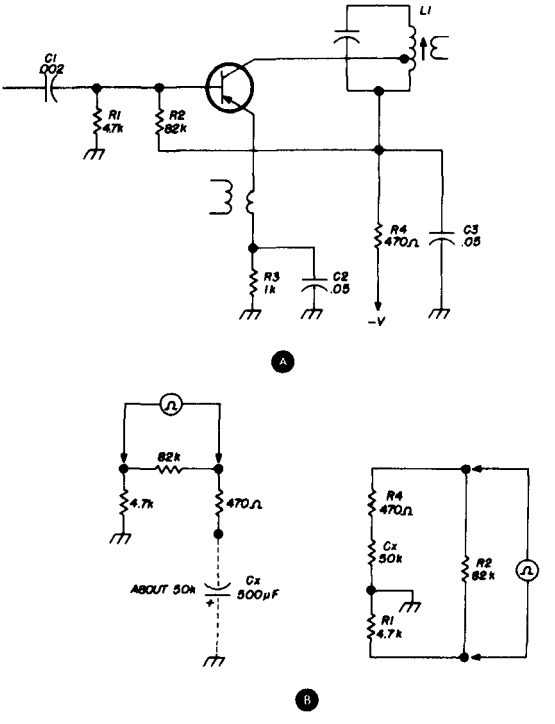


fig. 2. Hidden parallel paths in a transistor circuit.

reads only the 820 ohms of R4. Connected the other, it reads slightly less because diode action puts R1 in parallel; around 750 ohms seems about right.

From D, the ohmmeter mainly reads the value of leakage in the power-supply electrolytic—about 30k. The much higher values of R2 and R3 isolate any action of the base-emitter junction, or the effects of R4 or R1. The condition of the electrolytic determines exactly what the ohmmeter reads.

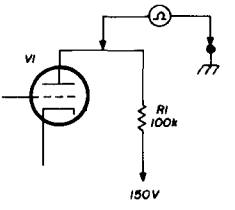


fig. 3. Sometimes a parallel path is hidden by the way the schematic is drawn.

knowing the cause of wrong readings

These general descriptions of where to look for "hidden" parallel paths also suggest ways to deal with them. When your ohmmeter readings are different from what the schematic leads you to expect, here are some quick steps to run down the cause.

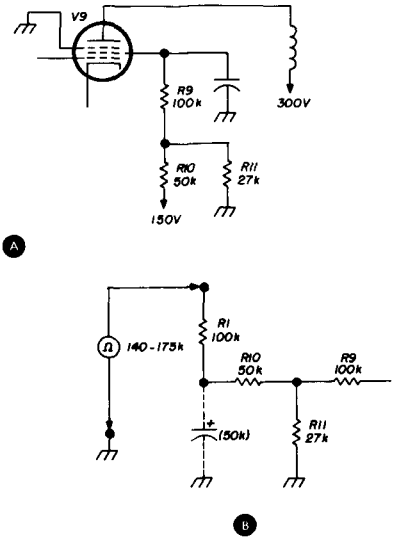
1. If a reading is low, reverse the ohmmeter leads. If the reading increases, there's diode action in the circuit, which may be caused by a diode, a power-supply rectifier, or a transistor. In unusual cases, **slight** differences may be traced to electrolytic capacitors that don't "form" under reverse polarity.

2. If an ohmmeter reading starts low and builds up slowly, an electrolytic capacitor is causing it. This is the normal charging action of the electrolytic. Reversing the ohmmeter leads gives a lower reading, which builds back up again to the higher one. The reading is anywhere from 25k to 50k, depending on the condition of the electrolyte in the capacitor. The charging action is what you watch for.

3. If you're still looking for the reason for a low reading, see if you can find any other parallel paths drawn elsewhere on the schematic diagram. If you don't find any, you are probably on the trail of the fault.

what to do about parallel paths

There are times when it's faster and easier to eliminate the effects of parallel paths or to get around their effects some way. Once you spot a wrong reading, track down the guilty parallel component. You can't always figure it out from Ohm's law, either.



One of my **first** suggestions is: Don't make resistance measurements with respect to ground. Don't clip the common lead of your ohmmeter to ground. Make each measurement between specific points **in** the circuit.

As an example, think about a circuit like the one in **fig. 1.** You can clip the common ohmmeter lead at the junction of R2-R3, and measure the branches through R9, R11, R4, etc., directly. That way, you eliminate any effects from power-supply electrolytics. To measure in the branch that starts through R5, you can clip the common lead at the junction of R5-R1 and eliminate any diode-action problem with the rectifiers.

And so on. By making point-to-point measurements, you don't have nearly so many parallel paths to consider. Also, as you move the main test lead on out a branch, it's easier to figure out the effects of added circuit resistances. Analysis is much simpler.

My **second** suggestion is to disconnect unwanted parallel paths when they get in your way. This happens seldom, if you plan your point-to-point measurements. But when it does happen, it's usually simple to unsolder a parallel component or branch.

On printed-circuit boards, you can often unsolder just one lead. Or, use a single-edge razor blade to slit across the foil and disconnect a circuit branch; that's easily restored afterward by a solder "bridge" across the tiny slit.

My **third** suggestion is to pull a tube or transistor out of its socket if you think it's fouling up your attempts to interpret resistance readings. Transistors that are soldered into their printed-circuit boards aren't that simple, yet can be handled without much trouble. Just unsolder the base connection (or slit the foil as already described).

In a circuit that contains a FET (field-effect transistor), unsolder the gate connection **and** the source connection. You can get low-resistance readings through some FET channels, even when the gate is disconnected.

My **fourth** suggestion for dealing with parallel paths is a last resort. When you can't analyze a circuit any other way, disconnect and test each part in the circuit—one at a time. It takes time, but if you've done your preliminary testing right, there aren't too many parts to test. At least you'll have narrowed the trouble down to one small section of the circuit.

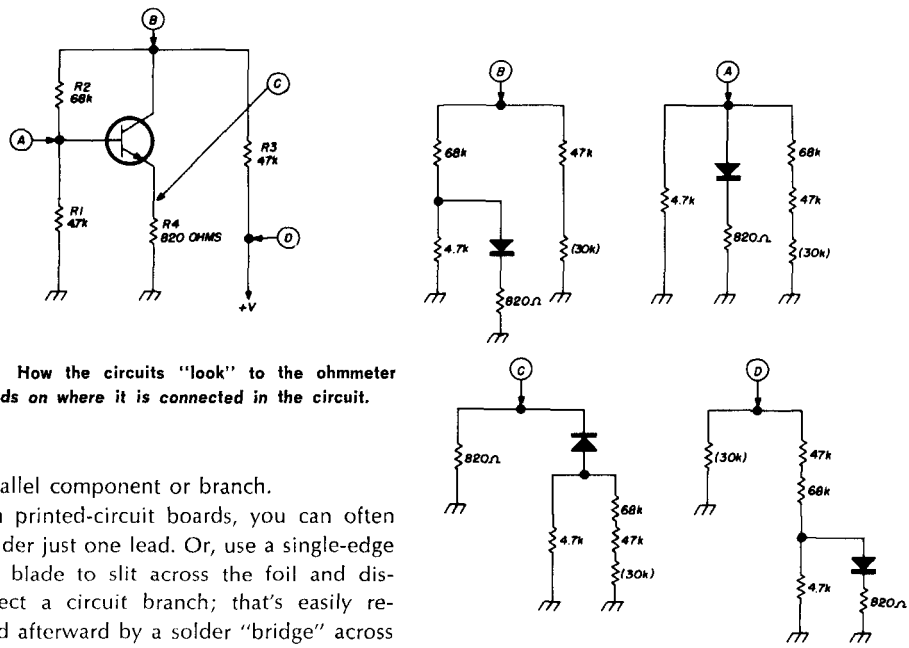


fig. 4. How the circuits "look" to the ohmmeter depends on where it is connected in the circuit.

in dangerous circuits . . . the safe way

I brought up resistance measurements in the first place to explain how to troubleshoot transmitters without exposing yourself to dangerous high voltages. Hunting a fault in the "live" plate circuit of an ssb linear can be a real pain in the neck. You need a special meter to measure high voltage, and usually you can't even reach test points without cheating a bunch of interlocks. There may be an overcurrent relay, too, or an undercurrent relay. In other words, the practical way to troubleshoot is with the transmitter or linear completely disconnected from power, and opened up. For that, you need ohmmeter measurements.

The plate circuit of a commercial linear

amplifier is shown in **fig. 5.** Mainly, you check for continuity. However, you can disconnect the power-supply lead and make measurements between ground and points in the circuit.

If an interlock switch isn't working, your measurements show it. The normally open (n.o.) switch is there to short out high voltage across the capacitors when you open the transmitter compartment. At the same time, the normally closed (n.c.) interlock switch removes applied voltage. Start your tests with power disconnected and the interlocks pushed in the way they would be with the compartment closed.

If everything's normal, you should get a low resistance reading from the plate cap of either tube to the clip that connected to the power-supply terminal. Check the opening and closing of the overcurrent relay with your finger. An open choke, tuning tank coil, relay contact, relay coil, n.c. interlock, or metering resistor (R1) spoils continuity, but each one is easy to track down. Just clip your common ohmmeter lead to the power-supply clip, and work your way to the tube plate-caps with the other test lead.

A shorted or leaky by-pass capacitor (C1, C2, C4) shows up when you connect your ohmmeter, set for its highest megohms range, between the plate-cap and ground. Be sure the PA current meter is not connected; it could be an unseen parallel path. Disconnect the power-supply clip, too, for the same reason. Set the ohmmeter to its lowest range to test the n.o. interlock switch; it should read zero ohms to ground when the cover is off the transmitter high-voltage compartment and infinity with the cover in place.

In high-voltage circuits, especially the ones that carry high-energy rf, certain troubles only show up when the circuit is energized. For example, capacitor C2 or C1 might break down under high-voltage stress, yet test okay by the ohmmeter. The only sure test is to remove it from the circuit and substitute another one. This is costly, though, when the capacitor is an expensive one, such as a bathtub type. For these unusual cases, there are some special tests I'll talk about in a future column. You can make these tests **without** working inside the "live" transmitter or linear amp.

individual parts tests

As a wrapup for this two-month coverage of ohmmeter tests, here are some parts tests. Usually, these tests are made with the part disconnected from its circuit. When other tests and resistance readings point to a particular part, the final test is of the part itself. The following tests are quick and dependable.

Test **resistors** and potentiometers by measuring their resistance. For potentiometers, also check how smoothly the resistance changes. Connect your ohmmeter between one end lug and the center lug, and turn the control shaft slowly; any unusual or sudden resistance change means you need a new control.

Test ordinary **capacitors** by measuring with the highest range on your ohmmeter. There should be absolutely no leakage (infinite resistance). Touch the two capacitor leads together for a moment before applying the ohmmeter. Capacitors above 0.01-μF show a slight charging "kick" of the ohmmeter pointer. Those that don't are probably open. A shorted capacitor reads zero ohms between the two leads.

Test **electrolytic capacitors** by applying the ohmmeter leads in first one direction and then the other. Settle for the connection that gives the highest reading. It should exceed 30k, but not go beyond 60k or so. If it's too low, the capacitor is leaky. If it's too high, the capacitor is becoming ineffective. Notice how long it takes to "build up" to the highest ohmmeter reading. If it takes more than 3 or 4 seconds, the capacitor needs replacing.

There are three tests for **coils and transformers.** Test them first for continuity of windings. The schematic diagram may list the dc resistance of each winding; if some turns are shorted, the reading will be much too low. If a winding is open, the ohmmeter shows nothing.

Test coils and transformers second for leakage between windings. Use the highest ohmmeter range. Even several megohms—an awfully high resistance—is no good between transformer windings; they should be totally isolated (infinite resistance).

Test coils and transformers third for leakage from windings to ground. With the transformer mounted as usual but with all its leads disconnected, clip one ohmmeter lead to

ground and touch the other to each winding lead. There should be infinite resistance, since each winding should be totally isolated from the frame of the coil or transformer. If you think maybe the coil frame isn't grounded, clip one ohmmeter lead to the frame and touch the other to each winding. There should still be no reading. A reading other than infinity indicates leakage.

Test a **relay** by checking its coil the same way you test a transformer winding. Check the coil for continuity; if you know the dc resistance, measure it. If the ohmmeter reads infinity, the relay coil is open. Then check the relay contacts, with the Rx1 ohmmeter range. Normally closed contacts should measure zero ohms when the relay is at rest; at the same time, normally open contacts should measure infinity. Push the armature in with your finger. The normally open contacts should measure zero ohms that way, and the normally closed contacts should measure open (infinite resistance).

Test **speakers and headsets** by measuring them with the Rx1 ohmmeter range. **Listen** as you make the ohmmeter connection; the voltage of the ohmmeter battery usually makes speakers and headsets "pop." The ohmmeter pointer should show very low resistance for speakers and a few hundred ohms for headsets.

Test **microphones** in one of three ways, depending on type. For **carbon** microphones, connect the ohmmeter across the element leads and whistle into the mike. The reading should vary with each whistle. If it stays steady, the granules are packed and the element needs replacing. If the ohmmeter reads infinity, the mike cord is probably open, or the element is making poor contact.

For **dynamic** microphones, the exact resistance depends on the impedance of the mike. However, there should be some sort of reading, even if an input transformer is used inside the mike. Also, if you listen, there is usually a "pop" in a dynamic mike when you connect or disconnect the ohmmeter.

For **ceramic** microphones, the easiest test is to connect the ohmmeter and listen for a slight "click." The ohmmeter shows a resistance reading only if the mike is defective; a good ceramic or crystal mike reads infinity resistance.

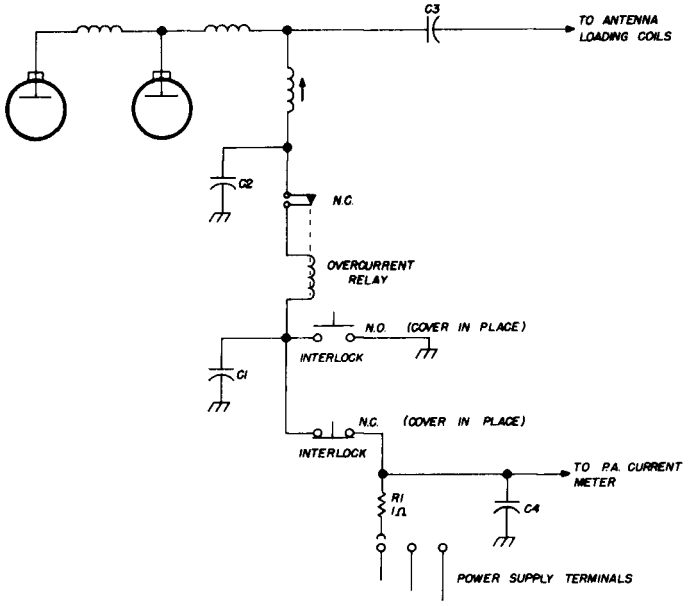


fig. 5. High-voltage circuits are where resistance troubleshooting serves best because dangerous voltages are gone.

Finally, connect the ohmmeter across the **push-to-talk** leads, and operate the button on the mike; a zero-ohms reading when the button is held means the p-t-t contacts and wires are okay.

Test **diodes** by measuring them first one way and then the other. A diode should measure low resistance in one direction and high resistance in the other; if the two readings are closer together than 100-to-1, the diode is probably bad. Power-supply rectifiers usually measure 100–200 ohms in the low-resistance direction; other types measure much lower.

A conventional **bipolar transistor** should show high resistance between emitter and collector, no matter which way the ohmmeter is connected. Between the base and emitter, however, resistance should be low in one direction and high in the other—just as in a double. If the base-emitter resistance is high in both directions, the transistor is open; if it's low in both directions, it's shorted. If resistance between emitter and collector is lower than several thousand ohms in either direction, the transistor is probably useless.

A **field-effect transistor** normally shows low resistance between drain and source—usually no matter which way the ohmmeter is connected. It should show extremely high resistance in one direction between gate and drain, and fairly high in the other direction. A MOSFET, sometimes known as an IGFET, should show infinite resistance between its gate and any other element, no matter which way the ohmmeter is connected.

next month

Everyone has his pet way to troubleshoot. In past **repair bench** columns, I've shown you several ways. You've read about signal tracing, signal injection, and now resistance measurement.

The best commercial technicians use several methods in various combinations that fit particular servicing problems. In my next column, I'll talk about one that is probably the most common: voltage testing. When a part goes bad, it usually upsets the dc operating voltages in its circuit. Those voltage changes, if you know how to interpret them, are a valuable clue to what part is bad. Next month, you'll find out how.

ham radio

RCA has all-new FCC commercial license training

Get your license— or your money back!

Now RCA Institutes Home Study Training has the FCC License preparation material you've been looking for—all-new, both the training you need, and the up-to-date methods you use at home—at your own speed—to train for the license you want!

***2 Convenient Payment Plans*—You can pay for lessons as you order them, or take advantage of easy monthly payment plan. Choose the FCC License you're interested in—third, second or first phone. Take the course for the license you choose. If you need basic material first, apply for the complete License Training Program.**

***SPECIAL TO AMATEURS.** This course—while designed for Commercial license qualification—contains much of the new material called for by FCC Docket 15928—advanced and extra class you'll want to qualify for before November of 1969. QRX until you get the information.*

Mail coupon today for full details and a 64-page booklet telling you how RCA Institutes Home Training can show you the way to a new career—higher income—and your FCC License.

RCA

RCA INSTITUTES, INC.
Dept. HR-19
320 West 31st Street, New York, N.Y. 10001

Please rush me, without obligation, information on your all-new FCC Commercial License training.

Name_____

Address_____

City_____ State_____ Zip_____

propagation predictions for january

Victor Frank, WB6KAP, 12450 Skyline Boulevard, Woodside, California 94062

Late reports that reached me in October indicated that ionospheric critical frequencies were not much higher (about 10%) than predicted by ESSA. Peak values at Raratonga in the Cook Islands (latitude 21° S, longitude 160° W) rose to almost 15 MHz, compared to about 20 MHz during the peak of previous cycles. Local midnight critical frequencies have been running as high as 12 MHz, however. On the West Coast, peak values of critical frequencies have been running as high as 11 MHz, again about 10% higher than predicted.

