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#129 June 1971

FEATURES

STAFF

Contents

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Cover: W2NSD/1 antenna. Three elements on 20 meters.

Amateur Radio News Page

NEW PROCESS FOR SEMICONDUCTOR MANUFACTURE

A relatively simple, inexpensive new process for making high-performance electronic semiconductors, the result of three years of research, was described by the scientists and engineers who invented and developed the technique at Signetics Corporation, a subsidiary of Corning Glass Works. The company calls the process "D-MOST," for Double-diffused Metal-Oxide Semiconductor Technology.

Devices made with the new process perform better than semiconductors made by all other techniques currently used for manufacturing MOS (metal-oxide semiconductor) devices, according to Dr. David Kleitman, Vice President for Research and Development. The process is practical for manufacturing complex integrated circuits and represents an inexpensive method of making individual semiconductors which are now very expensive. Dr. Kleitman predicted that the new process will be useful for manufacturing new kinds of linear and high-power discrete devices in addition to digital integrated circuits and discrete, small-signal microwave transistors.

Dr. Kleitman pointed out that Signetics has recently introduced to the marketplace a broad product line of digital integrated circuits made with a P-channel silicon gate MOS process. He anticipates a time lag of one year before the D-MOST process is put into full production.

The new Signetics D-MOST process

the maximum gain available at that frequency is 10–15 dB. Gain at 2 GHz is approximately 7 dB. The D-MOST transistors outperform JFETs because the D-MOST devices operate with very low feedback capacitance, lower distortion, less cross modulation, lower parasitics, and with greater linearity.

An inexpensive, advanced new process for making many different kinds of electronic semiconductor devices was invented by scientists and engineers in the Research & Development Department of Signetics Corporation. Principal inventors of the process, known as "D-MOST" for double-diffused metal-oxide semiconductor technology, include (left to right) Thomas P. Cauge, Dr. Joseph Kocsis, Dr. Hans J. Sigg, and George D. Vendelin.

Speed of digital circuits is determined by the length of the "channel," which is the area located beneath the gate and situated between the source and the drain. Speed is increased – that is, transfer time is shortened – as

Volunteer Examiners

NOW HAVE 30 DAYS TO RETURN AMATEUR EXAMINATIONS TO THE COMMISSION.

Time in which volunteer examiners must return Amateur Radio Service examinations has been increased to 30 days by the Commission. The action amends Section 97.29(b)(3) of the rules. Examinations were previously required to be back to the Commission in 20 days. The Commission said the time information appearing on the examination envelope furnished volunteer examiners does not conform with the rules. It said that Section 97.29(b)(3) will now specify that the examination papers, either completed or unopened in the event the examination is not taken, shall be returned by the volunteer examiner to the Commission's Gettysburg, Pennsylvania, office no later than 30 days after the date the papers are mailed by the Commission. The date of mailing is normally stamped by the Commission on the outside of the envelope, the Commission added. (Action by the Commission April 8, 1971, by Order. Commissioners Bartley (Acting Chairman), Robert E. Lee, Johnson, H. Rex Lee, Wells and Houser.)

INQUIRY INTO CARRIER-CURRENT RADIO STATIONS

AND OTHER LOW POWER COMMUNICATIONS SERVICES INITIATED BY FCC; COMMENTS ASKED ON OPERATIONAL REQUIREMENTS FOR INTERCONNECTION WITH OTHER SYSTEMS.

An inquiry to obtain further information on the operation of carrier-current radio stations and other low power communications devices (such as miniature transmitters) has been initiated by the FCC. Comments were also invited on proposed rules for those carrier-current systems using interconnection of two or more systems or interconnection of a system with other electronic media such as broadcast stations or CATV. The systems operate under Part 15, of the Rules.

In connection with the inquiry, the Commission adopted a questionnaire to be sent to all carrier-current stations operating under Section 15.7 of the Rules.

The questions generally relate to technical and programming matters, and to the commercial activities of the systems. The Commission stressed that the responses will be used solely for analytical and related purposes, and that the financial data would not be available for public inspection under Section 1.457(d) of the Rules. Comments and information were invited on both the carrier-current systems was required, a new proceeding would be initiated.

In 1969, carrier-current radio stations of Juniata College (WJC), Huntington, West Virginia, and The University of Cincinnati (WFIB), Cincinnati, Ohio, were authorized to expand their activities beyond the campus area. The requests were granted and WJC was permitted to feed its signal to a local CATV service and WFIB was granted authority to engage in networking with other college stations. Since the WJC and WFIB authorizations were granted, the Commission said it has received a substantial number of inquiries and requests similar to those of Juniata College. It noted that the results of a 1969 Ford Foundation study conducted by the Corporation for Public Broadcasting indicate that there has been an overall increase in carrier-current stations, as well as a growing interest in the stations as a communications medium. In view of these requests and the data submitted, the Commission said it believed additional information about the "contemporary carrier-current systems in necessary."

will enable the manufacturer to build integrated circuits which are more compact, less expensive, and better performing than circuits made today, a Signetic spokesman said. UHF and microwave devices now selling for about $50 (junction field-effect transistors, for example) could be manufactured with D-MOST and sold for one-tenth the price, he added.

Popular Techniques of Making Semiconductors

There are two popular techniques of producing semiconductor integrated circuits – the bipolar method and the MOS method. Bipolar circuits are known for their high speed, but MOS circuits are more compact and consume less power; MOS devices traditionally have been slower than bipolar devices.

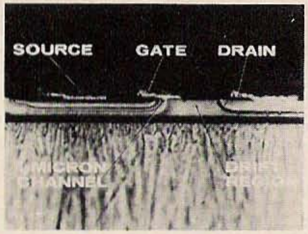
Within MOS technology, there are several processes which are being used today, primarily for making devices used in computer memories. These are known as N-channel, P-channel, ion implantation, nitride, complementary, 1-1-1, 1-0-0, and silicon gate. The new Signetics development currently uses N-channel MOS techniques, but others may be used in the future.

The Signetics "D-MOST" Process and Devices

Termed "D-MOST" devices made in the Signetics laboratoies have exhibited speeds five times faster than ordinary N-channel MOS versions and at least ten times faster than devices made by the P-channel MOS process. The D-MOS devices are comparable in speed to fast bipolar transistors, yet they retain the advantages of high density, low power consumption, and low cost.

In general, either "depletion" or "enhancement" type D-MOS devices can be made. High-frequency microwave devices can be produced as well as logic circuits and memory elements which could be used in computers.

Several D-MOS microwave transistors have been built at Signetics. The transistors operate at frequencies up to a maximum of 10 GHz. The typical noise figure at 1.0 GHz is 4.5 dB, and



A typical Signetics D-MOS transistor was cut apart vertically, and this photomicrograph was made to reveal the cross section of the device. By diffusing opposite dopant impuries under a single mask edge, the need for costly micron-dimensioned masks is eliminated and 1-micron channel lenghs for microwave performance are produced. The process is simple and inexpensive.

channel length is shortened, but with standard MOS process techniques, this has the undesirable effect of lowering the breakdown voltage, a problem which is eliminated with the D-MOST process. Sample D-MOST digital devices exhibit a typical rise time of 210 picoseconds.

W6LS DRIVE AIDS KIDNEY-TRANSPLANT FUND

The Lockheed Amateur Radio Club (W6LS) recently conducted a drive to raise money to help pay for a kidney transplant operation required to keep a 10 year old girl alive. The little girl is Anne-Marie Haddad of Beautiful Downtown Burbank. The club raised more than $250 with donations continuing to arrive. The operation was successful and Anne-Marie is well started on the road to full recovery. Mrs. Marie Welsh (W6JEP) ran this club drive; as the mother of 7 children, she knows that kids need every chance they can get to survive and succeed.

Donations were accompanied by personal notes on QSL cards and Anne-Marie has a fine selection of cards to look at while she recuperates. Donations and cards have been received from 13 states and 5 countries. Henry Radio of Los Angeles, 73 Magazine, and an SWL in El Zagazig, Egypt provided contributions which were entirely unexpected.

tems and low power communications devices from all interested persons including non-commercial and commercial broadcasters, advertisers and educational institutions. These comments should be submitted by June 4, 1971.

A carrier-current station operates on a low power radiation device, and the station signal, a modulated radio frequency signal, is conducted along distribution wires to buildings on a campus. Stations using this technique are required under the rules to use minimum power. The stations were originally permitted to operate under the Commission's 1938 Low Power rules – a forerunner of Part 15 – and were intended to be used as training laboratories for students interested in communications arts, with signal reception limited to the campus.

In 1949, a Notice of Proposed Rule Making was issued proposing a licensing of the stations under rules for broadcast stations. The proceeding was terminated in 1964 when it was found that regulation under Section 15.7 appeared satisfactory. It was noted, however, that if further study

73 REPEATER ON THE AIR

WA1KGO, the 73 repeater on top of Pack Monadnock mountain in Peterborough, New Hampshire, was placed into temporary operation in late April, within minutes after the snow melted enough to permit vehicle travel to the summit of the 2500 foot peak.

The repeater, set up with approximately one half mile separation between the receiver and the transmitter, was running about 30 watts into a new Gam antenna and, according to preliminary reports was furnishing excellent coverage for well over 100 miles in all directions, permitting mobiles in Maine to contact mobiles down in Connecticut.

Tests are being made with a 250 watt amplifier to check the coverage possible with a high power repeater. A Vanguard preamplifier is being installed at the receiving antenna to help equalize the performance of the receiver to the transmitter. If the coverage of the repeater can be extended to 150 miles this would enable it to cover virtually all of New England and Western New York, providing a very useful service.

RADIO CALL BOXES IN 450 MHz BAND FOR HIGHWAY SAFETY APPROVED BY COMMISSION

Rules reserving four pairs of 450 MHz frequencies for the operation of highway radio call boxes in an emergency communications system have been adopted by the Commission (Docket 19001). The action amends Part 89 of the rules and originated in an FCC rule making notice released September 11, 1970. The rule becomes effective May 21, 1971.

Previous Commission policy had generally excluded fixed operations such as call box systems from the 450–470 MHz band. The 450 MHz frequencies allocated for highway call box operation were formerly reserved for base-mobile and mobile-only communications.

The FCC rule changes will allow installation of call boxes along limited-access highways and major highways. Motorists needing assistance will be able to use the call boxes to communicate by voice and tone with control stations. Information about weather and road conditions can also be transmitted by tone from roadside sensor devices to control stations, and this information can then be used to activate highway alerting signs for motorists.

The Commission said that while it was authorizing limited use of 450 MHz frequencies to meet certain immediate highway safety and emergency needs, it had not determined that this kind of system is the most desirable approach to highway safety communications. The Commission explained that it wished to encourage development of a wide choice of possibilities for future communication systems, and that the rules it had adopted allow for the future development of a system of direct communication with motorists in their vehicles.

The Commission made minor modifications in the technical standards it will require for the operation of radio call boxes in the 450 MHz band, and expanded its original proposal, which provided for operation of call boxes only on the National System of Defense and Interstate Highways, to allow licensing of call box systems on any limited-access highway.

Action by the Commission April 8, 1971, by Report and Order. Commissioners Bartley (Acting Chairman), Robert E. Lee, Johnson, H. Rex Lee, Wells and Houser.

NORWAY CONSIDERING REPEATER REQUEST

Per Marienborg, LA8PM, reports that Norwegian authorities are considering a formal request by local amateurs to install a 2m repeater in the vicinity of Bergen. Amateurs in the area are reportedly optimistic about the decision, which is yet to come. If it goes through, Marienborg says, several other groups will make similar applications. And Norway, like the U.S., Germany, and Canada, will have entered the age of repeaters.

BLIND MAY GET CRACK AT THIRD-CLASS PHONE

An inquiry to consider rule changes to provide for issuance of all classes of radiotelephone licenses to blind persons has been adopted by the FCC. At present they can only hold Radiotelephone Third Class Operator Permits.

The Commission said the action was prompted by over-all concern to extend employment opportunities to handicapped persons. It cited in support of its proposal, advancements in technology in the radio electronics field, and experience gained through actual employment of blind operators.

The action, a Notice of Inquiry and Notice of Proposed Rule Making, would amend Part 13 of the rules.

The Commission pointed out that by its order (FCC 67-749) released June 23, 1967, it had amended Section 13.5 to permit blind applicants to be issued Radiotelephone Third Class Permits on the basis of oral examinations. Because of differences in privileges and responsibilities under the first or second class licenses – and because of hazards involved in higher class operator permits – the Commission said at that time that it was not practicable for sightless persons to hold first or second class licenses.

At the present time there are usually two types of operators at a radio station. The "maintenance" operator, who is required to hold a first class license and who is the more technically oriented, makes the internal transmitter adjustments and repairs. Eyesight in this instance is considered mandatory since some of the adjustments must be made while the transmitter is open and there is exposure to high voltage circuits. The "duty" operator's responsibility involves the more routine operation of the transmitter, with adjustments made only to the external panel controls. Eyesight is not mandatory in this instance if the special available equipment is installed by the station licensee to permit the blind operator to accurately less persons as operators and maintainers of transmitters will vary. Apart from the examining function, the Commission stated that it lacks both competence and staff to make selective determination concerning the radio operating or radio technician capabilities of sightless persons.

Written comments are invited to be filed on or before May 24, 1971, and reply comments will be due on or before June 8, 1971.

Because of the general nature of the inquiry, the Commission said no specific rule changes have been proposed. It added that if comments warrant, the rules will be amended or modified as appropriate, without issuance of a further notice, although, if the changes are not considered reasonably simple, there may be further proceedings.

Action by the Commission March 24, 1971, by Notice of Inquiry and Commissioners Burch (Chairman), Johnson, H. Rex Lee and Houser, with Commissioners Bartley and Wells dissenting.

1971 County Hunters CW Contest July 24-25

The CW County Hunters Net invites all amateurs to participate in the 1971 County Hunters CW contest. Portable and mobile operation in less active counties is welcomed and encouraged. Rules:

1) Contest period: 0000 GMT July 24 to 2400 GMT July 25, 1971.

2) General call: CQ–CH; Exchange – QSO number, category (portable or mobile), RST, state (province or country), and county (U.S. stations). Stations may be worked once on each band and again if the station has changed counties. Portable or mobile stations changing counties during the

HAMFESTS & SPECIAL EVENTS

MUSIC CITY – C & LC

The second annual Music City Hamfest will be held in Nashville, Tenn. on Sunday, June 20, at Edwin Warner Park: Picnic Area 3. Ample parking, shelters and playground. Bring picnic lunch; or food and soft drinks, ice cream, etc. will be available at the site.

Three main prizes: H W 101 with power supply, H A 460 6m transceiver, and a portable TV set. Numerous other prizes, plus a special ladies' drawing and favors for the children. Main drawing will be at 3:30 p.m.

ONTARIO QSO PARTY JULY 17-18, 1971

All single operator stations are invited to participate in the Ontario QSO Party, sponsored by the Radio Society of Ontario, Inc.

Rules: 1) The time period is from 1700 GMT July 17 to 2400 GMT July 18. 2) There are no power restrictions and all bands can be used. Points will be given for contact with the same station on different bands and/or modes. 3) Ontario stations score 1 point per contact and multiply by the number of ARRL sections and foreign countries worked. Outside stations score 3 points per Ontario station and multiply by the number of Ontario counties worked on each band. 4) Certificates will be awarded to the highest scoring station in each ARRL section. Certificates will be awarded to the highest scoring station in each Ontario county provided a minimum of 25 contacts had been made. A trophy will be awarded to the highest scoring Ontario station. 5) Suggested frequencies: 3560, 3685, 3855, 3909, 7030, 7240, 7290, 14,040, 14,140, 14,225, 14,290, 21,050, 21,300, 28,100, 28,600, 50,250, 50,360, 144,000–144,500 and 145,800 kHz. 6) Ontario stations send QSO number, report and county. Other stations send QSO number, report and section

NEW MEXICO

The Amateur Radio Clubs of New Mexico will sponsor The New Mexico Hamvention 1971 on September 17, 18, and 19, 1971. Convention headquarters will be the Sheraton Western Skies motor hotel on East Highway 66, Albuquerque, New Mexico.

The program will feature technical sessions on antenna theory, SSB, VHF/FM, traffic, MARS, QCWA, DX, solid-state electronics, and many others. There will be exhibits from major manufacturers and representatives will be available.

The ladies program will feature a fashion show by Rhodes Fashions and the theme will be "radio around the world."

There will be many major prizes and loads of smaller prizes. The ladies will have the opportunity at several prizes especially chosen for their program.

In addition to the regular program, there will be tours of the Albuquerque area available to those who wish to participate. We have reserved 120 rooms at the Sheraton for radio amateur guests. Contact Ray Hill, Box 14381, Albuquerque NM 87111.

PENN-CENTRAL HAMFEST

The eighth annual Penn-Central Hamfest will be held by the Williamsport and Milton clubs on Sunday June 13th, starting at 12 noon, at the Union Township Volunteer Fire Grounds on Route 15, Winfield, Pa. Informal atmosphere, bring your own lunch picnic style or use the snack bar. Both indoor and outdoor facilities provided. Auctions, contests, prizes, and swapping. Gate registration fee, $2.50, XYL and children free, free parking. Talk-in 3940 kHz, 50.4 MHz, and 146.940 MHz FM. For information contact: Al Owen, 2901 Highland Ave., Montoursville RD 3, Pa. 17754.

modes and discussions and reports on different aspects of FM techniques, state-of-the-art front-end stages of VHF receivers, digital frequency indicating modules for amateur use, etc.

For contest rules apply to DJ4JI, for general information and suggestions contact DJ1WM. The area is well covered by the local FM repeater "Steinberg-Relais-DJ4JIA" which receives/transmits on 144.15/145.85 MHz. An automatic tape recorder gives general information for mobile stations every time when signing off.

MICHIGAN

The Delta County Amateur Radio Society has just announced that the annual U.P. Hamfest will be held in Escanaba, Michigan on the weekend of July 31–August 1, 1971.

This gala two-day affair will include a banquet, displays, movies, contests of every nature; all hams are invited to display or sell any items they wish. The U.P. fairgrounds will house the Hamfest. Plenty of parking, and entertainment for the kids and XYLs.

Write B. P. Treml, W8KBZ, Route 1, Gladstone MI 49837.

COLORADO

The Rocky Mountain ARRL convention is to be held in the new and beautiful Antlers Plaza hotel in Colorado Springs on June 19th and 20th. Many prizes will be given away. The first prize will be a popular transceiver. There will be many contests for the amateurs as well as games for all. The ladies will also have many activities including a luncheon on Saturday. Further information may be obtained from Bill King WAØLKD, 2916 N. Institute, Colorado Springs, Colo. 80907.

NEW HAMPSHIRE

The Bow Radio Association and the Contoocook Valley Radio Club, Inc. are co-sponsoring an AUCTION read the meters and make the necessary adjustments. Only a third class license is required of the "duty" operator, and he may be employed on a full-time or part-time basis at 81% of the AM and 99% of the FM broadcast stations.

The Commission said the purpose of its present rulemaking proceeding is to inquire into ability of sightless persons to maintain as well as operate the radio station as required of a higher class operator, and to examine available technologies which would permit best use of the sightless person's ability. It said comments should be addressed to such matters as responsibility for personal safety from shock hazards; availability of safety devices for transmitter maintenance by sightless operators; restrictions for first or second class licenses for issuance to blind persons; should the maintenance function included as part of the higher classification be deleted from any blind operator classification; and what factors, other than operating or maintaining radio transmitters, would render the first or second class license desirable or advantageous, such as the fact that certain electronic equipment manufacturers or users require the employee to hold a particular operators license either for hiring or promotion; and should the blind operator be classified in an "ungraded" type of classification identified only by the highest number element examination passed, and be permitted opportunity to seek employment in the broadcast field commensurate with his own physical and mental abilities.

The Commission said it must be recognized that effectiveness of sight-

contest may repeat contacts for QSO points. Stations on county lines give and receive only one number per QSO, but each county is valid for multiplier.

3) Scoring: QSOs with fixed stations are 1 point, QSOs with portable or mobiles (categories P or M) are 3 points. Multiply the number of QSO points times the number of U.S. counties worked. Portables and mobiles calculate their score on the basis of total contacts within a state.

4) Suggested frequencies: 3575, 7055, 14070, 21070, and 28070 kHz.

5) Certificates will be awarded in three separate categories:

F) Highest fixed or fixed-portable station in each state, province, or country with 300 or more points.

P) Highest station in each state operating portable from a county which is not his normal point of operation with 300 or more points.

M) Highest mobile in each state operating from 3 or more counties with a minimum of 15 QSOs per county.

6) Logs must be complete showing category, date/time in GMT, stations worked, exchanges, band QSO points, location and claimed score. All entries with 100 or more QSOs must include a check sheet of counties worked. Enclose SASE if results are desired. Logs must be postmarked by September 1, 1971 and sent to CW County Hunters Net, Jeffrey P. Bechner, KØWNV, 42 East Signal Drive, Rapid City, South Dakota 57701.

or country. 7) The general call to be used is "CQ ONT" on CW, and "CALLING ANY ONTARIO STATION" on phone. 8) Logs should be postmarked no later than Aug. 31, 1971, and sent to "Contest Chairman, Radio Society of Ontario, Inc., P.O. Box 334, Toronto 18, Ontario." Stations sending an SASE will receive a copy of the results.

KANSAS CITY

KCØKC has been assigned by the FCC to be used July 1 through July 5, 1971 by the Independent County Hunters at their big convention at Kansas City, Mo. 14336 kHz and other frequencies will be used. QSL via WAØWOB.

INDIANA

FM HAMFEST Sunday August 1, near Angola, Indiana. Big prizes, free flea market, entertainment for the ladies and kids. Picnic grounds, campsites, boating, food, soft drinks available, rain or shine. Call-in freqs: 146.34/146.76, 146.94, 52.525. For information contact Fort Wayne Repeater Assn., Box 6022, Fort Wayne IN 46806.

MISSISSIPPI

The Jackson Co. hamfest will begin 9 a.m. CDST on July 24 at the Mississippi fairgrounds. A full schedule of events is planned and a Swan 270B will be given away as the main prize. The supper on the evening of July 24 will be highlighted by the film "Hams World Wide" and a talk by ARRL Delta Division Director, Mr. Max Arnold W4WHN.

For more information, tickets, or reservations, contact the Jackson Amateur Radio Club, Box 8371, Jackson MS 39204.

MILWAUKEE

The South Milwaukee Amateur Radio Club will hold it's second annual Southeastern Wisconsin Swapfest on July 17 at Shephard Park (VFW Post 434), 9327 South Shephard Ave., Oak Creek, Wisconsin. The activities will start at 7:00 a.m. and run until 5:00 p.m. or later. There is plenty of parking and a picnic area, as well as hold and cold sandwiches and liquid refreshments available on the grounds. Admission is $1, so bring your friends and whatever goodies you have to swap or sell. For more information, write to A.R.S. WB9EQA, 1900 West Kimberly Ave., Milwaukee WI 53221.

PENNSYLVANIA

The Two Rivers Amateur Radio Club will hold its annual hamfest July 18 at the Balcon Hotel grounds in McKeesport located 15 miles east of Pittsburgh. For information write Charles E. Thomas WA3MWM, 7022 Blackhawk, Pittsburgh PA 15218.

CALGARY STAMPEDE CONTACT

The Calgary Amateur Radio Association announces that it will operate station VE6NQ from the grounds of the Calgary Stampede from July 8–17, 1971 inclusive. The schedule calls for operation from 1900 to 0500 GMT daily. Prevailing band conditions will dictate which frequencies shall be used at any time. Operating frequencies will be near or at 3.560, 3.780, 3.825, 3.900, 3.943, 7.060, 7.190, 7.225, 7.270, 14.060, 14.150, 14.250, 14.336, 21.060, 21.240, 21.300, 28.060, 28.500, 28.600 MHz. Several transmitters will operate simultaneously. Net call-ins will be accommodated.

A special QSL card will be sent to all contacts. A QSO with VE6NQ during this period will count as two Calgary contacts for those amateurs working for their Calgary Stampede Certificate.

The theme of the Calgary Exhibition and Stampede this year is "Sports and Recreational Activities." CARA will have a prominent, "walk-through" working exhibit, displaying all modes of amateur radio communication. Special emphasis will be placed on the display of low-cost equipment within the reach of those with limited means.

Calgary Amateur Radio Association, Box 592, Calgary 2, Alberta.

NORTHERN GERMANY

On May 15th/16th, 1971, the 14th VHF Ham Convention in Northern Germany will be held in Klein Rhueden/Harz. This traditional meeting is organized by District Niedersachsen of Deutscher Amateur Radio Club (DARC) and directed by DJ1WM. Klein Rhueden is situated in the pretty landscape of the nearby Harz Mountains. It is easily within reach of the Hamburg–Frankfurt autobahn through exit "Klein Rhueden" (about 35 miles south of Hannover).

Main topics of the VHF meeting are a contest for mobile stations (145 MHz and 432 MHz) in all kinds of

and FLEA MARKET on Sunday May 23, 1971. The flea market will start at 10:00 AM (please bring tables) and the auction will start at 2:00 PM. There will be refreshments and recreation for all. The address is: Henniker N.H., Keyser Pond Cottages, off Rtes 202 & 9, near junction of Route 127 (near the Hopkinton Town Line).

BURBANK

The Lockheed Amateur Radio Club sponsors the only annual ham show in the Los Angeles area. These shows feature displays of the latest ham equipment by manufacturers and distributors plus technical presentations by the best available speakers.

These shows are open to all amateurs and prospective hams. A data sheet is available to those who request one from 2814 Empire Ave., Burbank CA 91504.

SPECIAL PREFIX OPERATION–KQØNEB

The Lincoln, Nebraska Amateur Radio Club has revealed plans to operate a special events, special prefix amateur radio station in connection with the 1971 Nebraska State Fair in Lincoln. Using the call KQØNEB, operations will commence at 2100 GMT September 1, 1971 and will be continuous 24 hours a day through 0500 GMT September 9, 1971. Transmitters will be on 10, 15, 20, 40 and 80 meters, both CW and SSB.

DX contacts will automatically be QSLed via bureaus. Stateside contacts must send cards with SASE to WØYOY, Box 5006, Lincoln, Nebraska 68505. As with past operations of the club, a special QSL card will be used.

DELAWARE

The Delaware Amateur Radio Association is planning a hamfest on June 6, 1971, at the Prairie Creek Reservoir shelter house on the northeast corner of the lake. There will be an auction, a flea market, and free coffee for everyone. Prizes given away, including a Temp I with power supply. Box 610, Muncie, Indiana.

NEVER SAY DIE

...de W2NSD/1

EDITORIAL BY WAYNE GREEN

For Sale?

The word is being whispered around that Green wants to sell 73 because business is bad. Business is undoubtedly bad for those originating the whispers, but it isn't all that bad here at 73.

What does a ham magazine earn? What are the expenses? What profits are possible? Our figures aren't complete for 1970, but we do have the 1971 first-quarter results, which are probably of more interest anyway.

The income for 73 is derived from advertising, circulation and book sales. Roughly speaking we figure about $15,000 for advertising, $15,000 for circulation and $10,000 for books per month. This rounds out to about $500,000 a year gross income.

Our expenses cover printing bills for 73, which is printed in Wisconsin, plus all of the salaries and overhead in Peterborough, payments for articles, drafting of diagrams, etc. We print most of our books here at 73 where we have an extensive printing plant with three fast offset presses, going up to 22" width, plus a complete book bindery. We also set all type here for 73 as well as our books, have our own complete art department to make up finished pages, and a darkroom for making offset negatives. This is all accomplished by a staff of fourteen very busy people.

Visitors almost always wonder why, considering the printing plant we have right here, we don't print 73. It is one thing to print 5,000 or 10,000 books and quite another to print 75,000 copies of a magazine. We can afford to take a month or two on books, but 73 must be out in just a twenty years now and I'd like to see an end ahead somewhere.

What have I to offer? Well, if someone wanted to take over the magazine as it is, it isn't a bad deal. We have the staff and the plant to provide a good income, plus a house to live in. The house is a bit crowded and the living is certainly informal, but it is one of the nicest areas in the world to live.

What is such a business worth these days? Some estimates are that it should be worth about the yearly income. Others put it at about ten times the yearly profits. In fact it is worth whatever someone is willing to pay. I'm in no rush to sell and still have to find out from a tax expert the best way to take payment so I will end up with enough to invest for retirement. Does anyone know of a good tax expert that might be able to help me with this problem?

Brou-ha-ha

The publisher of another ham magazine has, I hear, launched a circulation building attack on 73, using what appears to be self-written unsigned letters and other honest tools of his trade.

If my interpretations, giving more weight to his coverage than to his protestations of opposition to the proposed two meter emasculation, are in error, then I certainly apologize.

In fairness to our research staff I must admit that they attempted to check out the details of the matter, but found that most of the pages of the back issues of that magazine had been used in the 73 restroom.

the FM scene

by K6MVH

Dayton Hamvention

The Dayton Hamvention was a smash success this year. Of course, the Dayton thing is a smash every year – but this time, wow! Crowds were so abundant on the floor of the exhibit area that you could spend upwards of 15 minutes just getting from one end of the building to the other.

The biggest attraction of the day was FM, and I doubt that anyone would deny that. Pocket FM transceivers were part of the uniform of the day. It was certainly a strange sight, all those whips jutting up above the crowds on the floor. Manufacturers of gear for 2m FM reported unprecedented sales volume; and distributors were taking orders well after they'd sold every sample they had brought along.

At the 73 booth, sales of FM books exceeded sales of all other publications by a factor of three to one, with our just published *Best of FM,* an anthology of selected articles from the more recent issues of FM Journal, leading the field by a comfortable margin.

Mike Van Den Branden and Art Householder were there to tell about their new planned magazine (to be called . . . *rpt*). Mike was publisher of the now-defunct FM Bulletin, and Art is manager of Spectronics Inc., of Oak Park, Illinois, an FM dealer. The two say their new magazine should be published some time in July.

One of the busiest booths at the Hamvention was Regency's. The Regency boys had on display a rig that represents a new concept in FM transceivers. It was a rig built around a drastically improved version of the presses the button under the indicator lamp. As long as that button is down, the rig won't scan and he can transmit on that locked-in channel. When the QSO is finished, another button starts the scan sequence again. The whole thing is very impressive. One of the interesting features of this scanner that is not found on other units is its system of maintaining scanning speed regardless of the number of locked-out channels. On a conventional scanner, you can lock out as many channels as you like so that the frequencies are bypassed in the scanning process, but most receivers still use up the same amount of time to sample each channel, locked out or not. The new Regency transceiver, though, has a system that not only cuts out a locked-out channel but eliminates the sampling time of the locked-out channels as well. This system precludes the possibility of missing the first word in a transmission because the scanner is "someplace else."