We have reports of 50 MHz F2-layer openings during the first half of October between Hawaii and the Marshall Islands, South America, Mexico, and even (weakly) the West Coast of the United States; also between Japan and the Marshall and Cook Islands. Transequatorial scatter propagation between Hawaii and the Cook Islands was an almost nightly occurrence. However, the big, strong signal F2-layer openings into temperate latitudes hoped for this fall have so far been absent.

Quite a few six-meter operators have been missing a good bet by not running more nighttime schedules with and listening for beacon stations in the southern hemisphere. I was pleasantly surprised during the latter part of September to hear ZK1AA's beacon station on 51.022 MHz three nights in a row between 11 PM and 1 AM local daylight time. He was weak, both here and in Southern California at W6NLZ, but you'd never have guessed that 51 MHz was open to the South Pacific by monitoring the low edge of the band.

the active sun

Let's continue our discussion of the sun, which last month stressed its stability. The sun rotates in the same direction as the earth. An observer at the north star would see both the sun and earth rotating in a counterclockwise direction as the earth revolves counterclockwise around the sun. Thus the solar surface rotates from our east to west. Since the axis of the sun is inclined 7° to the ecliptic, we are able to see the sun's North pole only from June to December.

The sun does not rotate as a solid body—the equatorial regions rotate faster (25-day period) than the polar regions (30-day period). It is this equatorial acceleration and the presence of a general magnetic field that is the cause of the solar cycle. The sun's general field penetrates the surface only in polar regions (greater than 55° latitude) and is called a poloidal field. The intensity of the poloidal field is about 1 gauss, compared to fields of 0.24 to 0.61 gauss observed on the surface of the earth. At solar latitudes less than 30°, the general magnetic field is confined to a sheath of about 5% of the solar radius. At the equator, the general magnetic field is believed to have an intensity of about 5 gauss.

The motions of ionized media (plasma)

are closely coupled with the magnetic and electric fields. Relative motion between a plasma and a magnetic field is inhibited since such motion would produce an electric field which would result in large current flow (since the plasma is an excellent conductor). Therefore, the plasma is forced to move along magnetic field lines; otherwise the magnetic field is dragged along with the plasma.

The differential rotation wraps the subphotospheric field lines around the sun to form a toroidal field. The toroidal field strength continually rises as the field lines

Sunspots are believed to develop in pores; a pore is a small (1000- to 2000-mile diameter) moderately dark area which may occur anywhere on the sun and has a normal lifetime of a few hours. Only pores within centers of activity develop into sunspots. The surrounding hotter plasma tends to flow into a pore, carrying its magnetic flux along and concentrating it.

As the magnetic field strength grows, convection from lower hotter levels is decreased, the surface temperature drops, and the spot grows. At full development, the spot may be 20,000 miles or more across and

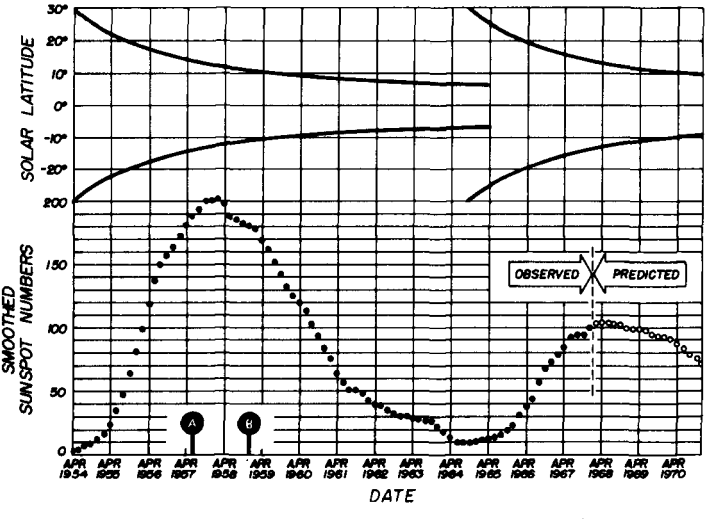


fig. 1. Smoothed sunspot numbers with latitude of maximum occurence (theoretical). The south poloidal field reversed near date A, and the north poloidal field reversed near date B.

are stretched and crowded together like a rubber band that has been wound up tightly. When the magnetic field strength reaches a critical value of about 250 gauss, tubes of magnetic flux may "bubble up" through the photosphere to form bipolar magnetic regions. It is in these "centers of activity" that sunspots, solar flares and filaments occur.

sunspots

Sunspots are visible as small dark areas on the solar disk. They appear dark because their temperature is only about 3000° K compared to 6000° K for most of the photosphere. The low temperature is due to the presence of high magnetic fields (about 3000 gauss) which inhibit convection.

consists of a dark umbra surrounded by a penumbra with very fine radial filamentary structure. It may last from as short as a few days to as long as a hundred.

The appearance and motion of sunspots, bipolar magnetic regions and other solar activity follow an eleven-year cycle, or, more properly, a twenty-two year cycle, since the magnetic fields reverse every eleven years.

Sunspots tend to occur at high solar latitudes early in the 11-year cycle and at low latitudes late in the cycle. The distribution of spot latitude vs age of the cycle follows a curve of

$$\sin \varnothing = \pm \frac{1.5}{n+3}$$

where Ø is the latitude of maximum occurrence and n is the age of the cycle in years. This theoretical curve is plotted on **fig. 1** along with the observed Zurich smoothed sunspot numbers from April 1954 to December 1967 and ESSA predicted smoothed sunspot numbers through 1970.

Over 84% of the sunspots occur in bipolar pairs. The preceding and following (with respect to solar rotation) spots have opposite magnetic polarity, and the preceding spot is closer to the equator. In the opposite hemisphere, the magnetic polarity of preceding and following spots is reversed. The preceding spot has the opposite polarity as the polar field in the same hemisphere at the beginning of the cycle. This is consistent with the theory of spot development from the twisting of the polar field due to equatorial acceleration.

The preceding spot is generally larger and has more magnetic flux (by a ratio of 3:1) than the following spot. Sunspots rotate about their axes (which are tilted in the forward direction) in the direction of the Coriolis force* (counterclockwise in the Northern Hemisphere, clockwise in the Southern Hemisphere). In general, however,

* Usually defined as a deflecting force acting on a body in motion (as an airplane or missile) due to the earth's rotation. In this case it refers to the force on a sunspot due to the sun's rotation.

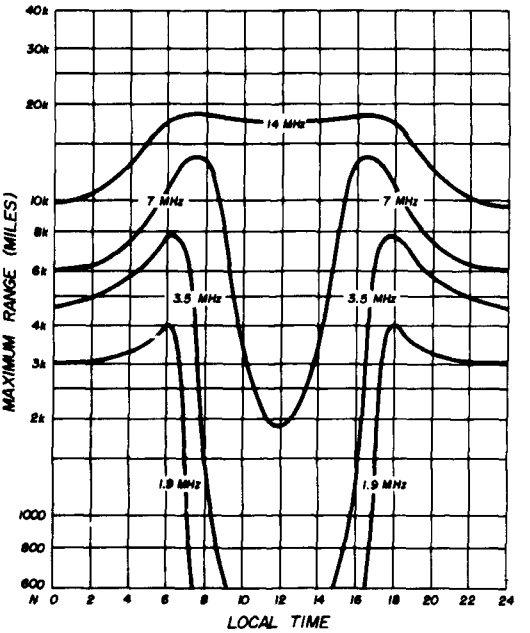
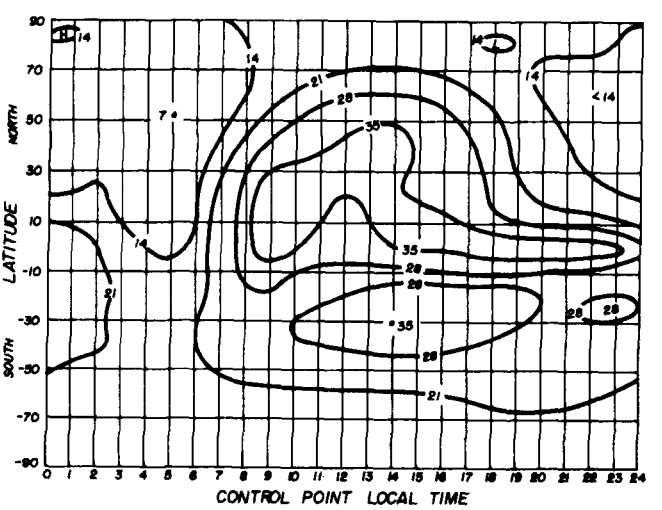


fig. 3. Maximum range to the north due to absorption.

the sunspots are calm magnetic lands in a sea of great turbulence that forms the rest of the bipolar magnetic region and the whole of the solar disk by comparison.

Sunspots are a secondary phenomenon since the bipolar magnetic region forms first; they themselves do not radiate increased ultraviolet and x-ray emission that affects the earth's ionosphere. In fact, the

fig. 2. Time chart of maximum usable frequencies for January, 1969 centered on 90° West longitude.



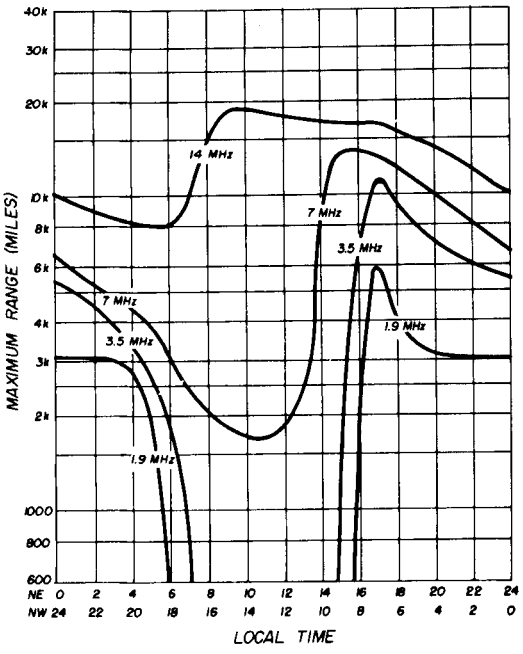


fig. 4. Maximum range to the northeast (top time scale) and to the northwest (lower time scale) due to absorption.

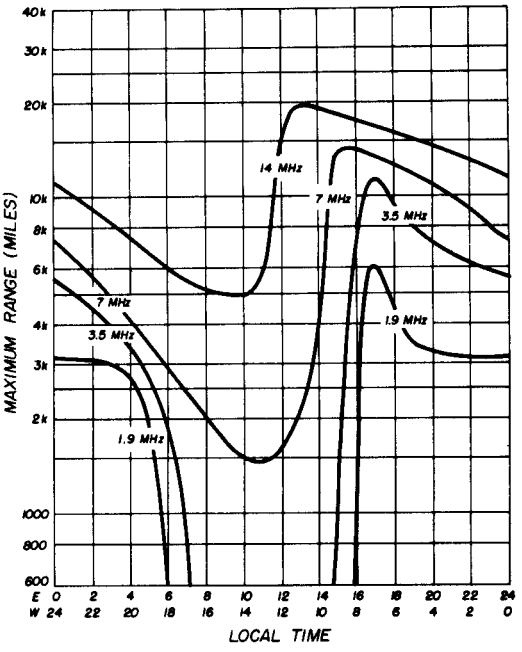


fig. 5. Maximum range to the east (top time scale) and to the west (lower time scale) due to absorption.

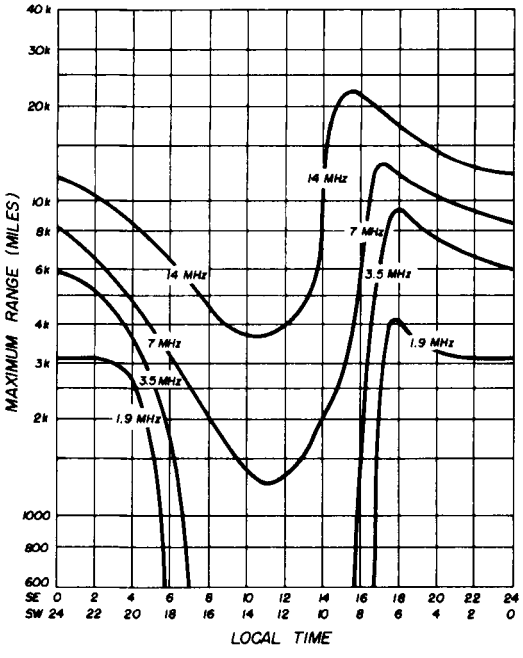


fig. 6. Maximum range to the southeast (top time scale) and to the southwest (lower time scale) due to absorption.

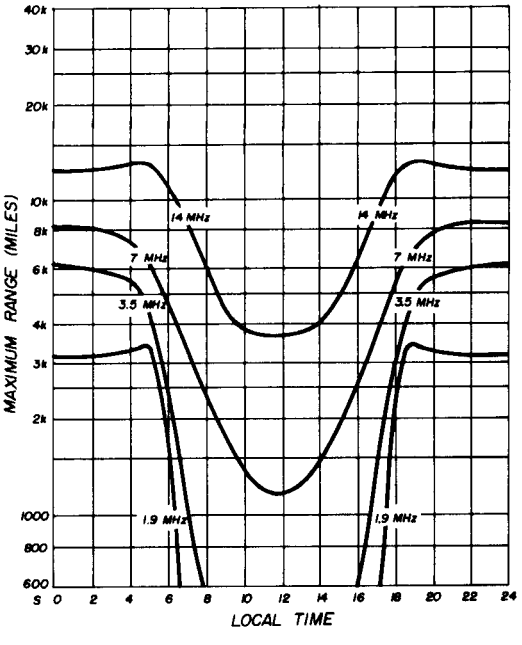


fig. 7. Maximum range to the south due to absorption.

total radiant energy output per unit area in a sunspot may be only a tenth of normal for the solar disc.

Sunspot numbers** are by no means as accurate an index of solar activity as you might wish, since they are somewhat artificial in nature. For example, a large sunspot pair somewhere on the solar disk would result in a Wolf number 12; add an insignificant small spot somewhere else on the surface, and the Wolf number becomes 23, a jump of almost a factor of two. This artificial nature of the sunspot numbers is one of the reasons for the poor correlation between monthly sunspot numbers and monthly average ionospheric critical frequencies. The answer is a better index of solar activity, such as the combined area of all the sunspots, or of bipolar magnetic regions, or (now that we have space probes) of the magnitude of the ionizing radiations that affect our ionosphere.

metamorphosis

The magnetic flux lines joining the two poles of a bipolar magnetic region may expand outwards to great distances in the corona—and may break away with the flow of plasma away from the sun. As the solar cycle progresses, the preceding regions of flux migrate towards the equator and neutralize each other; the following regions of flux migrate towards the poles where they first neutralize the old poloidal field and then from a new poloidal field of reversed polarity. The energy for maintaining and concentrating the magnetic flux comes from the kinetic energy of differential rotation.

The reversal of the poloidal field takes place near the maximum of the solar cycle, but strangely enough, both poles need not reverse simultaneously. At the peak of sunspot activity in the southern solar hemisphere in the middle of 1957, the southern poloidal field reversed, but the peak of sunspot activity and reversal of the poloidal field in the Northern Hemisphere did not occur until the end of 1958. These reversals left the poloidal field of the sun parallel to that of the earth. One or both solar poloidal fields may have already reversed this year.

** Sunspot numbers were discussed in detail in the November, 1968 issue of *ham radio*, page 72.

propagation for january

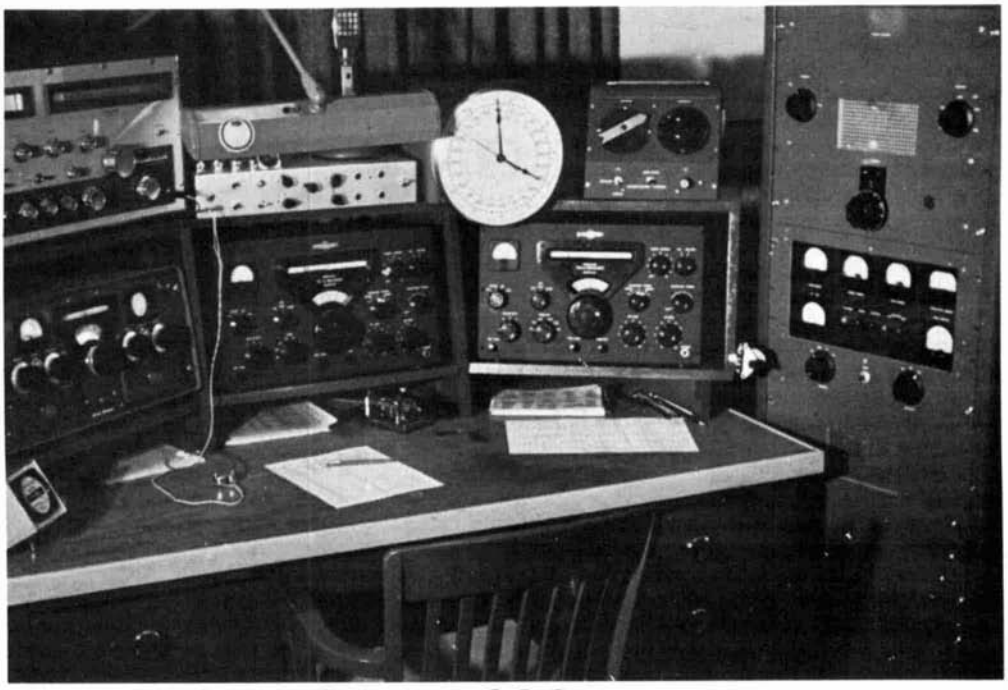
A time chart of predicted 4000-km F2-layer muf for January 1969 is given in **fig. 2.** Maximum range versus time of day charts for 160 to 20 meters are shown in **fig. 3** to **7.** The first half of January will be a repeat of December with conditions becoming more like those of November as the month progresses. It will be a great month for high-frequency propagation in the Northern Hemisphere from frequencies as low as 1.8 MHz at night to as high as 40 MHz during the day.

The 50-MHz operator aspiring to WAC is now wishing that (in addition to a kilowatt, a big beam and hilltop location) the location was south of 30° latitude and that he had enough time to keep the band under constant surveillance. With that, we offer a salute to those dedicated chaps who keep beacon stations running in Rhodesia, Mexico, Hawaii, the Cook Islands, Australia, and Japan.

references

1. D. H. Menzel, "Our Sun," Harvard University Press, Cambridge, Massachusetts 1959.
2. H. W. Babcock, "The Sun's Magnetic Field," *Annual Review of Astronomy and Astrophysics*, Annual Reviews, Inc., Palo Alto, California, 1963.
3. P. A. Sturrock, Lecture notes for "Introduction to Astrophysics II," Stanford University, 1965-66.

ham radio



State of the Art in '69? or...

THE GOOD OLD DAYS?

It wouldn't transceive . . . and it was big and heavy . . . But . . . K6CTV's 1959 station was designed for DXing and contesting . . . and **it was a joy to operate!**
REMEMBER WHEN . . .

YOUR DREAM RECEIVER

■ offered a choice of really steep skirted selectivities? ■ let you slice off adjacent-channel QRM **or** set the audio passband to your taste with a single control? ■ tuned anywhere in the band independent of the transmitter?

AND THE TRANSMITTER

■ didn't overheat if you held the key down for five minutes? ■ had effective speech clipping built in? ■ keyed silently and cleanly for instant CW break-in? ■ could be "spotted" exactly where you wanted it? ■ band-changed as easily as the receiver? ■ used rugged, high linearity output tubes for SSB?

AND BOTH OF THEM

■ completely covered **all** ham bands from 160 through 10 meters in convenient, full mega'cycle" ranges? ■ read out frequency simply and unambiguously to a kilo'cycle"?

Of course, hardly anyone who's enjoyed the convenience of transceiving on sideband is likely to give it up, and none of us really want to wrestle ninety-pound desk-crushers. **But is it necessary to sacrifice performance and convenience features that were readily available a decade ago?**

TODAY at SIGNAL/ONE we believe that "state-of-the-art" equipment ought to be **at least as convenient and effective in every respect** as were the "separates" of the "good old days". We're demonstrating that conviction with a smooth blend of sophisticated modern engineering plus traditional ham ingenuity—bringing you a superb new line of NO COMPROMISE equipment—a new criterion for the **next decade in amateur radio.**

Performance . . . Convenience . . . Quality . . .

"It Speaks for Itself"

signal/one

A Division of ECI/An NCR Subsidiary

2200 Anvil Street N. • St. Petersburg, Florida 33710

antenna and rotator preventive maintenance

Here's graphic proof that Ben Franklin's Advice about a pound of prevention is still true

Ted Woolner, WA1ABP, 30 Cedar Road, Shrewsbury, Massachusetts 01545

Most amateurs agree that the antenna system is the heart of any station. Much has been written on the emphasis that should be put on erecting the best possible radiating system to compete on the crowded bands. I'd like to add some footnotes to the antenna literature in the area of preventive maintenance.

The initial investment in an antenna and rotator is substantial. How many times have you heard fellows say on the air, "Sorry, my antenna's stuck on Europe. Big storm passed through, and I haven't had a chance to go up the tower and fix the rotator." With a little care and forethought, you can ensure reliable operation during the worst weather, even if you use the more inexpensive equipment.

The following notes explain how to avoid the disappointment and down time that can occur with stuck rotators and vibrating antenna elements during the winter months.

the antenna

It's pretty discouraging to come home, anticipating an evening of hamming, and find your pride and joy in bits and pieces all over the back yard. Beam antenna elements are usually made of aluminum alloy. Unless they're given the proper treatment, they just won't withstand the rigors of weather. Airframe manufacturers know this—aluminum

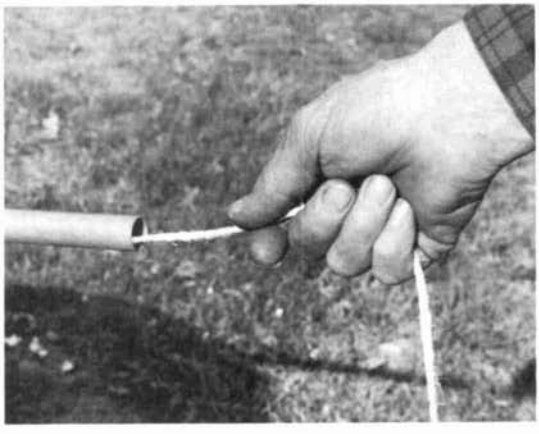
alloy is used extensively in this application. Where in the aircraft the aluminum is used determines the amount and type of treatment it's given before installation.

Most amateurs don't have the facilities for giving aluminum the correct treatment for withstanding environmental effects. The treatment is quite involved and includes chemical and electro-chemical techniques. It is quite expensive, also, if used for small quantities of metal.

One thing you **can** do, before hoisting your antenna to the top of your tower or mast, is give it several coats of zinc chromate paint. Put on as many coats as you can, and work it into every nook and cranny. For each coat of zinc chromate properly applied, you can count on at least six months of corrosion-free operation.

Now let's look at metal fatigue caused by vibration.

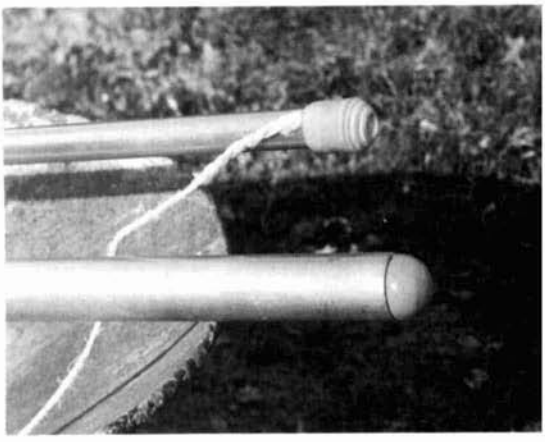
Tie a small weight on the end of the twine and drop it through the element.



taming the elements

No pun is intended in the heading of this part of the story. Every time your antenna sings in the wind, it's doing something other than playing a B-flat chord. Tiny cracks develop in the metal. They get larger, and as the element ices up, the added weight loads the metal. Vibration causes the metal to crystalize with resulting fatigue. Take a close look at your tubing the next time it falls to the ground after a storm. Those hairline cracks radiating from the break are a result of crystalization.

Hold the twine in place with a rubber foot, tennis ball or sponge rubber ball.



vibration proofing

All that's needed to dampen antenna element vibration is some sisal twine and something with which to plug the ends. Measure the length of all your elements plus a little extra, say a foot or so. Drop the twine through each element, and secure the twine with rubber caps over the element ends. A tennis ball is good. It may look a little strange, but who cares what the neighbors think? It's solid enough to make a good seal and will hold the twine securely. Make sure there's no moisture in the elements. The twine will dampen the vibration by changing the bending-mode frequency to some harmless low value.

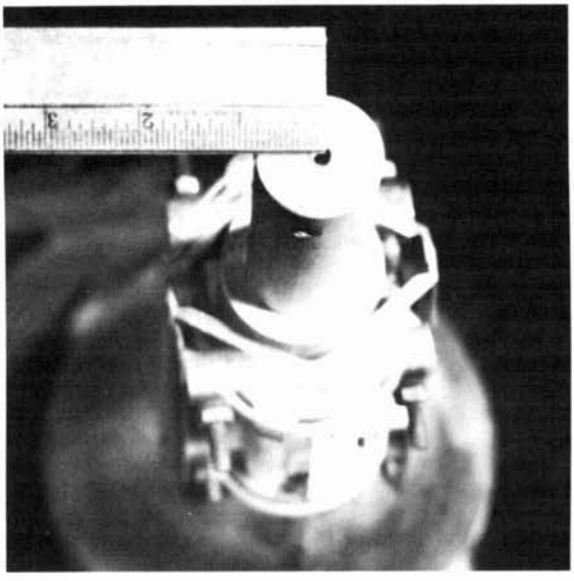
Another method is to pack the elements **loosely** with spun glass. Wear gloves when handling this stuff, though, because it can be pretty treacherous. It can penetrate your skin and cause all sorts of agony. Your boom can be sealed with a sponge rubber ball a little larger in diameter than the boom. Use the twine treatment here, also, and pull it up tightly. It will help keep your beam on a straight course and ease your jangled nerves

when your hear the wind wailing at 3 a.m. I'd like to emphasize that the spun glass **must** be packed into the tubing loosely. If it's packed too tightly you will zap the element.

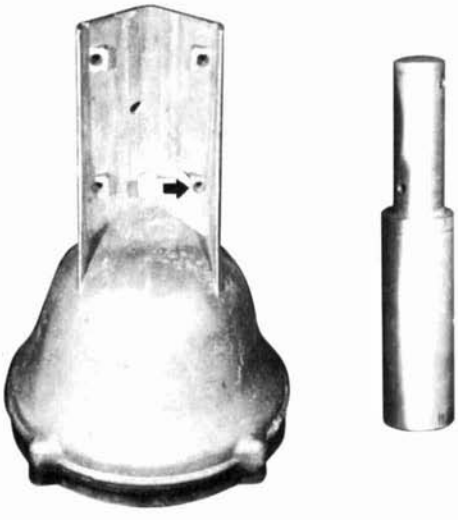
Another way of damping element vibrations is to fasten several rubber or plastic strips to the end of each element. Since the mechanical impedance of any rod-like element is high at the free end, an energy absorber at the end of an element will reduce the amplitude of vibration and minimize breakage. The energy absorber can be made from a five- or six-inch length of garden hose, split lengthwise every 90° and held at the end of the element with a hose clamp. These simple energy absorbers are most effective if they are clamped at the very end of each element, but to prevent changes in element electrical length and impedance, they should be placed so the free ends are about two inches in from the ends of the elements.

the rotator

Lots of stories have made the rounds about whether TV antenna rotators are strong enough to support amateur beams. The photos show my AR22 rotator, which was purchased, used, in 1963. At that time it had been in use for six months, and I've been using it constantly since. The reason it's down now is because I'm installing a new tower and two stacked five-element Cushcraft beams.



The top of the AR22 with reducer in place. The ruler was zeroed on the center. Right under the 1½-inch mark you can see the end of one U-bolt as it appeared with the rotor in the first direction; then it was rotated 180° and the U-bolts show again.



Rotator and reducer. The reducer is aluminum; large end is 2-1/16" in diameter and small end is 1½" diameter to fit inside mast. The holes running laterally were drilled through the mast to bolt the two together. Arrow points to one of four shoulders that may have to be filed off unless shims are used to center the reducer.

Given half a chance, I find that the AR22 rotator is very satisfactory. The secret is to eliminate the tremendous moment arm caused by a large mass of metal on a long length of mast above the rotator. Add to this the simple fact, sometimes overlooked, that any rotator must be perfectly centered with respect to its mast. Unless the correct diameter mast is bolted to the rotator, the eccentric rotation will load the rotator bearings, and you've got problems.

The AR22 manufacturer say that 1½-inch diameter pipe is correct. Maybe so, but I found this isn't true for my rotator. In my case, a diameter of two and one-sixteenth

inches is correct. I had a piece of aluminum stock turned down to this size, then had it stepped down above the rotator clamps to slip inside a 1½-inch mast.

It may be necessary to file down the edges

The hood or umbrella clamped on to the mast directly above the thrust bearing, which is out of sight and out of the weather; it's mounted on the plate welded to the tower cross-sections.

of the shoulders where the U-bolts come through to properly seat the aluminum reducer. I didn't have to, though.

The picture with the ruler has been purposely double exposed to show that the reducer is, in fact, centered in the rotator. I made the first exposure with the rotator pointed in one direction, then I turned it exactly 180 degrees and made the second exposure. Note that there's no visible deviation at the end of the reducer. If there were, two distinct centers would show, and two outer edges would also show.

the thrust bearing

A thrust bearing located somewhere between the top of the rotator and the top of the tower takes all the weight off the rotator. The only load on the rotator will then be turning torque, which is as it should be.

If the thrust bearing is exposed to the weather, it's going to get loaded with snow and ice. (California amateurs can skip this part. However, does anyone know what smog does to aluminum?) I made a copper umbrella to cover the thrust bearing, as shown in the photo. It slips onto the mast and is fastened with an ordinary automobile radiator hose clamp. The same idea can be used at the top of the tower where the mast enters the tubing.

Instead of a copper umbrella, you could wrap a piece of soft rubber around the mast and secure it with the same type of hose clamp. This will form a skirt to keep out the weather. Be sure the skirt flares at the bottom, else it might get loaded with ice and stick to the tower. It might help to lubricate the mast-skirt interface with low-temperature silicone to avoid this minor problem.

ham radio

a look at **those days before spark... b.s.**

"Yuh can't can't get thru a pileup like that . . . yuh gotta better chance out here on the edge."

VALUE ANALYSIS

From 80 meters . . .

SWAN 508 FULL COVERAGE EXTERNAL VFO

The Model 508 Frequency Control Unit is designed for full coverage of 80, 40, 20, 15, and 10 meters. It provides for transmitting and receiving on separate frequencies, and plugs directly into the back of the 500C. A separate Dual-VFO adaptor is no longer required, since the relay control circuitry is built into the 508. A panel control permits selection of VFO's so that operation may be transceive mode with the 500C VFO, transceive with the 508 VFO, or transmit on the 500C and receive on the 508. The Model 508 features eight ranges of 500 kc each, with 5 kc calibration. It may also be used with the 350C transceiver.

$125

MARS OSCILLATOR

Ten crystal controlled channels with vernier frequency control. Plugs directly into Model 500C and may also be used with Model 350C and other Swan transceivers.

MODEL 510X (less crystals) . . $45

SWAN SPEAKS YOUR LANGUAGE

SWAN 500C FIVE BAND TRANSCEIVER

80 through 10 meters • 520 watts • Home station, mobile, portable operation • SSB-CW-AM.

The new model 500C is the latest evolutionary development of a basic well proven design philosophy. It offers greater power and additional features for even more operator enjoyment. Using a pair of the new heavy duty RCA 6LQ6 tetrodes, the final amplifier operates with increased efficiency and power output on all bands. PEP input rating of the 500C is conservatively 520 watts. Actually an average pair of 6LQ6's reach a peak input of over 570 watts before flattopping!

The 500C retains the same superior selectivity for which Swan transceivers are noted. The filter is made especially for us by C-F Networks, and with a shape factor of 1.7 and ultimate rejection of more than 100 db, it is the finest filter being offered in any transceiver today.

For the CW operator the 500C includes a built-in sidetone monitor, and by installing the Swan VOX Accessory (VX-2) you will have break in CW operation.

Voice quality, performance and reliability are in the Swan tradition of being second to none.

$520

SWAN

ELECTRONICS

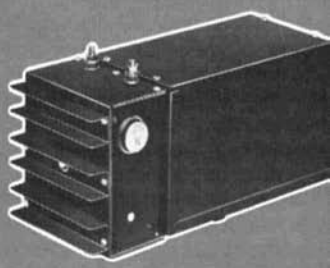
OCEANSIDE, CALIFORNIA

A Subsidiary of Cubic Corp

SWAN 117XC MATCHING AC POWER SUPPLY

Complete A.C. supply for 117 volts 50-60 cycles, in a matching cabine with speaker, phone jack, and indi cator light. Includes power cabl with plug for transceiver, and A.C line cord. Ready to plug in an operate.

$105



SWAN 14-117 12 VOLT DC SUPPLY

Complete D.C. supply for 12 vol mobile or portable operation. In cludes cables, plugs, and fuses. Wil also operate from 117 volt A.C. by detaching the D.C. module & plugging in 117 volt line cord. Negative ground standard. Positive ground available on special order.

$130

PHONE PATCH, Model FP-1 . . . . . $48

ASK THE HAM . . . WHO OWNS ONE

VALUE ENGINEERING

. . . to 2 meters

SWAN 250C
SIX METER TRANSCEIVER

We are proud to announce production of the deluxe model 250C, new contender for top honors on the 6 meter band. The 250C is built to performance standards of the highest order, including a receiver front end employing dual Nuvistors in cascode with a noise figure of less than 3 db. Deluxe features include a built in 250 KC crystal calibrator; 'S' meter; selectable sideband; vernier control of the megacycle tuning range; and accessory sockets on the rear apron to receive the model 210 external VFO, the new Swan Noise Silencer and the VX-2.
The famous model 250 is a consistent winner in VHF competition —The 250C is designed to set new records! We are confident that the 250C will satisfy the most critical requirements of the serious VHF operator.

$420

SPECIFICATIONS:

- Frequency Range: 50-54 MC
- Power Rating: 240 watts PEP Input in SSB mode, 180 watts CW Input, 75 watts AM input
- Two 6146 B Power output tubes
- Distortion Products: down approx. 30 db
- Unwanted Sideband: down more than 40 db
- Carrier Suppression: better than 50 db
- Receiver Noise Figure: Better than 3 db, with two 6CW4 nuvistors in Cascode
- Selectivity: 2.8KC at 6 db down, with crystal lattice filter at 10.9 MC.
- Antenna Matching: Wide range Pi network.
- Metering circuits: S-meter on Receive mode, P.A. Cathode Current and relative output in transmit mode.
- 250 KC Crystal calibrator
- Selectable upper and lower sideband
- Receiver Mode switch provides for AM reception
- Accessory sockets for noise silencer, external VFO and VOX unit

ACCESSORIES:

MATCHING AC POWER SUPPLY
Model 117XC $105

12 VOLT DC SUPPLY
Model 14-117 .....$130

SWAN NOISE SILENCER
Model NS-1 .....$ 36

EXTERNAL VFO
Model 210 .....$120

PLUG-IN VOX UNIT
Model VX-2 .....$ 35

PHONE PATCH
Model FP-1 .....$ 48

2KW LINEAR AMPLIFIER
Model 6B. With power supply $660

AND FOR 2 METERS
SWAN TV2 TRANSVERTER

A receiving and transmitting converter, which may be used with the 250C or 500C to operate in the 144-148mc band. Provides 240 watts P.E.P. transmit power, and low noise receiver front end with Nuvistors in Cascode.