Rent-A-Mobile

I really got the chance to get around in style in Dayton. The local repeater operates .34/.76, and both my Handie-Talkies are set up for .34/.94 and .94 simplex. So I was worried that I couldn't talk to any of the local repeater crowd. But things really worked out for me. I had tested a Regency transceiver several months earlier and applied too much dc input voltage, thereby blowing one of the transistors. Fortunately, the Regency people fixed the unit and returned it to me at the convention. Since the multichannel Regency HR-2 had .34/.76 as well as other standard the transceiver in the car I had rented from National.

But of course National Car Rental does not equip its fleet with two-way antennas or handy sources of battery voltage. The situation was still not hopeless, though. John Altmeier, from New-Tronics, said he had just the antenna I'd need for use in a rented car. He left his booth and dug up a brand new 2m gain antenna that mounts on the trunk without leaving any marks.

In only a few short minutes, Steve Holden installed the rig and antenna. And so I was mobile. The HR-2 worked extremely well through the repeater and the Hustler antenna from New-Tronics did a fantastic job.

Bumper Stickers

In a recent editorial I mentioned that 73 had printed a few hundred "ministickers" for car bumpers with the words, "Listening 94," "Listening 76," etc., for all the 2m FM channels. I also commented that these were available on a no-charge basis in exchange for self-addressed stamped envelopes. Well, the deluge of mail was overwhelming. We had to reprint the banners twice, and eventually we ran out of peel-off-back fluorescent paper – but still the orders kept coming in. Finally, we stopped fooling around and ordered a large quantity of new stock, reprinted the stickers to insure that we wouldn't be running out any time soon, and stockpiled the strips for immediate delivery. So if you got left out, or if you would like to advertise the channel you're monitoring, drop a note to me (including SASE), and I'll mail you a couple. (Be sure to indicate what channel you want.) This second batch of stickers differs slightly from the first: The letters themselves are a little larger than those of the first run, and a small ad for 73 is included across the bottom. The stickers now say:

LISTENING 94
. . . and reading 73

few days. This means that nothing less than a high speed web offset press is suited for the job, with fully automatic folding, binding and mailing machinery attached. Even with all three of our presses running day and night it would probably take about three months to print an issue of the magazine.

How is 73 doing in comparison to the other ham magazines? We do have a considerable advantage by virtue of some two years of selling 73 readers on the fun of FM. This is the most rapidly growing aspect of the hobby and advertisers have found that ads in 73 are the key to large sales volume since the 73 readers have been presold on FM. It is interesting that we have not had to resort to cut-rate subscriptions and super cut-rate advertising to keep going. To the contrary, our profit picture for 1971 is most encouraging.

Our first quarter report shows a net profit (before taxes) of $12,231.85. That is close to the expected 10% profit we consider acceptable, being about $4000 per month on about $40,000 sales.

We have several excellent books in the works which should bring up our second quarter income (and profits), plus of course the steady increase in interest in FM which should reflect in even more FM advertising in 73.

Why, then, am I talking about retirement? There are, of course, many reasons. I'd like not to be tied down so firmly . . . to be able to go on some DXpeditions without having to worry about the magazine . . . to be able to travel . . . to write some travel books . . . to write articles for other magazines . . . to move around and live where I want when I want . . . to ham all I want . . . some freedom.

Running 73 is fun. It is a lot of fun. But it is restrictive too. The monthly deadline is inexorable and is a basic fact of life that is sometimes oppressive. Eventually I want to get out from under. I've been at this editing and publishing business for

There was most certainly no intent to discredit the publisher of the other magainze, since we suspect that he is entirely capable of taking care of that without any help from us.

popular Regency scanner. The receiver section scans up to eight channels, and locks onto whichever channel is active. If the operator wants to communicate on that frequency, he just

frequencies, I tried to find a way to get a good portable power source so that I could use the rig during the Hamvention. Steve Holden (WA8RZL) suggested that I mount

Repeater Atlas

It's very difficult to keep apace editorially with the flood of repeaters making the scene across the continent. More than 150 additions have been noted since the April repeater directory was published, and new repeaters are appearing every day. The changes are happening at so swift a rate that 73 decided to hold off publication of the FM Repeater Atlas until things stabilize. We'd really like to make the Atlas into an accurate, up-to-date, and handy reference work that can be used by mobile ops and transient FM'ers. So, what we're doing is having the repeater photos and coverage maps printed now. The directory portion will be printed last. In all, it looks like the Atlas will be available for delivery about six weeks from the date this issue hits the stands. If your repeater has not been included in the Atlas, please make it a point to clue us in immediately. We want *no* repeater to be omitted from the Repeater Atlas – we're determined to make this volume our most comprehensive listing ever.

advised by my lawyers that
ou goons don't ever proofr
lousy [illegible] from bab
bunch of crooks are [illegible]n
you ignored my comments in
I insist that you print ev
should be boiled in oil ov

LETTERS

An All-New League

In regard to *The Institute?* (April 71): If you revived it you would gain more support than it did on its initial venture. After reading the article I would be willing to pay any necessary dues, as it would be going to good causes; i.e. legal funds, lobbying, etc. If you remuster, I would gladly give up my ARRL membership.

Scott Liebling WA3OXG
5616 Beacon St.
Pittsburgh PA 15217

I picked up 4 issues of your 73 radio magazine and sure opened my eyes as to what is going on at the ARRL (I have been a member since 1939). What Mr. Wayne Green writes sure makes a lot of sense.

John Sauritch W3RWA
829 Prospect Ave.
Charleroi PA

If Wayne would represent us in Washington, D.C. I would be willing to kick in $1 per month to support a *working League*.

William Tegtmeyer WB8AMQ
RD 3, Box 182
Wakeman OH 44889

I support Wayne for League manager, too.

Lyle C. Henry K9DKA
3365 Duluth
Sturgeon Bay WI 54235

Exams

I now hold a General class amateur license. I plan to file for the Extra class exam. If I pass only the Advanced part of the total exam, do I get an Advanced license?

Fred Martin
202 Kenny St.
Fayetteville NY 13066

You bet.

As a new member in the ham fraternity, I must admit that as magazines go, 73 is the best around. Your many articles on FM were responsible for finally giving me the push needed for my license, and I especially enjoyed the April issue on repeaters, which seem to be popping up on every mountaintop; however, after looking at your April directory, I'm slightly confused.

You list W1ABI on Mt. Killington as 34/94 with 2400 Hz tone burst under Vermont, New Hampshire, and Mass. Under New York, though, it's listed as 34/94 with 2100 Hz tone.

WA1KFX on Mt. Snow is listed with no 34/94 capability except under New Hampshire.

W1KOO on Mt. Mansfield has a 34/94 channel with 2400 Hz burst under most of the New England states, but as Mt. Mansfield and Mt. Killington are rather close to each other, shouldn't a 2400 Hz tone on 34 trip both repeaters even though only one is wanted?

Ken Fowler WA1NSR/O
PSC-1 Box 2215
Ent AFB CO 80914

According to information from Gordon Pugh (owner of both repeaters), WA1KFX is .31/.88, with tone provisions for .31/.91 and .31/.94. WA1ABI uses 2.4 kHz audio for triggering the .94 output from either .28 or .34. The NY listing was incorrect. Repeater owners and users should keep 73 informed of all statistical changes or errors in listing.

Small Print & Sidewise Pages

I would like to voice a sincere complaint about 73 magazine. I cannot understand why you persist in the small print and sideways pages that you have undertaken in the past several issues! I used to enjoy reading the letters and other trivia – but now?? I note that you printed one such complaint in the March issue. I wonder how many others you get . . .

I can understand you get more on a page so why don't you microfilm the whole magazine and rent us all readers.

Bob Carlson K6VOI
Member of the "ROYAL SOCIETY OF COSMOPHONISTS"
1309 E. Elgenia
W. Covina CA 91790

We're studying the feasibility of reader rental now.

In answer to your sincere complaint about the sideways pages of small print we would like to explain the rationale behind this curious change in 73. Ever since its start 73 has been known for its quantity and quality of technical and construction articles. Indeed, few amateurs who are interested in the technical side of the hobby are not regular readers of 73. Unfortunately this still left a lot of nontechnical amateurs withsno sound reason for reading 73. In order to provide more coverage of the news and events side of the hobby the news pages were inaugurated. After a little experimentation it seemed that the pages looked more like a newspaper when printed sidewise. This also had the benefit of permitting more of the pages to be used for printing than normal. The use of small type allowed even more material per page, thus enabling us to cut back very little on technical articles to make room for the new feature.

The newspages do seem to be providing interest to nontechnically inclined amateurs and may be worth their weight to all concerned. More subscribers mean more ads and that, in turn, means a bigger magazine overall. Bear with us . . . and let us know your reactions.

Here is my renewal for another two years. I enjoy 73 more than brand X, Y, or Z, and I take all of them. Some of the editorial comments are redundant, especially Dave Mann; but I even get a kick out of that. Don't like having to turn the mag sideways for hot news.

Clayton Dewey NØUMN, K8CKD
404½ S. Washington Ave.
Ludington MI 49431

Better redundant than dundant.

Cont. on News Page Four

Cont. from News Page Three

I just wanted to tell you that your "sideways" letters, news page, etc. doesn't bother me one bit. I *like* it, and I like everything you do. Keep it up.

Ira Lefkowitz WN1NMI
15 Carpenter Lane
Bloomfield CT 06002

Run That By Again

Too late for your repeater issue, but: .34/.94, 170 ft tower, 1 kW, no tone access. Can switch to .76 manually.

Bob WA8PIE

Great, Bob. Now tell us the repeater call, location, and coverage area.

Old Ads

Yes, I would like to see more of the 50-year-old advertisements in future issues of 73. Maybe something like one page every other issue so that the complainers could not say they were being shoved down their throats all the time, hi.

Also, I am working on a book about old-time radio, and as you say that you have a million of the old ads, I wonder if you would care to send me some of them so I might include them in the book.

Gordon E. Hopper W1MEG
75 Kendall Ave.
Framingham MA 01701

Million is only a figure of speech.

First, let me say that after being a ham for only nine months (and receiving 73 for an identical period of time) I have become an avid reader of 73 and a firm believer in its number one position among ham magazines. Your rag is clearly superior to any and all competitors.

Second, keep the old advertisement reproductions in each issue. They are both nostalgic and interesting.

Dr. Raymond L. Read WN4RCH
1534 Marston Road
Tallahassee FL 32303

The Institute

I just laid my hands on a recent issue of CQ and a most disturbing W2AOO gets my kudos – however, how does W2AOO state that his amp should be able to be built for less than $20? I am lost. What kind of junkbox is he referring to?

I have been in the game for more than 40 years, and even as a professional, I never stocked more than 3 horiz. output tubes. And considering the tubes list for $51.90 plus tax, these 6JE6 tubes would net more than $20. Therefore I must have the wrong sort of junkbox, or something is wrong.

Joseph T. Beck K4AQT
3810 Leila Ave.
Tampa FL 33616

Do what Seymour did (letter above) and drop the author a line.

FM-FM-FM-FM

Frankly, I am so sick of nothing but FM in 73, I could puke.

Until Ken got on this FM binge I have always considered him one of the best of writers, BUT as an *Editor*, he stinks.

Kayla was at least versatile and put in a very good selection of material – a very good editor. If 73 is going to stay an FM publication please stop my subscription and refund balance of my new 3 yr sub. I paid a few months ago. I have been a ham over 41 years now and have never canceled out from any mag before. Have always enjoyed 73 over the past years.

The sideways print is lousy too, but not as bad as FM-FM-FM-FM-FM-

D. M. Burrill K7JVZ
224 13th St.
Sparks NV 89431

I am interested in anything on antennas and almost anything relating to ham radio except FM, UHF and RTTY.

Francis McCray W3BZV
Box 103
Elgin PA 16413

I enjoyed the April issue of 73, especially the material on two meters which I have never thought very much

Your magazine is, with the April issue, regaining the quality of early last year, which seems to have been on vacation for the last few months.

Dan Deckert WA6FQC
3630 Bentley Ave.
Los Angeles CA 90034

The April 73 is great.

Larry Waggoner

editorial. In it, the author labeled you as an out-and-out thief! What I am referring to is where the publisher of CQ said that you collected money for your IoAR, but never started the organization and kept the money. Whether this is true or not is what I would like to know. I would be very grateful if you would tell me the truth about the above. I am a concerned 14-year-old Novice.

Robert Davidson WN8IPB
63 Paw Paw Lake Dr.
Chagrin Falls OH 44022

As you get older you will find that adults are not too hesitant to "imply" a scandal or similiar situation if it suits their purpose. I think adults have become very blasè in regard to smears, as yours is the only *letter with a request for enlightenment . . . for the thousands of other readers, it seems no one cares. This is refreshing and a marvelous reminder of what your generation can and will accomplish.*

If you've the April issue of 73 Magazine, please turn to page three for Wayne's editorial entitled "The Institute" . . . all your answers are there.

Horizontal-Output Linear

There was an article in your March issue, by W2AOO, on the construction of a "Horizontal Output Linear." Due to my limited knowledge, I wrote to Mr. MacDowell requesting some help. Words cannot express how encouraging and helpful Mr. MacDowell has been. It's very hard, this day and age, to find someone who will take the time and trouble to help someone just getting started.

As long as a magazine has people of this caliber writing for them I don't see how it can do anything but succeed. Congratulations to you for a fine magazine and thanks to W2AOO for his help.

Verlon Brewer WN9FQG
Seymour IN

A very fine article, and thanks for inserting this in the issue of 73. about. Anyway I sent off a check to one of your regular advertisers and shall get into 2m FM without going broke.

Louis O. Williams
1613 Cambridge Ave.
Floosmoore IL 60422

Your April issue was outstanding. I am a newly converted FM addict and I really got a lot out of the articles in that issue.

I am looking forward to finishing my school here and getting back to New England to try some of the repeaters there. I have really enjoyed using our local repeater (K5TYP) and I hope all FM'ers are as friendly as the bunch around here.

S/Sgt Rick Brown WA9FC G/1
CMR No. 4 Box 20016
Keesler AFB MS 39534

Fantastic April FM issue –
Gary Davis WB2PSS

Keep up the good work with FM. Nice mag – best in business.
Norm Zoltack WA3RGS
Bethlehem PA

Keep up the very good job with 73 . . . I operate .94 and .76 FM.
Stan Head W4BBD/8
Columbus OH

The "hot" subject at the present time in this area, and most others, is FM and your publication seems to be right on target with timely articles.

M. B. Farmer
Electronic Exchange Co.
Metairie LA 70005

Congratulations to you and 73 for the extremely interesting and comprehensive repeater directory contained in theApril 1971 issue.

Jack D. Forbing K9LSB
1416 Lakewood Dr.
Fort Wayne IN 46809

Doing an excellent job on FM in 73 Mag.
B. Walten WB4GZG

I enjoy your 73 Magazine. Keep up the good work. I'm glad there is finally a mag with some articles on FM, etc.

Jere D. Bruning, WAØUQA
White Cloud KS 66094

We enjoy your magazine very much, especially the FM articles. Keep up the good work.

Weldon Glenn WB5AEP
Route 1
Levelland TX 79336

Keep up the good work – FM is the most fun I have had in years.
David Dickson WA9JRA

Thanks in advance, and I think your magazine is tops all the way around. I operate FM on .94 and .73.

Les Hodges WB8ETP
2611 Pleasant Grove Rd.
Lansing MI 48910

Congratulations on your very fine issue covering the FM mode of communications. A continual updating of the repeater directory will be most helpful to all of us in traveling. Keep up the good work!

Robert T. Green K8JXE
5764 Heather Hollow
Dayton OH 45415

Tone Standardization

Our club supports proposal RM 1725 with the reservation that FM editors attempt to standardize tone frequencies as they have standardized input/output frequencies in order to provide repeaters that help serve all interested amateurs rather than limit repeater usage to a chosen few.

Kenneth H. Brockel WA2FPB
Secretary, ETSNJ
213 Cotter Ave.
Neptune NJ 07753

Tone frequency standards are 1650, 1800, 1950, 2100, 2250, 2400, 2550, 2700, 2850 Hz.

. . . Ken

MORE LETTERS

Girls

Let's have more covers like the April issue. Wow!!!

Bob Mackey WN9ERZ

Getting Started

I suspect the column by Fred Mocking "Getting started in Radio" was some sort of substitute (probably intended for Radio Today) but I want to say I thought it was great.

I am an "appliance operator" and I would like to see this column become a regular feature.

Mike Head WA5TWM

It is to be a regular feature.

Shame shame

Out of curiousity, how many hams wrote in asking how come your April cover girl was using the TR-22 without a ticket? Let's not leave openings like that!

S. D. Henderson K1VOL
595 Main St.
Cromwell CT 06416

You're the only one.

Is that an old J-38 key in the lower left-hand corner of the center foldout of the April issue of "Playboy"?

Alan Bloom WA3JSU/1
200 Washington St.
Middletown CT 06457

Who looks in the corner?

Much Ado About Nothing?

Come on now! UHF FM is great but it certainly shouldn't be taken all out of proportion as your magazine seems to be portraying it. It doesn't take the place of sex or of the lower frequency mainstay of amateur communications. I find it difficult to locate a purpose for this type of communication in amateur circles. To

I have subscribed to your magazine for quite a long period of time. Lately I have become dissatisfied with 73. In fact for the past year it seems that the magazine has been covering the most uninteresting subjects. Several issues including the current April 1971 issue deal with FM repeaters, frequencies, etc., and I realize you probably have a few screwballs who like that sort of ham radio. Personally, I find your magazine boring, and since I have no love for FM, repeaters, and other VHF and UHF type of radio, I now feel that when my subscription runs out, that I most certainly *shall NOT renew.*

I have felt that your editorial policy has been very good, and I agree with all your comments about the ARRL and its lousy attitude toward the amateur – especially the incentive license matter.

Truman P. Oliver W8FWT
12752 Chatham Ave.
Detroit MI 48223

Sorry to lose you, but magazines have a responsibility to provide more than the average amount of information on new developments such as FM. Keep in mind too that FM is the biggest new development in amateur radio in over ten years. Even so, few issues of 73 have more than one or two FM articles,. . . it just looks like a lot because the other ham magazines print so very little about FM.

I am an avid fan and subscriber to the 73 magazine but the April issue made me sit back and wonder why I am a subscriber. I used to enjoy the articles but lately all that is in it is – 2m FM. In this issue some 120 of the 144 pages are devoted to FM. That is fine for the amateurs who are devoted to FM but I am not, and I think that there are many more hams who aren't. Don't take me wrong – I

Great Mag. Enjoy the editorials and the FM articles and reviews. Would like to see some on conversion of some of the more recent commercial and military FM gear.

Bob Brunkow K7NHE
15112 S. E. 44th St.
Bellevue WA 98004

So would we.

Enjoy your magazine; mostly VHF projects and FM.

John Kurtinecz

73 for the Blind

My husband is blind and would like to know if 73 Magazine is offered anywhere recorded for the blind or available in large print? If so, where and how may we obtain them?

110 Polaris St.
Cocoa FL 32922

73 is available to blind and handicapped individuals. Write Science for the Blind, 221 Rock Hill Rd, Bala Cynwyd, PA 19440.

Gift Idea

When the recent issue of 73 arrived in the mail, it solved a great problem for me. A friend of mine recently invited me to his "over-the-hill" birthday party. (He'll be 30) I didn't know what to give him until I remembered that he had expressed interest in ham radio on several occasions. So here is the price of his first year's subscription. For only 50¢ a month he can enjoy 73 just as I do, and who knows, he just might be a subscriber from now on.

I think this is a great gift idea and wish I had done it for others before.

With all the letters to the editor praising 73, it is obvious that your readers support you and your efforts. I do too.

I'm sure all your subscribers have a friend who is a recent ham or a potential ham and who would appreciate a gift subscription. If each subscriber

money is entered into the LA5LG Memorial Fund, which is used to help handicapped individuals become hams.

This all started in 1966 when a young man from Oslo sent a letter to NRRL HQ containing a very simple question: "What shall I do to become a radio amateur?" The man was lame from the neck down after a diving accident. Obviously, he could not meet the CW requirements on the transmit side. A special agreement was obtained, however, by the president of NRRL. When he and the other members of HQ saw what it meant to the young man to be able to talk to others all over the world without being hampered by his handicap, they realized that many others may need help the same way without knowing how to set about it.

The plans for a fund and an organization to help them had hardly been initiated when LA5LG, then president, died. LA1TE, elected in his place, hurried to work, and soon the LA5LG memorial fund was established. A collection was set up among Norwegian amateurs to finance the purchase of rigs, and a special license was granted by the authorities.

It was a fantastic success, but the money available proved insufficient by a long way. Various organizations were asked to help, mainly Lions and Rotary, and both were positive. But it still was not enough.

During the summer of 1968 hams of Sweden and Norway occupied the independent territory of Morokulien, situated around the Norwegian–Swedish peace monument.

A special call (LG5) was issued, and operation, plus sale of QSLs (3 IRC) and letters of citizenship commenced. Since then the fund has been gaining steadily.

The real boost came last spring, when a TV program was sent over the national net, showing several cases and what amateur radio meant to them.

After the program a net started

About a hundred amateurs have started up in this way, and following them from the first day on the air, when they hardly dare speak at all – some hardly *can* speak, after years in institutions with only busy nurses and even busier doctors to talk to – it is gratifying to see them becoming more and more talkative, more and more interested in the world beyond their beds and wheelchairs, start learning code and thoery, then finally passing the full test.

LA8PM Per Marienborg
Stovnervn. 17
Hoeybraaten
Norway

Thanks

I would like to take this opportunity to thank you for furnishing 73 to the Army MARS stations in Vietnam (forwarded to us by Alex A9EU). 73 has not been available in the PX bookstores, so it is a rare privilege to receive a current issue regularly.

Vernon W. Ireland
SFC,E-7
NCOIC, AB8USA
Radio Company LBN
APO S.F. 96491

ARRL

I have been a Wayne Green supporter and agreed in his criticism of ARRL. I feel that he's done amateur radio a great service by opposing the dictatorship of ARRL.

O. A. Wise KØMVR
Corunna IN 46730

Net List

Would think it a good idea to publish a list of active nets on various bands, say once a year. A suggestion by you would elicit contributions, and it might well be a useful service in traffic handling.

J. F. Weatherly K1ZYG

me it seems as thrilling as getting a new telephone installed that is tied to a 100 party line. Maybe the thrill is in trying to get a word in edgewise or of listening to everyone else. TTime-sharing is great for computers but humans should be able to talk as long as someone else is willing to listen to them.

I can travel anywhere in the U.S. with my 10–80m mobile transceiver and nearly guarantee communications any hour of the night or day whether I am in Nevada or the middle of Pennsylvania. If the going gets rough on SSB, I switch over to CW. I more than suspect that a cross country drive with UHF FM will generate a minimal of QSOs and lots of frustration.

Let's recognize UHF FM for what it is – a darn good technology for local, noise free, communications, and a good opportunity for manufacturers to start making money again. What the percentage of need is for this kind of amateur service remains to be seen.

Herman Lukoff W3HTF
506 Dreshertown Rd.
Fort Washington PA 19034

The key to UHF FM superiority is in its repeatable performance reliability. True, you wouldn't make a lot of UHF contacts on a cross country jaunt – but that doesn't mean there isn't a lot of action on 450 MHz. Most of the UHF repeaters are "closed" to casual use of transients and are set up for the convenience of the local amateurs.

I am not too interested in FM. I tried it a few years ago and found it too much like CB. I sold both rigs and haven't tried it since. I decided recently to drop my subscription to CQ. I reviewed the issues for the past year and thought it a waste of money. Compared with the "good old days" of 1957–59 there is nothing in them. Except for too much FM, yours is tops.

Russ Lorentz W9HLN
Ft. Wayne IN 46815

FM has improved since the old days. Try it again and be astonished.

think it is fine that many amateurs are interested enough in the higher bands to keep them alive, but there are still a lot of us who like articles on other phases of amateur radio and would like to read about them in 73 magazine. So come on . . . let's give at least half to other phases of the spectrum.

Al Fudge
19-C Lyellwood Pkway.
Rochester NY 14606

You are probably right, we have been emphasizing FM a lot recently. Watch the next few issues and see how you think it is going. Keep in mind that one of the reasons that we have been talking FM so much is that it is a lot of fun, doesn't cost much to get on the air, and represents a new and very valuable growth of the hobby. How else can you have that much fun for a couple big ones in amateur radio? The gang using WA2UWQ in Rochester will welcome you to their repeater . . . give it a try.

FM FOREVER!

Have been enjoying FM since 73 turned me on to it.

E. Falhof K1RVR
VP, Middlesex ARC

Keep up the FM coverage! The magazine looks better all the time

Don KH6GKV/WA1UCR

Your mag is tops and the lads in this area are climbing on the FM bandwagon! The April issue far exceeds all former issues!

C. C. Foster VE1AMF
113 MacBeath Ave.
Moncton N.B. Canada

Enjoy reading the FM Scene (K6MVH).

Bud Link W1EKE/S
5911 Inwood No. 4
Houston TX 77027

Keep up the FM articles! 73 is a great mag.

Rick Brown WA0ZQX-FM

scriber gave only one gift subscription it might put 73 in the black.

Glenn Commons WA9ZGJ
5012 East 67th St.
Indianapolis IN

It might indeed!

Turncoat!

I feel it my duty to inform you that there is an enemy in your midst. The evidence can be clearly seen on Page 25 of your April issue under the heading, "War On Poverty."

Take note of certain subtle, but degrading statements cleverly worked into the copy. For example, the statement, "You will save tremendously on the highly overpriced individual=copy cost of $1."

Since when is one lousy dollar overpricing so bountiful a wealth of technical knowledge and ham news as is contained in that portable horn of plenty known as 73 magazine?

Next, your renegade has dared to imply that subscribing to the beneficent generosity of your publication is an act of charity to you when, in fact, the gain is so far outweighing the cost that it should be considered as taxable income to the subscriber. The fact that it isn't is what should be stressed.

Now, I don't question your claim to be running in the red, since you are, out of the extreme goodness of your heart, giving so much and asking so little for it, but so beneficent a philanthropist ought certainly be on the alert for enemies from within!

Bill Hood W2FEZ
116 West Park St.
Albion NY 14411

Who can argue against logic like that?

Citizenship for Fun

Honorary citizenship certificates are available for Morokulien (LG5). These honorary citizenship awards are usually forwarded on request, if the request contains $4 or more. The spontaneously on 80, discussing the show. It grew steadily, and soon about 100 hams were in, while several hundred were listening without checking in.

The next morning several people started working on their friends while the impressions were still fresh.

Expeditions set out for sports centers (this happened during the Easter holiday) equipped with megaphones and walkie-talkies to sell letters.

And on it went, after a while letters valuing more than 100,000 Kr were sold. Also, during last summer QSO nr 10,000 was worked from LG5LG in Morokulien (the name is made up of the words for "fun" in Norwegian and Swedish).

The main problem now is to reach the interested handicapped, and to train them properly.

All districts have a representative whose job it is to forward applications for stations, train the operators, make necessary alterations on the rigs so that those with serious physical defects can use them.

Sounds like a good idea. We'll publish a list of active nets if a sufficient number report in to us on a monthly basis. Any takers?

OT AMATEUR DIES

C. Kendall Morse, holder of amateur calls K1RYI and K4DCR, died March 2 at the Manatee Memorial Hospital in Bradenton, Florida.

He was born in South Newfane, Vt., the son of the late Judge John E. Morse and Emma (Chase) Morse. He married the former Jo Ann Tambasco of Flushing, NY, on Feb. 9, 1947.

He was the owner of Video Village in Brattleboro, Vt., until May 1964 when it became necessary for him to give up his business due to ill health.

SPECIAL CALL AND PREFIX

KC0KC will be heard on all bands for the period July 1st 1971 through July 5th 1971 GMT. Members of the Mobile Amateur Radio Awards Club Inc. (MARAC) and the Independent County Hunters Nets meeting in Kansas City thru these dates will man the station around the clock.

KC0KC will be on 10, 15, and 20 meters beginning when the band opens in Kansas City around 1300 GMT until the band closes late in the evening. Activity on 40 and 80 meters will probably begin around 2200 hours GMT until 1300 GMT the following day. However, activity will generally be on any band at any time that band is open. Activity is planned around the following frequencies:

BAND	CW	PHONE (1)	PHONE (2)
80 Meters	3550	3880	3910
40 "	7050	7205	7260
20 "	14050	14205	14285
15 "	21050	21280	21360
10 "	18050	18600	

NOTES

(1) Several times each hour operator will announce and listen 5 or 10 kHz below the bottom of the U.S. phone band for DX stations.

(2) If "pileups" develop operator may listen off his transmitting frequency.

LOG ALL CONTACTS IN GMTime.

For special QSL send SASE or 2IRCs to KC0KC, Box 753, Shawnee Mission KS 66201.

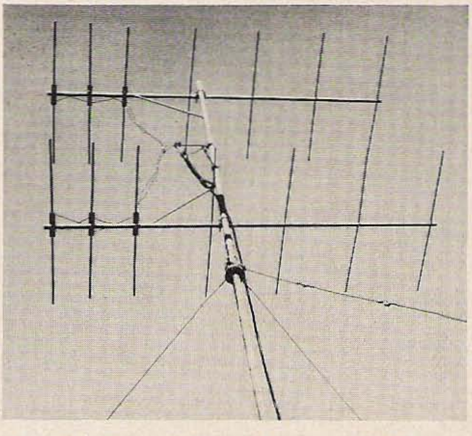
Frank C. Jones W6AJF
850 Donner Ave.
Sonoma CA 95476

DRIVEN VERSUS PARASITIC ANTENNA ELEMENTS ON TWO METERS

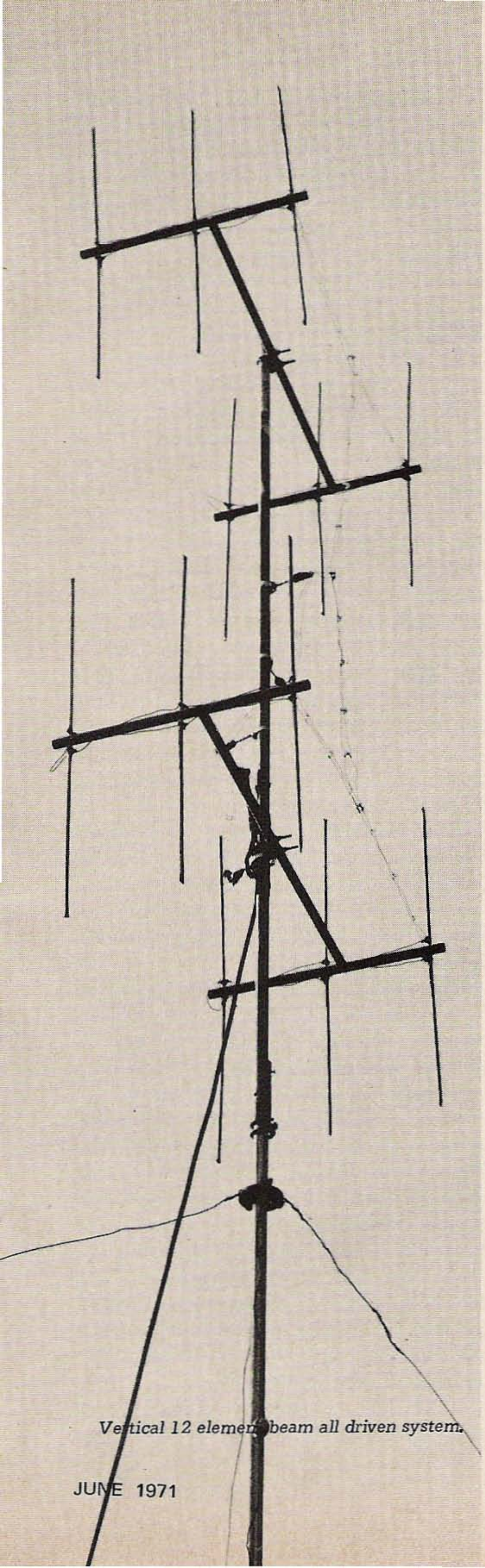
As an incurable antenna experimenter with 50 years of experience, it seemed that I had to compare all driven-element antennas with yagis. The results probably aren't too accurate since the work had to be done on the roof of my radio shack. The acre of ground here has long since become a jungle of trees and shrubs so the only space left is on a rooftop and even that has beams around it for 50, 144, 220, 432 and 1296 MHz on separate TV push-up masts.