$295

One of the main reasons Swan maintains its position as the leading manufacturer of amateur radio equipment is our dedication to the principles of Value Analysis, and Value Engineering.

We continually examine our products to find ways of improving their performance, reducing costs, and making them better values. As new components are developed in the electronic field, we analyze them to see how they can be used to improve the performance of our transceivers.

The most recent results of our Value Analysis and Value Engineering are shown on these pages: The 500C 5 band SSB Transceiver, our new External VFO, the 510X Mars Oscillator, and introducing our new 6 Meter Transceiver, the 250C.

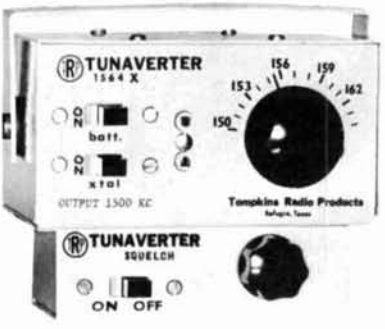
Yet with all the improvements, the increased reliability, and proven performance, Swan's Value Engineering results in substantially lower prices than competitive equipment. And every piece of Swan equipment is backed up by service second to none.

Value Analysis, Value Engineering keep Swan in the lead. Visit your Swan dealer soon.

SWAN
ELECTRONICS
OCEANSIDE, CALIFORNIA
A Subsidiary of Cubic Corp

new products

tunaverter squelch



Tompkins Radio Products has just announced a new squelch control for noise-free monitoring on hf and vhf Tunaverters. This makes it possible to have receiver squelch performance with an economical converter. The solid-state squelch circuit doesn't need any connections to the a-m broadcast radio **or** the converter other than the coaxial feedline.

This new unit features complete electronic control without relays and has a fully adjustable squelch setting. It is available in two models—the model ST that fastens to the bottom of a Tunaverter or the model SU which has its own mounting bracket. Furnished complete with connecting cable for $17.50 (model SU $1 extra). For more information, write to Herbert Salch and Company, Marketing Division of Tompkins Radio Products, Woodboro CTI, Texas 78393.

amateur and swl receiver

Allied Radio has recently announced a new solid-state receiver for amateurs and swl's, the A-2515. This new five-band receiver tunes all the amateur bands from 80 to 10 meters, international shortwave, aircraft, marine and the standard a-m broadcast band. The bands covered are 150-400 kHz, 550-1600 kHz, 1.6-4.8 MHz, 4.8-14.5 MHz and 10.5-30 MHz.

A total of 24 semiconductors are used in the circuit with two field-effect transistors in the front end for maximum sensitivity and low noise. Four mechanical filters provide sharp station separation. The noise limiter and agc reduce noise, blasting and fading. The built-in bfo and product detector give good reception of CW and ssb. The illuminated slide-rule dial has calibrated bandspread for the amateur bands; an S-meter is included on the front panel. Other features include a push-pull audio stage with a thermistor for low distortion, provisions for receiver muting and a headphone jack.

The receiver is equipped with dual power supplies, one for 117 Vac and the other for 12 Vdc, so the receiver may be operated from house current, autos, boats or camp sites. $99.95 from Allied Radio Corporation, 100 North Western Avenue, Chicago, Illinois 60680.

TALK POWER

The AutoLevel is the ultimate in volume compressors. This unique device provides all the talk power your transmitter can use. The AutoLevel was designed for use with SSB or AM transmitters, with or without ALC capabilities.

The AutoLevel is not an audio or RF clipper – all compression is attained by a photo-optical regulator which provides 14 dB's of compression with a minimum of wave form distortion.

The AutoLevel is easily installed in the mike line, and it contains its own power supply; (there's no need to bother with batteries). It can also be used with your phone patch for the utmost in ease of operation.

When you're ready for the finest, ask your local dealer for the AutoLevel.

SPECIFICATIONS

dB's compression – 14 dB minimum
Wave form distortion – neglible
Input impedance – suitable for dynamic or crystal microphone
Output impedance – 50K (nominal)
Power supply – 115 volts AC

Dimensions – 2-3/4" x 4-11/16" x 6-3/8"
H W D
Weight – 32 ounces
Color – Bone White with Black front panel
Price – $87.50

AUTHORIZED DEALERS (listed alphabetically)

AMATEUR ELECTRONIC SUPPLY
4828 W. Fond du Lac Avenue
Milwaukee, Wisconsin 53216
Tel: 414 – 442-4200

AMRAD SUPPLY, INC.
3425 Balboa Street
San Francisco, California 94121
Tel: 415 – 751-4661

AMRAD SUPPLY, INC.
1025 Harrison Street
Oakland, California 94607
Tel: 415 – 451-7755

COLE ELECTRONICS SUPPLY COMPANY
335 South Bonner
Tyler, Texas 75701
(214) LY-4-3545

COSTON ELECTRONIC DISTRIBUTORS
2345 Ferguson Road
Cincinnati, Ohio 45238
(513) 481-8555

ELECTRONIC CENTER, INC.
107 3rd Ave. North
Minneapolis, Minnesota
Tel: 612 – 338-5881

EVANSVILLE AMATEUR RADIO SUPPLY
1311 North Fulton Ave.
Evansville, Indiana 47710

GRAHAM ELECTRONICS SUPPLY, INC.
122 S. Senate Avenue
Indianapolis, Indiana 46225
Tel: 317 – 634-8486

HAM RADIO OUTLET
999 Howard Avenue
Burlingame, California 94010
Tel: 415 – 342-5757

THE HAM SHACK (Tel-Appliance Center, Inc.)
1966 Hillview Street
Sarasota, Florida 33579
Tel: 813 – 955-7161

HENRY RADIO STORE
931 N. Euclid
Anaheim, California 92801
Tel: 714 – 772-9200

HENRY RADIO STORE
11240 West Olympic Blvd.
Los Angeles, California 90064
Tel: 213 – 477-6701

L. A. AMATEUR RADIO SUPPLY
2302B Artesia Blvd.
Redondo Beach, California 90278

ED MOORY WHOLESALE RADIO
Box 506 -
De Witt, Arkansas
Tel: 501 – WH 6-2820

PIONEER-STANDARD ELECTRONICS, INC.
5403 Prospect Avenue
Cleveland, Ohio 44103
Tel: 216 – 432-0010

PIONEER-STANDARD ELECTRONICS, INC.
SREPCO ELECTRONICS DIVISION
314 Leo Street
Dayton, Ohio 45404
Tel: 513 – 224-0871

TYDINGS COMPANY
933 Liberty Avenue
Pittsburgh, Pennsylvania 15222
(412) 281-6640

UNIVERSAL SERVICE
114 North Third Street
Columbus, Ohio 43215
Tel: 614 – 221-2335

VALLEY HAM SHACK
4109 N. 39th Street
Phoenix, Arizona
Tel: 602 – 955-4850

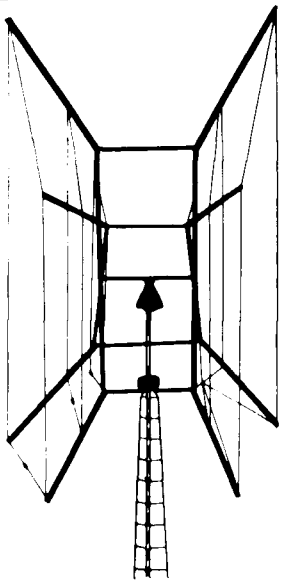
WORLD RADIO LABORATORIES
3415 West Broadway
Council Bluffs, Iowa 51501
(712) 328-1851

DEALERSHIPS AVAILABLE IN SOME AREAS — WRITE FOR FREE SPECIFICATION SHEET

RAYTRACK Company
NEW IDEAS FOR PROGRESS IN ELECTRONICS

2111 SPRINGHILL DRIVE Columbus, Ohio 43221

TELEPHONE 614/486-7090



2 Element QUAD

FOR 10 - 15 - 20

The "JOGA QUAD" is rated at 1KW AM and 2KW P.E.P. SSB. Features a single feed line. Enjoy maximum forward gain and very low SWR over the full bandwidth. The unique shape allows proper element spacing for all bands. It is easy to assemble and resists winds up to 100 MPH. It's lightweight with only a 4'6" boom length. A brochure with further information is free for the asking.

PRODUCTOS JOGA

CALLE 50 X 45 NUM. 431
MERIDA, YUC., MEX.

new allied catalog

Allied's new 1969 catalog "Electronics for Everyone," is now available. This new book presents the latest in electronic components, vacuum tubes, semiconductors, wire and cable, test instruments, microphones and speakers, antennas and towers and amateur equipment as well as a full line of high-fidelity equipment and tape recorders, transistor radios, TV sets and video tape recorders. Specialty lines include a big selection of electronics kits, cameras and accessories, weather instruments and a wide selection of electrical accessories. The 1969 catalog, number 280, is available on request from Allied Radio Corporation, Post Office Box 4398, Chicago, Illinois 60680.

motorola semiconductor catalog

Motorola has just announced a new catalog of 175 semiconductors, books and accessories in the HEP line of devices for the amateur, experimenter and electronic hobbyist. The HEP line includes semiconductors at reasonable prices for almost any experimental or replacement use.

There are many new devices listed in this catalog: high-voltage germanium power transistors, complementary silicon npn/pnp power transistors, a unijunction transistor, a bilateral trigger diode, a sensitive low-power SCR, digital RTL and linear integrated circuits, an IC kit, new IC sockets and a TO-5 heat sink.

Other semiconductors in the HEP line include small-signal and power silicon and germanium transistors, field-effect transistors, silicon rectifiers and bridges, zener diodes, SCR's, power transistor mounting kits, heat sinks and books.

Copies of this handy new catalog, the Motorola HEP Catalog, MHA27-4, are available at your local Motorola HEP distributor or by writing to the Technical Information Center, Motorola Semiconductor Products, Inc., Post Office Box 20924, Phoenix, Arizona 85036.

Jim Fisk W1DTY

editor of **Ham Radio**

reviews

The new

Radio Communication Handbook

published by RSGB

"One of the most exciting handbooks I have seen in a long time"

"This new book covers every aspect of amateur radio communications and is filled with solid state projects and circuits"

"If you're troubled by the lack of semiconductor circuits and modern technology, the Radio Communication Handbook is the answer; it is the most up to date radio handbook that has crossed my desk"

832 Pages — Hardcover

$11.95

Postpaid in
U. S. A. and Canada

order from

comtec

Box 592 • Amherst, New Hampshire 03031

Comtec also stocks most other R.S.G.B. publications

FREE!

ONE YEAR OF

ham radio

A one year subscription is $5.00. Take a three year subscription for $10.00 and you get the last year for nothing.

☐ Yes, I'd like the free year. Enclosed is $10.00. Send 3 years of HAM RADIO.

★

HAM RADIO MAGAZINE
GREENVILLE, N. H. 03048

Name ..... Call .....

Address .....

City ..... Zip .....

short circuits

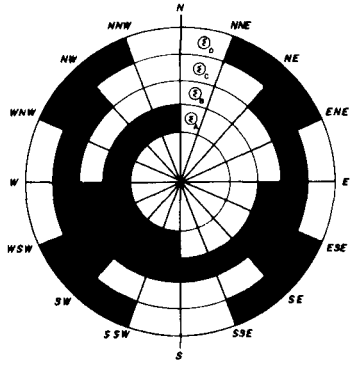
hammarlund ad

There's an error in one of the specs for the new Hammarlund HQ-200 receiver advertised on page 27 of the December issue—the a-m sensitivity should read 1 μV for 10 to 1 signal-to-noise ratio.

wind-direction indicator

The code wheels shown with the article on the digital wind-direction indicator in the September issue are in error. **Fig. 3,** shown as a Grey-coded wheel, is actually a binary wheel. **Fig. 2** is complete gibberish—a result of the photographic process used to make the illustrations for the magazine. A correct Grey-coded wheel is shown below.

fig. 1. Grey-coded direction wheel.



solid-state six-meter transmitter

In the schematic for the five-watt modulator on page 10 of the October issue, there should be a 270-ohm, 2-watt resistor in the line that runs from the center tap of the Stancor TA38 transformer (red lead) to the voltage supply. In addition, the line going to pin 9 of the integrated circuit should be connected to the two lines that cross it—one between pins 8 and 11 and the other from pin to the transformer.

calibrators and counters

In the decade counter shown in **fig. 3** on page 44 of the November issue, pin Q on flip-flop **C** should be connected to pin J of flip-flop **D.**

ham radio

THE *ICE-1*

2 METER FM TRANSCEIVER

FULLY SOLID STATE - NO TUBES

- Operates on 117 VAC — 12 VDC — or optional internal NI-CAD battery
- Self-contained 3" X 5" speaker
- Military type fiberglass printed circuit boards
- Epoxy painted cabinet
- Regulated power supply — cannot be damaged by reverse polarity
- May be ordered for either wide or narrow band operation at no extra charge (wide band supplied unless specified)
- Small size: 8"w X 3½"h X 9½"d
- Light weight — Less than 4½ lbs.
- Built in 117 VAC power supply
- Simply plug in proper power cable to charge from 117 VAC to 12 VDC operation
- Transmitter and receiver channels individually switchable
- 3 channels transmit — 3 channels receive
- Push-to-talk operation
- Transmitter output — 4 watts minimum

COMPLETE WITH ONE SET OF CRYSTALS ON 146.94, 117 VAC AND 12 VDC POWER CABLES, LESS MICROPHONE AND ANTENNA $285.00
MICROPHONE 16.00
EXTRA CRYSTALS (TRANSMIT OR RECEIVE) 7.00
BUILT IN NI-CAD BATTERY AND CHARGER 47.00

ICE

MANUFACTURED IN U.S.A. BY

INTERNATIONAL COMMUNICATIONS AND ELECTRONICS, INC.
1917 NW MILITARY HIGHWAY/SAN ANTONIO, TEXAS 78213/512 341-1311

LOW PRICE, QUALITY, COAXIAL SWITCHES...

Don't pay for the 5th and 6th position. The average HAM rarely uses more than 4!

SPECIFICATIONS: Silvered Contacts. Write-on ERASABLE escutcheon plate. AVAILABLE EITHER 4 PST (COAX-4) OR LINEAR (COAX-LINEAR) IN-OUT VERSION. Handles 1000 W AM or 2000 W SSB. Insertion loss negligible to 160 Mc. VSWR: Less than 1.2 at 160 Mc. Size: 3⅛" dia. x 1⅛" overall. Single hole mount. SPECIFY MODEL. $7.65 ea.

COAXIAL LIGHTNING ARRESTORS

Zero power loss. No increase in SWR at 150 Mc. Does not attenuate signals. Model 210 for 1000 W (AM) or 2000 W (SSB). Model 211 Electronic static arrestor for 50 W (AM) or 100 W (SSB). SO-239 UHF type fittings. Other fittings available. Size approx. 3½" x ¾" dia. #210 $3.15 ea. #211 $4.65 ea. SPECIFY model #.

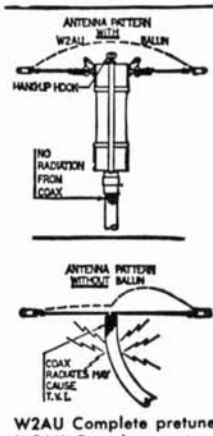
PRICES above are amateur net. Shipped ppd. in U.S.A. Send Check or M.O. (N.J. ADD 3% Sales Tax)

OTHER PRODUCTS: Feed thru capacitors. Tuned noise filters. Alternator, generator, low-pass and field filters. SEND FOR CATALOG.

"COMMUNICATION ENGINEERED"
By "HAMMIE" RICHARDT—W2WIY

ELECTRONIC APPLICATIONS CO.
ROUTE 46, Pine Brook, N. J. 07058

W2AU BALUN LETS ENTIRE ANTENNA RADIATE!



STOP WASTING YOUR SIGNAL! REMEMBER, YOUR ANTENNA IS THE MOST IMPORTANT PIECE OF GEAR YOU OWN.

- No Radiation from Coax
- No Center Insulator Needed
- Perfect for Inverted Vees (Use Hang-up Hook)
- Built-in Lightning arrester
- Broad-Band 3 to 40 Mc.
- Takes Legal Power Limit
- Two Models:
  1:1 50 ohm coax to 50 ohm balanced
  4:1 75 ohm coax to 300 ohm balanced
- A must for Inverted Vees, Doublets, Quads, Yagis and Multiple Dipoles.

$12.95 AMATEUR NET

W2AU Complete pretuned Fiberglas Quad $99.95
W2AU Complete pretuned Vinyl Quad.....$64.95

UNADILLA RADIATION PRODUCTS
Unadilla, New York 13849

The new SWAN 500-C 5 band, 520 Watt SSB-AM-CW TRANSCEIVER

The new Swan 500C offers you higher power, improved styling, and many new deluxe features, yet maintains the same high standards of performance, rugged reliability and craftsmanship that have become the trademark of the Swan Line. Backed by a full year warranty and a service policy second to none, we feel the Swan 500C will establish a new standard of value for the industry.

$520

SWAN 350-C	$420.00
SWAN 250-C (NEW MODEL)	$420.00

ACCESSORIES	
117XC AC/PS	$105.00
14-117 DC/PS	$130.00
14C DC MODULE	$ 65.00
VX-11 VOX	$ 35.00
100Kc Xtal Cal.	$ 19.50

RECONDITIONED USED GEAR
NINETY DAY GUARANTEE:

Collins: 30L1 Linear	$375.00
Drake 2-C (New)	$199.95
SBE-34	$300.00
HT-46 Hallicrafters	$225.00

WANTED:
WE BUY USED AMATEUR AND CB EQUIPMENT FOR CASH!

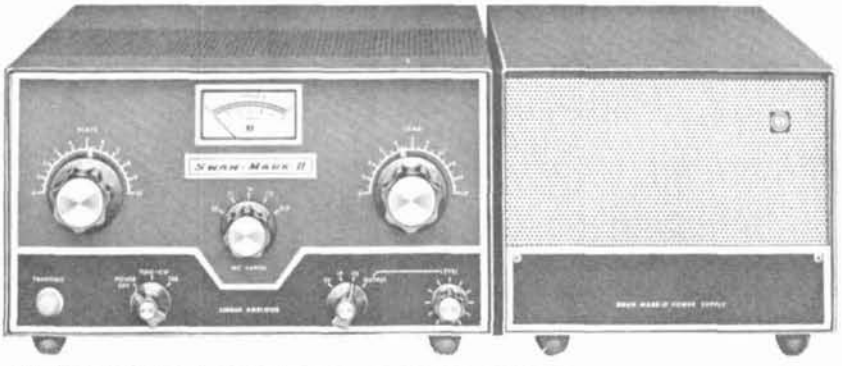
LOTS OF GOOD CHOICE GEAR FOR SALE OR TRADE — WRITE FOR LATEST LIST.
IN STOCK FOR IMMEDIATE DELIVERY, GALAXY, SWAN, SBE AND DRAKE.

Bob's AMATEUR ELECTRONICS
"THE COMPLETE HAM STORE"
Phone CE 5-6387
927 N.W. 1st Oklahoma City, Oklahoma 73106

"WE TAKE TRADE-INS ON ALL LINES OF NEW EQUIPMENT"
TWO-WAY RADIOS — SALES • SERVICE • INSTALLATIONS

SWAN MARK II
LINEAR AMPLIFIER

CONSERVATIVE **2000 WATT P.E.P.**



SWAN MARK II LINEAR AMPLIFIER
2000 WATT P. E. P.

The new Mark II provides full frequency coverage of the amateur bands from 10 through 80 meters, and also MARS frequencies. Two Eimac 3-400Z Triodes easily provide the full legal power input: 2000 Watts P.E.P. in SSB mode or 1000 Watts AM, CW, or RTTY. It may be driven by any transceiver or exciter having between 100 and 300 watts output.

Planetary vernier drives on both plate and loading controls provide precise and velvet smooth tuning of the amplifier. Greatly reduced blower noise is provided by a low RPM, high volume fan.

Complete with Tubes: **$395**

MATCHING POWER SUPPLY

The power supply is a separate matching unit which may be placed beside the Mark II amplifier, or with its 4½ foot connecting cable, may be placed on the floor. Component quality is of the highest caliber. Silicon rectifiers deliver 2500 volts D.C. in excess of 1.2 ampere. Computer grade electrolytic filters provide 40 mfd capacity for excellent dynamic regulation. A quiet running fan allows continuous operating with minimum temperature rise, extending the life and reliability of all components.

$235

WE HAVE THE BEST PRICES THAT CAN BE FOUND ANYWHERE

WEST COAST

L. A. AMATEUR RADIO SUPPLY

2302B ARTESIA
REDONDO BEACH, CALIF. 90278
213-376-4455

MIDWEST

EVANSVILLE AMATEUR RADIO SUPPLY

1311 N. FULTON AVENUE
EVANSVILLE, INDIANA
812-422-4551

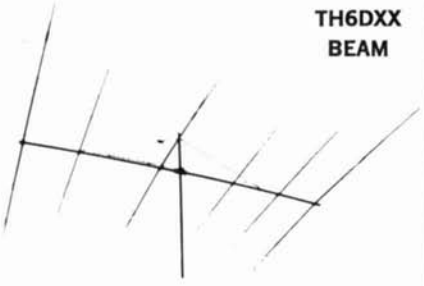
SATISFIED CUSTOMERS ARE OUR BEST ADS

Order Now . . . at ***MOORY ELECTRONICS, INC.***

DEWITT, ARKANSAS 72042

GALAXY V mark 3

and **Hy-Gain**



TH6DXX
BEAM

Mobile or Fixed Station
5 BAND TRANSCEIVER

Galaxy V Mark 3	$420.00
Galaxy AC-400 Power Supply	89.95
Galaxy SC-1 Speaker Console	19.95
Hy-Gain TH6DXX Beam	159.95
Electro Voice 719 Microphone	17.40
	$707.25

FEATURES

- New 500 Watt SSB Power
- Sharp, Crisp, Clear Audio
- New CW Sidetone Audio
- New Solid State VFO
- New CW Break-in Option
- New CW Filter Option
- New ALC Circuit
- New Precise Vernier Logging Scale

POST-CHRISTMAS PACKAGE FOR CASH

$595.00

Send $50 deposit — balance c.o.d.
Or Check in full — Immediate Delivery

Contact Ed Moory for similar good quotes or trades on other popular brands of Ham equipment — Drake — Swan — Mosley — TRI-EX — National — Waters — Johnson — Hammarlund — Hallicrafters.

Moory Electronics, Inc. has three stores to serve you:

MOORY ELECTRONICS, INC.
RAY COKER W5CQJ
Manager
724 LAWRENCE RD.
JACKSON, MISS.
PH. 362-9843

MOORY ELECTRONICS, INC.
ED MOORY — GENERAL MANAGER
P. O. BOX 506
DEWITT, ARKANSAS 72042
PHONE (501) 946-2820

MOORY ELECTRONICS, INC.
BOB WOOTEN W5EBE
"Sales & Service"
415 W. 33rd
N. LITTLE ROCK, ARK.
PH. SK8-0295

(Direct all mail orders to Home Office)

NEW FET SIX METER CONVERTER

The Horizon VI incorporates the latest in solid state VHF techniques. Field-effect transistors are used throughout the unit to provide excellent protection against overload and cross modulation.

All power is provided by a built-in 115 volt AC power supply – (no need to buy extras). An additional crystal position has been provided to allow the owner the option of expanded frequency coverage. Local oscillator output is accessible from the front of the unit for those who desire transceive operation.

The low noise figure of the Horizon VI assures the operator of excellent performance when stations are weak.

See your local dealer for a demonstration of the Horizon VI; you'll be impressed by its exceptional performance.

SPECIFICATIONS

Freq. range: 50 – 54 MHz; **I.F. output:** 14 – 18 MHz; **Input impedance:** 50 ohms; **Output impedance:** 50 ohms; **Noise figure:** 3 dB typical; **Gain:** 15 dB nominal; One 36 MHz crystal installed; **Built-in power supply:** 115 volts AC; **Weight:** 18 ounces; **Dimensions:** L-6¼" x W-3¾" x D-2"; **Price: $59.95.**

AUTHORIZED DEALERS (listed alphabetically)

AMATEUR ELECTRONIC SUPPLY
4828 W. Fond du Lac Avenue
Milwaukee, Wisconsin 53216
Tel: 414 – 442-4200

AMRAD SUPPLY, INC.
3425 Balboa Street
San Francisco, California 94121
Tel: 415 – 751-4661

AMRAD SUPPLY, INC.
1025 Harrison Street
Oakland, California 94607
Tel: 415 – 451-7755

COLE ELECTRONICS SUPPLY COMPANY
335 South Bonner
Tyler, Texas 75701
(214) LY-4-3545

COSTON ELECTRONIC DISTRIBUTORS
2345 Ferguson Road
Cincinnati, Ohio 45238
(513) 481-8555

ELECTRONIC CENTER, INC.
107 3rd Ave. North
Minneapolis, Minnesota
Tel: 612 – 338-5881

EVANSVILLE AMATEUR RADIO SUPPLY
1311 North Fulton Ave.
Evansville, Indiana 47710

GRAHAM ELECTRONICS SUPPLY, INC.
122 S. Senate Avenue
Indianapolis, Indiana 46225
Tel: 317 – 634-8486

HAM RADIO OUTLET
999 Howard Avenue
Burlingame, California 94010
Tel: 415 – 342-5757

THE HAM SHACK (Tel-Appliance Center, Inc.)
1966 Hillview Street
Sarasota, Florida 33579
Tel: 813 – 955-7161

HENRY RADIO STORE
931 N. Euclid
Anaheim, California 92801
Tel: 714 – 772-9200

HENRY RADIO STORE
11240 West Olympic Blvd.
Los Angeles, California 90064
Tel: 213 – 477-6701

L. A. AMATEUR RADIO SUPPLY
2302B Artesia Blvd.
Redondo Beach, California 90278

ED MOORY WHOLESALE RADIO
Box 506 -
De Witt, Arkansas
Tel: 501 – WH 6-2820

PIONEER-STANDARD ELECTRONICS, INC.
5403 Prospect Avenue
Cleveland, Ohio 44103
Tel: 216 – 432-0010

PIONEER-STANDARD ELECTRONICS, INC.
SREPCO ELECTRONICS DIVISION
314 Leo Street
Dayton, Ohio 45404
Tel: 513 – 224-0871

TYDINGS COMPANY
933 Liberty Avenue
Pittsburgh, Pennsylvania 15222
(412) 281-6640

UNIVERSAL SERVICE
114 North Third Street
Columbus, Ohio 43215
Tel: 614 – 221-2335

VALLEY HAM SHACK
4109 N. 39th Street
Phoenix, Arizona
Tel: 602 – 955-4850

WORLD RADIO LABORATORIES
3415 West Broadway
Council Bluffs, Iowa 51501
(712) 328-1851

DEALERSHIPS AVAILABLE IN SOME AREAS — WRITE FOR FREE SPECIFICATION SHEET

RAYTRACK Company
NEW IDEAS FOR PROGRESS IN ELECTRONICS

2111 SPRINGHILL DRIVE Columbus, Ohio 43221

TELEPHONE 614/486-7090

BRIDGE THE GAP TO PEAK PERFORMANCE

. . . . through either of these antenna noise bridge units, which provide accurate and fast testing of antennas and feed lines at a reasonable cost.

Model TE 7-01
- Antenna Noise Bridge
- Range — 1 to 100 MHz
- RCA Tip Jacks
- Resistance Testing: 0 — 100 ohms

$24.95

Model TE 7-02
- Extended Range Antenna Noise Bridge
- Range — 1 to 300 MHz
- BNC Connectors
- Resistance Testing — 0 to infinity, calibrated 25-100 ohms

$34.95

Features Applicable to Both Models:
- Test antenna for both resonant frequency and impedance.
- Replace VSWR bridges or other antenna test equipment.
- Optimum performance through alignment and test of mobile or fixed station antennas.
- Test beams, whips, dipoles, quads, or complete tuner systems.

Applications data and operating instructions included. For descriptive literature write:

omega-t systems incorporated

516 w belt line road • richardson, texas 75080
(214) ad 5-5286

NOVICE CRYSTALS

Fundamental frequencies in FT-243 holders. Pin size .093 in., spacing .486 in. Tolerance .03% measured in oscillator with 32 mmfd. capacity.

80 meters	**3705-3745 kc.**	**$1.75 ea.**
40 meters	**7155-7195 kc.**	**1.25 ea.**
15 meters	**7034-7082 kc.**	**1.25 ea.**

Add for postage and handling per crystal: 8¢ first class; 12¢ airmail. Specify frequency desired and nearest available will be sent. Other frequencies in stock. Send for free list. Satisfaction guaranteed.

NAT STINNETTE, P. O. Drawer Q-1, Umatilla, Fla. 32784

CQ de W2KUW
BEST OFFER!!

Paid ..... for any piece of aircraft or ground radio units, also test equipment. All types of tubes. Particularly looking for 4-250 • 4-400 • 833A • 304TL • 4CX1000A • 4CX5000A et al. 17L • 51X • 390A • ARM • GRM • GRC • UPM • URM • USM units.

TED DAMES CO., 310 Hickory St., Arlington, N.J. 07032

. . . THE BEST
6 METER
CONVERTER

Model 407
$34.95
ppd.

50-52 MHz in. 28-30 MHz out
or 52-54 MHz with a second crystal.

A full description of this fantastic converter would fill this page, but you can take our word for it (or those of hundreds of satisfied users) that it's the best. The reason is simple — we use three RCA dual gate MOSFETs, one bipolar, and 3 diodes in the best circuit ever. Still not convinced? Then send for our free catalog and get the full description, plus photos and even the schematic.

Can't wait? Then send us a postal money order for $34.95 and we'll rush the 407 out to you. NOTE: The Model 407 is also available in any frequency combination up to 450 MHz (some at higher prices) as listed in our catalog. New York City and State residents add local sales tax.

VANGUARD LABS

Dept. R, 196-23 Jamaica Ave., Hollis, N.Y. 11423

NEW FROM PALOMAR

Only
$37.50

- *Crystal controlled secondary frequency standard.*
- *Generates both 100-KHz and 10-KHz markers.*
- *100-KHz to 30-MHz adjustable to .0001%.*
- *Send QSL or postcard for free brochure.*

PALOMAR ENGINEERS
BOX 455, ESCONDIDO, CA 92025

OUR OWN PROFESSIONAL
STEREO-MONAURAL PHONES

"$25 VALUE"
QPH-1 8 OHMS — $12.95
QPH-2 600 OHMS — $15.95
ADD $1 FOR SHIPPING

Professionally Approved QUEMENT MODEL MT-2
Deluxe 20,000 Ohm/Volt VOM

COMPLETE WITH LEATHER CASE

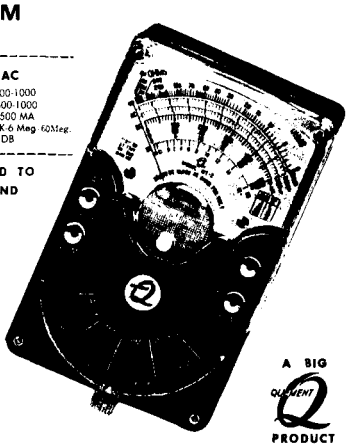
20,000 OHMS/VOLT DC—10,000 OHMS/VOLT AC

- Quick Range Selection
- Two-Color Expanded Scale
- Precision 1% Resistors
- Low Circuit Loading
- Jeweled Meter Movement

DC Voltage: 5-25-100-500-1000
AC Voltage: 5-25-100-500-1000
DC Current: 50 uA-5-50-500 MA
Resistance: 6K-60K-600K-6 Meg. 60Meg.
Decibels: —20 to +62 DB

THOUSANDS OF THESE FINE METERS SOLD TO HAMS, EXPERIMENTERS, GOVERNMENT AND INDUSTRIAL PLANTS

$13.95
SHIPPED PREPAID USA



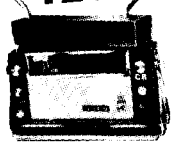
COMPLETE OUTFIT
Furnished with leather carrying case, test leads, instruction manual and batteries.

A BIG QUEMENT Q PRODUCT

ALL NOVA-TECH MODELS IN STOCK!
WITH FREE ANTENNA
$129.95

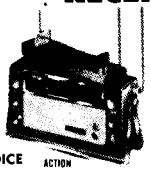
WE GIVE A **FREE!** OUTDOOR ANTENNA with every

nova-tech
RECEIVER



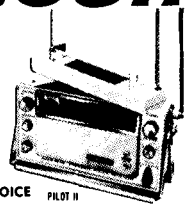
NOVA CB

WITH FREE ANTENNA
$129.95
YOUR CHOICE



ACTION

WITH FREE ANTENNA
$129.95
YOUR CHOICE



PILOT II

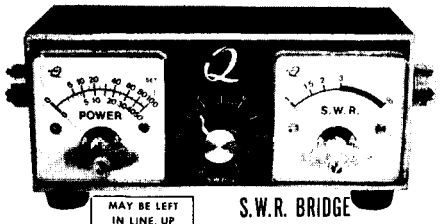
...ALL NOVA-TECH RECEIVERS SHIPPED PREPAID...

S.W.R. BRIDGE and FIELD STRENGTH METER

9.95

MAY BE LEFT IN LINE, UP TO 2000 WATTS.
GOOD THROUGH 2 METERS
THE BEST VALUE WE HAVE EVER OFFERED!
OUR MODEL SWB-2
ADD $1 POSTAGE

OUR MOST COPIED PRODUCT
"THOUSANDS SOLD"



MAY BE LEFT IN LINE, UP TO 2000 WATTS.

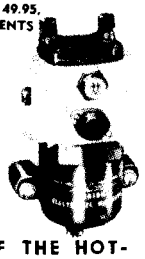
S.W.R. BRIDGE
- MODEL SWB-2
- READS FORWARD AND REFLECTED POWER SIMULTANEOUSLY
- "EASY READ" METERS
- USE FOR REFERENCE POWER METER
- DUAL 100-MICROAMP METER MOVEMENTS
- LOW INSERTION LOSS
- SIZE-5"X2"X2"

THE BEST VALUE WE HAVE EVER OFFERED!

$15.95
ADD $1 POSTAGE

JUDSON ELECTRIC MAGNETO
REGULAR 49.95, AT QUEMENTS
37.50

- Reduces fuel consumption
- Double plug and point life
- Instant starting every time
- Reduces down time
- It's like a permanent tune-up
- Better ignition guaranteed



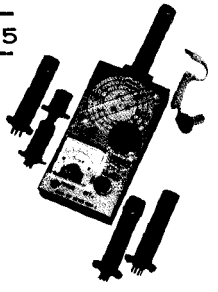
"ONE OF THE HOTTEST ITEMS WE HAVE EVER SOLD"
ADD $2 POSTAGE

- Compact
- Accurate
- Self-contained
- Highest Stability
- Heavy Dip

ALL-TRANSISTORIZED GRID DIP METER

$29.95

Allow $1.00 for packing and shipping. California residents include sales tax.



Assembled & tested, complete with six coils, ear phone and battery.
TUNES 500 Kc THRU 150 Mc
DOZENS OF USES

GDM-3

NEVER BEFORE HAS A PRECISION INSTRUMENT LIKE THIS BEEN OFFERED AT SUCH A LOW PRICE.