The test results over a period of about a year have led to the designs shown in the two photographs of a vertical all-driven 12-element beam and a combination beam for horizontal polarization. The latter is interesting in that it is somewhat similar to a Swan beam design, and I used some of his element insulators in the centers of the driven elements. The parasitic directors were part of an old 2-meter beam joined to the driven-element booms by hardwood dowels and an aluminum sleeve between the front driven element and the first director on each boom.

This 14-element beam gave about the same forward gain as a 16-element curtain with slightly extended elements and spacings. The curtain beam of this design should give about 14 dB gain over a dipole; but due to aging and oxidation in this antenna, the gain figure may have deteriorated by a couple of decibels over a period of several years of use. I live about 10 miles north of San Francisco bay and 30 or 40



Horizontal antenna: 6 driven elements and 8 directors



Vertical 12 element beam all driven system.

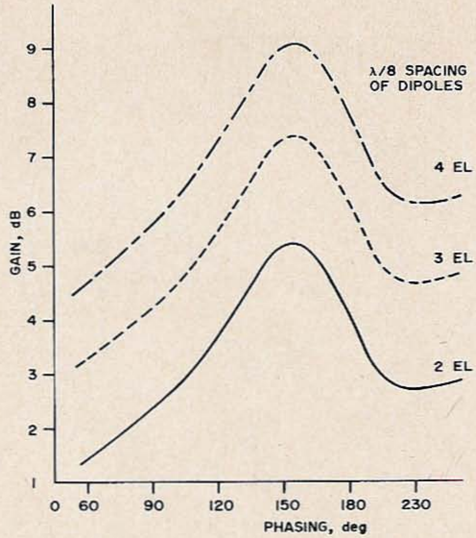


Fig. 1. Performance-vs-phasing curves for various multielement beams.

miles east of the Pacific ocean, so occasional fog conditions cause a little salt problem with aluminum tubing.

The 14-element horizontal beam in one photograph had slightly sharper forward lobe and smaller back lobe as compared to the curtain 16-element beam. Only the horizontal plane of radiation could be compared using a third test antenna feeding a receiver with a calibrated S-meter and 10 and 20 dB attenuator pads in the receiver input line.

The test antenna was not equidistant from the two antennas being tested, so only a few readings were made in comparing the two antennas. Many nights of listening on the 2m band more than confirmed the test results, since an added factor was present. Strong "power" buzz noises – mostly from electrical machinery, automobile ignition, and neon tube signals – were mainly from a direction to the rear of the two antennas. This meant less background noise from the "power" buzzes when using the antenna with the smaller back lobe.

Long yagi antennas of standard design usually have a better front-to-back ratio than curtains, but they often have less forward gain. However, even with a little less forward gain, the added benefit of less

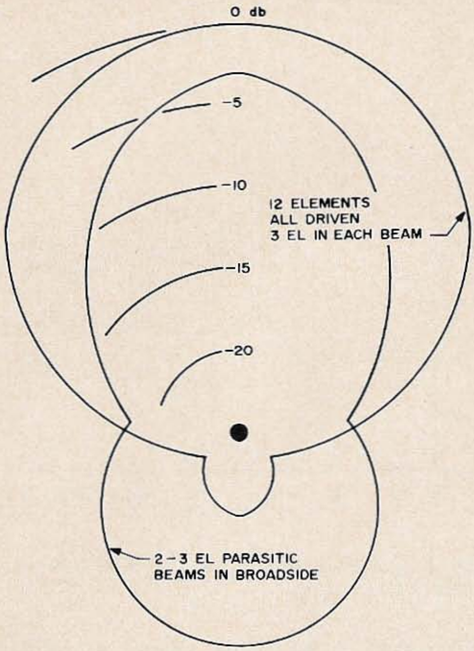


Fig. 2. Antenna pattern and gain comparisons.

QRM or QRN often makes a yagi beam give superior reception but not transmission.

A single yagi beam consists of a parasitic reflector, driven dipole, and one or more parasitic directors. All parasitic elements are excited by the driven dipole and if the lengths and spacings are approximately correct, the beam will show good forward gain and small rear gain (or loss, preferably).

Working for maximum forward gain means a sharper beam pattern but an increase in the rear lobe, often a disadvantage in reception. Adding lots of directors increases the forward gain and beam pattern sharpness, but also narrows the antenna bandwidth. Sometimes, the bandwidth of long yagis is restricted to about 1 MHz of the 2m band before the gain and directivity turn from good to bad. This may be fine for long-distance work at one end of the 2m band but leaves much to be desired for coverage of the entire band and some of the MARS frequencies outside of this 4 MHz band.

The all-driven beam of three dipoles and a three-element parasitic yagi beam were built up and tuned to 432 MHz and tuned for minimum swr at this frequency. A General Radio wideband power oscillator was used to excite the antennas. The yagi had a bandwidth of 8 to 10 dB at the 3 dB points of gain and swr effects. The three driven elements had about twice the bandwidth before the gain went down and the swr went up badly. The forward gain was difficult to compare accurately but seemed to be about 6 dB with both antennas.

There were rear reflecting surfaces between one and two wavelengths in back of the test antenna position, so front-to-back measurements at this near-ground level were meaningless, and even the forward gain measurement was questionable. The main purpose was to compare swr over a wide band of frequencies with a slotted-line device in the same piece of coax that fed each antenna through baluns and tuning stubs at the antenna. No retuning was done after the original 432 MHz measurement; only the oscillator frequency was varied. These effects could be transferred to 2m by dividing the bandwidth figures by 3 without much error since the frequency is about one-third.

Swr measurements, using an ordinary swr meter, over the range of 143.5 to 148.2 MHz on the 12-element all-driven array showed it to be in the range of 1–1.2. This seemed to be very good to the old experimenter.

The polar diagram of the all-driven 12-element job of 6 over 6 elements also pleased me when compared to two 3-element yagis in broadside (also vertically polarized). The back lobe was small enough to make reception of weak signals possible in spite of bad power noises to the rear. The yagis were tuned for best forward gain and had a pretty bad back lobe as shown on the curve sheet. The rear lobe on the yagis was down about 10 dB from the front lobe. The driven array had 20 dB ratio. The fact of 3 dB more gain forward was due to stacking of 6 driven elements over the other 6, which should not affect the polar diagram pattern.

After a few months of on-the-air tests with three vertical beams at the same

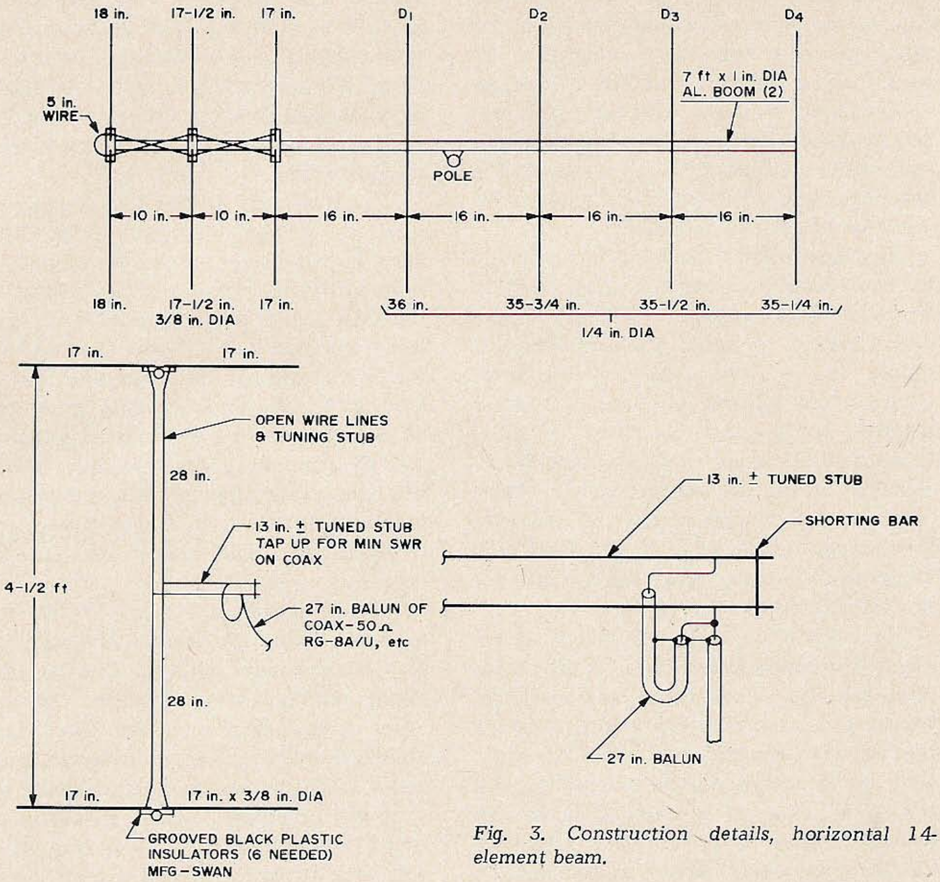


Fig. 3. Construction details, horizontal 14-element beam.

average height, the twin short yagi and the larger director beam (not shown) were pulled down and the all-driven 12-element vertical array boosted up as high as possible on its push-up mast for future use. The wide frontal lobe turned out to be a blessing since I could cover the whole San Francisco bay area with one beam bearing. The larger director beam had to be reset if the stations were more than 10 to 15 degrees apart in bearing, and its fairly large side and back lobes always picked up more noise when listening to weak signals.

The curves of driven-element antennas of Fig. 1 were interpolated from those of G. H. Brown (*IRE Proc., 1937*) for two elements for phasings of 60 to 180 degrees, and the curves of Chen T. Tai (Microwave Journal, 1964) for additional dipoles in driven arrays. If the interpretation of these curves is correct, two driven elements spaced $\lambda/8$ and phased at about 225 degrees would have a gain of 3 dB over a dipole and be nearly unidirectional. 180-degree phasing would provide nearly 4 dB gain but would be bidirectional, not a desirable characteristic for good front-to-back ratio.

A single reflector behind would add some forward gain and reduce the back lobe about 10 dB; however, a ratio of 20 dB was desired. An experimental model provided about 12 to 13 dB front-to-back ratio and a forward gain of about 5 dB.

Adding a third driven element gave better front-to-back results and is the form used in the beams shown in the photographs. Three driven elements phased about 225 degrees provided a little over 5 dB gain with at least 20 dB f/b ratio. The three elements gave a shade more than 2 dB improvement over two similar elements.

The dot-dash curve of Fig. 1 indicates that four driven elements would give about 1.5 dB more gain than three elements. An experimental antenna with five driven elements should have had 1 dB more gain, but as measured, did not prove much better than three elements. These experimental antennas require a lot of length and spacing variation to get best results.

The length of each driven dipole has to be shortened progressively from rear to front for best radiation pattern and gain characteristic. A short stub on the rear dipole and a tuning stub on the front element are needed to tune out some reactive components if coax or 300Ω twin-lead feeders are used. If several three-element beams are connected in phase, each one needs a short stub on the rear, four equal length lines at the front elements and a tuning stub and a balun for the whole array.

Half-wave spacing between three-element beams will add about 4 dB gain as checked by numerous measurements. Stacking six more driven elements below the top six elements will add 3 dB more gain, so if a good job of assembling and tuning is done, a 12-element beam will provide about 12 dB forward gain with exceptionally clean pattern as indicated on the polar diagram for a vertical array. (See Fig. 2.)

If directors are added to a driven array, the forward gain can be increased at the expense of a sharp frontal lobe, and two fairly large side lobes. Half-wave spacing betweeen beams can no longer be used since directors react badly with that spacing. Increasing the spacing increases the side lobes but finally up to 3 dB gain can be obtained with two beams as compared to one beam. No accurate gain measurements were made on the horizontal antenna, but some calculations indicated that its forward gain should be 1–2 dB more than the all-driven vertical array of fewer elements.

The horizontal beam insulators were of the type used in the very good Swan 2m beams (Fig.3). The 3/8 in. diameter aluminum tubing elements fit into grooves and are fastened in place with 6-32 machine screws. The insulators (six required) are grooved at right angles to the approximate 6 in. lengths, for 1 in. diameter booms each about 7 ft long in this array (two required). A small angle bracket about 2 ft long from the boom to the steel mast helps hold the booms parallel.

The usual TV ladder line is usable on moderate power at 2m but 13- or 12-gage bare wire is better. It can be melted into 5/16 or 3/8 in. diameter polyrod insulators cut into 1½ in. lengths. A 100W soldering iron (or better yet, a 200W size) will heat the wire enough to melt the polyrod around the wire when pressing firmly down on the wire at first over the polyrod then just to one side as the wire sinks into the insulator; 1 in. spacing is suitable for all phasing and tuning stubs. Insulator spacing of 10–12 in. is suitable for 14- or 12-gage wire lines.

The all-driven array used 3 x 5/16 in. diameter nylon rod insulators since nylon is a very tough material and weathers better than fiber or Bakelite. There are other tough plastics which have better electrical characteristics than nylon, but rf losses at the center of dipoles is very low.

It will be noted that the driven element lengths taper towards the front (Fig. 4) and help take up some of the crossed phasing line reactance. The short rear stub of 5 or 6 in. of wire also helps in this respect.

The spacing of about 1/8 wavelength between driven elements would reduce the gain if the wires weren't crossed over between elements. Crossing these subtracts 180 degrees and the wire lengths of about λ/8 subtracts another 45γ degrees, giving about 225 degrees phasing between adjacent elements. This phasing gives about 2 dB more gain than 45-degree phasing for three driven elements. 135-degree phasing would give more gain but would be difficult physically because of trying to get 45+90 degrees instead of 180 and 45. Actually, the phasing is a little less than 225 degrees in these antennas since the driven elements are a little less than a half wavelength electrically. This gets the point of operation a little higher up on the middle curve of Fig. 1. At the point of maximum forward gain of about 160 de-

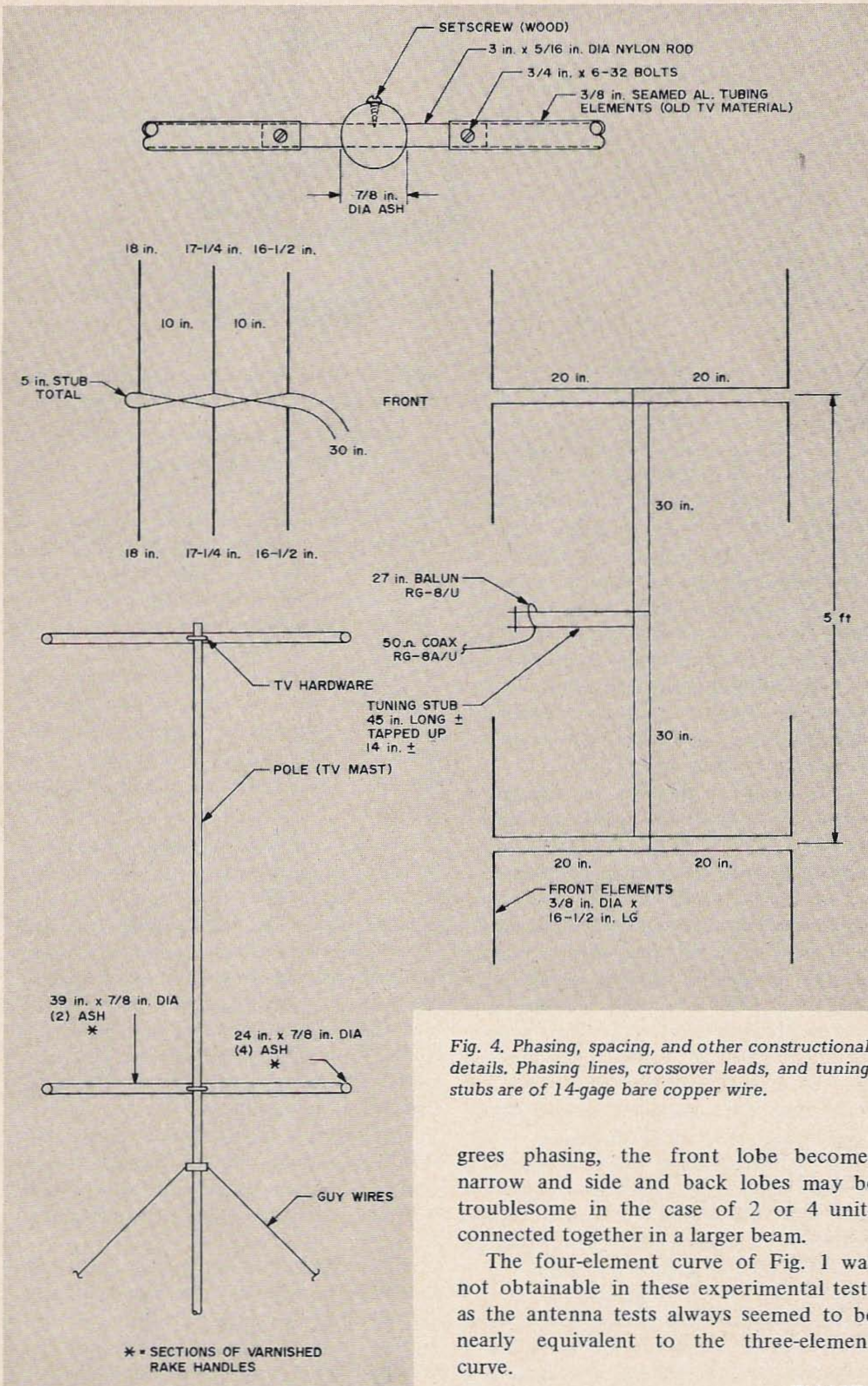


Fig. 4. Phasing, spacing, and other constructional details. Phasing lines, crossover leads, and tuning stubs are of 14-gage bare copper wire.

grees phasing, the front lobe becomes narrow and side and back lobes may be troublesome in the case of 2 or 4 units connected together in a larger beam.

The four-element curve of Fig. 1 was not obtainable in these experimental tests as the antenna tests always seemed to be nearly equivalent to the three-element curve.

...W6AJF■

3 SQUARES FOR TWO

J. V. McGinn K8CFY
19859 Nicke
Mt. Clemens MI 48043

In answer to many requests from local VHF enthusiasts, I would like to share with you my successful experiences with a good 2 meter antenna which evolved from my need for a simple antenna that would add zest to my "Twoer" transceiver. Most VHF'ers use a yagi, skeleton slot, or multielement collinear. Some use a basic type omnidirectional antenna. All are good but have specific characteristics that offer many limitations (bandwidth, weight, expense, etc.). So if you want to be different and still enjoy a good signal without the worries of weight, expense, complicated fabrication, etc., you may want to do as I did – build a cubical quad.

The "cube" is ideal for the apartment dweller, being small and lightweight, excellent for Field Day and portable work, can be made to fold or come apart easily, and best of all, it's cheap. Mine has withstood winter weather and severe winds for nearly five years. However, one winter, due to extreme ice-loading and the weight of a rotor, the whole works toppled and crashed, bending the elements like confetti. No trouble, though. I merely straightened them as best I could and everything still works fine. So ruggedness may safely be listed as another of its attributes.

The construction is most simple and very inexpensive. All basic data was derived from the VHF Handbook. Much experimentation has gone into the "playing around" phase of it, but basically it is as it started out to be. Anything nearly resembling my prototype model should work well. (I say prototype as this was built in contemplation of building an advanced form of it later; but it worked so well I just kept on using it. This is a 3-element, but I would prefer and recommend 4 elements.

Naturally any suitable materials can be used for the boom and supports. I used a length of 1 x 1 in. wood, but broomhandles, dowels, etc., can be used. Spraying the finished framework with Krylon plastic spray or varnish is highly recommended: Last inspection showed the wood to be severely cracked all over and the boom warped even though it had been treated originally. Elements are made of aluminum clothesline wire, but copper wire may be preferred for ease of construction. The aluminum wire may be soldered only with a torch and aluminum solder, and it's tricky.

An easy method of closing the loops is by butt-joining the wire ends and crimping a short length of copper tubing (or aluminum) which has been slipped over the joint. The reflector and directors are closed loops whereas the driven element is open at the feed point by about 0.5 in. with the feed points mounted on an insulating block. Use anything plastic for the insulator. I found a piece of toy train track and this became my insulator.

The antenna is fed directly with 50Ω coax without the use of baluns. For a perfectly nonradiating line the coax should be fitted with a detuning sleeve, (see Fig. 2).

The elements are supported at the top and bottom center by either passing them through a hole near the ends of the vertical support pieces or by lashing them to the ends with wire, tape, staples or whatever is handy. Originally I stapled mine and when

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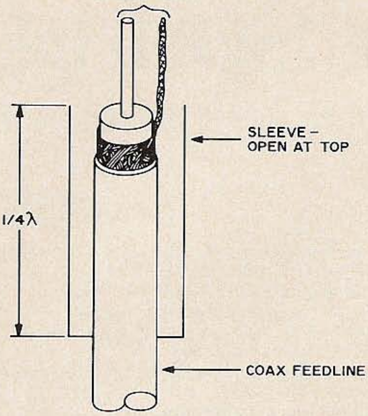

COAXIAL BALUN
(DETUNING SLEEVE)

they got a little loose I criss-crossed electrical tape around the element and end of the support piece. It is truly haywire and sloppy, but it performs like a champ.

Design center frequency of my antenna is 145.26 MHz, but the builder can easily alter this by application of the antenna formula and charts given in the reference books. In theory the rule of thumb is to make the reflector 5% greater, and the director 5% smaller than the driven element length.

For experimenters wishing to calculate the exact lengths involved for a particular frequency the formula is:

El. length = 984/f (MHz)

For various element diameters a corrective factor (k) can be important as this will affect the bandwidth of the antenna. Following is a listing of some values of k for various element diameters for 144 MHz:

Element dia. (in.)	Value of k
1.0	0.960
7/8	0.961
3/4	0.963
5/8	0.964
1/2	0.966
3/8	0.967
1/4	0.969
1/8	0.972
3/32	0.973
1/16	0.975

An extremely thin antenna will operate properly only over a very narrow band of frequencies, while a thick antenna element will cover a proportionately wider band. Practical and desirable element diameters for 145 MHz antennas should be at least 1/8 in. or larger.

Here are the actual dimensions for my quad:

Boom	34 in.
Element supports	wood, 1x1;
Reflector	88½ in.
Driven element	81 in.
Director	76¾ in.
SPACING SPECIFICATIONS	
R to DE:	.12 wavelength
DE to D1:	.25 wavelength

Polarization is horizontal with a very wide beam pattern; the main lobe seems to be about 35 degrees, or just off the right front corner, with a null off the left front corner sighting the beamed direction.

For vertical polarization, just turn the whole works on its axis 90 degrees, so that the feed point is now on one of the sides. Feeding at the center of the vertical element will give vertical polarization, and at the center of the horizontal wire element will give horizontal polarization.

On-the-air tests have proved its value. Comparison tests were made using a 3-element commercial beam on the same mast with separate feedlines and a coax change-oever switch so that antennas could be switched readily and at any time during a QSO. The quad outperformed the beam in every respect in every QSO for a period of one week of testing. Most tests were performed with a Twoer and at heights not exceeding 30 ft. I do not know what the true gain of the quad is but it did boost the effective power and range of the Twoer by 7 over that of a "Big Wheel" omnidirectional antenna.

K8CFY■

References:

1. The ARRL Handbook
2. The Radio Amateurs VHF Manual
3. VHF Antenna Handbook by Jim Kyle K5JKX

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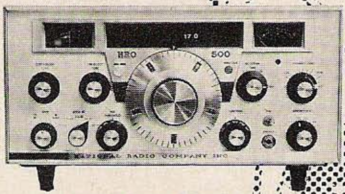

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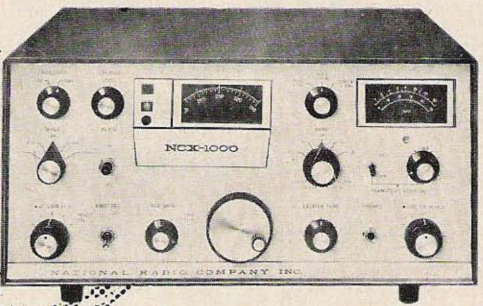

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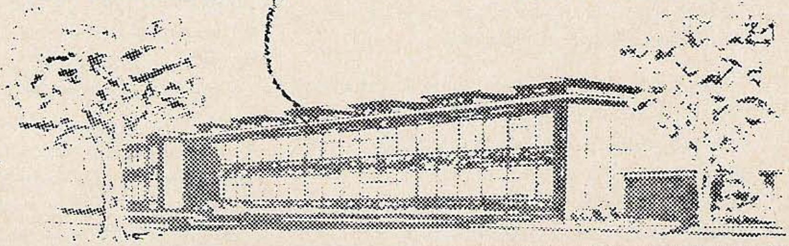

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"I CAN'T LEARN THE CODE!"

John J. Risch WØFEV
7135 Farley Avenue
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There are some people who just cannot learn the code, and I guess I'm one of them. It's no use trying again, I'll only fail the exam. Sound familiar? If you really think like that, you are right – you will never learn it, even though you can.

For those who truly believe that they cannot learn the code, and who have actually tried, I would like to relate my personal experience in this endeavor.

Before I do, however, I would like to dispel some popular myths: You do not need to have any musical or other special talent to learn it. Anyone with reasonable intelligence can learn it.

There are three basic prerequisites to learning the code: an honest desire to do so (motivation), a belief that you can do it (confidence), and perseverance.

My code career began when I was about 10 or 11 years old. I became interested in amateur radio and began building crystal sets (ones with a cat's whisker) and other basic circuits. I also "learned the code" – that is, I remembered the complete alphabet and numerals. Why, I could even send the code with a "toy" code oscillator. The only trouble was that I couldn't copy it a bit when anyone else sent it at more than one word a minute. Later, when I became a boy scout, I thought it would be a cinch to get a "radio" merit badge. I didn't get it because I couldn't learn the code.

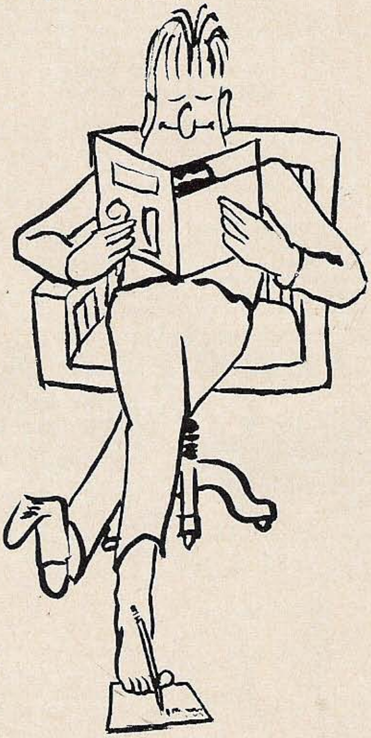
In high school, I joined a radio club that offered code lessons (1 hour a week). I thought "at last I'll get it." After one semester, I was advised by the instructor to give it up as I probably wouldn't make it and was holding up the rest of the group. Needless to say that by this time I was rather discouraged and believed that I would never be able to learn it.

Later when I entered the Air Corps my main desire was to become an aircraft radio operator. By that time I had progressed to building multistage receivers and test equipment, etc. I was given a chance to enter radio operators school. All I had to do was pass a simple test which consisted of signifying whether received signals were one, two, three, or four dots. The signal was sent and I was to indicate one, two, three, or four. I couldn't do it. No radio school for me! By then, I was really "brainwashed" and probably would have given up hope of ever becoming a ham. But, to my delight the Novice class was created with a 5 wpm code requirement. After several months of preparation, I somehow managed to pass and get a Novice

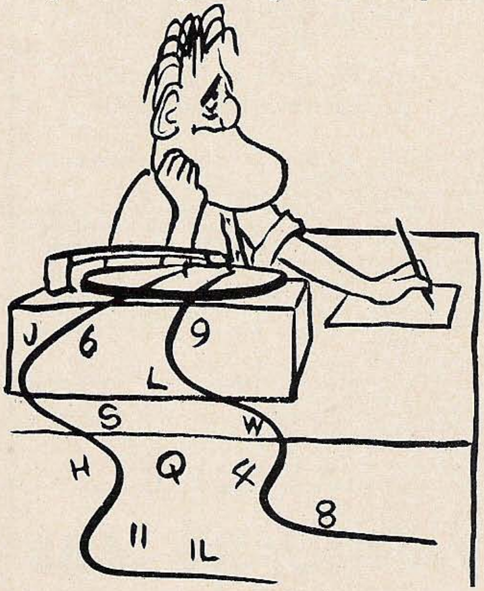
ticket. My first CW QSO ended in disaster. I called CQ and some other trusting Novice came back (I could recognize my call) but I never knew who he was because I couldn't even copy his call. Several more CQs furnished the same result. That was the end!

It would have remained the end except for the newly created Technician class. If you held a valid Novice ticket you only needed to take a General theory exam to qualify, which I did. At that time, 220 MHz and above were the only bands open to Techs. Later, when 6 meters was opened, I operated NBFM for 15 years or so. All this time I kept wishing I could get on 40 CW. By now I was 42 years old and thought "one more try!" I read all the articles on "how to learn the code," bought code records, etc., and once again set out for that elusive goal.

I set aside 15 or 20 minutes each evening and began. I soon realized that most code records were not what I needed as they progressed too fast. Next I began listening to the nightly W1AW code practice sessions. That is, when some "inconsiderate" wasn't giving them a bad time with QRM. That was the beginning. Two years later I managed to get up to the required 13 wpm and guess what? I passed the FCC exam on the first try! I now am active on 40 CW and have had many "successful" QSOs. I still listen to W1AW whenever I get a chance. I can now copy the 15 wpm text solid!



I still listen to W1AW once in a while and I copy it solid.



Most code records were just too fast for me.

I wish to say that the W1AW code practice sessions were invaluable. I'm sure I could not have done it without their help. I am also certain, however, that if I had help from another person who was also learning the code I would have progressed faster. I also wish to say that there is one series of code records known as the "word method" which I recently obtained from the local library. I'm sure they would have helped if I could have gotten them sooner.

My experience in this matter has convinced me that anyone who wants to can learn the code provided he is willing to exert a little effort and is not easily discouraged. Many times during the last two years I almost gave up but I did notice some gradual improvement and stuck with it.

. . .WØFEV

COVERING ADDITIONAL FREQUENCIES WITH DIPOLES

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Do you have a beam antenna and not know it?

If your major antenna problems are deciding whether your new rotary beam will be a yagi or a quad, or a multibander or a singlebander, this article is not for you. We are aiming at two groups of amateurs. Those in one group consider themselves lucky to have any antenna at all. Any antenna they put up must be simple, inexpensive, easy to erect, and hopefully a good radiator on a number of bands. Those in the other group are enthusiastic participants in amateur radio's favorite outdoor sport – experimenting with antennas.

A ½λ dipole, center fed with low-impedance transmission line is simple, inexpensive, is easy to erect, and it is an efficient radiator. Unfortunately, it is usually considered to be a singleband antenna. Before proving that this belief is not necessarily true, let us see how it acquired that reputation.

First, at its resonant frequency, the center impedance of a ½λ dipole has a purely resistive value of approximately 70Ω and closely matches standard 50 and 72Ω transmission lines. But when a dipole is operated off its resonant frequency, its center impedance becomes complex and no longer matches low-impedance lines. At its second harmonic, for example, the center impedance increases to well over 1 kΩ and is obviously a very large mismatch to a low-impedance line – as trying to operate such a 3.5 MHz dipole on the 7 MHz band quickly proves.

At the third-harmonic frequency of the dipole – so the theory goes – the feedline again "looks into" the center of a ½λ dipole (that has a ½λ dipole connected to each end) and again sees a low-impedance resistive load. At progressively higher harmonic frequencies, the center impedance of the dipole swings between a very high value on even harmonics to a low value on odd harmonics.

These facts prompt many amateurs to attempt to use their 7 MHz, low-impedance, center-fed dipoles on the 21 MHz band as third-harmonic dipoles. The usual results are that it is impossible or difficult to load the transmitter properly on 21 MHz, and the measured swr on the transmission line is high. But all is not lost. Once we learn why these antennas apparently defy basic antenna theory, we can use the knowledge to persuade many other dipoles to work efficiently on two or more amateur bands.

The basic problem is that, although radio waves travel through space at the velocity of light – roughly 186,000 miles or 300,000,000 meters per second – their velocity of propagation slows down on a conductor. Consequently, a ½λ (the distance a radio wave travels in the period of a half cycle) is measurably shorter on a conductor than in space. Worse, the speed and shortening effect varies from conductor to conductor.

In an antenna, for example, the amount of shortening depends on the ratio of its length to its diameter, – and, especially, the capacitance between its end sections and surrounding space. As a conventional antenna has only two ends, no matter what its length, a short antenna (measured in fractions of a wavelength) is shortened a greater percentage than a longer one.

The standard formula for calculating antenna lengths compensates for this variable factor. The formula for the length in feet is:

$$L = \frac{(492)(n-0.05)}{f} \quad (1)$$

where n equals the number of half-wavelengths in the antenna, and f is the frequency in megahertz.

When n = 1, (a ½λ dipole), the formula simplifies to:

$$L = \frac{468}{f} \quad (2)$$

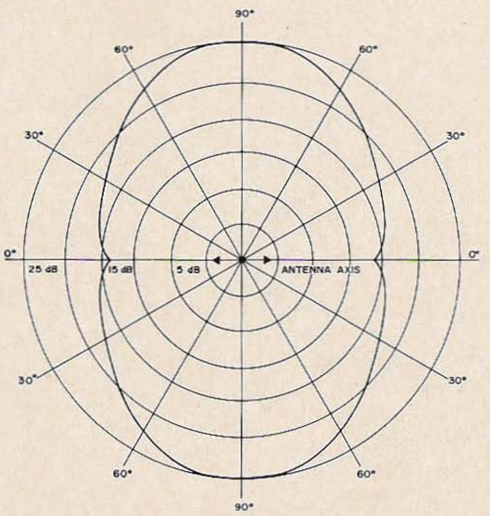


Fig. 1. ½λ antenna pattern

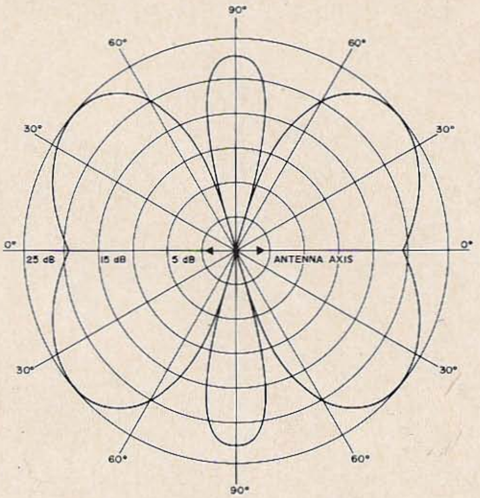


Fig. 2. 1½λ antenna radiation pattern

From either formula, the length of a ½λ antenna for 7.175 MHz (the center of the 7 MHz Novice band) is 65 ft, 2½ in. And Eq. 1 shows the length of a 1½λ antenna for 21.15 MHz in the 21 MHz Novice band to be 68 ft 7¼ in. Working the formulas backwards, the 7.175 MHz dipole has a third-harmonic resonant frequency of 22.25 MH z Conversely, the 21.15 MHz, 1½λ antenna resonates at 6.822 MHz as a ½λ antenna. Forwards or backwards, there is enough difference in the lengths of the antennas for an oversize yardstick.

These figures indicate why the average 7 MHz dipole does so poorly on the 21 MHz band. Being resonant far outside the high-frequency edge of the band is of minor importance as far as radiating efficiency is concerned. If we can get power into it, the antenna will radiate the power. Rather, the problem is that the off-resonant condition of the antenna produces such a high swr on the transmission line that the output circuits of most transmitters cannot compensate for the mismatch.

But if we increase the length of the antenna to make it resonant at the desired 21 MHz frequency, these problems disappear. In fact, the antenna should outperform a ½λ dipole for the same frequency, simply because a harmonically operated

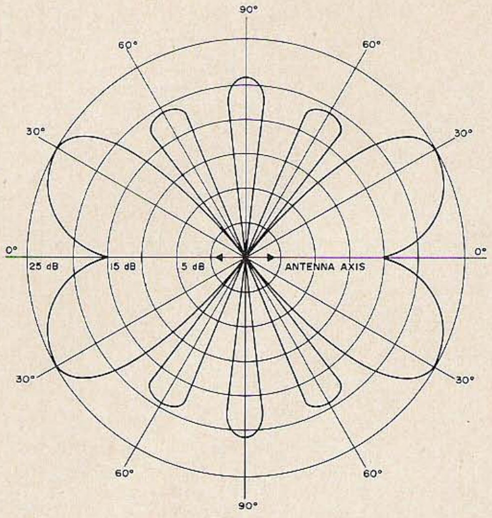


Fig. 3. 2½λ antenna radiation pattern

antenna exhibits gain in its favored directions over a ½λ dipole. While the gain of a ½λ antenna over a ½λ dipole is only 0.8 dB, it is enough to refute the belief of many amateurs that operating a low-frequency antenna on a higher-frequency band is an inefficient substitute for separate dipoles on each band.

At first glance, it may seem that increasing the antenna length for improved 21 MHz results is simply trading one set of problems for another. Certainly, the increased length resonates the antenna outside the low-frequency edge of the 7 MHz band. Fortunately, however, most transmitter output circuits have enough range on the 7 MHz band to compensate for the increased feedline swr at the operating frequency. And the mismatch is more acceptable on 7 MHz than on 21 MHz, because electrically a feedline of a given physical length is only a third as long is wavelengths on 7 MHz as it is on 21 MHz. Therefore, a particular value of swr increases the losses in the transmission line less on 7 MHz than on 21 MHz.

Moreover, if the antenna is an inverted V with the ends close enough to the ground to be reached without undue difficulty, its length can be adjusted for operation at the desired frequency on the 7 MHz band, and extensions approximately 20 in. long may be clipped to its ends for 21 MHz operation. The extensions may be allowed to drop vertically from the ends of the antenna.

Other antennas and other bands. Plugging the appropriate figures into the formulas will show that a ½λ dipole for 3.925 MHz (119 ft, 3 in.) will also resonate as a 3½λ dipole near 28.73 MHz. Other figures show that a 116-footer resonates near 4 MHz as a ½λ dipole and near 21 MHz as a 2½λ antenna. This pair of frequencies will not "turn on" many amateurs, but it might interest some MARS members. Also, if the ends of the antenna can be reached from the ground, butting it for 2½λ resonance in the 21 MHz band will permit clipping extensions to its ends for operation in the 3.5 and 28 MHz bands.

The possibilities: A Novice might cut his dipole for 2½λ resonance near 21.15 MHz and use 6½ ft extensions to reach 3.725 MHz. A General class phone operator, on the other hand, might select a length of 114 ft for 2½λ resonance near 21.36 MHz and 2½ ft extensions for operation in the 3.8 and 28 MHz bands. A third possibility is a 1½λ antenna for around 14.3 MHz (101 ft 6 in.). A couple of clip-on extensions at each end will permit operating on the 3.5, 21, and 28 MHz bands.

If you really want to think "big," a 3.7

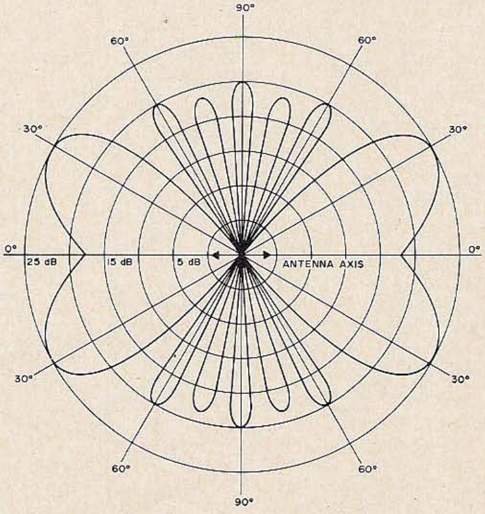
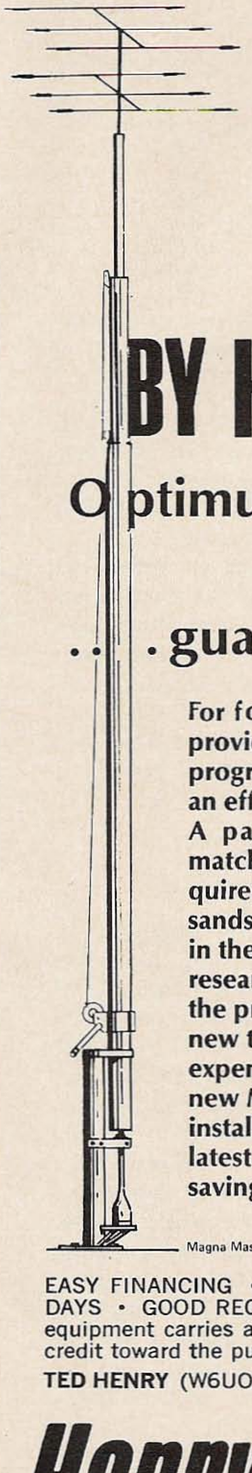


Fig. 4. 3½λ antenna radiation pattern



Magna Mast illustrated

MHz Novice band antenna will resonate as an 18½λ antenna near 145 MHz. It will radiate its best signal on that frequency in lobes centered at approximately 18 degrees off the axis of the antenna. And it has a power gain approaching 10 dB over a ½λ dipole.

Figures 1 through 4 show the directional patterns of ½-, 1½, 2½, and 3½λ antennas. And Table I gives the gain in decibels and other information on selected antennas. As the diagrams indicate, the length of an antenna in half-wavelengths determines it number of lobes of radiation. One ½λ: one lobe; three ½λ: three lobes, etc.

A ½λ dipole's single lobe of radiation (per side) is at 90 degrees to the antenna axis, and its minimum signal is radiated off the ends of the antenna. Distance, frequency, and other factors determine the exact shape of the radiation pattern of any antenna. For a ½λ dipole, however, the difference between the points of maximum and minimum radiation averages a bit under 6 dB on the 3.5 MHz band and between 12 and 20 dB above 14 MHz.

In antennas longer than a ½λ, the major lobe of radiation in each quadrant of the antenna is the lobe that makes the smallest angle with the axis of the antenna, and the minor lobes fill in the other directions. Thus, the major lobes of a 1½λ antenna occur at 42 degrees off the ends, and its minor lobe is at 90 degrees. This lobe is only slightly weaker than the major lobes; therefore (except for the indicated sharp nulls), it has an almost omnidirectional radiation pattern. But as the antennas become longer, their major lobes stretch out and become narrower. Consequently, they become hot performers in the directions of their major lobes and fair performers off their minor lobes.

Feedline SWR. As shown in Table I, the radiation resistance of long-wire antennas increases from about 70Ω for a ½λ antenna to approximately 150Ω for a 6½λ antenna. (The 18½λ antenna mentioned above has an indicated radiation resistance of 165Ω.) Assuming a 75Ω transmission line, the line swr should not exceed 2:1 at antenna

Table I.

Performance Data for Various Dipole Lengths

Length λ	Gain dB	Radiation α, deg*	Radiation Resistance,* Ω
½	0	90	70
3/2	0.8	42 & 90	110
5/2	1.8	31	120
7/2	2.3	26	130
9/2	3.5	22	138
11/2	4.25	21	145
13/2	5	20	150

*With reference to axis of antenna

resonance for antennas up to 6½λ long. Under these conditions, a random-length transmission line could present either a resistive or a reactive load of up to 150Ω to the transmitter output circuit.

Not all transmitter output circuits can successfully handle complex impedances over 100Ω. But, by making the line length an odd number of electrical quarter-waves at the highest frequency – where the antenna impedance is highest – the transformer action of the transmission line will transpose the high impedance to a low impedance at the transmitter.

Use the formula

$$L = \frac{246\nu}{f} \qquad (3)$$

to determine the physical length of an electrical ¼λ of transmission line. The velocity factor (ν) is 0.66 for conventional "RG" coaxial cable, 0.80 for polyfoam, and 0.71 for kilowatt 75Ω twinlead (*Amphenol* 214-023 or *Belden* 8210). Assuming RG-11/U cable and a frequency of 21.3 MHz, the lnegth is 7 1/3 ft.

Now estimate the length of transmission line required to reach from the antenna to the transmitter. Divide this length by the length calculated above. Choose the nearest odd whole number equal to or greater than the result of the division. For example, if the distance from the antenna to the transmitter is 50 ft, an actual feedline length of 51 1/3 ft (seven electrical quarter-waves).

Who said a ½λ dipole fed with low-impedance cable is a singleband antenna?

W9EGQ■

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WEATHER BALLOON VERTICALS

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With a CW DX contest coming up, I wanted to have a really effective antenna system for 80 and 40 meters. As my backyard is not very large, it was obvious that a vertical antenna of some type was needed. I was reading through back issues of 73 and other magazines getting ideas on antenna designs, when I found an interesting article on theoretical performance of 5/8 wavelength verticals, which supposedly would give maximum lowest-angle radiation on the first major lobe of radiation.

This was just what I needed. The article went on to state that if the antenna wavelength was increased any further than 5/8 wavelength, the major radiation lobe would begin to decrease in strength, although it would give a still lower radiation angle. I decided to shoot for the 5/8 wavelength goal, as this would give approximately 14-degree vertical radiation, very useful for DX.

I purchased an 8 ft diameter weather balloon from Edmund Scientific Co., 150 Edscorp Building, Barrington NJ 08007, for $2 postpaid. It's made of Neoprene and holds helium very well.

I bought a small cannister of helium. Don't forget to obtain a suitable fitting for the nozzle opening. The welder threw in a fitting with my helium, provided that I return it with the empty cannister.

My neighbor, WB4NFX, opened the cannister valve with a wrench while I held the balloon tight around the fitting. We filled it slowly, making sure no gas was escaping. At 3½ ft diameter, the cannister was empty, but the balloon was floating! We tied the balloon neck with heavy string in two places, as shown in Fig. 1. Watch your ceiling! Mine is made of a rough-finish plaster with sharp projections protruding perilously. No accidents here, though.

I measured 162 ft of wire. I tied one end to the balloon, the other to an insulator anchored to a 5 lb brick. The antenna wire was fed to the center conductor of RG–58/U coax, the coax shield

Balloon dia, ft.	Gas vol, cu. ft.	Lift power, lb (with He at 32° F)	Lift power, lb (with He at 70° F)
2	4	1/4	1/4
3	14	1	3/4
4	33	2	2
5	65	4	4
6	113	7	7
7	180	12	11
8	268	18	17
9	381	26	24
10	523	36	33
11	696	48	44
12	904	62	58
13	1150	79	73
14	1436	99	92
15	1767	122	113
16	2144	148	137

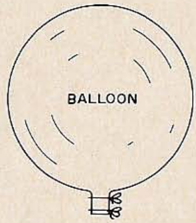


Fig. 1. Balloon lift and helium fill requirements. Note string is tied twice on balloon neck.

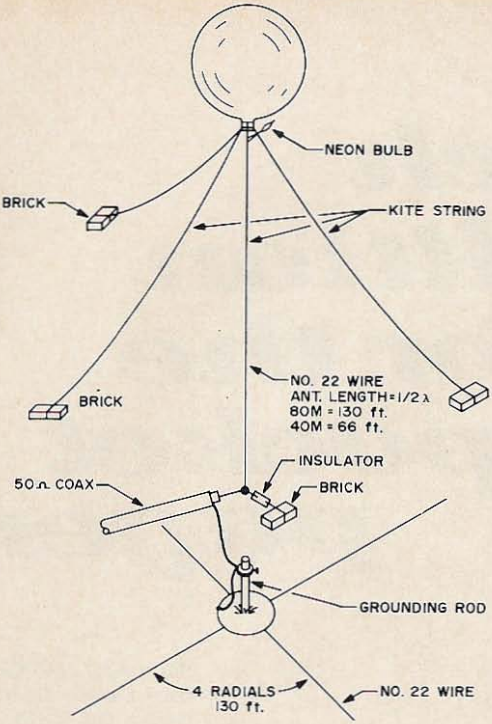


Fig. 2. Kite-string "guys" will hold balloon well even in wind. Be sure to ground the coax lead to an earthrod.

connected to a rod driven into the ground beside the brick, four 130 ft radials were connected to the ground rod and left lying on the ground, each radial 90 degrees apart. (See Fig. 2.)

With this 5/8 wavelength vertical, a matching network is necessary, so I jury-rigged a tuner with some B & W coilstock and a transmitting-type variable capacitor. Tapping off turns on the coilstock with alligator clips, we obtained our lowest swr, which was about 4:1! Band: 80m.

We had a QSO on CW with W6EAC in San Mateo, who gave us an RST of 559! It was obvious that the Apache's 180W just wasn't doing its thing for us.

Recalling in some gray matter that a half-wave vertical offers a better match to 50Ω coax, I hurriedly ran out into the backyard with a tape measure and cut off 32 ft of the wire. Don't forget to hold the balloon! Back in the shack, we removed the tuner and connected the coax directly to the transmitter's SO-239 connector. We tuned up and called W6EAC again on 80m. RST was 589 and peaking 599 through the QSB!

At the end of our QSO, the plate current went wild. Running out back again (I was huffing and puffing by this time), I was amazed to see that the balloon was at 2000 ft and still rising, trailing 100 ft of wire!

I made the mistake of using 30-gage wire, and the rf burned the wire in two!

Another balloon and another cannister of helium later, we prepared a second antenna. Again, WB4NFX opened the cannister as I held the balloon tight against the fitting. Using 22-gage wire this time, *and a* ball of kite string as a safety measure, the balloon went up without a hitch. An NE-2 neon bulb was attached to the wire just under the balloon and would tell me if the wire burnt up again. 130 ft of wire was used, which is a half-wavelength on 80m.

The same antenna was used on 40m, also with good results. However, bear in mind that 130 ft of wire is one wavelength on 40m, and the major lobe of radiation has decreased in power – 66 ft of wire would have given better results on 40.

The helium balloon will remain aloft for 2–3 days. Three kite-string "guy wires" would hold such a balloon in a fixed position in wind. Most ham "contests" last only 48 hours, so the balloons should be filled just before the start of an event.

In the VP7AS pileup on 40m, I only had to wait once before he answered my call. In previous pileups, I've waited a BUNCH! When I reduced power from 180W to 35W, my RST changed from 589 to 579.

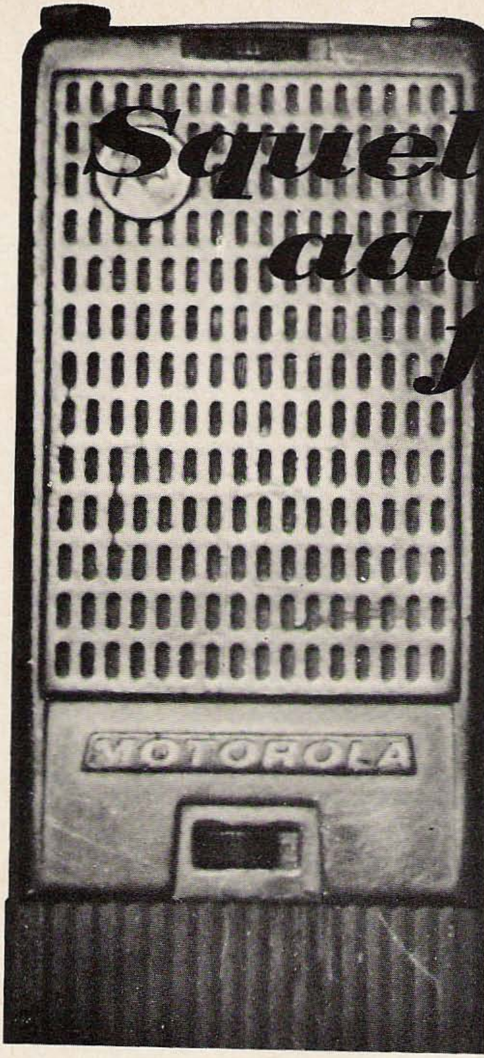
All QSOs were made with 180W input. I've often wondered what a kW would do to signal reports.

The following chart will give you an idea of the helium required, balloon diameters, and lifting characteristics.

K4EPI will use balloon verticals in future contests. These will be mainly on 80 and 40m. A half-wave balloon vertical on 160m has not been tried, but should perform better than a dipole. Perhaps this is all W1BB needs to get that 100th country on 160!

...K4EPI■

Squelch addition for the pocket pager



Bill Mengel WA8PIA
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Dayton OH 45415

The Motorola VHF pocket pager is a completely self-contained FM receiver operating in the 136–174 MHz band. If it were not for the fact that it had to be keyed by a tone to denote the presence of a carrier or that it had to have its push-to-listen button constantly depressed in order to hear anything, it would make an ideal monitor receiver adaptable to amateur use on 2 meters, or for eavesdropping on the 150 MHz public service band. The main objective of this article is to remove the tone circuitry and to replace it with a squelch that can be triggered with the presence of an rf signal tuned to the frequency of the pager.

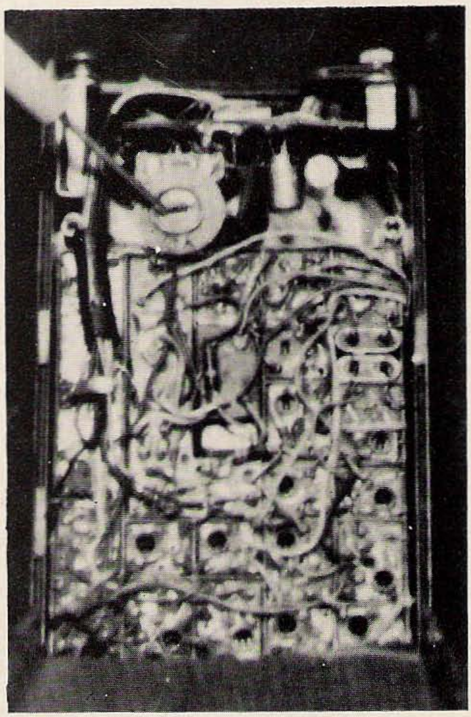


Photo showing location of squelch control inside of pager housing.

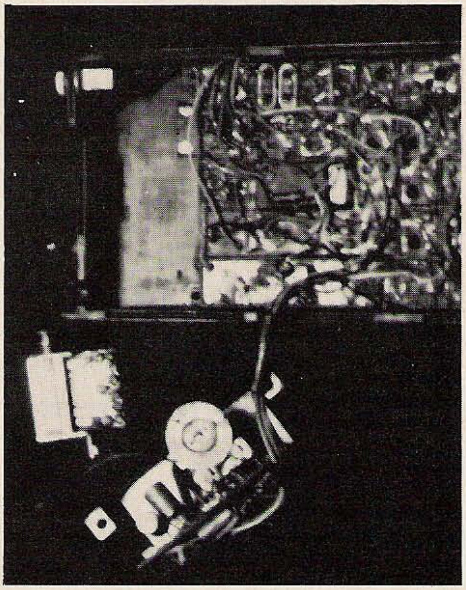


Photo showing squelch board and push-to-listen switch removed from pager.

It is not too difficult to remove the tone circuitry and to enable the receiver to work all the time; but the noise present when a carrier is absent may prove to be very annoying. By adding a squelch to the pocket pager, the receiver will remain silent until there is an rf carrier present to trigger it on.

Before proceeding to modify the pocket pager, the operation of a noise squelch should be discussed. First of all, the squelch circuit I have used has three basic stages: filter network, two-stage amplifier, and a switching transistor.

With no rf carrier present, the rushing sound coming from an unsquelched receiver is known as air noise. What is

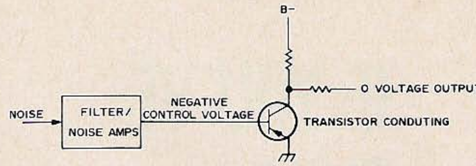


Fig. 1. Squelch operation without carrier.

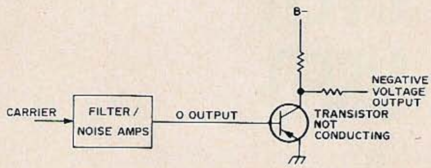


Fig. 2. Squelch operation with carrier.

accomplished is that the noise is filtered, amplified to a usable level, and used to control the squelch switching transistor. (See Fig. 1.)

With no signal present, all the pager will receive is noise. This noise is picked up by

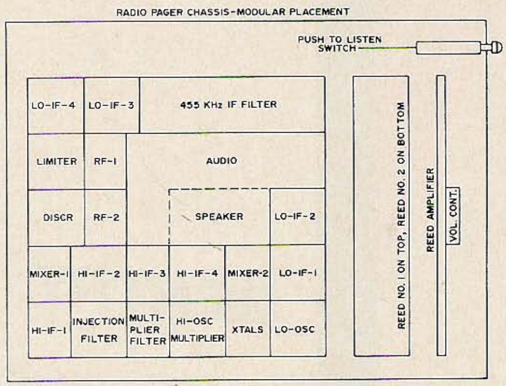


Fig. 3. Layout diagram showing location of pager components and stages.

the filter and coupled to the noise amplifiers. After amplification, the noise is a negative-going signal. This negative signal is then applied to the base of a switching

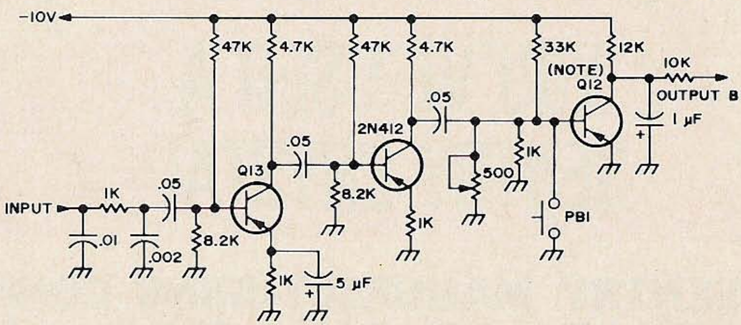


Fig. 4. Schematic diagram of noise-actuated squelch unit.

transistor which will place the transistor into a state of conduction.

In the presence of an rf signal such as is represented in Fig. 2, there is no output from the noise amplifiers. This zero potential when applied to the base of the switching transistor will do nothing, and the transistor will cease to conduct.

The first stages of modification will concentrate in the removal of the tone and push-to-listen circuitry from the reed amplifier board. By following the instructions step by step, no difficulties should be encountered and a very neat modification should be the result, leaving plenty of room in the crowded chassis to incorporate a squelch. Before proceeding in the removal of the tone circuitry, I might point out that only certain parts are going to be removed; so don't get carried away removing all the components. Refer to Fig. 3 during the removal of the circuitry.

Steps required for removal of tone and push-to-listen circuitry.