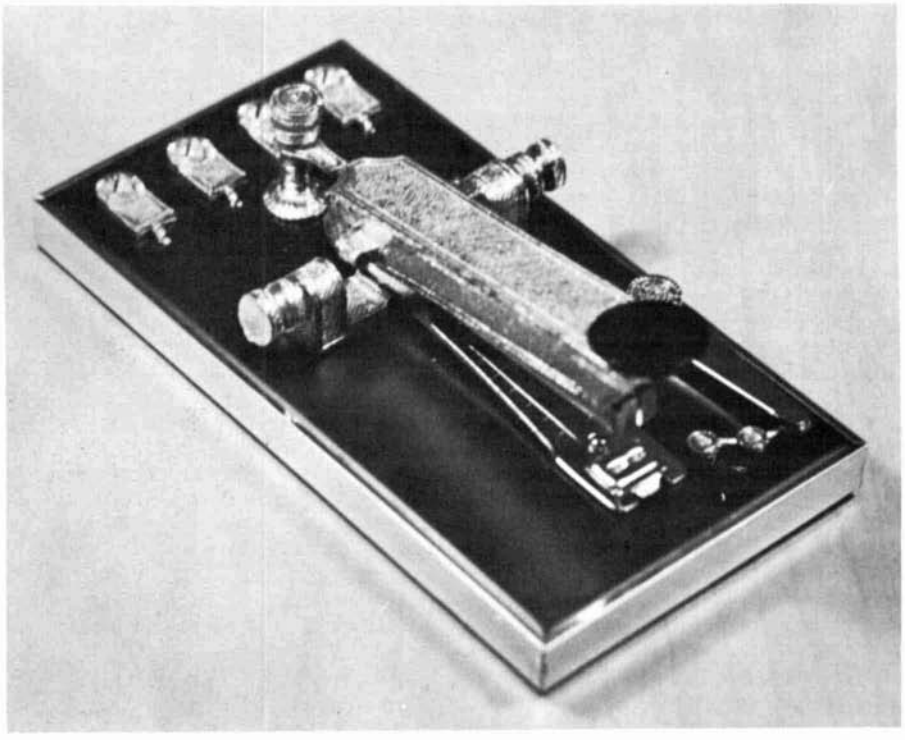
QUEMENT Q

SINCE 1933 PHONE AREA 408 294-0464 FAST SERVICE

QUEMENTS

1000 SOUTH BASCOM AVE. SAN JOSE, CALIF. 95128

NOTICE: CALIFORNIA RESIDENTS INCLUDE 5 PERCENT SALES TAX



TELEGRAPH KEY STAPLER

HANDSOME REPRODUCTION OF ANTIQUE TELEGRAPH KEY

THIS MORSE CODE TELEGRAPH KEY CLEVERLY FUNCTIONS AS A STAPLER. BOSTITCH STAPLING MECHANISM. THE RHEOSTAT IS A STAPLE REMOVER. ANTIQUE GOLD FINISH ON BLACK METAL WITH CHINESE-RED VELVET BASE. 6½ X 3½. IDEAL FOR AN ORIGINAL GIFT FOR THE OFFICE OR THE SHACK.

PLEASE SEND ..... TELEGRAPH KEY STAPLERS AT $10.59
PLUS 80c POSTAGE. ENCLOSED CHECK FOR .....
NAME..... CALL.....
STREET.....
CITY..... STATE..... ZIP.....

BUILT TO LAST

$10.59 + 80c POSTAGE

10 DAYS MONEY BACK GUARANTEE

SORRY NO C.O.D.

HUGO H. ROUSSEAU & SONS

210 POST STREET • SUITE 915

SAN FRANCISCO CALIFORNIA 94108

flea market

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

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

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

WRL'S USED GEAR has trial-terms-guarantee! Galaxy 300 — $139.95; Galaxy V — $249.95; Galaxy Vmk2 — $299.95; Swan 350 — $299.95; SR150 — $299.95; HW22 — $89.95; HT40 — $49.95; VHF62 — $89.95; HX500 — $269.95; Galaxy 2000 & PS — $329.95; SB300 — $249.95; hundreds more. Free blue-book list. WRL, Box 919, Council Bluffs, Iowa 51501.

QSLS. GORGEOUS RAINBOWS, *cartons etc. Top* quality! Low prices! Samples 10¢ refundable. Joe Harms, ex-W1GET, 905 Fernald, Edgewater, Fla. 32032.

GOLDEN BEAR QSL PARTY. All amateurs are invited to participate in a QSL party sponsored by THE GOLDEN BEAR AMATEUR RADIO NET INC. Operating freq. — 3975 kc. Mode of operation — LSB, AM or CW. Time and date — 0500 GMT, Jan. 18, thru 0200 GMT Jan. 19, 1969. Operating rules: To qualify for the Golden Bear Net QSL Certificate, any operator must satisfactorily provide to the Net Control Station, the correct call, name and mailing address of his station. No other requirements have been set for aspirants of the Golden Bear Net Certificate.

DON'T MISS **RADIO COMMUNICATION HANDBOOK.** 832 pages — Complete technical guide — Brand new — Only $11.95 postpaid U.S.A. and Canada. Comtec, Box 592, Amherst, N. H. 03031.

The **WHEATON COMMUNITY RADIO AMATEURS** (WCRA) will hold the seventh annual Mid-Winter Swap and Shop on Sunday, February 16, 1969 at the DuPage County Fair Grounds, Wheaton, Ill. Hours — 9:00 a.m. to 5:00 p.m. $1.00 donation at the door. Hams, CBers, electronic hobbyist, friends and commercial exhibitors are cordially invited. Contact *Bill Lester, WA9FGP, Box 1, Lombard, Ill. 60148,* for information.

Q.S.L. CARDS $6.95 (1,000). C. B. Wholesale Printers, P. O. Box 994, Anderson, Indiana.

The **BEST DEAL** going is a subscription to **HAM RADIO.** One year $5.00 or three years only $10.00.

TEST EQUIPMENT WANTED: Any equipment made by Hewlett-Packard, Tektronix, General Radio, Stoddart, Measurements, Boonton. Also military types with URM-( ), USM-( ), TS-( ), SG-( ) and similar nomenclatures. Waveguide and coaxial components also needed. Please send accurate description of what *you have to sell and its condition to Tucker Electronics* Company, Box 1050, Garland, TX 75040.

ORIGINAL EZ-IN DOUBLE HOLDERS display 20 cards in plastic, 3 for $1.00, 10 for $3.00 prepaid. Guaranteed. Patented. Free sample to dealers. Tepabco, John K4NMT, Box 198R, Gallatin, Tennessee 37066.

PROBLEMS? Send them to J & J Electronics, Canterbury, Conn. 06331.

FOR SALE: 312B5, cables, connectors, manual; $265. 30L-1; $375. KWM-2, with Waters Q-Multiplier 516F-2; $800. 75A4 # 3481 (with 2.1 and 3.1 kcs filters; $425. 75A3 (late series) with 75A4 vernier knob, 3.1 and 6.0 kcs filters; $250. HQ-215 (new in May, '68); $375. Henry 2K-3 with spare 3-500-Z; $625. T4X, AC-4, MS-4; $350. (or trade for SW-500-C and 117XC). 75S-1 # 11472, 0.5 and 2.1 kcs filters; $275. 32S-1, # 10100, 516F-2; $425. 312B-4; $135. HT-32-B, HT-33-A; $275.00 each. P & H. "SPITFIRE" linear, new, $85. P & H AFC-2 speech processor; $25. HW-12-A, HP-23; $150. HW-22A, HP-23; $150. HW-32, (factory-reconditioned/modified), HP-23; $135. James W. Craig, W1FBG, 29 Sherburne Avenue, Portsmouth, N. H. 03801, Phone: 603-436-9062.

WANTED ANTIQUE RADIOS, Catalogs, tubes, send model, price, condition. Farrell, 2252 Dixie, Pontiac, Michigan 48055.

SWAN 250 6 METER TRANSCEIVER with power supply, $250. Vanguard TV camera, $175. Lafayette HA-6, $65. P. Franson WA7KRE, 7312 E. Oak Street, Scottsdale, Arizona 85257. 602-947-6052.

TOROIDS: 44&88mhy., center-tapped, unused, 5/$2.00 POSTPAID. 11/16" reperf tape $3/box. FM-FM-FM TRANSCEIVERS Motorola P33- 5 watt and H23 Packsets with Ni-Cads, complete. Write. Eico 720 Transmitter, Excellent $40. Johnson 6N2 and matching VFO $100. Teletype model 32 and 28ASR equipment, write. "AZL" two meter converter with P.S. $25. Dow-Key relay $10. Gonset GC-105 two meter communicator $85. WANTED: Drake 2B&2BQ. Model 14TD gears (80165-80166). RTTY & FM gear. Receiver (HQ180, NC-300, SX101A etc.) Stamp for list. Van W2DLT, 302H Passaic, Stirling, N. J. 07980.

SPACE PROBLEMS SOLVED with Joystick Variable Frequency Antennas. With Tuners for 10 thru 160 Meters. Under $50. Brochure. Shortwave Guide, 218-H Gifford, Syracuse, NY 13202.

CLEANING HOUSE. 6-meter linear amplifier, Knight T-175, 300 watts PEP ssb, 150 watts CW, requires less than 10 watts drive; may be used on a-m, built-in power supply; almost new, $90. Cushcraft 6-meter 6-element beam, $15. Johnson 275-watt Matchbox with swr bridge, mint, $50. Cavity oscillator with tubes, tunes from 300 to 3000 MHz, nationally advertised at $80; excellent, $20. Waters model 384 dummy load, like new $50. W1DTY, Box 25, Rindge, N. H. 03461. (603-899-2860)

GONSET GSB-6 SIDEWINDER, brand new, sealed factory carton, $285; ac supply, $60; dc supply, $50; 500-watt 913A linear, $245; all new equipment. WB2LZD. 607-785-5862.

DAYTON Hamvention April 26, 1969: Sponsored by Dayton Amateur Radio Association for the 18th year. Technical sessions, exhibits and hidden transmitter hunt. An interesting ladies program for XYL. For information watch ads or write Dayton Hamvention; Dept. H, Box 44, Dayton, Ohio 45401.

COLLINS 75S-3B RECEIVER for sale. Clean, excellent operating condition. $450.00. W1DHZ, Box 185, Amherst, N. H. 603-673-4885.

HAM-AUCTION, Feb. 16, 14th Annual by Toledo Mobile Radio Ass'n, at the Lucas County Recreation Center, 2901 Key St., Maumee, O. $1.00 Registration, open table sales, map and further info. write Ron W8STA, 1939 Cone, Toledo, O. 43606.

POLICE-FIRE RADIO STATION DIRECTORIES show callsigns, frequencies; nationwide. Used by AREC, CD, RACES, Vamps, VHF buffs. Stamp brings catalogs. Communications, Box 56-HR, Commack, N. Y.

The **LAKE COUNTY AMATEUR RADIO CLUB, INC.,** announces its 16th Annual Banquet to be held at Teibel's Restaurant, U.S. 30 and 41 (near Schererville, Ind.), at 6:30 p.m., CST, February 8. Chicken dinner, entertainment, speeches. Plan to attend with your wife or girl friend. Tickets $4.00 each from Herbert S. Brier, W9EGQ, 385 Johnson Street, Gary, Indiana 46402. Positively no tickets sold at door.

NEW ELECTRONICS PROJECT BOOKS! Fifty IC Projects, $3.95 — 101 Ham Radio Projects, $3.95 — 49 Transistor Projects, $1.75 — 104 Transistor Projects, $3.95 — 101 Audio Projects, $3.25 — 101 CB Projects, $3.25 — 101 Test Instrument Projects, $3.95 — "The VHF Amateur" (VHF techniques plus 33 easy projects), $4.50. Postpaid. Brown, W9HBF, 5611 Middaugh Ave., Downers Grove, Ill. 60515

QUARTZ CRYSTALS for Two Way communications. *Amateur netting. Price list. American Crystal Co.,* 821 East Fifth Street, Kansas City, Missouri.

"Your Friendly Supplier"

OFFERS

THE LARGEST INVENTORY

of USED EQUIPMENT in the NORTHEAST. SEE SAMPLES BELOW.

NEW YEAR SPECIALS

B&W 5100	$114.00
B&W 5100B	144.00
Collins 32V1	89.00
Collins 32V2	114.95
Collins 75A1	139.95
Collins 62S-1	599.00
Eico 753 Transceiver	149.00
Eico 753 Transceiver w/AC Supply	199.00
Globe 300A	114.00
Globe 350	149.95
Hallicrafters S-108	84.95
Hallicrafters SX-43	79.95
Hammarlund HQ-129X	89.95
Hammarlund HQ-140X	109.95
Johnson SSB Adaptor	164.00
Johnson Viking II	69.95
Johnson Viking II w/122 VFO	84.95
Johnson Valiant	159.00
Johnson Valiant II	239.95
Mosley CM-1	89.00
National HRO-50 w/A,B,C,D, Coils	139.95

Time Payment Plan Available

WRITE FOR LATEST COMPLETE LIST

Evans RADIO

BOX 893 CONCORD NH 03301

FONE 603-225-3358

MOTOR KITS

FOR THE HAND WINDERS
FITS ANY CRANK UP TOWER
COMPLETE WITH WATERPROOF MOTOR
$199.95
Without Motor $129.95

HYGAIN — MOSLEY — NEW-TRONICS
TRISTAO — MYLAR ROPE — TIMES COAX

Write for latest catalog

ANTENNA MART

BOX 7, RIPPEY, IOWA 50235
Telephone 2279

ATV'ERS

For the largest US ATV magazine; Technical reports & ATV directory SEND $2 for a 1 year subscription TO:

A5 MAGAZINE 150 Delong Ave., Dumont, NJ 07628

HIGHEST $ $ PAID FOR TUBES

CrCo 120 WEST 18th STREET

NEW YORK 10011 . 212-242-7400

Free Tube List

top notch articles
and
great ideas

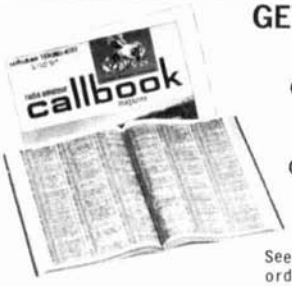
the monthly for amateurs that's different!

to see for yourself, write to HAM RADIO magazine GREENVILLE, N.H. 03048 Include address, call and zip code.

free copy, or

4 months @	2.00
12 months @	5.00
3 years @	10.00

radio amateur callbook



GET YOUR *NEW* ISSUE NOW!

Over 283,000 QTHs in the U.S. edition
$6.95

Over 135,000 QTHs in the DX edition
$4.95

See your favorite dealer or order direct (add 25¢ for mailing in U.S., Possessions & Canada. Elsewhere add 50¢).

These valuable EXTRA features included in both editions!

- QSL Managers Around the World!
- Census of Radio Amateurs throughout the world!
- Radio Amateurs' License Class!
- World Prefix Map!
- International Radio Amateur Prefixes
- Radio Amateurs' Prefixes by Countries!
- A.R.R.L. Phonetic Alphabet!
- Where To Buy!
- Great Circle Bearings!
- International Postal Information!
- Plus much more!

WRITE FOR FREE BROCHURE!

RADIO AMATEUR callbook INC

Dept. Q 4844 W. Fullerton Ave.
Chicago, Ill. 60639

PUT THE POWER WHERE IT BELONGS
LET THE **VANGUARD HI-Q BALUN**
PUT IT IN YOUR ANTENNA

- Full legal power 3 to 30 MC
- Sealed lightning arrester protects your equipment
- Reduced coax pick-up improves reception, reduces interference
- Reduced coax radiation — helps TVI
- 1 to 1 impedance ratio
- Small — lightweight — weatherproof
- Replaces center insulator
- Precision machined PVC plastic — coax conector

NET PPD IN U.S.A.
FULLY GUARANTEED **$9.95**

VG **VANGUARD ENGINEERING**

BOX 513 · BRIELLE, NEW JERSEY 08730

mark 2
oscillator/monitor

- makes an audible tone to monitor the RF of any CW transmitter from 10Mw to 1 Kw & 100Kc to 1000Mc, using only an 8" pickup antenna.
- can be self-triggered for code practice or the testing of solid state components and circuits.
- aids in tuning up & testing RF oscillator and power circuits.
- 4 transistor, 2 diode circuit, speaker, tone adjust, AA pencell, test leads, 8" ant., & magnetic base.
- cabinet is 16 gauge black & clear anodised aluminum, 3.4 x 2.3 x 1.2" US made & guaranteed for 1 year.

14.95 complete, ppd usa & can. send a check or m.o. sold by mail only

James Research company, dep't: HR-M
11 schermerhorn st., brooklyn n.y. 11201

Beware . . . of the Dreaded **SHREW**
linear amplifier

- 200 watt PEP.
- 25-54 MHz.
- 2-20 watts drive.

$89.95

Matching AC Power Supply $39.95
DC-2 12 Volt Supply $44.95

Write for complete details & **FREE SHREW** Patch

G **Communications Division**
GAUTHIER INDUSTRIES
P. O. Box 216
Lynwood, California 90262
Dealer Inquiries Invited

New! **TEKRAD Mark V ANTENNA SYSTEM $32.50** TAX & POSTAGE PAID)

CHARACTERISTICS:

- 80 through 10 meters
- Essentially constant feed impedance
- Balanced system for high efficiency
- Balanced 450 ohm feed
- Very light, minimum wind-resistance
- Omnidirectional
- Large aperture
- Wide angle of radiation for constant hi-level signals
- A matching device is required – 50 ohm unbalanced to 450 ohm balanced

The Tekrad Mark V Antenna system is ready for delivery in completely assembled units, ready to hang up with supporting cords and transmission line attached.

TEKRAD, INC.
P.O. BOX 57
VALPARAISO, FLORIDA 32580

FOR THAT
"Extra Class"
YOU NEED THE

BTI LK-2000
LINEAR
AMPLIFIER
For SSB, CW, RTTY
Maximun legal input
Full loading 80-10M
Rugged Eimac 3-1000Z
Dependable operation
Easy to load and tune
No flattopping with ALC
Distinguished console
Instant transmit
High efficiency circuit
Designed for safety
Fast band switching
Real signal impact
Price $795.00
READY TO OPERATE!