1. Remove reed amplifier board, reed 1, and reed 2 from unit, leaving wires intact.
2. Disconnect wires on four solder lugs of reed 1, reed 2; set reed relays aside.
3. Remove orange and green wires interconnecting reed 1 to reed 2 and set aside.
5. Remove metal mounting bracket on reed amplifier board and temporarily set aside.
6. Unsolder the orange, yellow, and brown wires from reed amplifier board that previously went to reed relay and set aside.
7. Remove tape and cable restraints from push-to-listen switch.
8. Unsolder red and brown wires from push-to-listen switch.
9. Cut brown wire that previously went to push-to-listen switch about 1½ in. away from its soldered connection on the audio board.
10. Unsolder red wire going to the audio board previously connected to the push-to-listen switch.
11. Solder loose end of 1½ in. brown wire of step 9 to terminal on audio board where red wire was just unsoldered in step 10.
12. Unsolder gray wire from push-to-listen switch and cut 1 in. from terminal on audio board.
13. Remove the white wire with brown tracer, the white wire with green tracer, the white wire with red tracer, the white wire with blue tracer, and the yellow, blue and white wires from the push-to-listen switch.
14. Unsolder white wire with brown tracer from terminal on audio board, set aside, and solder the 1 in. gray wire in step 12 to that terminal.
15. Unsolder other end of white wire with green tracer of step 13 from terminal on audio board and set aside.
16. Remove knob from volume control.
17. Take 5½ in. piece of yellow wire previously used with reed relay. Remove yellow wire from terminal on audio board that previously went to push-to-listen switch and solder 5½ in. yellow wire in its place.
18. Unsolder blue wire going to volume control on reed amplifier board and set aside.
19. Solder other end of 5½ in. yellow wire used in step 17 to terminal where blue wire in step 18 had previously been soldered.
20. Cut wire with blue tracer ½ in. from terminal on audio board.
21. Cut white wire with red tracer ¾ in. from terminal on audio board.
22. Unsolder white wire that previously went to the push-to-listen switch from speaker terminal board.
23. Solder ½ in. white wire with blue tracer and ¾ in. white wire in step 22 was previously connected.

At this point, the VHF pocket pager is operative and any carrier tuned to the frequency of the pager will be heard without the need of a tone signal or of having to depress the push-to-listen button.

With the reed relays and some of its associated wiring removed, there is sufficient room to construct the squelch (Fig. 4). The complete squelch, including the potentiometer, is constructed on the reed amplifier board. Figures 5 and 6 show a phantom view of the reed amplifier board and parts placement before and after modification.

Steps required for addition of noise operated squelch.

1. Remove R47 (100) and replace with a 1 kΩ resistor and a 5 μF capacitor.
2. Remove R44 (10K) and RT1 (10 kΩ) and replace with an 8.2 kΩ resistor.
3. Remove C49 2 μF electrolytic.
4. Parallel R42 (1 kΩ) with the 500Ω potentiometer.
5. Remove R43 (4.7 kΩ.
6. Disconnect the base and the emitter of transistor Q12. Connect the base where the emitter was previously located and connect the emitter to ground.
7. Remove CR6.
8. Remove CR8 and replace with .002 μF capacitor.
9. Remove R64 (15 kΩ).
10. Remove R63 (220 kΩ) and replace with an 8.2 kΩ resistor.
11. Remove C53 (1 μF) and replace with a 1 kΩ resistor.
12. Remove C51 (1 μF) and C52 (1 μF).
13. Place .01 capacitor between emitter of 011 and ground.
14. Place 1 kΩ resistor between emitter of Q11 and junction of C71 (.05) and C3 (.002).
15. Remove R46 (82 kΩ).
16. Remove CR5 and replace with a 4.7 kΩ resistor.
17. Remove R48 (1 kΩ).
18. Place 2 wires (5 in. long) to two normally open contacts of the push-to-listen switch. Connect one of those wires to ground and connect the other wire to the base of Q12.
19. Insert C6 (1 μF) from collector of Q12 to ground. Connect positive end to ground.

20. Remove C72 (2 μF), R67 (27 kΩ), and R68 (22 kΩ) from the audio board.
21. Insert a 4½ in. piece of wire between point B on the reed amplifier board and point A on the audio board. (See Fig. 6).
22. The following parts and jumper wire should now be inserted as per Fig. 6.

Q20-2N412	R6-47 kΩ	R10-10 kΩ
C1-.01	R8-33 kΩ	R11-4.7 kΩ
C5-.05	R9-12 k	R14-47 kΩ

On completion of all these steps, the unit is ready to be put back together. After the push-to-listen button and the reed amplifier board are reinserted, the squelch control can be set to eliminate any noise present in the absence of a carrier. The push-to-listen button is now a squelch-defeat button. At this point, the back can be secured and the squelch modification for the pocket pager is completed.

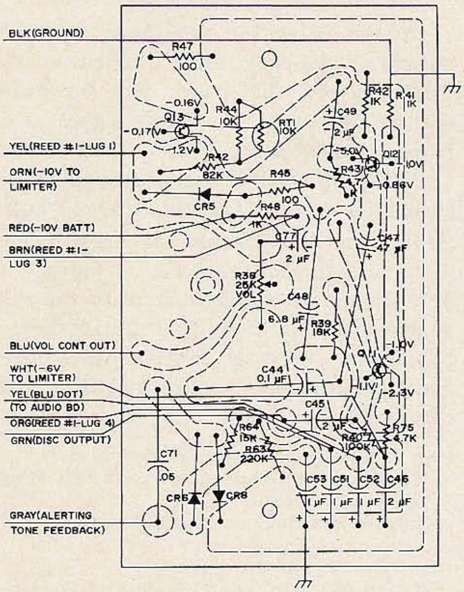


Fig. 5. Phantom view of copper side of reed amplifier board showing parts location before modification.

Here is some crystal correlation data used for changing the frequency of the pager. The recommended alignment tool for adjusting the transformers is either the Motorola type NLN6127A/NK111 or the more readily available GC9440. The crystal closest to the reed amplifier board is the intermediate frequency crystal Y2.

If the intermediate crystal Y2 is 11.545 MHz, the i-f is 12 MHz, and the high oscillator crystal calls for a Motorola type YM-29.

If the intermediate crystal Y2 is 11.245 or 12.155 MHz, then the i-f (f_i) is 11.7 MHz and the high oscillator crystal should be a Motorola type YM-35. The formula used for determining the frequency of the high oscillator crystal Y1 is as follows:

$$f_{Y1} = \frac{f_o - f_i}{3}$$

Where: f_{Y1} = Crystal Frequency
f_o = Frequency of operation
f_i = Intermediate frequency

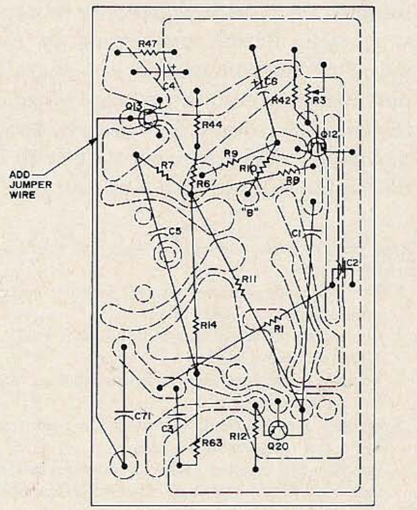


Fig. 6. Phantom view of copper side of reed amplifier board showing location of squelch after modification.

This pager (Newsome Electronics, $34.95), when properly adjusted, should operate superior to any other type of VHF pocket receiver available at this price. In strong reception areas the built-in antenna of the pager should be adequately sufficient. To increase reception, simply plug an 18 in. whip into the antenna jack. Whether the Motorola pocket pager is used for listening on the 2 meter ham band or for eavesdropping on the public service band, it ought to be good for many hours of enjoyment. . . .WA8PIA■

The 2N412/HEP 3 ($1.25) is available from Circuit Specialists Co., Box 3047, Scottsdale AZ 85257. Please include 25¢ for shipping.

Paul Snyder WA3HWI/3
900 Valley Road
Philadelphia PA 19126

VFOing the Twoer

Many of us 2 meter QRP diehards are using the Heathkit Twoer, a little 5W transceiver. Aside from 100 kHz receiver selectivity, we also wish for vfo control. Thank your local apostle, here's how.

Step 1: Get a vfo. This isn't too hard; the Knight V-107 vfo is perfect. Its output is about 15V, just fine for the Twoer. Build a separate power source supplying all the voltages that it needs.

I'm using the Heath HG-10B vfo. A few modifications are necessary. In the Twoer, add a .001 μF 1 kV capacitor from pin 8 of V5A to ground, and change R2 from 22 kΩ to about 18 kΩ. Now the tube is an amplifier for the vfo instead of an oscillator. The vfo input goes directly into the pin 7 side of the crystal socket.

In the HG-10B, connect a shorting wire across the 10 kΩ, 10W resistor, and change the OB2 to an OA2 or OD3A. Build a separate power supply, with a filtered 175V dc, at about 30 mA, 6.3V ac or dc at 1A, and -70V bias, as shown in Fig. 1. The bias is connected via the green wire of the HG-10B. On terminal strip A, disconnect the green wire from terminal two and solder it onto terminal three. Remove the jumper on the key jack, between terminals two and three.

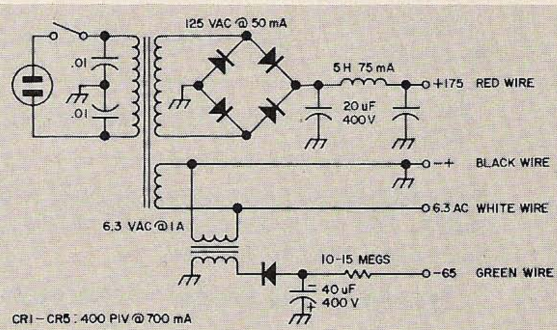


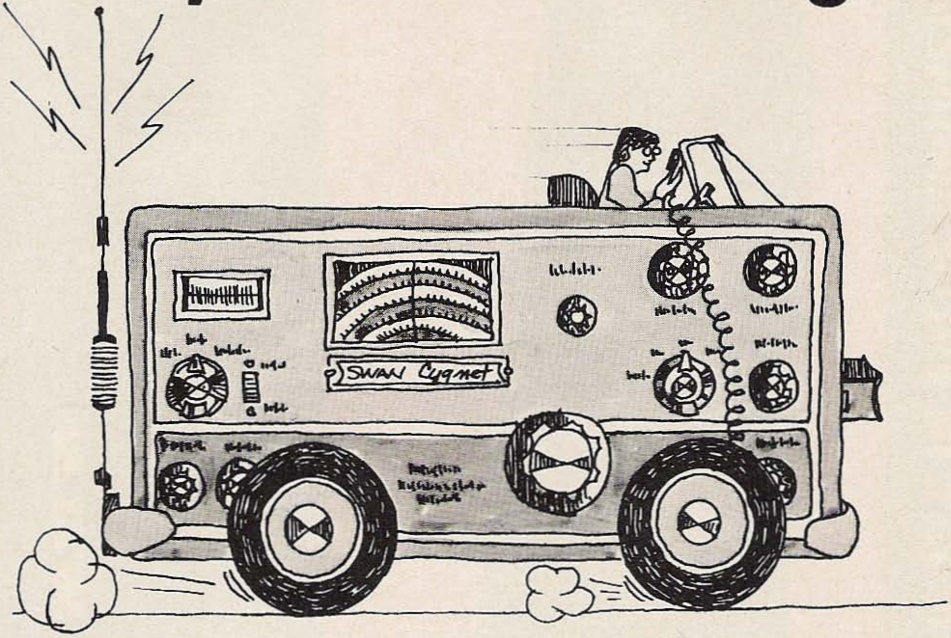
Fig. 1. Schematic

The second wish is to increase the selectivity of the Twoer. Simply change R10 to anywhere between 20 and 30 MΩ. (It's the one mounted on that big coil in the center.) This will change the calibration but not the sensitivity of the receiver.

My thanks to W. J. Remer K8GND, of the Heathkit technical staff, for his help in the modification of my Twoer.

. . .WA3HWI■

the perfect mobile rig...



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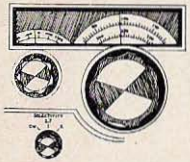
600R RECEIVER SPECIFICATIONS:

SSB, AM, CW superheterodyne receiver.

FREQUENCY RANGE with built-in tuning system:
3.4 to 4.4mc, 6.7 to 7.7mc, 13.8 to 14.8mc, 20.9 to 21.9mc, 27.5 to 30mc.
With external tuner, Model 330: General coverage from 3 to 30mc.
With external crystal oscillator, Model 510X: 3 to 24mc, 10 crystal positions. These external oscillators plug directly into the 600R.

TUNING SYSTEM: The lower bands, 80 through 15 meters, are covered in 200 kc segments. 10 meters is covered in 500 kc segments. 100 kc and 25 kc crystal calibrator markers provide for highly accurate frequency readout on a large, easy to interpret dial.



Ultra smooth vernier tuning with large knobs gives you the incomparable feel of a Swan tuning system.

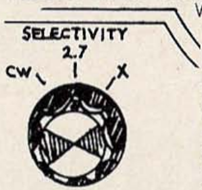
SENSITIVITY: Superior front end design gives you 1/4 microvolt sensitivity for 10 db signal plus noise to noise ratio at 50 ohms input impedance. At the same time, front end overload, cross modulation, image, and spurious responses have been reduced to "state-of-the-art" minimums.

R.F. SELECTIVITY: Antenna tuning circuitry in the 600R front-end provides continuous coverage from 3 to 30 mc. This is accomplished in 5 frequency ranges selected by the band switch: 3 to 5.5 mc, 5.5 to 10 mc, 10 to 16 mc, 16 to 24 mc, and 24 to 30 mc.

Reception outside the normal VFO range of the receiver requires an external oscillator which can be the Swan 510X crystal controlled oscillator, or the Model 330 general coverage tuner. Either of these external oscillators plugs directly into the 600R.

Image rejection is a minimum of 55 db at 30 mc, increasing to better than 75 db at 3 mc.

I.F. SELECTIVITY: Swan's standard crystal lattice filter with 2.7 kc bandwidth, 1.7 shape factor, and ultimate rejection in excess of 100 db makes the 600R's selectivity superior to any other production receiver on the market.



With installation of the optional 16 pole crystal lattice filter (SS-16B), the 600R offers selectivity that far exceeds any receiver, at any price, anywhere! Selectivity then becomes truly incredible, with a shape factor of 1.28 and ultimate rejection exceeding 140 db.

Two additional crystal lattice filter options are available: One is a narrow band CW filter, the other is a broad band AM filter. There are provisions in the 600R for the installation of up to 3 filters, with front panel selection.

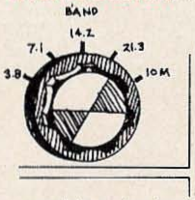
A.F. SELECTIVITY: Audio response of the 600R is 300 to 3000 cycles, ± 3 db, with 3 watts output to a 4 ohm external speaker. Headphone jack is provided with the speaker accessory unit.

An optional IC Audio Filter accessory is available for installation in the 600R. It provides a choice of either notching or peaking a selected audio frequency, and greatly enhances both phone and CW reception.

I.F. NOISE BLANKER: (optional) Installs inside 600R. Extremely effective in suppressing impulse noises such as auto ignition interference.

EXCLUSIVE SINGLE CONVERSION DESIGN: with fewer spurious responses than multi-conversion designs.

HYBRID DESIGN: 7 tubes, 8 transistors, 12 diodes. Transistors used where they provide definite advantage. Tubes used where they still provide superior performance.



FULLY COMPATIBLE WITH 600T: providing for transceiver operation as well as separate frequency control. Also CW sidetone and genuine CW break-in operation.

BUILT-IN AC POWER SUPPLY: for 117 volts, 50-60 cycles.

DIMENSIONS: 15" wide × 6½" high × 12" deep. Weight: 23 lbs.

600R with standard 2.7 kc crystal lattice filter, less speaker **$395***

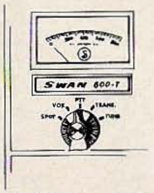
600R Custom with SS-16B super selective filter, I.F.Noise Blanker, and IC Audio Filter factory installed. Less speaker **$560***

600T TRANSMITTER SPECIFICATIONS:

FREQUENCY RANGE: Full coverage of 10, 15, 20, 40 and 80 meters. Extended frequency coverage for MARS operation with plug-in crystal oscillator accessory, Model 510X.

TUNING: Internal VFO system is identical to that used in the 600R.

POWER RATING: 600 watts P.E.P. with a pair of 6KD6 power tubes. 500 watts CW, 150 watts AM, 100 watts continuous RTTY/SSTV.



Pi-Network output for 50 or 75 ohm coax.

Suppression: Carrier 60 db down, unwanted sideband 50 db, third order distortion approx. 30 db.

Audio response: ± 3 db from 300 to 3000 cycles.

CW Keying: Grid block, full break-in system. Includes sidetone to receiver.

INTERNAL POWER SUPPLY for 117 volts, 50-60 cycles.

DIMENSIONS: 15" wide × 6½" high × 12" deep. Weight: 32 lbs. **$495***

ACCESSORIES:

STANDARD SPEAKER
Has tone switch and headphone jack **$18***

DELUXE SPEAKER (illustrated)
Includes Swan phone patch, tone switch and headphone jack **$59***

I.F. NOISE BLANKER
Installs internally in 600R............ **$79***

IC AUDIO FILTER
Installs internally in 600R............ **$44***

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SS-16B Super Selective 16 pole.... **$75***

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SWAN DESK MIKE Model 444 ..... **$25***

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Transmitter Tuning of Mobile Antennas

A method is presented for utilizing the high Q loading inductor of a low frequency mobile whip as part of the transmitter output circuit to permit wideband operation of a short mobile antenna. The simple modifications necessary to typical transmitter output circuits are illustrated by several circuit diagrams.

The usual approach to low-frequency mobile antenna construction is illustrated in **Fig. 1A**. A short whip antenna is used which is either base or center loaded so that the antenna has an effective electrical length of ¼λ and can be directly connected to a non-resonant coaxial transmission line. In order to reduce ohmic losses in the loading inductor, its "Q" is made as high as possible. The high "Q" results in greater radiation efficiency due to the reduced I^2R loss but it also results in a very restricted bandwidth for the antenna – 10 to 20 kHz being typical for many 80 meter mobile whips. Whenever one wishes to change the transmitter frequency to any great degree, it is necessary to readjust either the loading inductor on the antenna or the length of the whip antenna itself.

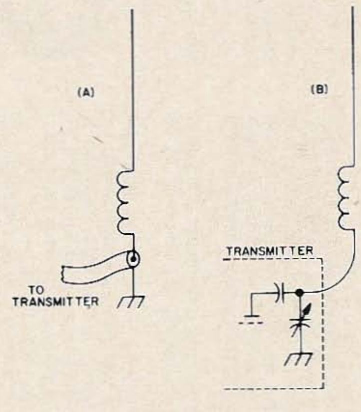


Fig. 1. Usual base or center loaded whip antenna which utilizes a non-resonant transmission line (A). Concept of using the high Q loading coil directly as part of the transmitter tank circuit.

It should be recognized that even with high-Q loading inductors, the radiation efficiency of an 8 ft whip on a low-frequency band is a matter of a few percent. No manner of loading inductor is going to make an 8 ft whip radiate like a 60 ft whip unless the losses in the loading inductor can be reduced to zero, a condition only possible if the *resistance* of the loading inductor can be reduced to *absolute* zero. The restricted bandwidth of low-frequency whip antennas is due to the fact that it is desired to have them self-resonant and operate into a non-resonant transmission line. This concept has no real basis as far as improving the radiation efficiency of an antenna in a low-frequency mobile installation and simply imposes a severe bandwidth restriction upon the operation of the mobile installation.

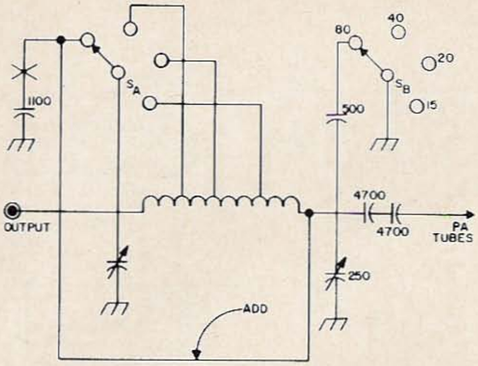


Fig. 2. Simple tank circuit switching connections changes necessary to bypass pi-network coil on 80 meters only. Circuit shown is for SB-34 but typical of a wide variety of transceivers.

Non-Resonant Loaded Whips

If one considers the loading inductor used either at the base or center of a whip as necessary to increase the effective electrical length of the antenna to the point where the antenna system can resonate at a given frequency, there is no theoretical reason why this resonant circuit cannot simultaneously act as both the resonant output circuit for a transmitter and as the radiating medium or antenna for the transmitter. This concept is illustrated in **Fig. 1B**. The line section between the whip and transmitter also becomes part of the radiating antenna.

This idea is not really new and, indeed, in basic concept goes back to the earliest days of radio. Some readers will immediately relive some of the nightmares of harmonic radiation and interference that were present using AM transmitters with class C output stages when they look at **Fig. 1B**. However, several factors have changed which make the scheme much more practical now, mainly the use of linear output stages and the high Q of most loading inductors. The scheme is certainly not recommended for fixed station usage in a location where TVI is a problem already, since the output is not filtered and harmonic reduction is mainly a function of that provided by the single tuned circuit which is involved. However, for mobile use, the scheme does have particular appeal; although the possibility ignored. Mobile operation is often conducted remote from housing areas and the approximate 30 – 40 dB second harmonic attenuation provided by most good loading coils tuned as shown suffices with low power transmitters to avoid any interference problem. This is especially true for mobile operation on 80 meters.

Practical Considerations

When the scheme of **Fig. 1B** is used, only the variable capacitor in the transmitter need be adjusted for wide frequency excursions once the loading inductor and capacitor values have been balanced to provide proper transmitter loading. This adjustment is described in more detail later, but in most cases, the adjustment range required is within the existing range of the component values of the variable plate tuning capacitor within the transmitter and of the whip loading inductor. No component modifications need be made in most cases.

One area that does require some minor modification, however, is the line between the whip antenna base and the transmitter. Since the line becomes part of the antenna circuit, it will radiate and, also, it will carry the greatest portion of the antenna current. The radiation that takes place from this line where it runs in the automobile is, of course, shielded by the automobile body and lost. However, as was mentioned before, the radiation efficiency of a loaded

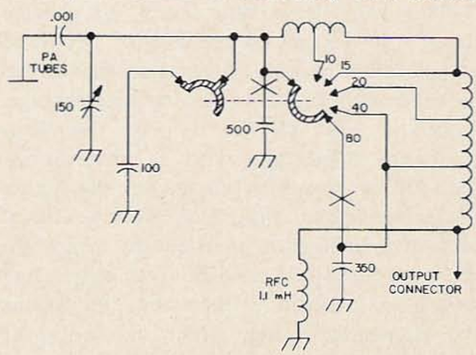


Fig. 3. Pi-network circuits employing continuous shorting type switches may be slightly more difficult to modify. The output circuit of the Heath HA-14 linear is shown. Although the switching arrangement shown may appear correct, it actually has several faults. See Fig. 4.

low-frequency whip is only several percent anyway and the additional radiation lost is not significant in most practical situations. It certainly is a small price to pay for the ability to tune a mobile rig freely across major portions of a band. Nonetheless, the line should be kept as short as possible.

Because of the heavy current that flows in the line, it should be made from heavy wire—and not just the inner conductor of a small coaxial cable. Heavy battery cable of the type with a thick covering, in order to provide the necessary voltage insulation, or the inner conductor and dielectric of a really heavy coaxial cable (shield removed) such as RG 14/U or a larger cable should be used.

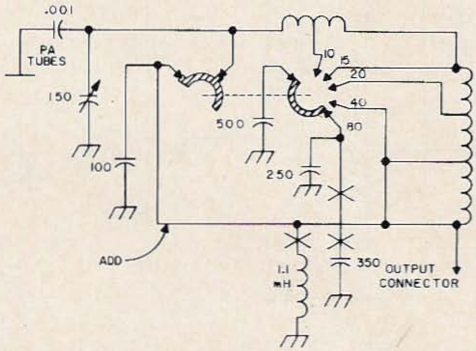


Fig. 4. Although an extra component must be used, this modification to the HA-14 output circuit provides a far better switching arrangement than that shown in Fig. 3.

Output Circuit Modifications

If a multiband transceiver is used for mobile operation, it may be found advantageous to use the method described for mobile antenna coupling on 80 meters, or both 80 and 40 meters, and a conventional loaded mobile antenna feed by a coaxial transmission line on the higher frequency bands. This situation occurs since the radiating portion of the feedline which is enclosed within the automobile increases in terms of wavelength with higher frequency and the losses encountered with the antenna coupling method of **Fig. 1B** exceed those of the method illustrated in **Fig. 1A**.

Therefore, it is very handy to provide some modification to the output circuit of a transceiver or transmitter such that it can be used with the antenna coupling arrangement of **Fig. 1B** on one or two low-frequency bands and with a conventional, unmodified coupling scheme on the higher frequency bands. **Figs. 2–4** show details of various modification methods to typical pi-network output circuits. The only other switching involved is then that concerning the transmission line which can be done manually or with relays.

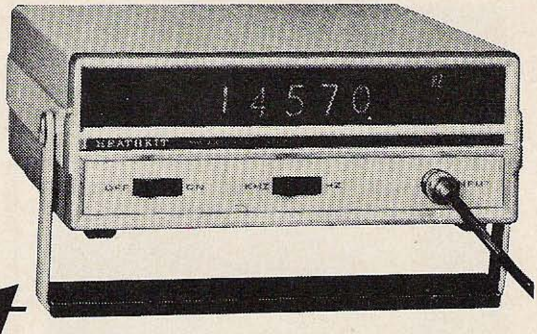
Adjustment

Initial adjustment should be done at a low power level by reducing the drive to the output stage of a transceiver. The output loading capacitor (which is in parallel with the plate tuning capacitor once the transceiver is modified) is initially set at minimum although it can be used later if more capacitance is required. The drive is increased and the transceiver checked for the usual meter indications of resonance and proper loading. If resonance is indicated but the loading is not correct, one can try increasing the value of the plate tuning capacitor by changing its setting and reducing the value of the antenna loading inductor (or vice versa) until adequate loading is achieved.

One must use a wavemeter or some other device to check the radiated frequency since it is possible to have the system falsely tuned in some cases. When the system is tuned correctly, one should also be responsible enough to check the harmonic radiation and interference levels as compared to the usual setup. Although with the use of linear amplifiers, etc., the harmonic level should be well below any illegal level, it certainly would be completely irresponsible to operate without being certain of this. A check with a receiver tuned to the various harmonic frequencies will quickly indicate if the harmonics are at least 30–40 dB down from the fundamental frequency.

. . . W2EEY

I built a counter



Kendall Sessions III

My neighbors say I have a "way" with electrical things. They always bring me their TV sets whenever a tube goes bad or a fuse blows or a wire breaks. And when I fix the problem – very seldom serious – they think I'm a genius. Now, I don't mind, you understand – this kind of thing would be good for the ego of *any* 17-year-old. But there was a time recently when I thought my reputation was really going to get me in a jam: My own father brought me an electronics job to do.

Now, I don't know how it is with *your* dad, but mine, unfortunately, is pretty hard to fool. He doesn't sit around the house every night building repeaters and things any more, but he does write an occasional book about some field of electronic endeavor; and he *is* the editor of a fairly famous ham magazine. When he told me about the project he had for me, I was pretty up-tight – even though I exhibited only the bravest show of confidence to him.

He handed me a large box of miscellaneous electronic parts and said, "This is a Heathkit frequency counter in kit form. Read all the instructions and put it together for me." He asked me to take notes on any problems I might have and jot down anything that I thought ambiguous in the step-by-step instructions; then he just left me standing there with my mouth open.

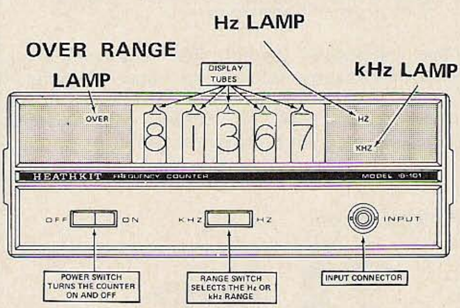


Fig. 1. Panel layout of Heath counter.

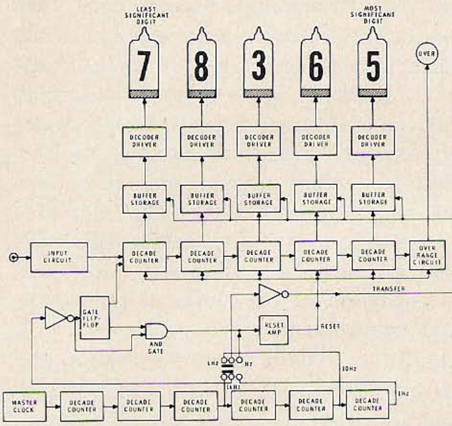


Fig. 2. Block diagram of Heath's IB-101 fre-

Well, I closed the doors to my room and gathered all my tools around me at my desk. It was Friday afternoon . . . a little past five. I opened the "tips and hints" book that comes with every Heathkit and thumbed through it. Most of the advice given here was pretty old hat to me so I decided to start right in on the counter.

I figured to work for an hour or so on the kit before cutting out to a movie with my brother. Boy, did I ever figure wrong! Kit-building is rather like eating potato chips; it's as impossible to work for a few minutes on a kit as it is to be content with munching just one lone salty cruncher. If my mother hadn't used her very effective form of coercion, I wouldn't have even broke for supper..

After dinner I was back at it again. I was soldering components to a double-sided epoxy-glass PC board, and I was almost ready to mount the IC sockets. So far, the job looked very professional, in my none-too-humble opinion. And I doubt if my father could have done as well (he's very old, you understand – in his late thirties – and his hands shake with the typical senility of his generation).

I finished the job about two in the afternoon, next day. I stopped for a short nap early in the morning after breakfast and again for an hour or so at lunch time.

The only thing remaining to be done at noon was the connection of the primary power cord, final checkout, and a calibration procedure that looked pretty simple. The kit had taken about 18 hours to complete, I estimated, without hurrying or cutting any corners. My father tells me that a kit of this complexity would have taken many months to build a few years back, and it would have ended up the size of a Mack truck. You can pack a lot of electronic circuitry in a single integrated circuit!

The unit I put together is called the IB-101; it is a very compact and lightweight digital counter capable of reading frequencies from near dc to 15 MHz. And, according to the manual, the basic functions and uses of the instrument are like those found on the very highest priced frequency counters (needless to say, the Heath IB-101 is not high-priced).

In general, the counter has the overall appearance of simplicity, despite the complex circuitry and number of features. (See Fig. 1.) Five cold-cathode display tubes, an "overrange" lamp, and two range indicator lamps make up the entire readout lineup. The accuracy of the readout is assured by a crystal-controlled digital clock. A high-impedance input circuit presents minimum loading to the circuit you want to test, and automatic level triggering lets you make measurements without having to fiddle with controls and such. It's all pretty nice. The block diagram of Fig. 2 shows the operational arrangement.

A feature I particularly like about the IB-101 is the simplicity with which it can be calibrated. If you don't happen to have an accurately calibrated frequency counter around to check the Heathkit against (and chances are you won't or you wouldn't have bothered to buy the Heath in the first place), all you *really* need is any old AM broadcast radio receiver. All you have to do is tune in a station on the BC set and hold it near the oscillator crystal in the counter. Then you just listen for a beat note on the radio and adjust the calibrate control (frequency adjusting trimmer) on the IB-101 for a zero beat.