Listen for the hundreds of LK-2000 linears now on the air and judge for yourself. Write for free illustrated brochure or send $1.00 for technical and instruction manual.

BTI AMATEUR DIVISION
Hafstrom Technical Products
4616 Santa Fe, San Diego, Ca. 92109

LET W3KT
FORWARD YOUR
DX QSLS

Join the thousands of satisfied hams who have been using this service for the past seven years. During 1967 alone, over 200,000 QSLs were forwarded to DX stations. This is a DELUXE service, insuring prompt and continuous mailings, and involving a minimum of effort on your part.

Just fill in your QSLs and send them to W3KT. You don't have to address the cards, or indicate the QSL manager, or send any SASEs. Where a DX station uses a stateside QSL manager, your card will be sent to him with an SASE, and the reply will come back to W3KT, who will send it to your call area QSL bureau. Other QSLs will be sent to the proper QSL Bureau, or, if necessary, direct.

Remember, your QSL is a personal message. Therefore W3KT sends it by FIRST CLASS MAIL only.

The charge: Four cents per QSL, 30 cards per dollar. **NO MEMBERSHIP FEE.**

SAVE TIME! SAVE MONEY!

W3KT QSL SERVICE

RD 1, Valley Hill Road Malvern, Penna. 19355

. . . THE BEST
2 METER
CONVERTER

Model 407
$34.95
ppd.

**144-146 MHz in. 28-30 MHz out
or 146-148 MHz with a second crystal**

A full description of this fantastic converter would fill this page, but you can take our word for it (or those of hundreds of satisfied users) that it's the best. The reason is simple — we use three RCA dual gate MOSFETs, one bipolar, and 3 diodes in the best circuit ever. Still not convinced? Then send for our free catalog and get the full description, plus photos and even the schematic.

Can't wait? Then send us a postal money order for $34.95 and we'll rush the 407 out to you. NOTE: The Model 407 is also available in any frequency combination up to 450 MHz (some at higher prices) as listed in our catalog. New York City and State residents add local sales tax.

VANGUARD LABS
Dept. R, 196-23 Jamaica Ave., Hollis, N.Y. 11423

Radio Amateurs
Reference Library
of Maps and Atlas

WORLD PREFIX MAP — Full color, 40" x 28", shows prefixes on each country . . . DX zones, time zones, cities, cross referenced tables . . . . . postpaid **$1.00**

RADIO AMATEURS GREAT CIRCLE CHART OF THE WORLD — from the center of the United States! Full color, 30" x 25", listing Great Circle bearings in degrees for six major U.S. cities; Boston, Washington, D.C., Miami, Seattle, San Francisco & Los Angeles. . . . . postpaid **$1.00**

RADIO AMATEURS MAP OF NORTH AMERICA! Full color, 30" x 25" — includes Central America and the Caribbean to the equator, showing call areas, zone boundaries, prefixes and time zones, FCC frequency chart, plus informative information on each of the 50 United States and other Countries . . . . postpaid **$1.00**

WORLD ATLAS — Only atlas compiled for radio amateurs. Packed with world-wide information — includes 11 maps, in 4 colors with zone boundaries and country prefixes on each map. Also includes a polar projection map of the world plus a map of the Antarctica — a complete set of maps of the world. 20 pages, size 8¾" x 12" . . . . . postpaid **$2.00**

Complete reference library of maps — set of 4 as listed above . . . . . postpaid **$3.00**

See your favorite dealer or order direct.

WRITE FOR FREE BROCHURE!

RADIO AMATEUR callbook INC.
Dept. Q 4844 W. Fullerton Ave.
Chicago, Ill. 60639

KEEP UP TO DATE ON YOUR DXING

A weekly magazine (16 to 24 pages each week.

Current DX that's on the air, and info about what's planned for the immediate future. What's being heard by the boys. Etc.

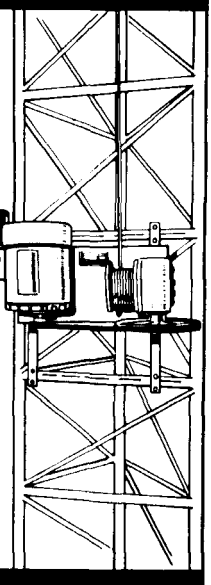
FULL DX INFO EVERY WEEK.

Per year—Surface mail (they say most 1st class mail actually goes via air) $11.00

The DXERS Magazine, (W4BPD)
Route 1, Box 161-A,
Cordova, S.C. 29039

INTRODUCING . . . TRISTAO'S new, low cost motor drive unit for crank-up towers.

Here's a deluxe motor unit that's a work and money saver. Designed for rugged use and long life, TRISTAO'S new MU-33 fits most crank-up towers made today. And it takes just minutes to install. The MU-33 features a 1/3 hp totally enclosed and weather proof motor, a precision 30-1 sealed gear box, sealed ball bearings, reversing switch and NAC cord. For hams who need the unit without the motor, belt and switch, it's available as MU-31.
For more information Call or write:



TRISTAO TOWER CO.
P. O. Box 115, Hanford, California 93230

WE PAY CASH FOR TUBES
LEWISPAUL ELECTRONICS INC.
303 W. Crescent Avenue
Allendale, New Jersey 07401

CONVENTION 69
ARRL NATIONAL
DES MOINES, IOWA
JUNE 20, 21, 22
P.O. Box 1051, 50311

"Beamed-Power" ANTENNAS, "BALUNS" I. V. KITS and ROTATOR SYSTEMS!

Most Technically-Perfected, Finest Communication Arrays in the World! Precision-Tuned-Matched and "Balun" Fed for "Balanced-Pattern" to assure "TOP-MAN-ON-THE-FREQUENCY" Results

— with a MATERIAL DIFFERENCE!

Use. is one of the most dependable testimonials of endorsement. and Telrex products are in use in 139 Lands

Enjoy World renown TELREX performance, value and durability! Send for PL68 tech. data and pricing catalog, describing professionally engineered communication antenna systems, rotator-selsyn-indicator-systems, "Baluns", I.V. Kits, Towers, "Mono-Pole", "Big-Berthas", accessories, etc. etc.

COMMUNICATION SYSTEMS SINCE 1921 — Communication Engineering Telrex Laboratories

ASBURY PARK, NEW JERSEY 07712, U.S.A.

WHOOPEEEEE

Fell in again — only deeper!

More HALLICRAFTERS' Solid States Modules for TR-35A

SIDETONE OSCILLATOR . . . . . **$1.50 ea.**
On board, 2 1/4" x 1 1/2". Use for code oscillator. **4/$5.50**

RECTIFIER . . . . . **$4.00 ea.**
8 silicon diodes, in full wave bridge, with protective resistors, on board 4 1/2" x 1 1/2". Output, as used in TR-35A, 490v DC at 390 ma. **4 for $15.00**

FILTER . . . . . **$2.50 ea.**
4 40 mfd 450v DC, tubular lytics, in 2 sets, 2 in series, for 20 mfd 900v, protective resistors, 3 7/8" sq. **4/$9.50**

Filter Combination . . . . . **$6.00 set.**
Both above, rectifier & filter board. Schematics, from Tech manual included with all above. **4 sets $23.00**

MORE VARIABLE CAPACITORS.

EFJ #167-161 . . . . . **$1.50 ea.**
4.7 to 55 pf, 600v spacing. Double bearing, double ended ceramic plates 3/8" sq. 1/4" shaft, 3/4" long + threaded bushing 3/8" long. **4/$5.50**

MC-50M . . . . . **$1.25 ea.**
6.3 to 50 pf, 1 KV spaced, straight line frequency, double bearing, double ceramic end plates, 1 3/4" x 1/2". Double 1/4" shafts, 1/2" + 3/8" threaded bushing & rear 3/8". **4/$4.50**

Either above ideal for BFO on receiver module. (See Nov. 1968 HR).

DUAL 30-211 pf. . . . . . **$6.50 ea.**
CARDWELL, 6500v spacing, double bearing. 5 3/4" wide, 3 1/2" high, 11" long, + 2 1/2" for single 3/8" shaft. (9 lbs.)

Quantities very limited – *FIRST COME FIRST SERVED.* All prices are NET, FOB our store, Chicago. All items are subject to prior sale. *PLEASE* include sufficient to cover shipping costs, any excess remitted, returned with order. Illinois deliveries, add 5% to quoted prices to cover "sales tax". For 1968 "GOODIE SHEET" send *SASE, PLEASE.*

B C Electronics
Telephone 312 CAlumet 5-2235
2333 S. Michigan Ave. Chicago, Illinois 60616

LARGEST SELECTION in United States
AT LOWEST PRICES — 48 hr. delivery

JAN CRYSTALS

Thousands of frequencies in stock. Types include HC6/U, HC-18/U, FT-241, FT-243, FT-171, etc. SEND 10¢ for catalog with oscillator circuits. Refunded on first order.

2400H Crystal Drive
Ft. Myers, Florida 33901

HEY THERE!
YOU WITH GEAR
IN YOUR SHACK!

Don't clutter up your home with all that stuff! Better to clutter up our warehouse — and get paid in the bargain! Don't waste time asking us for prices. **Tell us exactly what you want** for your Gen. Radio, H-P, Tektronix, ARC, GRC, TED, PRC, VRC, ARN, URR, APN and other military/commercial gear. Call or write today!

COLUMBIA ELECTRONICS, Dept. H

4365 W. Pico Blvd., Los Angeles, Calif. 90019
Phone: (213) 938-3731 Cable: COLECTRON

DIODES

EVERY DIODE WE SELL IS CURVE TRACED ON A SPECIAL TESTER. THIS TESTER DRIVES **2 AMPS** AVERAGE CURRENT THROUGH THE UNIT IN THE FORWARD DIRECTION WHILE THE REVERSE LEAKAGE IS MEASURED. (25 MICROAMPS). THE OPERATOR EXAMINES THE CURRENT-VOLTAGE PLOT OF EACH DIODE ON AN OSCILLOSCOPE SCREEN. WE FULLY **GUARANTEE** EVERY UNIT SOLD OR YOUR MONEY REFUNDED.

PIV	TOP-HAT 1.5 AMP	EPOXY 1.5 AMP	EPOXY 3 AMP	STUD-MOUNT 6 AMP
50	.04	.06	.12	.15
100	.06	.08	.16	.20
200	.08	.10	.20	.25
400	.12	.14	.28	.50
600	.14	.16	.32	.58
800	.17	.20	.40	.65
1000	.20	.24	.48	.75

M. WEINSCHENKER K3DPJ
PO BOX 353
IRWIN, PA. 15642

INTERESTED IN SERIOUS WORK ABOVE 50 MHz?

You should read
VHF COMMUNICATIONS

It brings you — sixty pages of technical articles in each quarterly issue. Applications of the latest techniques. Advanced designs using printed circuits and solid state technology.

Typical topics? VHF & UHF single sideband receivers and transmitters, antennas, converters, transverters and test equipment. Complete schematic diagrams, component requirements, construction details and performance data.

VHF COMMUNICATIONS is the English language edition of UKW BERICHTE, the German VHF Magazine, since 1962 regarded in Europe as the most authoritative in the field of amateur VHF. Try a subscription for a year, you'll like it!

Calendar year subscription U.S.A. and Canada $3.00 (US)

VHF COMMUNICATIONS
P. O. BOX 87
TOPSFIELD, MASSACHUSETTS 01983

Other countries: UKW Berichte, 6520 Erlangen, Gleiwitzer Strasse 45, West Germany

Eliminate "walking" and increase your sending speed.

C-R Key Kit
for Electronic Keyers

$13.95
Iowans add 3% sales tax

With the new C-R Key Kit you can increase your efficiency by eliminating unwanted "walking", increase your signal strength and enjoy continuous, trouble-free sending. The Key comes in ready-to-assemble kit form requiring only the simplest hand tools for assembly. Parts include: heavy steel base with rubber feet, finished in umber gray metallic — large silver contacts — black bakelite knob and paddle — other parts are nickel plated brass.

Order now! Shipped postpaid in U.S.A. Check or money order. No COD's please.

ELECTRIC SPECIALTY MFG. COMPANY
P. O. Box 645
Cedar Rapids, IA 52406

SPACE PROBLEMS SOLVED WITH
JOYSTICK
VARIABLE FREQUENCY ANTENNAS
Send for Brochure
SHORTWAVE GUIDE
218-H GIFFORD ST., SYRACUSE, N. Y. 13202

SURPLUS EQUIPMENT WANTED TO BUY BY THE FASTEST GUN IN THE EAST

No horsing around, we pay fast . . . in 24 hours . . . and we pay more. We'll swap or trade new equipment too . . . We quote fast too. We also pay for shipping, insurance, etc. You call fast, now, collect, for fast quote.

SPACE ELECTRONICS
div. of MILITARY ELECTRONICS CORP.
11 Summit Ave., East Paterson, N. J. 07407, (201) 791-5050

the permaflex key

- both a twin lever & straight hand key in a pivotless 2 paddle design.
- gives instant choice of automatic semi-automatic & straight hand keying.
- use directly with any transmitter or through an electronic keyer.
- 8 amp. gold diffused silver contacts adjust from 0-.060" & 5-50 grams.
- distinctive blue paddles are of rugged G-10 fiberglass epoxy.
- cabinet is 16 gauge polished chrome steel: 1.95" sq. x 3.75", paddles extend 1.25", weight app. 1 pound.
- silicone rubber feet for stability.
- 100% US made & guaranteed for 1 yr.

19.95 complete, ppd usa & can. send a check or m.o. sold by mail only

James Research company, dep't: HR-K
11 schermerhorn st., brooklyn n.y. 11201

LIBERTY PAYS MORE!!
WILL BUY FOR CASH — ALL TYPES
Electron Tubes · Semiconductors · Test Equipment
Military Electronic Equipment
Wire, write, phone collect! We pay freight on all purchases!
LIBERTY ELECTRONICS, INC.
548 Broadway, New York, N. Y. 10012
Phone: 212/925-6000

SPECIAL

HEADSET WITH HEADBAND, 2 receivers, cord and plug. 2000 new at **$1.25**

TRANSMITTER COMMAND SET BC-458/ARC-5 5.3 to 7.0 mc. Scavenge for parts or convert to SSB exciter. V.F.O., or 100 w. xmtr. **TUBES:** 2-1625's (12v. 807's); 1-1626 (V.F.O.); 1-1629 tuning eye (for calibration). Plus crystal for calibrating V.F.O. Loads of parts. New only **$5.50**

BENDIX 3611 telephone amplifier with dynamotor DS100, input 24v. at 1.2a out 220v. at .060a., also 2 tubes 6SJ7 and 6V6, 250 of each new **$4.50**

TELEPHONE REPEATER type **EE89,** 40 new **$2.50**

TALLEN CO., INC. 300—7th Street Brooklyn, N.Y. 11215

BARRY PAYS CASH FAST

You can be sure with Barry . . .
Fair dealing since 1938

Send lists of your unused TUBES, Receivers, Semi-Conductors, Vac. Variables, Test Equipment, etc.

No Quantity too Small.
No Quantity too Large.

Write or Call now . . . BARRY, W2LNI

BARRY ELECTRONICS
512 BROADWAY • NEW YORK, N. Y. 10012
212 - WA 5-7000

U. S. and CANADIAN HEADQUARTERS for
Radio Society of Great Britain Publications

RADIO COMMUNICATION HANDBOOK — Fourth Edition
A complete guide to virtually all technical aspects of amateur radio. Over 50% larger than previous editions. Prepared by the outstanding amateurs in Great Britain today. **832 pages Hardbound $11.95**

AMATEUR RADIO TECHNIQUES — Second Edition — J. Pat Hawker, G3VA
Brand new edition — completely revised. A very complete collection of short articles and ideas covering many aspects of amateur radio. Includes new enlarged semiconductor section.
160 pages Only $2.50

AMATEUR RADIO CIRCUITS BOOK
Completely revised — new edition. A very handy collection of many useful circuits for amateur use. Loaded with good ideas for that new converter, exciter or other project you are working on.
Only $2.00

RADIO DATA REFERENCE BOOK — Second Edition — By G. K. Jessop, G6JP
Here in a 148 page book is one of the most complete compilations of radio and electronic charts, nomographs, formulas and design data available. Whether you design, build or operate, this is a book you must have. **Only $2.50**

WORLD AT THEIR FINGER TIPS — John Clarricoats G6CL
A very interesting history of the RSGB and of amateur radio in Great Britain. It gives a great insight into the development of our hobby. **Paper back edition $2.50**
Deluxe edition $6.50

ALL PRICES POSTPAID IN U. S. A. AND CANADA

book division

comtec

Box 592 • Amherst, New Hampshire 03031

"WE ARE THE EXCLUSIVE NORTH AMERICAN DISTRIBUTOR FOR RSGB PUBLICATIONS — DEALER INQUIRIES INVITED"

TRADE EVEN

NEW BOXED SWAN 500C WITH 117XC POWER SUPPLY FOR ANY OF THE FOLLOWING SURPLUS IN GOOD CONDITION.

TEST EQUIPMENT: SG-IA/ARN WITH PP-348, SG-2/GRM-4, SG-13/ARN, UPM-98, UPM-99, ARM-22, ARM-25, ARM-47, HLI-103A, ARC H-14A, MD-83A/ARN, HEWLETT-PACKARD 606A, 608D, 612A, 618A, 620A, COLLINS 479S-3, 479T-2, 477U-2, 678Y-3, TEKTRONIX 535A, ETC.

AIRBORNE EQUIPMENT: ARC-51, ARC-54, ARC-94, ARC-102, ARC-134, RT-220C/ARN-21, 618T, 618S, ARN-83.

RECEIVERS: R-390A/URR WITH DUST COVERS.

Write, wire, phone (813) 722-1843, Bill Slep, W4FHY, if you have any of the above and we will trade even!