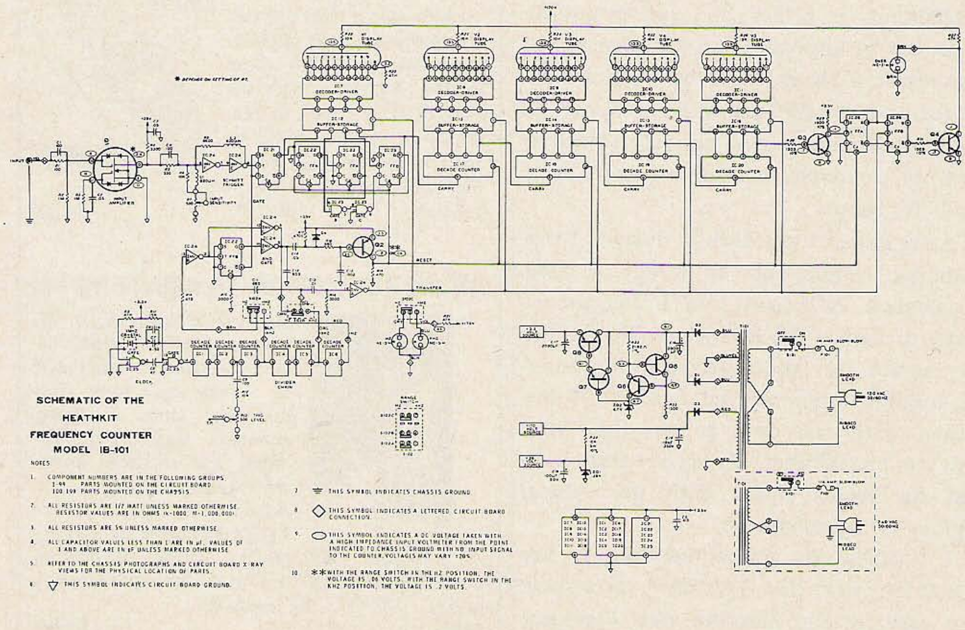


Fig. 3. IB-101 schematic diagram.

Even though there are only five digits readable on the counter, you are not restricted to reading out frequencies of that order. To count a frequency of 14.210450 MHz, for example, push the range switch on the counter to the kHz position and take a reading. The display will read 14210. Just keep this figure in mind and press the switch to the Hz position to read 10450. The overrange light will come on now to show that the frequency you're reading is actually higher than the Hz indication in the readout. Putting the two readings together gives the actual operating frequency: 14.210450.

The schematic diagram of Fig. 3 shows what the IB-101 is made of. The input amplifier and Schmitt trigger circuits accept and shape the input signal into a square wave. Decade counters change these sequential input pulses into a binary coded 8-4-2-1 output and recycle on every tenth input pulse. The four bits of binary coded information are then connected to the buffer/storage units which accept and store the count data on command of the transfer signal. The decoder drivers translate the binary coded information from the buffer/storage units into decimal form and drive the proper display tube cathodes. Timing signals for gating, transfer, and reset are generated in the clock and divider chain. It's all quite neat, you'll have to admit.

My advice to builders of this useful little instrument would only be to follow these simple suggestions: Before starting to assemble the kit, be sure you know all there is to know about soldering and wiring. If you don't, you'd better break down and read the "kit-builders's guide" that accompanies the kit.

Because of the very small circuit-board space between some of the printed conductor material, you have to be extremely careful to prevent solder bridges. Play it cool and don't try to use a big gun or eighth-inch-diameter solder! Use the minimum amount of solder required to get the job done and use heat sparingly. You'll really need a tiny tip on your iron to do the job right; and Heath recommends using an iron of not more than 25W.

If, by some flaky fluke of fate, you don't happen to have a low-wattage, tiny-tip iron, you can adapt a normal-size iron to the task: Be sure your iron is cool, then wrap a hunk of 14-gage bare wire around the tip as shown in Fig. 4. You can file the end of the wire to a sharp chisel edge, giving you the equivalent of a low-power iron. The only hassle with this approach is that the wire does tend to loosen after awhile; and it always seems to come loose at the wrong time. Irons are relatively cheap, though. So if you aren't also, your best bet is to get an iron tailored for the

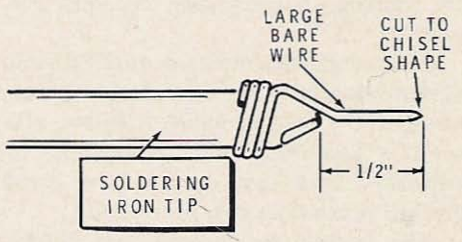


Fig. 4. Poor man's low-wattage iron: Wrap a piece of 12- or 14-gage solid copper wire around the tip of your regular iron, letting the wire end protrude a half inch or so. File the end of the wire to shape.

job. Who knows – you might want to build another kit one day, then at least you'd be prepared in advance.

The counter is accurate – or at least it seems to be. Like all counters, the inherent error is plus or minus one digit in the least significant column (regardless of range) – and you could hardly kick about that.

Mr. Green is using the counter I built to check against the dial on his National NCX-1000. And he tells me that the National dial and the Heath counter agree consistently. All of which says a great deal for the National transceiver, too.

. . .Sessions■

LOW COST TRANSISTOR POWER SUPPLY

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23550 Whittaker
Farmington MI 48024

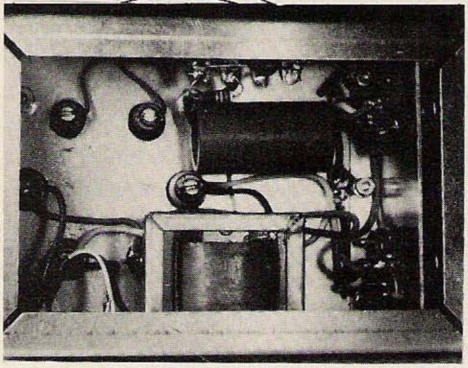
If you want to take your Twoer or Sixer mobiling or on Field Day next year, you'll need a 12V power supply for it. As Heath no longer lists the vibrator supply in the catalog, homebrewing becomes necessary.

This article describes the operation and construction of such a transistorized power supply. It is easy to build, compact, efficient, hash-free, and best-of-all, inexpensive. Parts cost, even without a well stocked junkbox, is only around $10.

The circuit (see diagram and illustration) is a novel one which was inspired by an article in *Electronics* magazine.[1] It prevents any switching transients from occurring, thereby removing this cause of transistor failure. The reason for this is the fact that the feedback transformer (T1) secondary is equally loaded through all parts of the switching cycle. Reverse voltage on the base–emitter junction of the "off" transistor is limited to the diode (D1 or D2) voltage drop across it. This allows use of inexpensive 2N3055s, which have emitter-to-base breakdown voltage ratings of 7V. These transistors, which are available very reasonably have collector current ratings of 15A maximum, so no large heatsinks are required.

The main power transformer (T2) is a dual-winding 6.3V filament transformer. The secondary windings are used as the primary and vice versa.

After much experimentation, it was found that a small 115-to-24V 250 mA unit made a good feedback transformer (T1). When connected as shown, it furnishes more than enough base current to insure driving the 2N3055s into saturation, providing low switching losses and good efficiency. Measurements indicated 315 mA of base drive per transistor. According to specifications, this is sufficient for switching 9.45A amperes collector current, assuming a minimum beta of 30.



Transistors are mounted on the L-bracket at right, along with diodes D1 and D2. Diodes D3 through D6 and resistor R2 are mounted on a tie-point strip at top center. Power cable enters at lower left, and C1 is not visible, being covered by lower left chassis lip. R1 is connected between a single tie-point strip and the base terminal of the upper transistor socket.

Resistor R1 provides a small base–emitter forward bias. As the secondary dc resistance of T1 is only 8Ω and small by comparison to R1, it is not necessary to bias each transistor with a separate resistor.

Imbalance is immeasurable.

Capacitor C1 helps filter out any transient spikes appearing on the 12V line. The secondary circuit is a conventional bridge rectifier and filter setup which furnishes about 210V under transmit conditions. Because the original Heath vibrator pack furnished 250V under the same conditions, a 330Ω 5W resistor was used in the Twoer (R14) to reduce it to 225V. To bypass this resistor, move the wire connected to pin 5 of the Twoer octal plug from the junction of D3, C32, and R14 to the junction of R14, C33A and R15. This will result in less power loss and proper operation from the lower power supply output.

This same circuit can be used with regular 12V vibrator transformers, making cannibalization of an old car radio worthwhile to obtain a suitable power transformer.

Owners of earlier FM gear using vibrator supplies can transistorize them inexpensively, gaining efficiency and reliability in the process. Just remember to provide

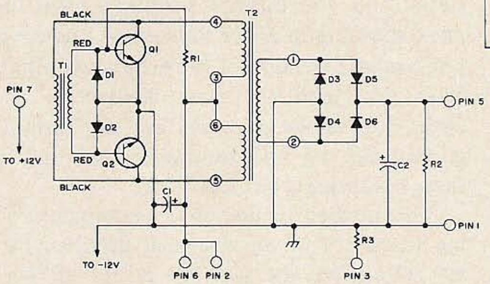


Fig. 1. Schematic diagram of power supply. The pin numbers refer to those in Twoer, and may be ignored if supply is used for FM receiver.

adequate transistor heatsinking, if you plan on making a 100 or 200W supply, for example. The circuit will also provide an ideal receiver supply for 450 MHz FM'ers who want to "duplex" their surplus mobiles.

About the only difficulty which might be encountered in the construction of this supply is its failure to oscillate. Should this happen, merely reverse *one* set of leads on the feedback transformer.

Don't worry about overheating *either* transformer. I have run this supply at *full load* for 4 hours continuously, and neither of them became even warm. Uncle Sam must have rated T2 very conservatively, and I'm sure it would withstand the continuous usage of a Field Day weekend without difficulty.

Parts List

T1	=	115V to 24V 250 mA (Fair Radio MW#4528)
T2	=	115V to 2/6.3V 1.2A (Fair Radio #7629809
D1, D2	=	silicon diode, 1A 50 PIV or more (Poly Paks)
Q1, Q2	=	2N3055 (Poly Paks)
D3, D4, D5, D6,	=	silicon diode, 1A and 400 PIV or more (Poly Paks)
C1	=	100 μF 25V electrolytic
C2	=	20 μF 350V
R1	=	1000Ω
R2	=	470kΩ
R3	=	150Ω

1. Roy Hartkopf, "Diodes prevent power loss and burnout in converters," *Electronics* September 14, 1970, p. 103.

W8AUR■

Don't Trust the Ground Wire

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Equipment with a 3-wire (grounding) plug is too often regarded as being safe; but don't be fooled. Even though the equipment may be safe, the wires connecting power to the outlet may be defective, resulting in that safe ground wire connecting you directly to 120 volts, and maybe even a one-way ticket to the grave.

Last week my wife was walking down the carpeted hall in our two-year-old home when I asked her to turn off the light in the study. She reached inside the study door to turn off the switch while still walking in the hall. Her hand touched the screw holding the plastic protective plate over the switch simultaneously with her bare foot contacting the metal strip used to hold down the edge of the carpet. The result, a loud OUCH!

I promptly got out the voltmeter and played electrical detective. The meter indicated 120 volts between the metal strip and the screw in the outlet box containing the light switch. I suspected leakage, but when a 60-watt 120-volt lamp lighted to full brilliance, all doubts were removed. I connected a long wire from the cold water pipe in the kitchen to one lead of the meter. Then I checked every switch and outlet in the house. Sure enough, seven 3-wire receptacles and two light switches were connected with 120 volts on the metal outlet box. I checked the breaker box and found that all of these outlets were on the same circuit.

The cover plates were removed and the wires were disconnected one by one with an ohmmeter check being made after each was removed. The result was that the hot 120 volt wire in one of the outlet boxes in the study was stripped back about a half inch too far and when the outlet was installed in the box by the electrician the bare hot wire contacted the normally bare ground wire. Normally, this would have only resulted in a tripped circuit breaker; however, in this case, the ground wire in one outlet was wrapped loosely and the poor connection resulted in the ground wire burning in two at that point. This left the majority of the outlets on that circuit with the ground lead connected to 120 volts.

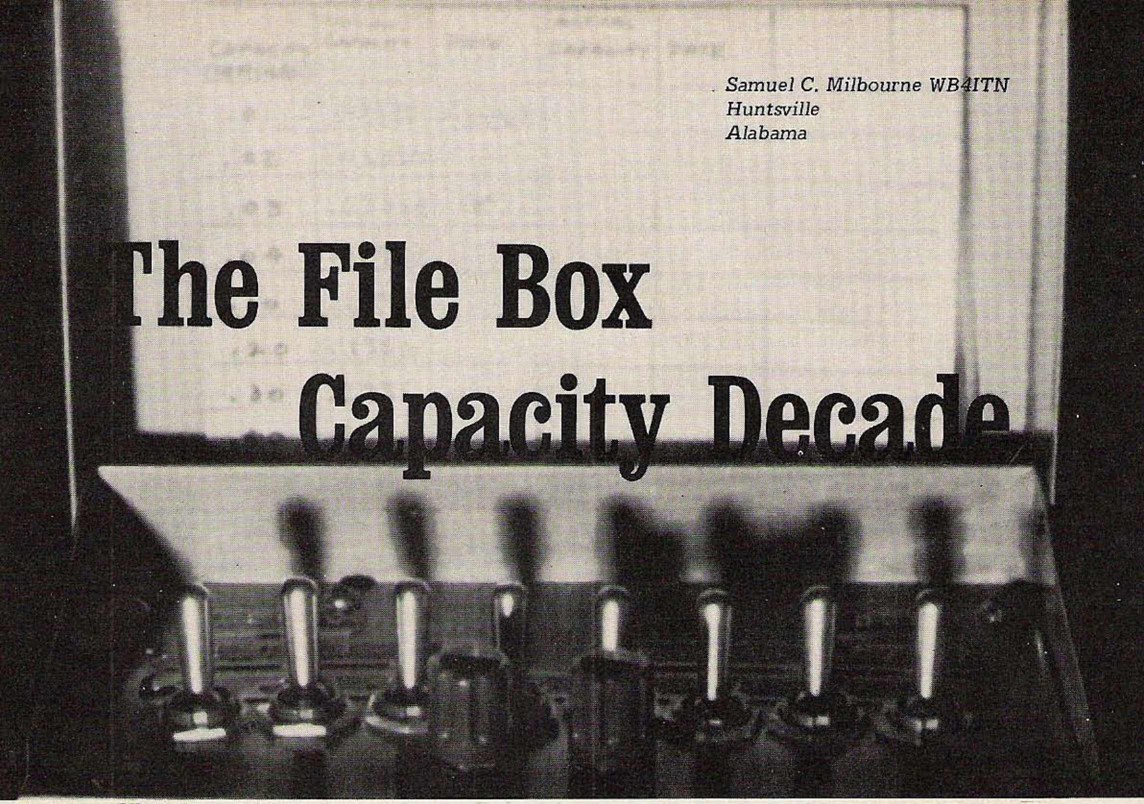
Just imagine your rig plugged into that outlet and you outside holding a piece of coax standing in a wet flower bed knowing you are safe because of the grounding plug. Then you grab the coax connector. . . ! Sure, our safety practices say we should ground the rig and remove power under these conditions; but, do YOU?

This incident is just one of many involving discovery of an electrical problem by my wife. Yet, she says she is not electrically inclined. When we first moved in, she was waxing the den floor before moving in the furniture. She reached up to adjust the chandelier and *******OUCH! Since we had not signed the final papers for the house, we called the builder and he sent the electrician over the next day. No one was home and he couldn't find anything wrong. He asked our nextdoor neighbor if she was familiar with the problem and she suggested he take his shoes off to duplicate the conditions my wife was working under. (It is surprising how much ham gear can be bought with shoe money.) Needless to say, after a shocking experience, he found a short in the fixture and no ground connection.

You may ask, how do these things get past the building or electrical inspectors? In Plano, like many other rapidly expanding communities, the inspectors just do not have time to check every detail and outlet. Certainly, you could sue if a member of your family were injured; but no one likes to be dead right! Many progressive cities, like Plano, have adopted modern standards requiring the 3-wire grounding receptacles in all new construction, while others only require the grounding receptacles to be installed in outdoor locations or laundry rooms.

In summary, it would be time well spent for you to check all outlets in your home to insure a proper ground. To do this, use a 120 volt, 60 watt lamp with one lead connected to a waterpipe ground. Using the other lead, check each outlet box and each terminal of the receptacle. Note the location of the hot terminal of each outlet. Then, check from the hot wire of each outlet to the outlet box to determine if the box is grounded properly. The lamp should light on only one terminal of each receptacle when one lead is connected to the waterpipe. If it lights when connected to an outlet box or grounding terminal of the outlet a serious problem exists. The lamp must light with one lead connected to the hot lead and the other lead connected to the outlet box or ground (120 volt return). If it does not, you do not have a proper ground connection to the box. Keep in mind that, if you live in an older home, you may not even have a ground lead in the wiring, other than the 120 volt return wire. To determine if you do have a ground wire, remove the outlet cover plate and count the number of leads in each cable entering the box. If each entry to the box has only two wires and metallic sheathed cable is not used, chances are you do not have a ground. (Metallic sheathed cable is seldom used in residential wiring.) If the outlet is of the 3-wire type and you do not have a ground in the wiring you are flirting with danger if you depend on the ground for protection.

W5FQA■



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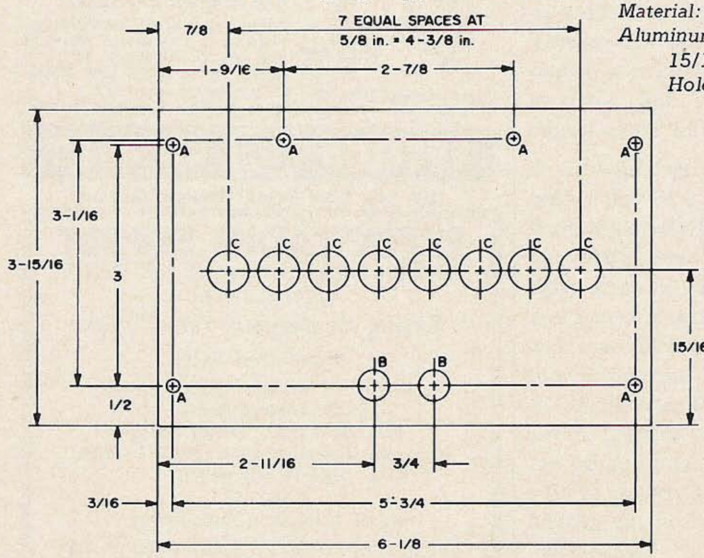
Alabama

The File Box Capacity Decade

In several previous articles, a compact, economical way to package many small test equipment circuits was described. This month we will consider capacity decade circuits, which can be packaged in a less-than-a-dollar 4 x 6 x 4½ in. file card box. This box has a swinging top, and is usually painted green or gray.

This, together with 1/2 x 1/2 x 1/16 in. aluminum angle, four rubber mounts, a 6 1/8 x 3 15/16 in. aluminum panel and mounting hardware complete the packaging parts list which is detailed later in the article.



Material:
Aluminum – .030 in. thick x 6 1/8 x 3 15/16
Holes – A ( ) #25 drill
B ( ) 3/8 in. drill or punch
C ½ in. drill or punch

HOLE CHART		
SYM	SIZE	QTY
A	NO. 25 DRILL	6
B	3/8 in.	2
C	1/2 in.	8

Fig. 1. Panel layout .01–1.0 μF decade capacity box.

Mounting the feet and cards

Mount the four rubber feet on the bottom of the box. Position them ½ in. in from each of the four sides. This will allow a space 3 x 5 in. within which a schematic can be mounted. A 3 x 5 in. file card will be fine. Draw your schematic on this card and cover with pressure-sensitive transparent film such as acetate or Mylar. Fasten to the bottom of the box with 3M (Scotchbrand) #400 double-coated tape having adhesive on both sides or Goodyear Pliobond glue can be used to glue the card to the box bottom.

Brackets

Mount the two brackets by drilling two holes on each end of the box, 2½ in. from the box bottom and 2 in. apart. This will allow 1 in. between one hole and the box front. Use a #25 drill. Draw a horizontal line on each bracket, about ¼ in. from the bend in the bracket. Place each bracket inside and against the side of the box. Spot the line through the holes. Mark little circles on the bracket. Drill these four holes using a #35 drill. Slowly tap them with a 6-32 tap (use a light oil on the tap). Attach brackets to the box using (4) 6-32 x ¼ in. machine screws.

The panel (along with other holes for parts) will have two mounting holes on each panel end. See Fig. 1 for panel holes. Place the panel in position and mark circles through the panel holes and on the brackets. Drill with a #25 drill and tap with a 6-32 tap. Finally, attach the panel with 6-32 x ¼ in. Phillips-head screws.

Preparing the panel

The blank panel should be prepared for layout by attaching to it a 4 x 6 blank card. Use library paste or flour and water. The layout can then be made on the card,

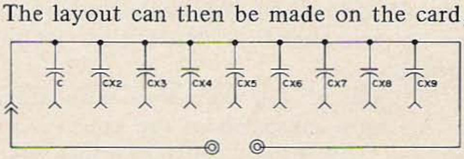


Fig. 2. Basic capacitor decade circuit where C is any value such as 0.001 μF, 0.01 μF, etc. and the remaining capacitors are multiples of C.

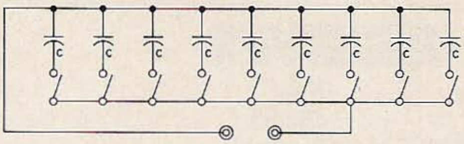


Fig. 3. Basic capacitor decade circuit where all values of capacity are the same, and one to nine switches are thrown to make up the desired value.

the panel drilled or punched out and finally, the card removed by soaking for a minute in hot water. The panel should then be cleaned thoroughly on both sides by using steel wool. A coat of zinc chromate should then be sprayed on both sides. Better, spray two light coats and steel wool between coats. Clean with alcohol to remove any steel particles or dirt. Finish with two light coats of your favorite color lacquer. A semigloss gray such as an RCA #222627 Light Umber Gray lacquer is my preference. If the panel is laid out symmetrically, you can pick the best side for the panel top.

All titles are in embossed tape. I use ½ in. tape, but ¼ or 3/8 in. tape is adequate.

Basic capacity decade circuits.

Figure 2 shows a basic individual-value capacity decade where each capacitor equals *C*, *C* x 2, *C* x 3, etc., *C* being the smallest value of capacitance in the decade. This configuration requires nine values per decade and, unless patience and a large quantity of each value capacitor is available, it is not recommended.

Figure 3 shows a capacity decade circuit composed of 10 individual capacitors, all having the same value. This requires only one basic capacity value against which all others are matched. However, it requires nine capacitors and nine switches per decade. Also, as many as nine switches have to be thrown (for *C* x 9) – a time disadvantage.

However, if you can obtain a quantity of precision capacitors of the same value, and the toggle switch inventory is high, this may be your circuit.

Personally, I am partial to the H configuration shown in Fig. 4. This uses only four capacitors mounted on a subpanel or swung between switches and a terminal strip. These values are *C*, *C* x 2, *C* x 3 and *C* x 4. If *C* and *C* x 2 are connected simultaneously (in parallel), they will equal C x 3. All connected, they equal *C* x 10.

Figures 5 and 6 show two dual-decade capacity boxes using eight electrostatic capacitors in one and seven electrolytic capacitors in the other. Note that in the first we have capacity values of *C*, *C* x 2, *C* x 3 and *C* x 4. Any value from *C* to *C* x 10 can be obtained by paralleling the correct capacitors. The second circuit shows a modified capacity decade using electrolytic capacitors. This circuit covers from 1 μF to 101 μF. These circuits also use toggle switches and can each be accommodated in a file box.

Note the calibration card in the lid of the file box. Calibration can be made at the finish of construction and at convenient times thereafter. Inasmuch as the circuit using electrolytic capacitors is not likely to be too accurate, no calibration card was included. Most electrolytic capacitors are marked with the value and the tolerance of minus 0% and plus 40%.

If you elect to build these two dual-decade file boxes, you will have a source of from .01 to 101 μF using only a total of 15 capacitors.

You will note that no working voltage has been specified for the capacitors. Obviously, the higher the working voltage the better. I have 400V capacitors in the .01–1.1 μF, and 250V in the 1.0–101 μF

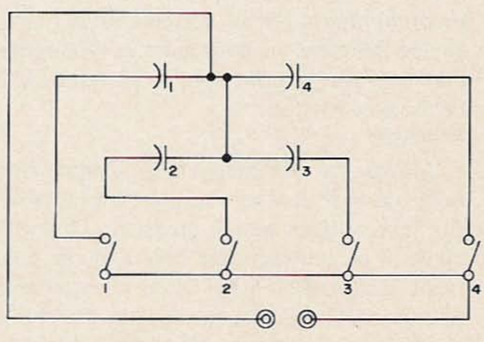


Fig. 4. H configuration capacity decade. The total output capacity is equal to the sum of the switches thrown (C x 10).

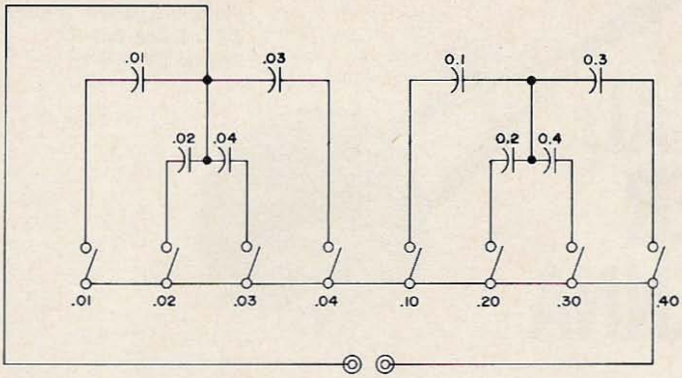


Fig. 5. Two-decade capacity box using only eight electrostatic (paper) capacitors and covering .01–1.1 µF.

decade units. There is room for up to 600V capacitors if desired.

When electrolytics are used, specify the plus and minus binding posts on the panel.

After mounting the switches and the 10-position terminal strip on the panel, the capacitors are mounted between one side of the toggle switches and the terminal strip. The other side of the toggle switches are connected together and to one binding post. The lugs on the terminal strip are connected together and to the other binding post.

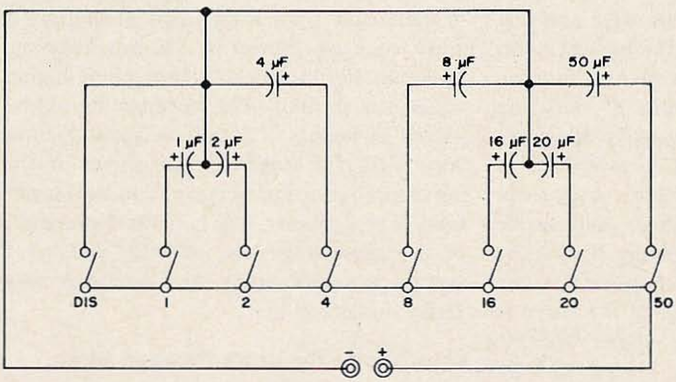


Fig. 6. Two-decade capcity box using only seven electrolytic capacitors and covering 1–101 µF. Note the first position marked "DIS" or discharge.

Figure 1 will show you my layout of the two decade capacity box panel. Be sure to check the diameters of the holes against the parts that you will use. For instance, there are two sizes of five-way binding posts, and you may want to use a different terminal strip with different mounting hole dimensions.

Parts List for File Box Cabinet.

(1) File box, 4 x 6 x 4½ in. Ohio Art Co.
(2) pcs. ½ x ½ x 1/16 x 4 in., alum. angle bracket
(4) Rubber feet with 6-32 mounting screws and nuts
(1) Panel, alum., 6 1/8 x 3 15/16 x .030 in.
(8) Machine screws 6-32 x ¼ in.

Miscellaneous Tools and Material

#25 and #35 twist drills
6-32 tap and holder
Fine steel wool
Alcohol
Zinc chromate spray
Tape embosser and tape

Capacitor Type Dual Decade Parts List

(8) Toggle switches
(8) Capacitors
(1) Terminal strip 10-lug
(2) 5-way winding posts
(2) 6-32 x ¼ in. Phillips screws and nuts

Capacitor values for .01–1.1 µF decade box

(1) ea. .01, .02, .04, 0.1, 0.2, 0.3, and 0.4 µF

Capacitor values for 1–101 µF decade box

(1) ea. 1, 2, 4, 8, 16, 20, 50 µF

. . .WB4ITN■

A PRACTICAL 40 METER DX ANTENNA

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Here is an inexpensive and rather simple DX array for the serious low frequency DXer. This antenna is called a Bruce antenna. It was sometimes used for point to point work in the late 1930s, but has never been extensively used by amateurs.

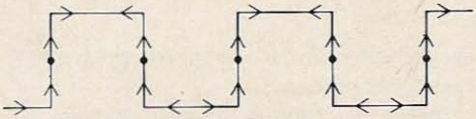


Fig. 1. Critical elements of line. Dots show current points; arrows show phase relationships.

A Bruce antenna can be built utilizing nearly any single piece of wire of sufficient length since it will only be necessary to make the measurements and bends in the wire. In this system, as seen in Fig. 1, each vertical wire is in phase, whereas the horizontal portions are electrically out of phase. This can be determined due to the horizontal portions being tied end to end and that on any simple half-wave antenna there appears at each end the highest radio frequency voltages. Therefore the antenna radiates broadside to its line of radiating elements and the radiated signal will appear at a distant receiving point, as shown in Fig. 2. This will show that the energy from one of the vertical radiators will arrive nearly as soon as the energy from the others at the DX receiving point. If the receiving point is too far off of the antenna effective beamwidth, the signal will be weak. If the receiver is placed exactly inside the beamwidth, it will be seen that the energy will arrive at the given DX point simultaneously thereby giving a much stronger reception of the transmitted signal. This can be seen in Fig. 3. This antenna will give about 1 dB of gain for each two vertical elements in the system. My own 5-element Bruce gives an honest 4 dB. With this antenna pointed on Japan it is hardly possible to copy a VE7!! Also with this type antenna using up to five vertical elements, no secondary lobes have been observed. Apparently the Bruce, while not having as much "published gain" as wider-spaced arrays, has less phase shift and internal problems as some of the others. The beamwidth of the five-element antenna appears to be only about between 15 and 20 degrees and the vertical polarization seems to give a slightly lower angle of radiation than a standard groundplane array such as utilized in AM broadcasting. This can be due to a current point higher above the ground. The antenna should be placed at least 8–12 ft above ground, since very high rf voltages at the center of the horizontal coupling sections can be dangerous. If any reader has had the experience of a high-voltage arc off the end of a voltage antenna point, this becomes very easily understood.