SLEP ELECTRONICS CO.
2412 NORTH HIGHWAY 301 N. ELLENTON, FLORIDA 33532
PHONE (813) 722-1843

WE PAY **HIGHEST**
PRICES FOR ELECTRON TUBES AND SEMICONDUCTORS

H & L ASSOCIATES
ELIZABETHPORT INDUSTRIAL PARK
ELIZABETH, NEW JERSEY 07206
(201) 351-4200

R13B: Command rcvr 108-132 mc AM, 9 tube, 2 uv sens. No dial, we give knob, tuning graph, tech data. Needs pwr sply & controls as other Commands. **NEW!** 27.50
R22: Command rcvr 540 to 1600 kc, with knob & tuning graph & tech data, grtd OK 17.95
R23/ARC-5: Command rcvr (Q 5'er) 190-550 kc has dial, w/knob & tech data, OK'd 14.95
R-392: Compact version R-390. Digit tune by kc & mc, 0.5 to 32 mc. Select pass 2, 4 or 8 kc. Ready to use w/pwr sply & book. 525.00
R-390A: In cream puff condition! With serialized nameplate and book 750.00
AN/ALR-5: *Tunes 38-1000 mc with ONE tuning unit CV-253 included, brand new,* w/rcvr late type converted to 60 cy (R-444) also new or like brand new w/book. 275.00
Sil. Rectif. 8000 PIV, 400 ma, brand new contract termination Pair Ppd. 5.30
LM-14 freq. meter .125-20 mc, .01%, w/ser. matched calib & tech data, 100% OK 57.50
TS-323 freq. meter 20-480 mc w/chart to approach .001%, tech data, 100%, OK 169.50
TS-175, Gertsch FM-3, 3AM, 6, 9 freq. meters, also Deviation Meter. Ask for List #11b.

WANTED: GOOD LAB TEST EQUIPT & MIL COMMUNIC.

WE PROBABLY HAVE THE BEST INVENTORY OF GOOD LAB TEST EQUIPMENT IN THE COUNTRY. BUT PLEASE DO NOT ASK FOR CATALOG! ASK FOR SPECIFIC ITEMS OR KINDS OF ITEMS YOU NEED! WE ALSO BUY! WHAT DO YOU HAVE?

R. E. GOODHEART CO. INC.
Box 1220-HR, Beverly Hills, Calif. 90213

JOHN MESHNA JR.

19 ALLERTON ST., LYNN, MASS. 01904

COMPUTER GRADE CAPS

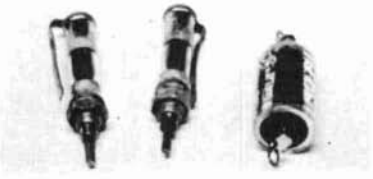
4,000 mfd at 50 volt ... **$1.00 ea., 12 for $10.00**
6,500 mfd at 18 volt ... **$1.00 ea., 12 for $10.00**

60 WATT TRANSISTORS 80 VOLTS

From computer assemblies, board with 4 each power transistors 2N1137B, 60 watt, 80 volt PNP power ..... **$1.25 per board**

SUPER VALUE $2.50

Computer boards with 8 each 2N1137B power transistors and mounting hardware, also include on the board, 4 each 10 volt zeners, 4 silicon diodes 1 amp 800 volt PIV, computer grade cap 2000 mfd 65 volt Bourns trimpots, precision resistors, etc. Complete assembly like new ..... Ship wgt. 3 lb. **$2.50**



RF FILTER

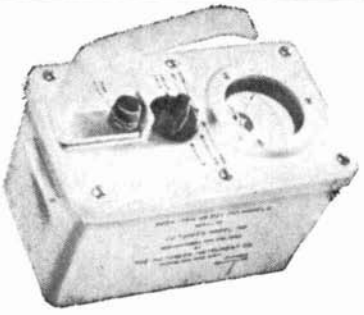
From HAWK MISSILE termination contract. Good for 5 amps, 600 volt, 10 cycles to 500 mc, insertion loss 60 DB-plus, low pass pi-network type, excellent as feed-thru filter in converters, transmitters. Hermetically sealed inside are 2 toroidal chokes and 4 low induct. caps. #41102 ..... **$1.00 each, 6 for $5.00**

PISTON CAPS

Corning glass, direct traverse type, min. Q at max. C—500 at 50MC. 500 volt breakdown. Capacitance range 1-8 uufd. Brand new military surplus ..... **3 for $1.00 or $3.00 per doz.**

GRAB BAG IC's

Mixture untested IC's, flat pack, dual inline, TO-5. Most factory marked. Package of 12 units W/10 pages RTL and DTL specs. **$2.00**



GEIGER COUNTER, MLTRY SURPLUS

like new with book, untested
SURPLUS SPECIAL **$10.00**

FACTORY NEW INTEGRATED CIRCUITS

Manufacturer's name withheld, but you will find it marked on every unit. Manufactured to Fairchild 900 RTL Series. All first grade, spec sheets included. A really amazing buy. Never previously offered by anyone at these ridiculous prices.

1.00 each or $10.00 dozen

Buffer	900
Dual Input Gate	2-903
JK Flip Flop	923
Dual JK Flip Flop	2-923
Dual 2-Input Gate, Dual Expander	1-914, 1-925
Dual 2-Input Gate Expander	925

VARACTOR SIMILAR TO MA4060A

Good for 40 watts at 432 MC, ea. tested in circuit, w/diagram for 432 MC tripler. **$5.00 ea.**

IBM WIRED MEMORY FRAMES.

Removed from high priced computors. Exlnt condition.

4,000 Wired Core Plane	$ 9.00
4,096 Wired Core Plane	$12.50
8,000 Wired Core Plane	$13.50
8,192 Wired Core Plane	$15.00
16,384 Wired Core Plane	$19.00

$10 TRANSISTOR IGNITION $10

Complete electronic 2 transistor dual ignition system for cars, boats, trucks. Fully wired harness, dual primary coil, instant changeover from transistor to conventional or back. Neg. ground, 6 or 12 volt system. Complete with instructions, ready to install. Original price $35, now only $10.00 postpaid.

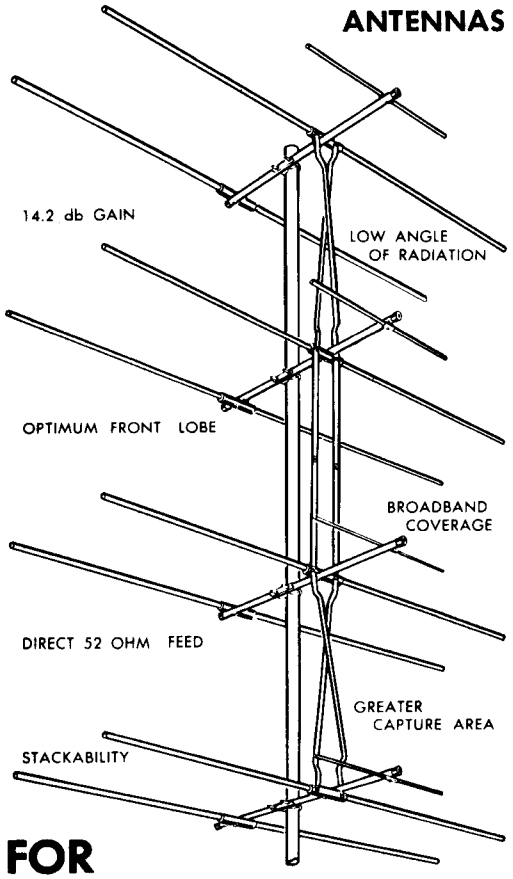
INTEGRATED CIRCUITS

711 Dual Comp. Amp.	$2.00
910 Low Power Dual Gate	$1.50
926 High Speed 923 (20 MHz)	$1.50

All above items plus postage except postpaid items.

DX-ARRAY

NEW 20 ELEMENT ANTENNAS



FOR

144 mhz 220 mhz 432 mhz

A breakthrough in VHF/UHF Amateur antennas! The new Cush Craft DX-Arrays combine the best yagi and colinear features into the World's most advanced amateur communication antennas.

Realizing that the antenna is the most important part of your station, Cush Craft engineers have devoted two years of intensive development and testing to perfect DX-Array. DX-Arrays have already established new records in Dx-ing and moon-bounce programs.

Whatever your interest may be, ragchewing, contests, DX, or moonbounce, get in on the excitement of VHF hamming today with DX-Array.

DX-120 — 144 mhz	**$29.50**
DX-220 — 220 mhz	**22.50**
DX-420 — 432 mhz	**17.50**

See your local distributor or write for complete specifications on these exciting new antennas from the world's leading manufacturer of UHF/VHF Communication Antennas.

Cush Craft

621 HAYWARD STREET
MANCHESTER N H 03103

Advertisers Index

A-5 Magazine 86
Aerotron, Inc. ..... Cover IV
Amateur-Wholesale Electronics 95
Antenna Mart 86

B & F Enterprises 92
BC Electronics 90
Barry Electronics 91
Bob's Amateur Electronics 78

Ceco 86
Collins Radio Co. ..... Cover II
Columbia Electronics 90
Comdel, Inc. 46
Comtec, Book Division 75
Convention '69 89
Cushcraft 94

Dames Co., Theodore E. 82
DXer's Magazine 89

Essco 45
Electric Specialty Manufacturing Co. 91
Electronic Applications Co. 78
Evans Radio 86
Evansville Amateur Radio Supply 79

Gauthier Industries 87
Goodheart Co., Inc., R.E. 92
Gordon Co., Herbert W. ..... Cover III

H & L Associates 92
Hafstrom Technical Products 88
Ham Radio Magazine 76
Hammarlund Manufacturing Co., Inc. 2
Harrison Radio 96
Heath Co. 27
Henry Radio Stores 5

International Communications & Electronics, Inc. 77
International Electronics Systems, Inc. 95

James Research 87, 91
Jan Crystals 90
Joga, Productos 74

L. A. Amateur Radio Supply 79
Lewispaul Electronics, Inc. 89
Liberty Electronics 91

Meshna, John, Jr. 93
Military Electronics Corp. 91
Moory Electronics, Inc. 80
Mosley Electronics, Inc. 1

National Radio Co., Inc. 6, 7

Omega-T Systems, Inc. 82

Palomar Engineers 82

Quement Electronics 83

Radio Amateur Callbook, Inc. 86, 88
Raytrack Co. 73, 81
RCA Institutes, Inc. 59
Rousseau & Sons, Hugo H. 84

Shortwave Guide 91
Signal/One 65
Slep Electronics Co. 92
Spectronics 33
Stinnette 82
Swan Electronics 70, 71

Tallen Co., Inc. 91
Tekrad 87
Telrex Communication Engineering Laboratories 89
Tristao 89

Unadilla Radiation Products 78

VHF Communication 90
Vanguard Engineering 87
Vanguard Labs 82, 88

W3KT QSL Service 88
Weinschenker, M. 90
Westcom Engineering Co. 51

HOLIDAY PACKAGE SALE!

SR-400 Cyclone Transceiver

HA-20 VFO

hallicrafters

SR 400 $799.95

PS 500 AC $119.95

$919.90

Write for SPECIAL PRICE!

hallicrafters

DISCOUNT PRICES. **NO ONE ANYWHERE** will beat our price! We will **TOP** any advertised or written price from any other dealer. We trade on both new and used equipment and we service what we sell. Instant credit on both new and used equipment. American Express and General Electric revolving charge.

AMATEUR-WHOLESALE ELECTRONICS

A DIVISION OF

International Electronic Systems, Inc.

280 ARAGON AVENUE, CORAL GABLES, FLORIDA 33134

Cable: "INTEL" 305-444-6207 Export orders our specialty

WANT *MORE* FOR YOUR MONEY?

Then latch on to one of these FB Hallicrafters HT-46 transmitters before they're all sold!

At our special price slash you're getting top performance and unbeatable value — a bargain you can't afford to pass up. Rush your order in, now.

73 *Bil Harrison* W2AVA

SAVE $145.

ON BRAND NEW *hallicrafters*

famous HT-46
5 band transmitters

•

Plenty sold at $395.00 Amateur Net

SPECIAL!

While our supply lasts

ONLY $250.

Complete, with full factory warranty

- 180 Watts PEP SSB
- 140 Watts CW
- Selectable Sideband
- Internal AC Supply
- Plug-in VOX ($44.95 extra)
- "Transceive" input

Harrison

HEADQUARTERS
for all
hallicrafters
FINE EQUIPMENT

Here you can save with safety, because we'll top **any** "deal"! Shop around first, then see us last.

PROMPT ORDER DEPT.

We carefully pack and ship ham gear, accessories and parts to most any part of the world.

Address your orders to:

22 SMITH STREET
Farmingdale, N.Y. 11735

Please include ample postage (plus $1 handling cost with orders under $10.)

OR, PHONE YOUR ORDERS TO (212) BA 7-7922 OR (516) 293-7990

PREFER A TRANSCEIVER?

THE NEW
hallicrafters
SR400 CYCLONE
is the biggest bargain around!

WITH THESE PLUS FEATURES:

• Receiver incremental tuning • Noise blanker • Built-in notch filter • 400 watt SSB • 360 watt CW • 200 cycle CW filter • 1 kHz readout • .3 microvolt sensitivity • 60 db carrier suppression.

ENJOY YOURS NOW FROM

"DUAL RECEIVE" VFO
Plug in the HA-20, and split transmit/receive frequencies. A "must" for DX and X Band operation!

Harrison

"HAM HEADQUARTERS, USA"®

NEW YORK CITY
8 Barclay St.
(212) BArclay 7-7922

JAMAICA, L. I.
139-20 Hillside Ave.
REpublic 9-4101

FARMINGDALE, L. I.
Route 110 at Smith St.
(516) 293-7995

Seasonal Ham Goodies

O.M. This is the time to give the XYL a hint on what to get you for Xmas. Look at the outstanding list of station accessories we have for you. All are designed to make your operation more convenient and enjoyable.

1. **Brown Straight Key** — Model ST
   ¼" silver contacts, chrome plated arms and screws, black wrinkle finish. (The ultimate in a straight key.) . . **$8.95**
2. **Comdel Directional Wattmeter** — Model DW1550
   Frequency range 1.5 to 60 MHz, power accuracy ± 1 DB, direct reading .2 to 1500 watts and 1.0 to 4.0 VSWR **$95.00**
3. **Comdel Speech Processor** — Model CSP11
   Talk power gain 10 db, negligible distortion (like switching in a linear **$120.00**
4. **Dow-Key Coaxial Relay** — Model DK6C-G2C
   Part No. 60-262842
   SPDT with auxiliary contacts, 115 vac coil 1 KW rated (switch antenna from RCVR to XMTR) **$18.00**
5. **Dow-Key Coaxial Relay** — Model DK2-60-2C
   DPDT, 115 vac coil, 1 KW rated (switch your linear in and out) **$26.40**
6. **Numechron Tymeter 24 Hour Clocks**
   Plastic Case **$15.00**
   Stainless steel and walnut case **$25.00**
7. **Numechron Tymeter 24 Hour Clock**
   with Ident. 10 minute timer in Plastic Case **$22.00**
8. **Numechron Tymeter 12 Hour Clock** — Model 765
   Plastic case, with built-in TV Lamp **$14.95**
9. **PIC Polyswitch Coaxial Antenna Switch** — Model PS-750, single pole five position 1 KW rated, rear-mounted SO239 connectors . . . **$10.75**
10. **Shure Dynamic Microphone** — Model 444T
    Built-in transistor amplifier, PTT Stand **$29.70**
11. **Superex Deluxe Amateur Earphones** — Model AP-S
    4, 6, 600 ohm impedance (the best) **$24.95**
12. **Superex Excellent Hi-Fi Earphones** — Model SX300
    4, 8, 16 ohm impedance (very good for amateur use) **$14.95**
13. **Superex Earphones** — Model Deluxe S2000
    2000 ohm impedance (very comfortable) **$2.70**

We can ship any of the above items to you prepaid to your door in the United States and Canada, immediately upon receipt of your remittance.

"SPECIAL BARGAINS"

5-6 Foot lengths RG8/U with PL259's on each end (Great for equipment interconnection) 1.5 lbs. shipping weight . . . . . **each $1.00**

Kilowatt loading capacitors, 1200 MMF (Building a linear — this is the capacitor for you) 2 lbs. shipping weight . . . . . **each $3.00**

Muffin Fans — 115 VAC or 230 VAC, state your choice 230 volts . . . **$6.50**
2 lbs. shipping weight 115 volts . . . **$7.50**

RCA 6 volts DC to 12 volts DC converters — 75 watts, 9 lbs. shipping weight . **$12.95**

HERBERT W. GORDON COMPANY

Harvard, Massachusetts 01451 • Telephone 617 — 456 — 3548

"Helping Hams to Help Themselves"

PRESENTING THE ALL NEW

AMECO PT

ALL BAND TRANSCEIVER PREAMPLIFIER

■ 6 THRU 160 METERS ■ FEEDS 2nd RECEIVER

Model PT, with built-in power supply, transfer relay, connecting cables, wired and tested. Amateur Net **$49.95**

- A frame grid pentode provides low noise figure with ability to handle strong signals, greatly improving the sensitivity of the receiver section of a transceiver.
- A unique built-in transfer circuit enables the PT to by-pass itself while the transceiver is transmitting. The PT also feeds the antenna input of a 2nd receiver as well as muting it.

AMECO

DIVISION OF AEROTRON, INC. ■ P. O. BOX 6527 ■ RALEIGH, N. C. 27608

GONSET

GSB 201 MK III

10-80 METER LINEAR AMPLIFIER

...THE WORK HORSE

Exceptionally compact—only 8½" high, 12⅝" wide and 17" deep—the GSB 201 lends itself readily to table top mounting.

- Four (not two) type 572B tubes for a full 2000 watt P.E.P. SSB input.
- Full wave solid state power supply.
- Universal rear of cabinet circuitry may be connected for transceiver or receiver-transmitter use without internal modification.
- Plus many, many more features.

AMATEUR NET $375.00

Also available: GSB 201 MK II — employs four type 811A economical triodes for 1500 watt P.E.P. input.

AMATEUR NET $325.00

See your favorite distributor — Write for brochure

GONSET® ANOTHER DIVISION OF AEROTRON, INCORPORATED

P. O. Box 6527 / Raleigh, North Carolina 27608