Constructing the Bruce Antenna Array

Fig. 4 shows the five-element Bruce. If space is a problem, you can make up a smaller array; of course it will sacrifice gain, but remember, this is *honest gain* This is gain over one vertical element and not over some theoretical isotropic type of antenna. The gain figures sometimes published by sly antenna salesmen are often misleading.

The dimensions of each section are shown. They are calculated from the

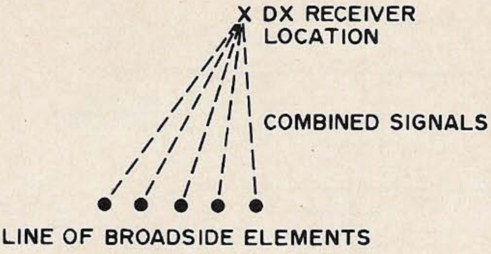


Fig. 2. Broad coverage area of Bruce antenna.

"stacked dipole" formula as can be found in such manuals as the Radio Handbook (Editors and Engineers). If several elements are involved, the dimensions are not too critical; but try to stay within the dimensions shown so the array will be self-resonant inside the band. When tuning the stub, any resonant discrepancy can be overcome by adding or subtracting slightly from the small horizontal end-fed portion. It would be well to note here that you can use the inexpensive galvanized electric fence wire sold by Sears and Roebuck for the entire antenna and feedline. Also the porcelain electric insulators for the feed system can be purchased at the same time. Be sure to use double lenghts (slightly twisted together) for the tie wires and for the horizontal top runs between insulators and be assured that the antenna will not come down in the wind. This wire will stretch very little and is durable. It can be soldered with no problem. Its size is #19 AWG and comes in half-mile reels for about $6. The small egg-type insulators should be used at the tie points as they have enough strength and insulation to effectuate the job. If the ends of the antenna are to be hung over high-enough tree limbs you can use the excellent hemp ropes (at least ¼ in. type) which can be purchased quite cheaply at surplus and farm supply stores.

The Open-Wire Feedline System.

For simplicity, let's construct your quarter-wave matching stub. For 40 meters this will figure out to require two pieces of wire 35 ft long. Make up a jumper wire for the outer end with alligator clips soldered to each end. Take eight of the electric fence insulators and four lengths of some kind of wood spacer about 10 in. long. This material can be pieces of 1 x 2 in. lumber. Nail the round edge of the insulators up against each end of these spacers on the wide side. This is an easy method and looks quite pleasing hanging up horizonally while not being heavy. This whole system using five vertical elements has withstood very high winds. You will find the whole system to be very light in weight. Use the strongest antenna insulators you have available for the top ends and hang up the antenna.

If you use more than three vertical elements, be sure it is exactly broadside to the DX location you wish to cover. Now no matter what they say the stub must be adjusted for maximum rf indication on any simple field strength meter.

Set up your meter somewhere between any two elements and place it far enough away from the antenna so that you can still be able to see its indications. The feedline is constructed just about like the stub (and I prefer the wide-spaced feeders). Nail on the insulators and place these feeder cross arms high enough above ground. Small trees will work fine. The 10 in. spacers are fine. and when the lines are attached and pulled tight it will be unnecessary to worry about the lines swaying and shorting together. My feedline is over 300 ft long and only supported every 75 ft or so. This feedline can be run off in *any* direction. Mine is 12–14 ft above ground.

Make your feedline any odd number of quarter waves in length and you will find a point where 50Ω coax can be attached at a current point and it will also be feeding an

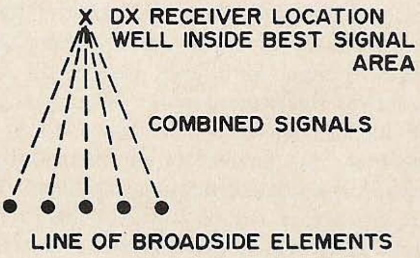


Fig. 3. Radiation from line of broadside elements.

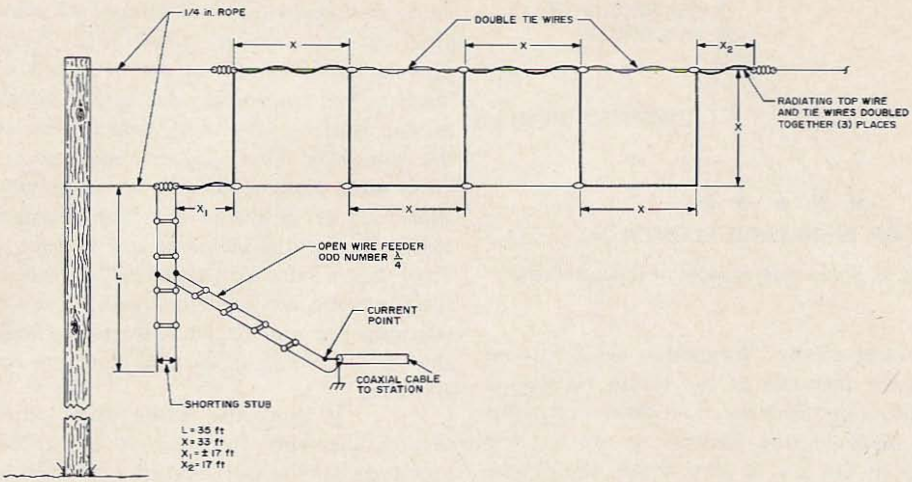


Fig. 4. Dimensions and layout of 5-element Bruce at W7JLU.

unbalanced system. This will only take a little trial and error and can be done perfectly well using a noise driven bridge (I used an Omega T Systems type). Before this input end is completed, however, place the shorting wire on the stub out from the antenna end to about 33½ ft. Then tap the open-wire feeders described or any other type of open wire feeders you may wish to use about one third of the way toward the antenna end on the stub from the stub end.

Tuning it up.

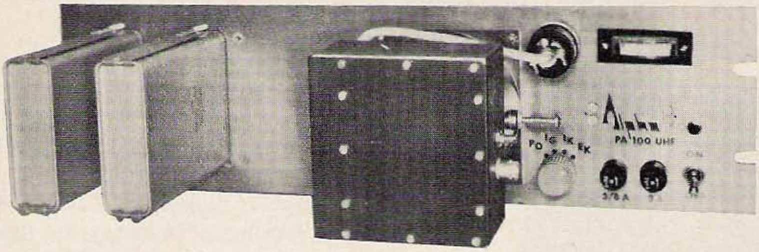
After hooking your coax at the current point, feed a couple of watts into the beam. Tune your transmitter to the portion of the band that you like best and preferably set up zero beat with some commercial broadcast station so you will not bother the other amateurs. Next, go out to the antenna on a stepladder and set both the stub and the feeders until you get the best signal as indicated on the field strength meter. I should mention here that alligator clips were also placed on the feeders at the antenna point. When you get the highest signal, solder (use a torch if possible), but be careful of overshooting the proper soldering temperature here. You can just solder the clips to the stub right where they are. Be sure to solder all four clips. It will only next be necessary to slightly readjust and possibly bridge your coax feedline at the transmitter output end of the line. In this case, the transmitter is shut off and you are using your station receiver as an impedance and null indicator.

Performance and Results

Using this antenna it is possible to work stations such as JAs several hours earlier than usual. Since the antenna is bi-directional the South American stations sound like locals, yet W signals are not too loud so it shows a very worthwhile low angle. Opening the antenna at the third element made it possible to contact UAO in zone 18 and KG6 – both at an early hour so the effective beamwidth seems to sharpen up with more than three elements. With tests with W7CAL in Arizona the antenna showed around 20 dB difference just off its beamwidth as compared to another curtain favoring that particular direction. Stations coming in from off the end of the array being picked up on another curtain on the North Pole usually completely disappear when the Bruce is switched on. Thus, I can assume that the horizontal portions are very ineffectual – even on signals arriving from a high angle. The signal from W7MVC located about 35 miles off its end dropped 30 dB as compared to another curtain operating in that direction, using a Drake R4-B S-meter.

W7JLU■

a commercial bid for the 450 market



With 2m FM repeaters being the "in" thing these days, you might well wonder why a manufacturer would bother marketing an amplifier designed for the 450 MHz band. But have you ever stopped to think that behind nearly every 2m system there's a 450 MHz repeater? It's true. Those fellows who install their VHF repeaters can't do it without some form of control, either by a wireline or by some frequency above 220 MHz. Since wirelines are expensive, and little gear is available for 220 MHz operation, the 450 band gets the action.

But the 450 region is used for a great deal more than accessing 2m and 6m repeaters. Many groups install their own "closed" repeaters operating exclusively on 450. And many more have 450 repeaters serving as remotely controlled telephones, access repeaters for remotely operated base stations, and repeater-to-repeater links.

So it is not surprising that some enterprising manufacturer has made available a fairly high power 450 MHz class C amplifier designed for unattended operation at remote locations. Alpha's PA-100-UHF is it. The amplifier is capable of delivering 100W into a 50Ω antenna with a lowly 10W of drive required.

The manufacturer, Alpha Electronic Services, Inc., 8431 Monroe Ave., Stanton, California 90680, is not producing these amplifiers exclusively for the amateur remote/repeater crowd, incidentally. The UHF amplifiers complement the firm's line of tone encoding and decoding equipment, all of which are quite popular with commercial radio users occupying the spectra adjacent to the VHF and UHF amateur bands. It's just that the company's decision to open their marketing to include the amateur was only recently formulated.

Although designed to operate in the 450–470 MHz range, 73 found that no modification was required to get the amplifier perking as low in frequency as 440 MHz. With approximately 12W of drive from a sick T44, the amplifier kicked out a signal that exceeded 125W, as measured on a Bird Thruline wattmeter.

The PA-100-UHF has a self-contained power supply (solid state, of course) that incorporates no moving parts (no relays, yet). It is designed for rack mounting, and requires slightly more than 5 in. of panel space. The simplicity of its design, couple with the "unitized" construction of its major components lends itself nicely to plug-in interchangeability, too – a factor that is quite attractive when the remote location is a long way from home and in an isolated area.

The amplifier consists of a grid input chassis, a tuned coaxial plate cavity, and the power supply. The power supply is itself built as an integral part of the rack panel. The plate cavity and the grid input chassis are mounted to each other and the assembly is mounted to the rack panel. The switches, fuses, pilot light, tuning controls, meter, and input and output connectors are all accessible from the front of the cabinet, simplifying tuneup, checkout, and testing operations.

Power Amplifier

The power amplifier itself is an ac-ground cathode, grid driven, power tetrode. Since the plate of the tube is designed for conductive cooling, the dc power supply voltages have been inverted to take maximum advantage of this feature. This has been accomplished by making the plate of the tube a part of the center conductor of the coaxial cavity resonator that serves as the plate tank circuit. By inverting the power supply voltages, the plate is at chassis potential, therefore the entire cavity and associated mounting surfaces (the whole panel) are utilized as a heat-dissipating element, reducing hazard to the operator.

The grid input to the tube is a modified pi-coupled circuit chosen to absorb the grid lead inductance of the tube and to overcome the high grid input capacitance of the tube. The tube is operated class C, thus assuring maximum plate efficiency during operation and practically no idling current in the absence of a drive signal. Typical plate efficiency of the tube in this unique configuration is typically 60–65%. The high plate efficiency of the coaxial cavity assures maximum realizable useful power output under the power input limitations imposed by the FCC, and at the same time optimizing harmonic or spurious rejection.

The dc power for the tube is obtained from conventional bridge rectified supplies. Screen grid voltage is derived from the cathode supply by the use of zener diode regulators.

In all, the PA-100-UHF was found to be very conservatively rated, more than living up to the published specifications – a moderately priced and very desirable piece of gear for the modern UHF man. . . .Staff ■

Modifications to HW Transceivers

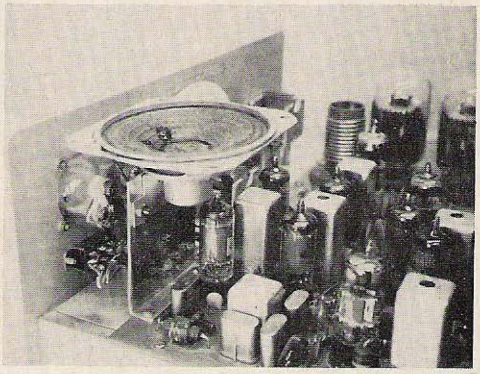
Bud Michaels WB2WYO
713 High Street
Victor NY 14564

The Heath HW series of monobanders are really great! They can be used for mobile and fixed-portable use as well as in your home station. And with 200W PEP input, you can make a healthy dent in the QRM.

Two minor annoyances with these rigs are the need for a separate loudspeaker and the phono jack in place of a standard phone jack. You need an adapter if you want to use headphones. Happily, these two points can be easily remedied with no metal work or permanent alterations to the appearance of the unit.

I mounted a 3½ in. speaker on an aluminum bracket which in turn is bolted to the chassis using the same screws that hold down the printed circuit board. The speaker is located just behind the panel meter and has no effect on the transceiver or impairs the cooling in any way. The Utah line of "Microgap" speakers come with a convenient transformer bracket which makes mounting that much simpler. Connect one wire from the speaker to the ground lug on the pilot lamp assembly. Run the other wire from the speaker under the chassis, loosely wrapping it around the wiring harness to keep it out of the way. Use a piece long enough to reach the speaker jack on the rear skirt.

Bracket mounts to chassis with screws holding down printed circuit board. Speaker can be mounted using pop rivets. The 6BE6 under the speaker can be removed without removing the speaker.



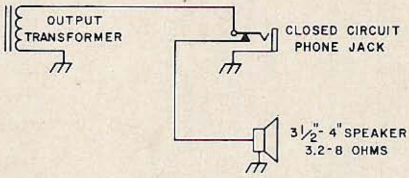


Fig. 1. Circuit diagram of add-on speaker arrangement.

A standard phone jack will fit perfectly in the hole for the speaker jack; no filing or drilling is necessary. Use a closed-circuit type jack so the speaker will automatically be shut off when you insert the headphone plug. You will find that by using low-impedance headphones, you can hear the weak stations much better than with the speaker.

. . .WB2WYO■

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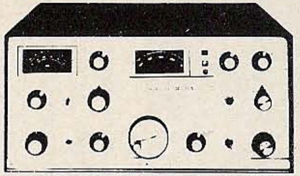

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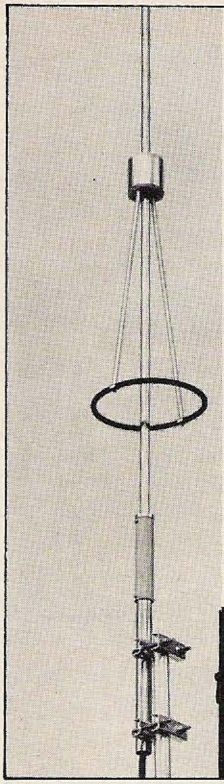

CW SELECTIVITY

B. J. Kirkwood ZL4OK
2 Albany Street
Dunedin, New Zealand

The 3.0 kHz crystal or mechanical filters now in general use for SSB reception generally have excellent skirt selectivity, but the nose bandwidth is too broad for satisfactory CW work under crowded band conditions. Undoubtedly the best solution is a commercial narrowband filter, but these are expensive, often hard to obtain, and may be difficult to fit into an existing unit. A parallel i-f strip or "Q-5-er" is a relatively clumsy and complicated method and the use of another mixer stage to get down to an i-f of 50 kHz or so adds to overload and cross-modulation problems. Filters at audio frequency are of limited help, as strong adjacent signals are still amplified before detection and by overloading punch holes in the desired signal.

A relatively cheap and simple solution is to follow the 3.0 kHz filter with a single crystal gate. This provides sharp nose selectivity while the 3.0 kHz filter helps with the skirt selectivity. The circuit shown uses no tuned normal conditions, is a few kHz higher in frequency than the series resonance. Overtone crystals will work in this circuit at overtone frequency.

Start by testing the circuit with the crystal switched out and the trimmer disconnected. Check that the electrode voltages are correct and that the stage is providing normal gain. Now switch in the crystal and slowly tune across the pass band, monitoring the i-f output with the existing S-meter or a VTVM. A rather poorly defined peak should be found at crystal series resonance. Tune to one side of this peak and connect up the neutralizing trimmer and adjust it for minimum output. Now sweep slowly across the passband once more. A very sharp peak should now be apparent. Continue adjusting the trimmer and sweeping the passband until you get a symmetrical peak. My crystal required 4 pF, but this value will vary for other crystals. Finally, tune to the crystal peak, switch the crystal circuits and may simply replace an existing first i-f amplifier tube without any material loss of gain. In my case, a combination of a small Japanese HC 6/U filter crystal at 455 kHz following a 2.1 kHz bandwidth Kokusai crystal-mechanical filter gave a bandwidth of about 220 Hz at -6 dB, 600 Hz at -20 dB, and 3 kHz at -60 dB. Where the unit is incorporated into existing equipment the crystal can be switched out by a small relay or a low capacity diode switch. In a transceiver, where the first i-f stage is common to both transmit and receive modes, this relay or diode could be coupled with the normal transmit receive switching so that the crystal is never operating on transmit.

The triode stage acts as a cathode follower giving a little less than unity gain. Signals, at the series resonance of the crystal, pass through it and are amplified by the second stage, which is a conventional pentode amplifier. The small capacity from the triode anode neutralizes the parallel capacitance of the crystal and its holder, which would otherwise couple unwanted signals through to the second stage. Setting up the unit is simple, once you have obtained a crystal with its series resonance falling within the SSB filter pass band. Remember that most crystals are specified for parallel resonance, which, under

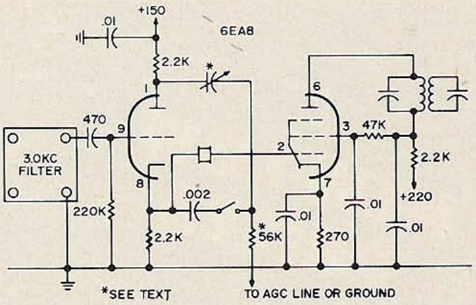

Fig. 1. A sharp i-f amplifier circuit for CW selectivity.

out and observe any change in gain. If the gain is lower in the 3.0 kHz position, decrease the value of the grid resistor of the pentode stage, or vice versa, until you have equal gain at both selectivity positions.

The degree of selectivity possible with the circuit described demands high stability at both receiving and transmitter ends.

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to switch to 3.0 kHz selectivity to copy him!

. . .ZL4OK■

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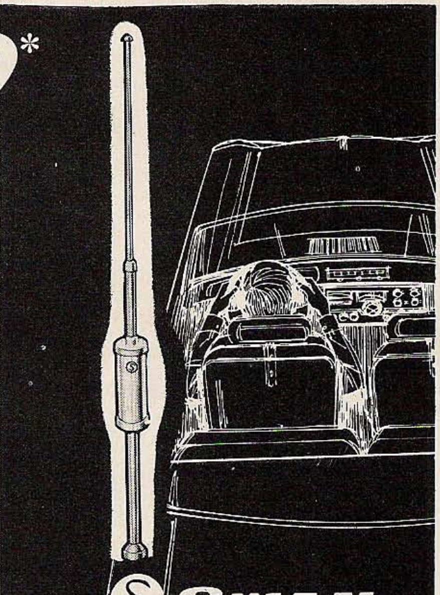

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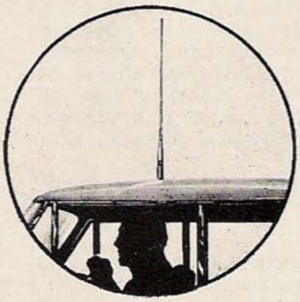

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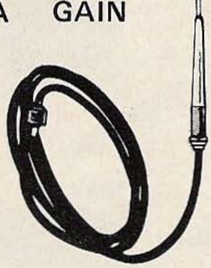

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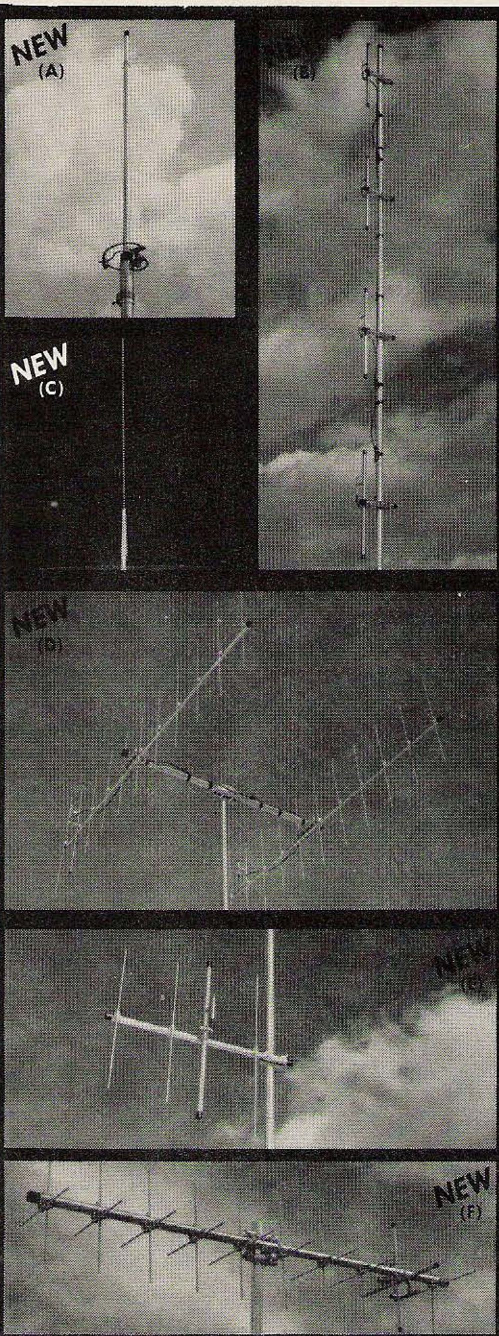

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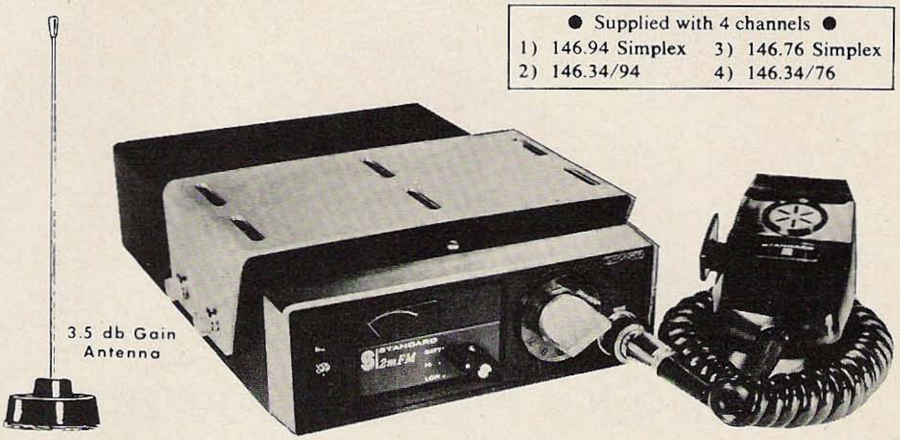

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Part IX: Putting the "TELL" in "TELE"

While some of us might find it amusing for a little while to turn on a radio transmitter without transmitting any information, that's not really the purpose of ham radio. In fact, it's so far from the purpose that the broadcast of a raw carrier is prohibited by FCC rules (except briefly for test purposes) at all frequencies below the UHF region.

The real purpose of almost every radio transmitter we're likely to come across or operate is to transmit *information.* So far in this study course directed toward the General class ham ticket, we haven't bothered to look at how this purpose might be accomplished. Now we'll remedy that, and spend this chapter examining rather closely the why, what, and how of modulation.

In so doing, we will cover the following five questions from the FCC study list (numbers, as always, are those assigned by the Commission in their official list of study questions):

9. What is amplitude modulation (AM)? How is the intelligence conveyed in an AM signal?

19. What symbols does the Commission use to designate how the main carrier of a signal is modulated?

24. What is meant by percentage of modulation? What is the maximum legal limit to which an amateur transmitter can be modulated?

31. What is meant by the bandwidth of a signal? Compare the maximum necessary bandwidth occupied by a CW signal, an SSB signal, a double sideband signal, and an ordinary voice signal.

52. How is the bandwidth of an FM signal related to the bandwidth of the modulating audio signal?

These questions presuppose some knowledge of just what modulation amounts to, but we won't make that same assumption. Rather than dwell on the specific points raised here, we'll take a more general outlook and rephrase the questions into four others which cover the subject.

The first, "Just what is modulation?" will give us the background to understand the role of "modulation" in the transmission of information by any means, not just radio. With this established, we'll return to a more technical viewpoint and ask "How is it related to bandwidth?" The answers to this should provide all the ammunition necessary to handle questions 31 and 52. We will then concentrate our attention on voice communications and ask "How do AM and FM carry voice?" This question should take care of questions 9 and a part of 52, plus any variations which might be sprung as a surprise. Finally, we'll inquire "Why and how is modulation measured?" Here, we'll examine the rules and regulations governing modulation, as well as the techniques used to measure it.

Although we have only four questions on our revised list, they're all rather tough ones. Let's not waste time getting started.

Just What is Modulation?

If we were to look "modulation" up in a dictionary, we would find that it means (in general) "the act of modulating, or the state of being modulated." To modulate, continuing our search, is to "vary the tone, inflection, or pitch" or "to regulate or adjust, temper, soften." The word comes from the Latin "modulus" or module, which in turn comes from "modus" which meant "to measure." None of which, unfortunately, is of much direct help in determining just what modulation amounts to.

All these assorted definitions of "modulation" are, however, quite relevant to our purpose here. In communications, "modulation" is the variation of *any* characteristic of something, in order to convey information or "intelligence." The white paper upon which these words are printed could be said to be "modulated" by the ink which forms the letters, for the purpose of conveying this information to you.

The characteristic which is modulated may be almost anything capable of being varied, regulated, tempered, or measured. In radio, only three characteristics of a transmitter's signal are normally modulated, and normally only one of these three is modulated in any specific transmitter.

For instance, the amplitude or strength of the signal may be changed. A simple example occurs in a CW transmitter, where the signal is either full on (with the key down) or turned off (key up). This *is* a form of modulation, since it is a variation of the signal strength caused for the purpose of conveying information. Most folk (including the FCC), however, distinguish between AM and CW despite the fact that CW operation is a simplified form of amplitude modulation.

Amplitude is not the only characteristic available to be varied. We can, if we choose, keep the amplitude constant and vary the frequency of our signal. This is just as effective in changing its strength – in many cases, more effective. This technique is known as "frequency modulation" or FM.

The third characteristic which is frequently used for modulation purposes is the "phase" of the signal; the technique is called "phase modulation" or PM, but in practice is virtually indistinguishable from the FM technique since the frequency cannot remain constant as phase changes – which means all FM has some PM and vice versa.

Since all FM does have some PM, and vice versa, these two types of modulation are usually lumped together in engineering textbooks under the heading "angle modulation" (the "angle" referred to here is the "phase angle"). The FCC, however, has very little to say about PM in the amateur license exams; all the questions deal with either AM or FM.

For that reason, in this installment we'll deal with AM and FM. It'll be up to you to remember that in most cases, what we say about FM is also true of PM. In those rare occasions when this is not the case, we'll let you know.

So far, we have defined modulation as the variation of "any characteristic of something in order to convey information," and have identified three characteristics of a radio transmitter's signal which may be varied in order to modulate the signal. We then reduced the resulting three types of modulation (AM, FM, and PM) to only two for the purposes of this discussion (AM and FM).

That part of a radio transmitter's signal which is sent out in the *absence* of any modulation is called the "carrier wave." This name, like the British term "wireless," comes to us from the days of early radio when everyone thought that the purpose of the radio signal was to "carry" the information from place to place, just as the wires do in a landline situation. While we now know better (and have since 1927), the old name has persisted.

The carrier wave is the signal generated by the transmitter's oscillator and built up to strength by the amplifier (refer to the previous chapter for discussion of these parts of a transmitter). The modulator then controls either the amplitude or the frequency of this carrier wave, to produce the final radiated signal.

In general, this control process which does the actual modulation of the output signal adds something extra to the signal.

In the case of AM, the "something extra" is usually in the form of added power imparted to the signal. The exact amount of power added by a typical voice signal is almost impossible to estimate; engineers use a steady sine-wave signal instead of voice for measuring the effect, and the FCC expects to see the engineer's answer on the exam. With 100% (we'll get into percentage of modulation later) sine-wave modulation of a carrier, one half again is the amount of power added. That is, a 500W AM transmitter would be operating with 750W input during this type of modulation. The added power, being ac, does not show up on your input-power measurements, nor need it be included in your records.

With FM, the "something extra" takes the form of a frequency change in the signal sometimes called "vanishing carrier." At certain specific levels of modulation with FM, the carrier wave literally disappears and all the power shows up at other frequencies in the immediate neighborhood. This vanishing point for the carrier is sometimes used to measure modulation levels for FM transmitters.

With any form of modulation of a carrier wave, sidebands are created. The unmodulated carrier is, just as closely as we can make it so, a single spot-frequency signal. That is, if we are operating at a frequency of 3.735 kHz, *all* of our output energy is at 3.735 MHz; none at all is at 3.735000001 MHz, or at 3.734999999 MHz, even though these frequencies are only 1/1000 of 1 Hz away from our chosen frequency. Of course, no known measuring technique can prove that this is the case, but it's what we are trying to achieve.

When we modulate, with a single-frequency tone, we introduce additional frequencies into the output signal which are known as side frequencies. If we apply AM, using a 1 kHz tone, one side frequency will be 1000 Hz higher than the carrier, and the other will be 1000 Hz lower. The first of these is known as the "upper side frequency" and the other is the "lower side frequency." They are also called sum and difference frequencies, because the upper side frequency is the *sum* of the frequencies of the carrier wave and the modulating signal, while the lower side frequency is the *difference* between the frequencies of the carrier wave and the modulating tone.

A man named John Carson developed the theory of side frequencies and "sidebands" (with voice rather than single tones, a whole band of frequencies is involved in the modulating process, and the side frequencies smear out to become sidebands) in 1927, and obtained a patent in that year for a system of radiotelephone transmission which made use of only one of the two mirror-imaged sidebands. Even though his technique worked, and was used for many years by the Bell System for transatlantic conversations, most people felt that it was a mathematical fiction and refused to believe that the side frequencies really existed. Development of accurate measuring apparatus in connection with radar's development in the years 1940–45 made it possible to actually see the sidebands in a scope display of a radio signal and proved their existence. Since 1948, single sideband has been an important technique of ham radio voice communications. While SSB is a special form of AM, it differs rather drastically from ordinary AM and so we won't talk about it any more in this chapter. Here, we'll look only at ordinary AM and at FM.

The sidebands do a bit more than merely making SSB possible. They cause the signal to occupy more spectrum when it's modulated than it does when it's not. That, however, is getting ahead of our subject, and means that we're ready to ask our next question.

How is Modulation Related to Bandwidth?

We observed, a few paragraphs back, that the *unmodulated* output of a radio transmitter is (to the limit of our ability to achieve the goal) a single, spot-frequency signal. Strange as this may sound, such a signal would occupy no space at all in the radio spectrum, because it would be present only at one single frequency.

The space in the spectrum occupied by an actual signal, on the other hand, is known as the bandwidth of that signal, and is measured in hertz or kHz just as is the signal's frequency. The bandwidth is determined by subtracting the lowest frequency in the signal from the highest frequency present; the resulting difference is the bandwidth of that signal.

Our example spot-frequency signal at 3.735 MHz would have both its highest and lowest frequencies equal, and their difference would be zero. That's why we say that such an ideal signal would take up no space at all.

However, one of the lesser-publicized researchers into communications discovered that such a signal, while it might occupy no space at all, would be rather useless because it could not convey any information either! The man who made this discovery was also involved in circuit design, and his name is more familiar to most hams in connection with an oscillator circuit he derived, but Hartley's Law relating information rate and bandwidth is probably more important because it sets an absolute limit on the amount of information which may be sent in any specific portion of the rf spectrum.

The law itself is simple: the bandwidth required to transmit information is directly proportional to the information transmission rate. To see why this is so, it's easiest to look at a simple case involving only one item of information such as presence or absence of a carrier wave. This is known in *information theory* as one "bit" of information.

If we need not know whether the carrier is on or not more often than once every second, and look at it no more frequently than this, then it would be sufficient to turn it on for a full second and then leave it off for the next second. This would be an information rate of one bit per second, or one "baud." The baud is a unit of information transmission speed, named for Georges Baudot, the French telegrapher who invented the 5-unit teleprinter code used in radioteletypes.

Going further, we could represent this one-baud information rate by a sine wave with a frequency of 0.5 Hz because one bit of information would correspond to each half-cycle of the sine wave.

This sine wave could not, however, tell us anything about events happening more often than once per second. If we wanted to know conditions 20 times a second (an information rate of 20 baud), we would have to look at things 20 times more frequently, and the lowest-frequency since wave which could carry this information rate would be one of 10 Hz.

To carry information at a rate of 200 baud, we would have to increase the frequency of the sine wave to 100 Hz, and to get up to 2000 baud, we would require a frequency of 1000 Hz. That is, the frequency is always half the information rate, according to Hartley's Law.

This is, however, the theoretical limit, and has never yet been achieved in a practical system. Even more frequent sampling than Hartley's Law would indicate is required; to carry an information rate of 2000 baud in practice requires a sampling rate of 5000 Hz.

Now let's go back to "sidebands" and see what happens when we attempt to transmit our information, using the corresponding sine wave (and the frequencies determined by Hartley's Law). Even with our theoretically perfect zero-bandwidth carrier wave, as soon as we put even a one-baud information rate onto it we create side frequencies 0.5 Hz either side of the original, so it now has a bandwidth of 1 Hz – just the same as the baud rate of the information. If we attempt to transmit information at the rate of 2000 baud, we will have a signal with a bandwidth of 2000 Hz, 1000 either side of the carrier.

What this means in practice is simply that even were we able to achieve a "perfect" zero-bandwidth carrier, just as soon as we add modulation to it to convey information it will require sidebands. These sidebands must be large enough (wide enough) to "carry" information at the rate we are pumping it in.

And if you think this is just an exercise in doubletalk, then fire up a supersharp receiver, crank its selectivity down to a needle-sharp 10 Hz or so. (It can be done, with a good crystal filter together with a Q-multiplier and a sharp audio filter – ask any serious VHF man.) Then try to copy some of the 100 wpm CW that shatters the airwaves down around the low end of 40 meters. You'll find that the dits and dahs all run together into a solid tone. We normally say that the filter is "ringing" in such a situation, but what's really happening is that the sharp filtering is shaving off the sidebands which carry the 100 wpm information, leaving you only the carrier.

When we deal with phone signals and ordinary voice modulation we don't speak of "baud rate" or "bits"; these terms are more often encountered in commercial telegraphy and the computer industry (where they are standard) than in radio to begin with. The principle of Hartley's Law still applies to voice communications, however. Through experiment (mostly by the telephone people over the years) it has been determined that the normal frequency range used for voice communication is from 300 to 3000 Hz, which means a bandwidth of 2700 Hz.

This means that for normal communication, each of our sidebands extends from 300 to 3000 Hz away from our carrier frequency, giving us a total bandwidth for normal AM of 6 kHz (from −3000 to +3000 Hz).

We don't get this automatically, though. The voice contains frequency components ranging up to 15 kHz, and if we go for "hi-fi" or "broadcast quality" communications, we will take up 30 kHz of the spectrum instead of 6. That's five times as much space as we need, and means that we stand to create five times as much interference to other stations. For this reason, it's considered good operating practice to restrict the frequency range of a phone transmitter to 3 kHz at the upper end, thus limiting its bandwidth requirement to 6 kHz.

While courtesy and sharing are important, there are more selfish reasons also for limiting the frequency range of a phone signal. The phone company studies have shown that voice components outside the 3 kHz "communications" region are not worth the effort required to transmit them. By restricting the bandwidth, then, you can make all the sideband power into *effective* power and not waste any of it. This means a stronger signal at no extra cost, or, to put it another way, less cost per unit of signal strength! If courtesy doesn't convince you, maybe economy will.
that

If we're using FM rather than AM, then the relation between modulating signal and bandwidth is a bit different. We'll go into that in more detail when we look at how AM and FM carry voice. For right now, the key difference is that with AM, it's the frequency range or bandwidth of the audio which determines the bandwidth of the transmitted signal, while with FM, it's the amplitude or intensity of the audio which sets bandwidth of the transmitted signal.

Even with AM, though, the amplitude of the signal has some effect upon bandwidth. Specifically, if the audio signal is too strong for the carrier, it will tend to cut off all carrier power on negative-going peaks. This causes a "clipping" of the audio, which creates an extremely wide band signal. The "splatter" which results can interfere with all the signals in a single ham band, and is prohibited by FCC regulations. So long as signal amplitude is kept below this limit, however, only the frequency of the audio can affect bandwidth of an AM signal.

The important points to remember out of what we've covered so far, then, are these: Any modulation of a signal must increase its bandwidth, with the bandwidth increase being determined by the rate or speed at which information is conveyed. Slow-speed CW has the narrowest bandwidth, and TV video (which must carry the equivalent of millions of bits of information per second) the widest. For any one type of modulation, the bandwidth is primarily dependent upon a single characteristic of the modulating signal. And finally, signals with greater bandwidth than that required to carry the desired information are to be avoided for many reasons.

Now that we've learned a little more about just what modulation amounts to and how it's closely interwoven with signal bandwidth, let's see just how voice signals are carried by AM and FM.

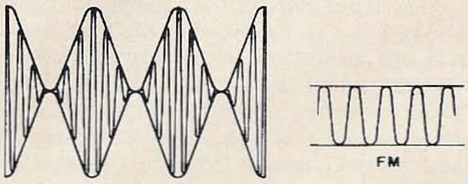

Fig. 1. Envelope waveforms of AM (left) and FM signals show that amplitude varies in AM, but remains steady with FM.

How Do AM and FM Carry Voice?

As we have already seen, the principal types of modulation used for ham phone transmission are AM and FM. The question now before us boils down to "How do they do it?"

The oversimplified view of how is far too condensed to be precise, but it is useful in getting a starting point: AM varies the strength of the signal (leaving the frequency constant), and FM varies the frequency (leaving the strength constant). This is often shown by "envelope waveforms" which are supposed to look something like those in Fig. 1, and "spectrum distribution" charts such as in Fig. 2.

As you can see, these show no significant frequency distribution for the AM signal, and no significant change in amplitude for the FM signal. And since you can actually see such displays on the face of a scope properly connected to the output of an FM or an AM transmitter, it's sometimes difficult to see just why these ideas should be "too simple."

Fig. 2. Spectrum distribution charts for AM and FM show that AM occupies fixed positions in the rf spectrum, while an FM signal appears to vary in frequency over a band of closely related frequencies. With most receivers, the AM spectrum distribution would appear to be a single point rather than the three points shown.

The problem is that any scope hookup, and for that matter any receiver, cannot examine a single spot-frequency signal. Instead, it must act on a whole band of signals which make it through the "selectivity curve" of the device, and the result is influenced by all the signals in that band.

Thus when you have a 1000 kHz carrier wave, together with two side-frequency signals at 1000.5 and 999.5 kHz (each with the proper phase relationship to the carrier), neither the scope nor the receiver will actually show you these three signals as individuals. Instead, the overall *average* strength of the three will be shown – and that comes out as the typical "AM" envelope waveform. Figure 3 shows this by comparing two different spectral charts.

It's possible to prove this out by drawing each of the three signals separately, and adding up the instantaneous values for each at each point in time.

Fig. 3. AM appears to be a single-frequency signal to almost all receivers, and many spectrum analyzers, because the receiver's selectivity curve is so broad as to include the carrier and all sidebands as shown at left above. An extremely selective receiver (right), or analyzer, is capable of selecting any one component of the complete signal and isolating it.

What really makes the whole thing a bit mystifying at first is that the conventional modulator circuits used to achieve AM really look as if all they do is control the amplitude of the signal. Take, for instance, the high-level plate-modulation circuit shown in Fig. 4.

Nothing would be easier than to look at this circuit as a means of controlling power output of the rf amplifier by adjusting its plate voltage with the audio signal to be transmitted. In fact, a couple of generations or so of hams learned solidly that this was just how it worked – the rf amplifier was said to act "like a resistor" and vary its output power according to the plate voltage, which was either lowered (if the audio was going negative) or raised (when audio went positive). This is simple and clear-cut – and wrong. Those hams who learned it so solidly had a really rough time adapting to SSB when it came in, because SSB forces you to know how it really does work instead of a might-be explanation that isn't correct regardless of its glibness.

What really happens is this: The amplifier receives two separate signals, one at radio frequency (the normal input signal) and the other at audio frequency (though its power leads). Because of the variation in operating conditions, and more to the point, because the rf amplifier distorts its signals (and therefore is not a linear device), these two separate signals interact with each other and the result is not just one, or even two, but four signals at the output. These four output signals consist of the two input signals and two new signals. One of the new signals has a frequency equal to the sum of the frequencies of the two input signals, and the other has a frequency equal to the difference.

same process every time – any time that two signals meet in a nonlinear device (it doesn't even have to be an amplifier), we're going to get four signals out.

You may have noticed that these "new" signals which appear in the output of our modulated amplifier are identical with the side-frequency signals we met earlier.

The appearance of a change in signal strength is, as we mentioned, because at any one instant the net energy in a circuit depends on *all* the signals present, and the phase relation between carrier and sidebands is such that the sidebands alternately add to and subtract from the carrier-wave signal's power to give the appearance (and practical effect) of varying signal amplitude.

Once the basic idea of what really happens during modulation takes hold, it's much easier to see how such circuits as the grid-modulated amplifier (Fig. 5) can work. These are a bit difficult to comprehend on a straight amplitude-control basis, but when you look at modulation as being essentially a mixing process, things come

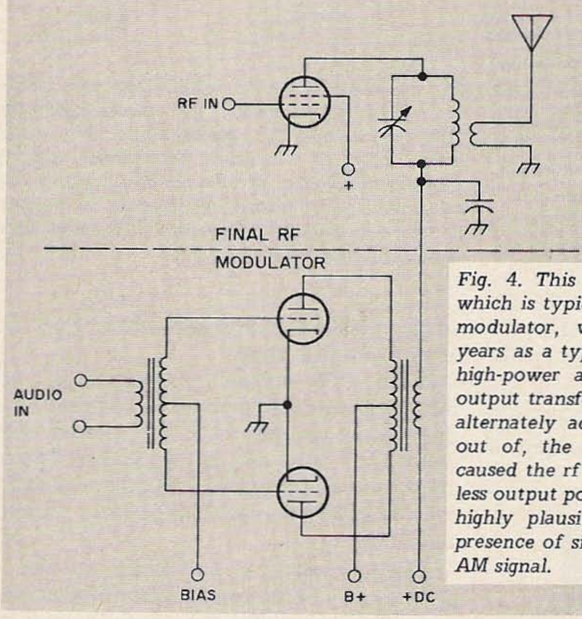

Fig. 4. This high-level plate-modulation circuit, which is typical of the most popular type of AM modulator, was wrongly explained for many years as a type of "valving" action in which the high-power audio signal from the modulator's output transformer or "modulation transformer" alternately added power to, or canceled power out of, the steady dc supply level, and thus caused the rf amplifier stage to produce more or less output power accordingly. The explanation is highly plausible, but fails to account for the presence of sidebands which are present in every AM signal.

When the two input signals are far apart in the rf spectrum, as they are in this case, we call this process amplitude modulation. If the input signals are closer together, we call it "mixing," and we'll meet it again several times as we progress through this course. No matter what we call it, it's the

through more clearly. The major difference between the different amplitude modulators then boils down to "where the audio is fed in."

The mixing-action principle also explains why bandwidth of an AM signal depends upon the bandwidth of the audio

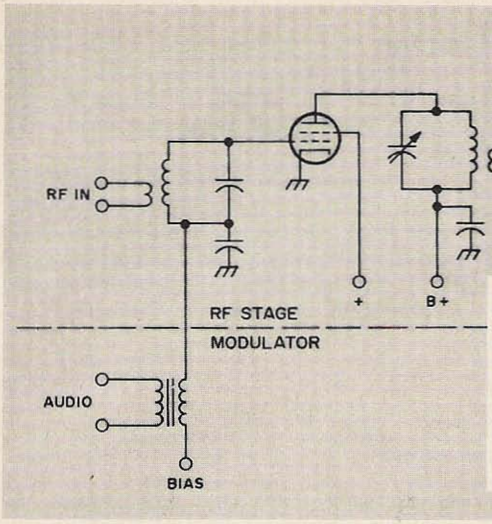

Fig. 5. Grid-modulator circuit for AM could be viewed as valving action by way of grid bias, but it's much easier to take the correct viewpoint and see that the rf and audio input signals mix together in the amplifier stage to produce a modulated signal as the output. Mixer circuits used in receivers and SSB exciters, which we'll examine next time, are very similar to this grid modulator circuit.

signal applied to the modulator. The higher the maximum frequency in the audio signal, the higher will be the sum or upper sideband limit, and the lower will be the lower sideband limit. Since signal bandwidth is the difference between upper and lower sideband limits, this means that high-frequency audio means wider bandwidth.

With single sideband signals, incidentally, both the carrier and one sideband are normally suppressed, and the bandwidth is thus cut to be roughly equal to that of the audio signal fed in (or half that of the corresponding AM or DSB signal).

The basic principle of FM is, unfortunately, not so easy to see accurately. The simplified principle (which is no more

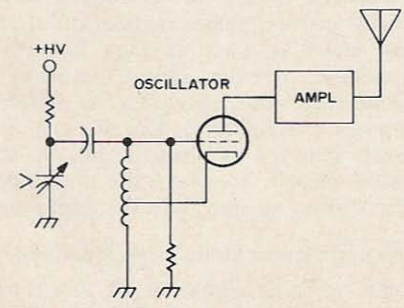

Fig. 6. Oversimplified view of how frequency modulator works is provided here, where capacitor microphone (in which capacitance is changed by sound waves striking it) serves as tuning capacitor for oscillator in the transmitter. Speech causes capacitance to vary, which changes transmitter's frequency. In practice, voltage-variable capacitor is used and voltage applied to it is varied by audio signal.

accurate than the amplitude-control idea of how AM works) is typified in Fig. 6, where a capacitor microphone is used to vary the frequency of an oscillator, directly controlling the frequency of the transmitted signal. This was the old standard explanation, but as we said it's not accurate. The fact is that FM signals have sidebands just like AM signals do, and what's more the only difference between (ham style) FM and AM in the sidebands is that FM's sidebands are phased differently with respect to the carrier. (Wideband broadcast FM has many more pairs of sidebands than does AM; that's where much of its improved audio quality comes from.)

The big difference in sideband phase is shown in Fig. 7. You can see that where both the AM sidebands are going up, one of the FM sidebands goes down. Thus the two FM sidebands appear to cancel each other so far as amplitude is concerned, giving rise to the steady envelope we saw in Fig. 1. However, this imbalance between the sidebands makes their effect on apparent carrier frequency much greater, so that the frequency of the composite signal appears to swing with FM, where it remains constant with AM. In fact, as the modulation level is increased, you can reach a point with FM where the effect of the two sidebands is to completely cancel the carrier wave. This is called the point of "vanishing carrier" and can be used to measure modulation level.

The fact that sideband phase makes the difference between AM and FM is the basis of the Armstrong system for frequency modulation, which made commercial FM practical. This system used conventional AM techniques, but took the carrier out of the signal and shifted its phase by 90 degrees, then put it back. The result was FM.

A not-so-widely known fact, suggested by the sideband relationships shown in Fig. 7 and proved by experiments a number of years ago, is that you can combine AM and FM of the same signal to produce an AM output signal with only one sideband.

Fig. 7. Essential difference between AM sidebands (left) and FM sidebands (right) is in their phase with respect to carrier signal. AM sidebands are completely symmetrical about carrier; FM sidebands are offset in phase and so pull frequency to one side or other instead of affecting envelope amplitude. This is shown in these plots by reversed direction of lower FM sideband.

This is not SSB as we know it, because the carrier is not suppressed, but by proper adjustment of the levels of both types of modulation you can make the "upside-down" FM sideband cancel the corresponding AM sideband, while the carrier and the other sideband reinforce each other. The technique has been used on SWBC stations, but it's illegal for hams — because FCC regulations prohibit simultaneous FM and AM of the same signal.

Practical ham FM modulator circuits usually involve phase modulation of some type which is made to look like FM by adjustment of the audio frequency response (that's the only effective difference between FM and PM). The phase modulation is achieved by electronically detuning a tank circuit, to cause the tank's phase shift to vary in step with the audio signal.

Why and How is Modulation Measured?

To carry information of any sort, a radio signal must be modulated. Modulation consists of varying the characteristics of the signal in order to transmit the information. Naturally, when we vary any characteristic we can either vary it only slightly, or we can carry the variation to extremes — and so the degree of modulation applied to the signal can vary from almost none up to some limiting point.

The measurement of modulation is the determination of the degree of modulation applied to a signal, and it's necessary to measure modulation of any modulated signal for a number of reasons.

Most of these reasons boil down to the basic factor of complying with rules and regulations. For instance, we've already mentioned that it's illegal to apply both AM and FM to the same signal at the same time in the ham bands. To be sure that we are complying with this rule, we have to be able to measure both the AM and the FM of the signal, and be certain that whenever one is present, the other is not.

We've also seen that the bandwidth of the modulated signal is determined by its modulation. FCC rules limit the bandwidth of a ham signal, and so we must perform modulation measurements to be certain that we remain within the bandwidth limit.

When too much AM is applied to a signal, we saw that the result is "splatter," which interferes with other communications over a wide band of the spectrum. Because of this, the level of AM permitted is limited. Again, we must make measurements to assure ourselves that we are complying with the rules.

Before we can examine the how of modulation measurement, we must meet some of the words and phrases we'll be using. The quantity most often measured is known as "percentage of modulation," and is derived from the instantaneous rf voltages present in the modulated signal as shown in Fig. 8 when we're talking about AM. An unmodulated carrier has a modulation percentage of zero, while a fully modulated signal is 100% modulated. While it's possible to exceed 100% modulation, doing so is forbidden by FCC rules because of "splatter," and such a condition is called "overmodulation." Most good AM signals average about 80% modulation; some safety factor is necessary to keep from going over 100% with audio peaks. The average broadcast signal has only about 30% modulation.

Since the amplitude of an FM signal does not vary when it is modulated, "modulation percentage" as defined in Fig. 8 is meaningless if applied to FM; all signals would be 0% modulated. The corresponding term for FM is "modulation index," which is the ratio of signal frequency deviation to modulating signal frequency. For broadcast FM, the modulation index is

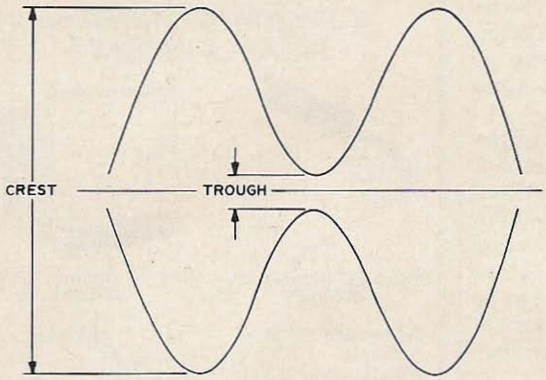

Fig. 8. For AM signal, modulation percentage is a function of "crests" and troughs on a "sum and difference" basis. The resulting fraction is multiplied by 100 to change it into a percentage. Both crest and trough quantities are usually measured as voltages. In this example, crest is 86 units and trough is 12 units, so modulation percentage is (86–12)/(86+12) or 74/98, which comes out to 0.755, or 75.5%. Modulation percentage as defined here is meaningful only for AM; since FM has no amplitude variation, it would always come out to 0%.

usually much larger than 1.0, but in ham FM the modulation index is usually 1.0 or less.

Now we're ready to look at the techniques of modulation measurement. We'll take up AM measurements first, since most ham work on the HF bands makes use of AM, and then turn our attention to FM.

For AM, the most useful measurement is that of modulation percentage. The oscilloscope is the best instrument for measuring modulation percentage, but simpler devices may also be used to assure compliance with FCC regulations.

With most types of AM, the plate current of the final rf amplifier remains constant with proper modulation, but overmodulation (more than 100%) will cause the plate-current meter's needle to flicker. This is the simplest go/no-go measurement of modulation, and will suffice to meet FCC requirements.

A high-resistance ac voltmeter may also be used to measure the ac voltage produced by the modulator; this can be calibrated in percentage of modulation (by comparison with scope measurements, one time) and is more accurate than the plate-current indication. The calibration will be correct only so long as the dc voltage to the modulated stage remains unchanged.

Neon tubes may be used as visual indicators of modulation percentage, by connecting them through diodes so that they compare the instantaneous supply voltage of the modulated stage to the unmodulated voltage and thus flash whenever a specified percentage of modulation is exceeded. Figure 9 shows such a circuit, set up with three bulbs which glow at 50%, 80%, and 100% modulation. Similar circuits may be set up with "magic-eye" tubes as indicators.

To measure modulation percentage with an oscilloscope, the modulated rf signal is applied directly to the vertical plates and the modulating audio signal is applied to the horizontal plates. In the absence of

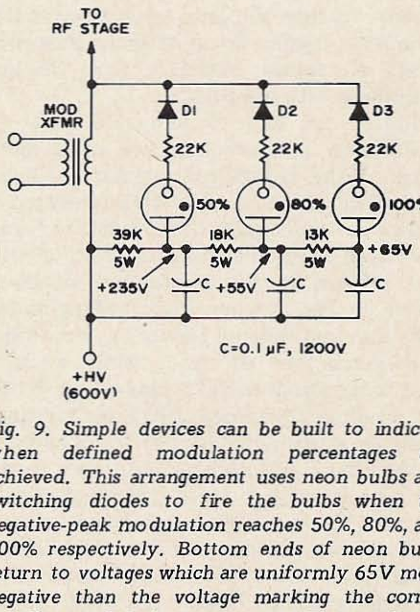

Fig. 9. Simple devices can be built to indicate when defined modulation percentages are achieved. This arrangement uses neon bulbs and switching diodes to fire the bulbs when the negative-peak modulation reaches 50%, 80%, and 100% respectively. Bottom ends of neon bulbs return to voltages which are uniformly 65V more negative than the voltage marking the corresponding modulation percentage. These voltages, and the resistance values in the divider which establishes them, depend upon the voltage supplied to the transmitter (here assumed to be 600V). The 65V offset is the firing voltage of the neon bulb. When the upper end goes 65V more negative than the lower end, the corresponding bulb can fire. In use, the object is to keep the 50% bulb on all the time, the 80% bulb on as much of the time as possible, but never permit the 100% bulb to flash.

modulation, the display is a single vertical line in the center of the screen, because no horizontal deflection voltage is available. This vertical line is a picture of the carrier, and its height is proportional to the carrier's intensity.

When modulation is applied, the modulating signal provides horizontal deflection to the scope and at the same time causes the carrier's intensity to vary. At the positive peak of the modulating signal, carrier intensity will be maximum, and the display will be at one limit of its horizontal deflection. At the negative peak of the modulating signal, carrier intensity will be minimum, and the display will be at its other horizontal limit.

With 100% modulation, in which the maximum carrier intensity is twice that of the unmodulated carrier and the minimum carrier intensity is zero, the resulting display is a triangle. With less than 100% modulation, it is a trapezoidal shape, and for this reason the scope measurement method is often called a "trapezoid pattern" modulation measurement. With more than 100% modulation, the triangle develops a horizontal line at its tip, representing the excess modulating signal (the carrier

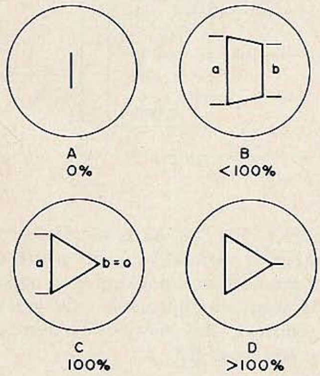

Fig. 10. Trapezoid patterns for 0%, less than 100%, 100%, and greater than 100% (overmodulated) modulation percentages are shown here in ideal form. Modulation percentage can be measured directly from scope screen by taking the fraction (a—b)/(a+b) and multiplying by 100 (patterns B and C). When b=0 as in C, this becomes a/a or 1 times 100, for 100% modulation. In addition to indicating modulation percentage, this measurement tells whether modulator is distorting the audio signal. Clean signal is indicated by straight sides. Any kinks or curvature of the slanting parts of the display mean trouble in the transmitter.

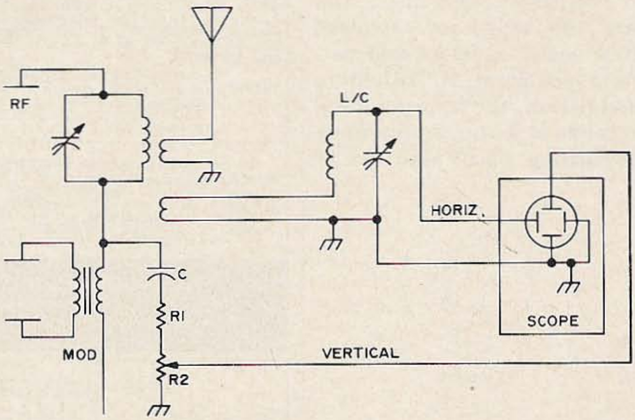

Fig. 11. This is how to hook up scope to get trapezoid patterns of Fig. 10. Rf is sampled from final tank circuit by means of link coil and tuned circuit L/C, and fed to vertical plates of scope through short, direct connections. Audio is sampled from secondary of modulation transformer and applied to horizontal plates. Capacitor C is safety blocking capacitor to prevent supply voltage from getting into scope; resistors R1 and R2 cut down audio signal level as required, and may not be necessary for low-power rigs. Size of display is adjusted by tuning of L/C and setting of R2.

cannot reach less than zero intensity). Figure 10 shows these patterns, and Fig. 11 shows the typical test hookup for the average ham transmitter.

The value of the scope method over all simpler techniques is that the two vertical edges of the display are direct representations of the quantities which define modulation percentage, and so you can calculate modulation percentage accurately from the scope display by the formula shown in Fig. 10. In addition, the slanting edges of the display are drawn by the two signals involved, and should be straight at all times. Any kinks indicate distortion being produced by the modulator, which could result in interference to other signals and even at best would mean a sloppy output signal.

Scope measurements can be made on any AM transmitter, since they simply compare the signal doing the modulating to the signal being modulated. The simpler techniques apply primarily to high-level plate-modulated transmitters (the most common type), and must be used with caution if any other modulating technique (screen, grid, or cathode modulation, for instance) is employed.

When it's FM instead of AM you're measuring, the situation is somewhat different. Most of the common modulation measurement techniques apply only to AM, and cannot be used for FM.

The accurate technique for measuring FM involves a device known as a spectrum analyzer, which is not normally found in a ham shack. The normal ham technique is to locate the point at which the first pair of "extra sidebands is produced. This requires a 3 kHz oscillator and a sharp-tuning receiver capable of detecting one signal which is only 3 kHz away from another, stronger signal.

The transmitter is modulated with the output of the 3 kHz oscillator, and the output signal is examined with the receiver. Both the carrier and the side frequencies 3 kHz either side of it should be detected. Audio gain of the modulator is now slowly increased until a second pair of side frequencies, this time 6 kHz away from the carrier, appears. The gain should be backed off until the second sidebands just disappear, and this point marked as a modulation index of 1.0.

An ac voltmeter may be installed in the modulator to measure signal level for the 1.0 modulation index, and when a microphone is substituted for the oscillator the gain can be adjusted so that this modulation index is never exceeded.

At certain points, the carrier of an FM signal appears to vanish. This occurs as the modulation index is increased past 1.0. The first point of vanishing carrier is at a modulation index of 2.4; the next one is at a modulation index of 5.52, and the third at 8.65. Similarly, the first pair of sidebands vanishes at modulation indexes of 3.83, 7.02, 10.17, and 13.32. Modulation indexes greater than about 8.0 are too wide for even VHF FM bands, but the points of vanishing carrier and vanishing sidebands can be used to set certain indexes with certainty.

The technique is similar to detecting the second sideband pair; the difference is that the receiver is left tuned to the carrier, and the audio gain increased until the carrier vanishes. This represents a modulation index of 2.4. The receiver is then tuned to the first pair of sidebands, and gain increased until they vanish. This is a modulation index of 3.83. Back to the carrier, and increase modulation until it vanishes again at 5.52, and so forth. If two separate audio gain controls are provided on the modulator, one can be used to set modulation level and it can be calibrated by this technique; the other can then adjust for differences between microphones.

VHF FM enthusiasts sometimes use "frequency deviation meters" to adjust or measure modulation level of their transmitters. These meters are similar to FM receivers, and provide direct indication of the bandwidth of the modulated signal.

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